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Economic Modernization and Land Use Transitions: The Indian Experience

Jitendra Kumar Sinha

Directorate of Economics & Statistics, Bihar, India

Corresponding author: **Jitendra Kumar Sinha** | E-mail: **jksinha2007@rediffmail.com**

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Abstract

India's high population density results in very low per-capita land availability, making efficient and sustainable land use a critical policy goal. Against the backdrop of rapid structural transformation, this study investigates the relationship between sectoral shifts in Gross Value Added (GVA) and long-term land-use dynamics from 1951 to 2020. Using official datasets from the Government of India, the analysis integrates ratio computation, percentage distribution, trend-line mapping, and econometric estimation of exponential and compound annual growth rates to assess inter-sectoral variations in land productivity and use efficiency. The findings reveal that while the agricultural sector's share in GDP and land use has stabilised since the mid-1960s, its output continues to grow through productivity gains, technological advances, and input intensification. In contrast, non-agricultural sectors—particularly industry and services—have achieved much higher land productivity, primarily by converting barren, unculturable, and cultivable wastelands into productive uses rather than through large-scale displacement of farmland. Forest land productivity, however, has remained largely stagnant, reflecting limited integration of ecological resources into the economic growth process. The land-use transition matrix demonstrates a dual dynamic: increasing efficiency through reclamation of marginal lands and progressive conversion of cultivable land to non-agricultural uses. These shifts underscore both the efficiency-driven nature of land transformation and the emerging tensions between economic expansion, food security, and ecological stability. Overall, India's land-use trajectory reflects a gradual realignment toward high-productivity, non-agricultural sectors consistent with sustainable resource utilisation. The study emphasises the need for geospatially informed land-use planning, institutional coordination, and policies that integrate economic, agricultural, and environmental priorities. Strengthening the National Land Information System, enforcing GIS-based zoning, and empowering local governance can collectively ensure that India's finite land resources support inclusive, resilient, and ecologically balanced development.

Keywords: *Land-use pattern; Structural transformation; Sectoral allocation; Partial land productivity; Agricultural sustainability; Food security; Urbanisation and land dynamics.*

Introduction

Land, being a finite and virtually inelastic resource, demands careful and judicious use to support competing human, economic, and ecological needs. The land-use pattern of a country provides a systematic account of how its available land is distributed across alternative purposes such as agriculture, forestry, habitation, infrastructure, and other productive or non-productive uses. In the trajectory of economic development, land-extensive agriculture gradually loses its dominance to manufacturing and services, as these sectors deploy land with higher intensities of physical and human capital, thereby enhancing land productivity even when land's relative share as a factor of production declines [1]. These dynamics of structural transformation naturally reshape land-use patterns over time.

The present paper examines the interaction between the structural transformation of the Indian economy and the country's evolving land-use pattern since 1951. It is motivated by a critical question: Has inter-sectoral land allocation in India been aligned with relative sectoral land productivity? This inquiry is particularly relevant in a nation where land is scarce relative to population, and its optimal use is vital for sustaining growth, employment, and food security.

Economic theory suggests that structural transformation involves a sequential shift in the dominance of GDP and employment shares—first from agriculture to manufacturing and subsequently to services [2–6]. This pattern has been the hallmark of many advanced economies and has underpinned Asia's growth experience, with manufacturing-led industrialisation playing a central role [7]. India's trajectory, however, has been distinctive. In 1950, agriculture accounted for nearly 60% of GDP and 75% of the workforce, while services contributed 27% of output and 16% of employment [8]. Over time, agriculture's GDP share plummeted to around 14% by 2010–11 [9], yet unlike the conventional model where industry becomes the intermediate driver of growth, India leapfrogged into a service-dominated economy.

Despite state-led industrialisation efforts from the Second Five-Year Plan onward, manufacturing never assumed primacy. Instead, India's growth acceleration from the 1990s onwards was fuelled by services, particularly Information Technology and Business Process Outsourcing (IT-BPO), supported by a large pool of educated human capital [10,11,12]. This makes India a unique case of "service-led growth" rather than the classical three-stage transformation.

