



Agricultural Land Loss And Its Implications For Sustainable Farming In Bankura District, West Bengal, India

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Abstract

Agricultural land constitutes the foundation of rural livelihoods and food security in India; however, rapid urbanization, infrastructure expansion, and population pressure have increasingly threatened its sustainability. Bankura district of West Bengal, located in the lateritic plateau fringe of eastern India, represents one of the most vulnerable agrarian regions due to its semi-arid climate, poor soil fertility, low water-holding capacity, and heavy dependence on rainfed agriculture. Against this backdrop, the present study examines spatio-temporal land use and land cover (LULC) changes in Bankura district between 1995 and 2015, with a particular focus on agricultural land loss and its implications for sustainable farming systems.

Multi-temporal satellite data from Landsat-5 Thematic Mapper (1995) and Landsat-8 Operational Land Imager (2015) were analysed using supervised classification based on the Maximum Likelihood Algorithm in ERDAS Imagine software. Post-classification change detection techniques were employed to quantify land-use transitions and assess spatial patterns of conversion. The analysis identified five major land-use categories: agricultural land, forest land, built-up area, barren land and sandbar, and river and water bodies.

The results reveal a significant decline in agricultural land by 4.42 percent, decreasing from 59.46 percent (4091.64 km²) in 1995 to 55.04 percent (3787.53 km²) in 2015. The lost agricultural land was primarily converted into built-up areas (+1.46 percent) and barren land and sandbar areas (+1.76 percent), reflecting the combined impacts of urban expansion, infrastructure development, and land degradation. Forest cover exhibited a marginal increase of 0.88 percent, while water bodies showed a slight expansion of 0.32 percent. Spatial analysis indicates that agricultural land loss was widespread but particularly concentrated in transitional zones along roads, urban fringes, and development corridors, resulting in increasing fragmentation of cultivable land.

These land-use changes pose serious challenges to sustainable farming in Bankura, where over 80 percent of cultivators are small and marginal farmers with an average landholding size of approximately 1.02 hectares. Agricultural land loss, combined with limited irrigation coverage and climatic uncertainty, constrains crop diversification, reduces productivity, and heightens livelihood vulnerability. Although West Bengal maintained a relatively stable gross cropped area (approximately 10,259 thousand hectares) and high cropping intensity (around 194 percent) up to 2021–22, district-specific pressures related to drought proneness and land fragmentation continue to undermine agricultural resilience in Bankura. The study highlights the urgent need for protective land-use policies, sustainable intensification strategies, and integrated soil and water management to ensure long-term agricultural viability in this fragile semi-arid region.

Keywords: Agricultural land loss; Land use–land cover change; Semi-arid lateritic region; Urbanization; Sustainable agriculture; Bankura district

1. Introduction

Agriculture remains the backbone of India's socio-economic structure, supporting the livelihoods of more than half of the population and playing a decisive role in ensuring national food security. Despite structural transformations in the economy and the growing contribution of the industrial and service sectors, agriculture continues to sustain rural employment, stabilize food prices, and support allied activities. However, in recent decades, rapid urbanization, industrialization, and infrastructure expansion have significantly altered land-use patterns across the country, resulting in the progressive conversion of agricultural land into non-agricultural uses. This trend poses a serious challenge to sustainable agricultural production, particularly in ecologically fragile and resource-constrained regions.

At the national level, India's net sown area has remained relatively stable in recent years, accounting for approximately 45–46 percent of the total geographical area. Nevertheless, more than two million hectares of cultivable land have been diverted to non-agricultural purposes over recent decades, primarily due to urban expansion, industrial development, transportation networks, and real estate growth. A substantial proportion of India's agricultural land also remains rainfed and highly dependent on monsoon rainfall, making it vulnerable to climate variability, droughts, and extreme weather events. In this context, geospatial technologies such as remote sensing and geographic information systems (GIS) have emerged as indispensable tools for monitoring land-use dynamics, identifying hotspots of agricultural land loss, and supporting evidence-based land management policies.

West Bengal represents a unique agrarian paradox within India. The state accommodates nearly 8 percent of the country's population on only about 2.7 percent of its land area, exerting immense pressure on land resources. Agriculture occupies a central position in the state economy, with a net cropped area of approximately 52.05 lakh hectares, constituting nearly 68 percent of the geographical area and over 90 percent of the arable land. West Bengal is characterized by one of the highest cropping intensities in India, fluctuating between 184 and 194 percent in recent years, and reaching around 194.2 percent in 2021–22. The total cropped area stood at approximately 10,259 thousand hectares during 2021–22, indicating overall stability at the state level. However, this aggregate stability conceals pronounced regional disparities, particularly between the fertile Gangetic plains and the drought-prone western districts.

The western part of West Bengal—including Bankura, Purulia, Birbhum, Paschim Bardhaman, and Jhargram—forms part of the plateau fringe region characterized by undulating lateritic terrain, erratic rainfall, low soil fertility, and limited irrigation infrastructure. Among these districts, Bankura occupies a critical transitional zone between the fertile alluvial plains of the east and the rugged extension of the Chotanagpur Plateau to the west. The district experiences a semi-arid climatic regime, with recurrent droughts, high surface runoff, gully erosion, and poor water retention capacity of lateritic soils. As a result, agriculture in Bankura is predominantly rainfed and highly sensitive to monsoon variability.

Bankura district has a net cultivable area of approximately 4.30 lakh hectares, with an average landholding size of about 1.02 hectares per cultivator. More than 80 percent of farmers belong to the small and marginal category, making agricultural livelihoods particularly vulnerable to land fragmentation, declining soil productivity, and market uncertainties. Cropping intensity in the district remains relatively low (around 147 percent) compared to the state average, reflecting structural constraints related to water availability, soil quality, and farm size. In recent years, the district has also witnessed increasing conversion of agricultural land for urban growth, road expansion, industrial estates, and non-farm activities, further intensifying pressure on the already limited cultivable land base.

In such a fragile agro-ecological and socio-economic setting, agricultural land loss has far-reaching implications. The reduction of net sown area limits opportunities for crop diversification, restricts the adoption of improved technologies, and undermines farm-level economic viability. Moreover, the conversion of agricultural land into barren or degraded surfaces exacerbates soil erosion, reduces groundwater recharge, and accelerates environmental degradation. These processes collectively threaten food security, rural livelihoods, and sustainable development in backward semi-arid regions like Bankura.

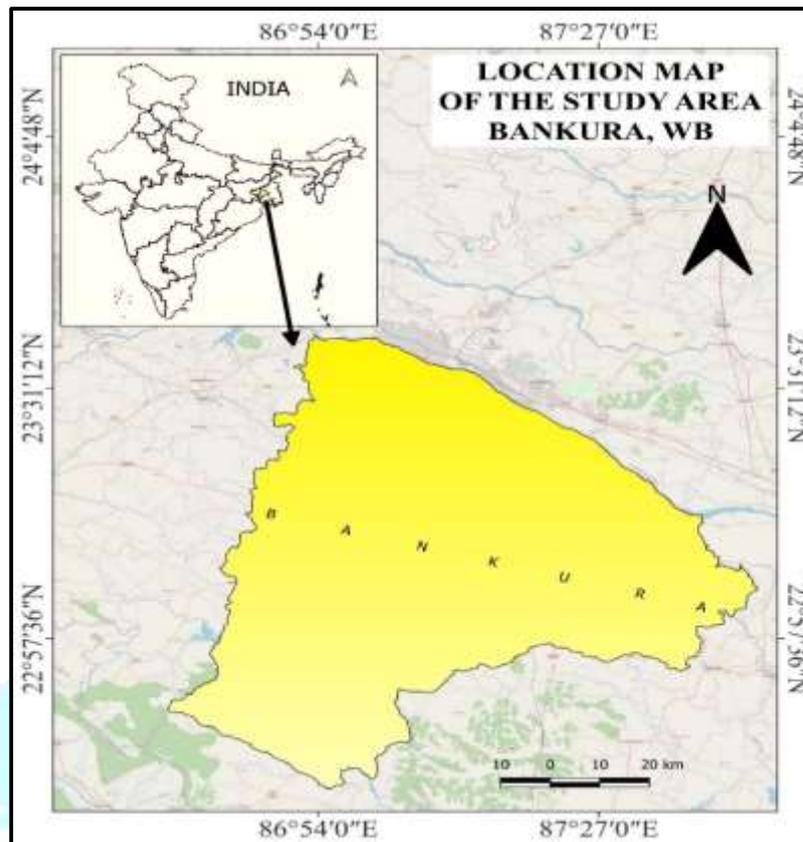
Against this background, the present study seeks to systematically analyse spatio-temporal changes in land use and land cover in Bankura district over a twenty-year period (1995–2015), with a particular emphasis on agricultural land dynamics. By integrating multi-temporal satellite imagery with GIS-based change detection techniques, the study aims to identify the magnitude, spatial patterns, and drivers of agricultural land loss and to assess its implications for sustainable farming and rural livelihoods. The findings are intended to provide a scientific baseline for land-use planning, policy formulation, and adaptive strategies aimed at safeguarding agricultural viability in one of West Bengal's most vulnerable regions.

2. Study Area

Bankura district is located in the western part of West Bengal between 22°38'N to 23°38'N latitude and 86°36'E to 87°46'E longitude, covering a geographical area of approximately 6,882 km². The district is bounded by Paschim Bardhaman to the north, Purulia to the west, Medinipur district to the south, and Hooghly district to the east. Geographically, Bankura forms a transitional zone between the fertile alluvial plains of eastern West Bengal and the undulating lateritic plateau of the Chotanagpur fringe.

The physiography of the district is characterized by gently undulating terrain with elevations ranging from 70 to 300 metres above mean sea level. Lateritic and red soils dominate the western and central parts of the district, while limited patches of alluvial soil occur in the eastern riverine tracts. These lateritic soils are coarse-textured, acidic in nature, poor in organic matter, and have low water-holding capacity, making them highly vulnerable to erosion and land degradation. Climatically, Bankura experiences a tropical monsoon climate with hot summers, moderate winters, and an average annual rainfall of about 1,300 mm, nearly 80 percent of which is received during the southwest monsoon season (June–September).

Agriculture in Bankura is predominantly rainfed, with irrigation coverage remaining significantly below the state average. The main crops include aman paddy, aus paddy, wheat, oilseeds, pulses, and vegetables. Due to limited irrigation facilities, erratic rainfall, and frequent droughts, cropping intensity remains relatively low compared to the eastern districts of West Bengal. Socio-economically, the district is characterized by a high proportion of small and marginal farmers, scheduled caste and scheduled tribe populations, and widespread dependence on agriculture and allied activities for livelihood.

Map No 2.1: Location of the study area.

3. Data Sources and Methodology

The present study is based on the analysis of multi-temporal satellite imagery and secondary data sources. Landsat-5 Thematic Mapper (TM) data for the year 1995 and Landsat-8 Operational Land Imager (OLI) data for the year 2015 were obtained and processed to analyse land use and land cover changes in Bankura district. The spatial resolution of 30 metres was considered adequate for district-level land-use analysis.

Satellite images were geometrically corrected and radiometrically enhanced to ensure spatial accuracy and consistency. Supervised classification was carried out using the Maximum Likelihood Classification (MLC) algorithm in ERDAS Imagine software. Training samples were selected based on field knowledge, Survey of India topographical sheets, and high-resolution Google Earth imagery. Five land-use classes were identified: agricultural land, forest land, built-up area, barren land and sandbar, and water bodies.

Post-classification comparison techniques were employed to detect land-use changes between 1995 and 2015. Change matrices were generated to quantify the extent and direction of land conversion, particularly focusing on transitions from agricultural land to non-agricultural categories. Accuracy assessment was conducted using reference data and confusion matrices, ensuring acceptable classification reliability. GIS-based spatial analysis was further used to identify zones of concentrated agricultural land loss and to interpret their implications for sustainable farming.

4. Results and Major Findings

4.1 Land Use–Land Cover Changes in Bankura District (1995–2015)

Quantitative assessment of land use–land cover (LULC) change between 1995 and 2015 reveals substantial transformations across all major land-use categories in Bankura district. Among these, agricultural land—forming the backbone of the district’s agrarian economy—experienced the most significant decline. The detailed area-wise and percentage-wise changes are presented in Table 3.4, which provides the empirical foundation for spatial interpretation and subsequent analysis.

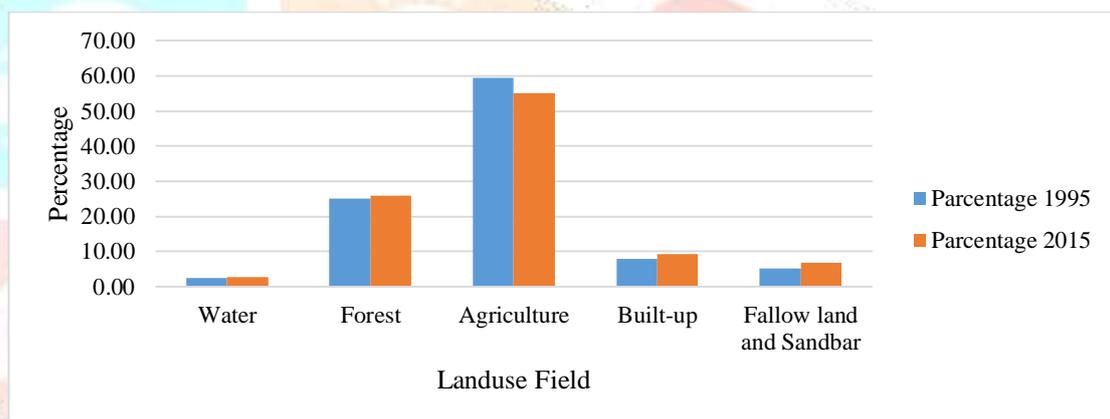
Table 1: Changes in Land Use Patterns in Bankura District (1995–2015)

Land Use Category	Area (km ²) 1995	Area (km ²) 2015	% 1995	% 2015	Change (%)
River & Water Bodies	163.56	185.74	2.38	2.70	+0.32
Forest Land	1730.93	1791.66	25.15	26.04	+0.88
Agricultural Land	4091.64	3787.53	59.46	55.04	-4.42
Built-up Area	543.49	643.96	7.90	9.36	+1.46
Barren Land & Sandbar	351.55	472.51	5.11	6.87	+1.76

Source: Calculated by the authors from Landsat-5 TM (1995) and Landsat-8 OLI (2015) satellite imagery using Remote Sensing and GIS techniques.

The results indicate a decline of approximately 304 km² (4.42%) in agricultural land during the study period. This reduction is spatially widespread but more pronounced in transitional zones adjoining urban centres, transport corridors, and infrastructure development areas. In contrast, built-up areas expanded considerably, reflecting growing settlement concentration and infrastructural expansion.

Barren land and sandbar areas also increased substantially, indicating progressive land degradation and exposure of fragile lateritic surfaces. Forest cover and water bodies recorded marginal gains; however, these increases remain insufficient to compensate for the loss of productive agricultural land. The spatial expression of these transformations is clearly illustrated in Fig. 1, which shows fragmented agricultural patches increasingly encroached upon by expanding built-up areas.

**Fig1:** Changes in Land Use Patterns in Bankura District from 1995 to 2015

5. Discussion and Analysis

5.1 Spatio-Temporal Dynamics and Drivers of LULC Change (1995–2015)

The observed land use–land cover changes in Bankura district are the cumulative outcome of demographic pressure, infrastructural expansion, environmental constraints, and evolving livelihood strategies. The decline in agricultural land, as identified in Section 4, reflects a gradual but persistent conversion of cultivable land into non-agricultural uses over the two-decade period.

Rapid expansion of built-up areas is closely associated with population growth, rural–urban transition, road connectivity, and the emergence of block-level market centres and service hubs. Unlike metropolitan-driven urbanization, the pattern in Bankura is largely dispersed, extending along highways, block headquarters, and peri-urban fringes, thereby exerting pressure on nearby agricultural land.

The increase in barren land and sandbar areas suggests intensifying land degradation processes. Lateritic soil characteristics, seasonal droughts, declining soil fertility, deforestation in upland tracts, and unsustainable land management practices have collectively contributed to the transformation of marginal

farmland into degraded surfaces. Riverbank erosion and seasonal exposure of sandbars along the Damodar and its tributaries further accentuate this trend.

Although forest cover shows a marginal increase, largely due to social forestry initiatives and plantation programmes—particularly in the Khatra subdivision—the scale of afforestation remains inadequate in addressing the ecological imbalance created by agricultural land loss and degradation. Similarly, the slight increase in water bodies reflects the construction of small reservoirs and check dams; however, their seasonal nature limits long-term hydrological sustainability.

Overall, the spatio-temporal analysis highlights a shift from an agrarian-dominated landscape towards a more fragmented and anthropogenically modified land-use structure, raising concerns regarding food security, livelihood sustainability, and environmental resilience in Bankura district.

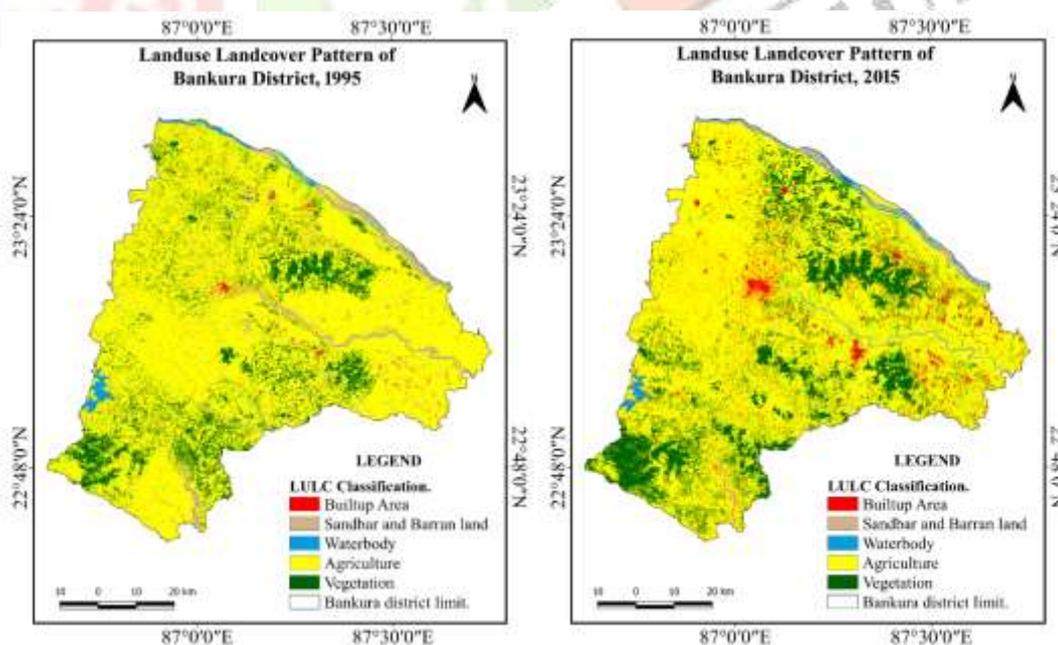
5.2 Spatial Pattern of Agricultural Land Loss

The spatial distribution of land-use changes (Fig. 2 and 3) highlights a fragmented pattern of agricultural land loss across the district. Agricultural areas, represented by yellow patches in the classified maps, appear increasingly dissected and encroached upon by expanding built-up areas shown in red. This pattern is most evident in transitional zones located near major roads, railway lines, urban fringes, and block-level administrative centres.

The Bishnupur and Bankura Sadar subdivisions exhibit pronounced conversion of agricultural land into built-up areas, driven by urban expansion, tourism-related infrastructure, educational institutions, and service-sector growth. In contrast, the Khatra subdivision shows relatively lower built-up expansion but a higher conversion of agricultural land into barren and degraded categories, reflecting harsher biophysical conditions and limited irrigation infrastructure.

The progressive fragmentation of agricultural land has reduced the contiguity of cultivable plots, adversely affecting mechanization, irrigation efficiency, and economies of scale. Small and marginal farmers, who dominate the agrarian structure of Bankura, are particularly vulnerable to the impacts of such fragmentation.

Fig 2 and 3: Changes in Land Use Patterns in Bankura District from 1995 to 2015



6. Discussion: Implications of Land Use Change for Sustainable Farming

The observed 4.42 percent decline in agricultural land in Bankura district mirrors broader national and regional trends but carries more severe implications due to the district's fragile agro-ecological setting. Unlike irrigated alluvial regions, Bankura's lateritic soils exhibit low fertility, poor moisture retention, and a high susceptibility to erosion, making it more difficult to reverse agricultural land loss.

The expansion of built-up areas reflects development-driven land conversion; however, in the absence of strict land-use zoning, this process has frequently occurred at the expense of fertile agricultural plots located near settlements and transport corridors. Once converted, these lands are effectively removed from the agricultural system, reducing the scope for future expansion of cultivated area.

The increase in barren land and sandbar areas is particularly concerning from a sustainability perspective. It indicates not merely land-use conversion but progressive land degradation, which undermines long-term agricultural productivity. Marginal lands, once abandoned due to declining yields and water stress, gradually transition into degraded surfaces, exacerbating livelihood insecurity and prompting seasonal migration.

Although forest cover and water bodies show marginal gains, these increases are insufficient to compensate for the loss of agricultural land and the growing pressure on remaining cultivable areas. The persistence of rainfed agriculture, limited irrigation coverage (approximately 46 percent of net sown area), and increasing climate variability further constrain sustainable farming prospects.

Despite these challenges, state-level data indicate that West Bengal maintained a relatively stable gross cropped area and high cropping intensity (around 194 percent) up to 2021–22. However, this apparent stability masks district-level disparities. In Bankura, cropping intensity gains have been achieved largely through increased pressure on shrinking land resources, raising concerns about soil health, groundwater depletion, and long-term sustainability.

The findings underscore the need to interpret land-use change not merely as a spatial transformation but as a socio-ecological process that directly affects food security, farmer resilience, and rural livelihoods. Without targeted interventions, continued agricultural land loss may push the district towards greater dependence on external food supplies and non-farm employment.

7. Implications of Agricultural Land Loss for Sustainable Farming in Bankura District

The gradual yet persistent decline of agricultural land in Bankura district has far-reaching implications for the sustainability of farming systems, rural livelihoods, and regional food security. In a semi-arid, lateritic environment where agricultural productivity is already constrained by biophysical limitations, even modest reductions in cultivable land exert disproportionate pressure on farmers and agro-ecosystems.

7.1 Impact on Crop Productivity and Cropping Systems

The reduction of agricultural land by **4.42 percent** between 1995 and 2015 has resulted in increased cultivation pressure on remaining farmland. Farmers are compelled to intensify production through repeated cropping, often without adequate soil nutrient replenishment. While this has helped maintain cropping intensity at the state level, it has simultaneously contributed to soil fatigue, declining organic matter, and reduced yield stability in Bankura.

Traditional rainfed crops such as Aman paddy, pulses, and oilseeds dominate the district's cropping pattern. The loss of fertile plots near settlements and transport corridors has pushed cultivation towards more marginal lands with poor soil depth and moisture-holding capacity. Consequently, farmers increasingly rely on mono-cropping of low-risk crops, reducing crop diversity and resilience against climatic shocks.

7.2 Livelihood Stress and Smallholder Vulnerability

More than **80 percent** of cultivators in Bankura are small and marginal farmers with average landholdings of approximately **1.02 hectares**. Fragmentation of agricultural land due to land-use conversion and inheritance practices has further reduced operational holding sizes, limiting economies of scale and mechanization potential.

Agricultural land loss has intensified livelihood stress by reducing on-farm employment opportunities and income security. Seasonal underemployment has increased, particularly during drought years, compelling rural households to depend on wage labour, public employment programmes, and seasonal migration to urban centres. This transition undermines the socio-economic stability of agrarian communities and weakens traditional farming knowledge systems.

7.3 Water Stress, Land Degradation, and Climate Vulnerability

The expansion of barren land and sandbar areas (+1.76%) reflects growing land degradation driven by soil erosion, deforestation, and erratic rainfall. Inadequate irrigation coverage—approximately **46 percent** of the net sown area—exposes farmers to rainfall variability and recurrent dry spells. The conversion of agricultural land into degraded surfaces reduces groundwater recharge and further intensifies water scarcity.

Climate variability, manifested through delayed monsoons, prolonged dry spells, and short-duration high-intensity rainfall events, compounds these challenges. Agricultural land loss reduces the adaptive capacity of farming systems, making them increasingly vulnerable to climate-induced shocks.

7.4 Food Security and Regional Sustainability Concerns

Although West Bengal has maintained a relatively stable gross cropped area and high cropping intensity (~194%) up to 2021–22, district-level disparities remain pronounced. In Bankura, food grain production stability has been sustained largely through increased pressure on shrinking land resources rather than genuine productivity gains.

Continued agricultural land loss may gradually erode the district's food self-sufficiency, increasing dependence on external food supplies and market fluctuations. This scenario poses long-term risks to regional food security, especially for low-income rural households.

8. Policy Recommendations for Sustainable Land and Agricultural Management

To mitigate agricultural land loss and strengthen sustainable farming in Bankura district, a combination of regulatory, technological, and community-based interventions is required.

8.1 Protection of Agricultural Land

- Implementation of **strict land-use zoning regulations** to protect prime agricultural land from unplanned conversion.
- Regular **GIS- and remote sensing–based monitoring** of land-use changes to support evidence-based planning.
- Integration of agricultural land protection policies into district and block-level development plans.

8.2 Sustainable Intensification and Soil Management

- Promotion of **soil conservation measures**, including contour bunding, mulching, and organic amendments.
- Adoption of **drought-tolerant and short-duration crop varieties** suited to lateritic soils.
- Encouragement of **crop diversification** to reduce risk and improve nutritional security.

8.3 Integrated Water Resource Management

- Expansion of **rainwater harvesting structures**, check dams, and farm ponds.
- Strengthening of **watershed development programmes** in upland and degraded areas.
- Promotion of **micro-irrigation techniques** such as drip and sprinkler systems to enhance water-use efficiency.

8.4 Livelihood Diversification and Institutional Support

- Support for **agroforestry and allied activities** (horticulture, livestock, fisheries) to supplement farm incomes.
- Strengthening of farmer collectives and **institutional credit access** for small and marginal farmers.
- Capacity-building initiatives to enhance farmers' awareness of sustainable practices and climate adaptation strategies.

These measures, when implemented in an integrated manner, can help balance development needs with agricultural sustainability and environmental conservation in Bankura district.

9. Conclusion

This study has systematically examined spatio-temporal changes in land use and land cover in Bankura district, West Bengal, over a twenty-year period (1995–2015), with particular emphasis on the decline of agricultural land and its implications for sustainable farming. Using multi-temporal Landsat satellite data and GIS-based analysis, the research provides robust empirical evidence of significant land-use transformations occurring in a fragile, semi-arid agro-ecological setting.

The findings reveal that agricultural land declined by **4.42 percent**, equivalent to approximately **304 km²**, during the study period. This loss was primarily driven by the expansion of built-up areas and the growth of barren land and sandbar surfaces. While forest cover and water bodies showed marginal increases, these gains were insufficient to offset the adverse impacts of agricultural land conversion and land degradation. Spatial analysis indicates that agricultural land loss was most pronounced in transitional zones near urban fringes, transport corridors, and block-level administrative centres, leading to increased fragmentation of cultivable land.

The implications of these changes are particularly severe for Bankura's predominantly smallholder-based agrarian economy. Fragmentation of landholdings, declining soil quality, limited irrigation coverage, and increasing climate variability collectively undermine crop productivity, livelihood security, and long-term sustainability. Although West Bengal as a whole has maintained a high cropping intensity and relatively stable gross cropped area up to 2021–22, this apparent stability conceals significant district-level vulnerabilities. In Bankura, continued reliance on intensification of shrinking agricultural land raises concerns regarding soil health, water availability, and resilience to climatic stress.

The study underscores that agricultural land loss is not merely a spatial phenomenon but a complex socio-ecological process with far-reaching consequences for food security, rural livelihoods, and environmental sustainability. Without timely and targeted interventions, ongoing land-use changes may irreversibly weaken the district's agricultural base and increase dependence on non-farm income sources and external food supplies.

To address these challenges, the study emphasizes the need for integrated land-use planning, protection of prime agricultural land, promotion of sustainable intensification, and strengthened water and soil management strategies. GIS- and remote sensing-based monitoring should be institutionalized to support evidence-based decision-making at the district and block levels. Community participation, institutional support for small and marginal farmers, and alignment of local development strategies with national food security and climate adaptation goals are critical for ensuring long-term agricultural sustainability in Bankura district.

10. Significance of the Study

The present study contributes to the growing body of literature on land use and land cover dynamics in semi-arid regions by providing a district-level assessment of agricultural land loss and its implications for sustainable farming. By integrating spatial analysis with socio-economic interpretation, the research offers valuable insights for planners, policymakers, and development practitioners concerned with balancing development and agricultural sustainability in ecologically fragile regions.

The methodological framework adopted in this study demonstrates the utility of multi-temporal remote sensing and GIS techniques for monitoring land-use change at a fine spatial scale. The findings are particularly relevant for plateau fringe districts of eastern India, where similar biophysical constraints and development pressures prevail.

11. Limitations and Scope for Future Research

Despite its contributions, the study has certain limitations. The analysis relies on medium-resolution Landsat imagery, which may not capture micro-level land-use changes and small-scale conversions. Additionally, the study focuses primarily on spatial patterns and does not incorporate detailed household-level socio-economic data.

Future research may address these limitations by integrating high-resolution satellite imagery, field-based surveys, and participatory approaches to better understand farmer decision-making processes. Longitudinal studies examining post-2015 land-use dynamics, climate impacts, and policy interventions would further enhance understanding of agricultural sustainability in Bankura district.

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