Understanding land use in this context is critical. The term land use refers to human utilisation of land for agriculture, settlements, protected areas, or infrastructure, while land cover denotes the natural vegetation or physical surface features shaped by climate and geomorphology [13]. In India, regional land-use patterns are determined not only by physical characteristics but also by institutional frameworks, technology adoption, population dynamics, and policy choices [14–16]. Recent decades have witnessed a gradual shift of land from agriculture to non-agricultural purposes such as urbanisation, infrastructure expansion, and industrialisation [17]. This transition, while economically rational, raises concerns regarding agricultural sustainability, food security, and ecological balance. Further, climate-induced rainfall variability, groundwater stress, and limited mechanisation have contributed to a rise in fallow lands, which simultaneously signals both vulnerability and opportunity: vulnerability to climatic and resource shocks, but opportunity for improving productivity if these lands are sustainably harnessed [18].

India's demographic pressure intensifies the stakes. As the world's most populous country, with a density of nearly 477 persons per square kilometre [19], India's per capita land availability is significantly below the global average. This makes efficient, equitable, and sustainable land use not merely an economic imperative but also a developmental necessity.

2. Land-Use Transitions and Economic Modernization in India

India's land-use transitions represent a critical interface between economic modernisation and resource sustainability. Land, being a finite and non-renewable asset, forms the foundation of the country's socio-economic and ecological systems. The pressures of rapid population growth, urbanization, industrial expansion, and changing consumption patterns have led to complex shifts in land-use dynamics, intensifying competition among agriculture, infrastructure, energy, and conservation priorities.

Over the past seven decades, India's land-use structure has transformed from predominantly agrarian to increasingly diversified, reflecting the structural reorientation of the national economy. The share of land under forests and non-agricultural uses has steadily increased, while the net sown area has either stagnated or declined marginally in several regions. This transformation mirrors broader economic shifts—from primary to secondary and tertiary sectors—underpinned by policies aimed at industrialisation, infrastructure expansion, and urban development [20-21]. Urbanisation, in particular, has emerged as a defining force: India's urban population is projected to reach 600 million by 2036 [22], driving peri-urban expansion and conversion of fertile agricultural land into built-up areas, industrial estates, and transport corridors.

Agriculture, which sustains nearly 43% of India's workforce [23], remains under pressure from declining landholdings (from 1.15 ha in 1990–91 to 0.53 ha in 2015–16) and resource degradation. Approximately 30% of India's land is degraded [24], largely due to soil erosion, deforestation, and unsustainable input-intensive practices initiated during the Green Revolution [25]. These changes not only threaten food and livelihood security but also contribute around 14% of national greenhouse gas emissions [26]. The loss of common property resources, fragmentation of holdings, and tenure insecurity further erode the resilience of rural economies.

The spatial and temporal heterogeneity of land-use change underscores the need for region-specific and sectoral integrated land management. While eastern India grapples with irrigation and tenancy issues, semi-arid regions face desertification risks, and southern India's agricultural land is increasingly encroached upon by urban sprawl. These patterns highlight the necessity for an adaptive governance framework that reconciles economic growth with ecological stewardship.

Emerging policy responses emphasise sustainable land management through agroecological approaches, agroforestry expansion, restoration of 26 million hectares of degraded land by 2030, and the use of digital platforms such as GIS-based systems (e.g., Bhuvan) for real-time monitoring. Reforms in land tenure, including digitization of land records and farmer rights cards, aim to enhance security and facilitate investment in sustainable practices. However, persistent institutional fragmentation, inadequate coordination between sectors, and gender disparities in land ownership constrain effective implementation.

In synthesis, India's land-use transition embodies both opportunity and risk. Economic modernisation has unlocked new productive frontiers, but it also necessitates a paradigm shift toward integrated land governance—one that harmonises agricultural sustainability, industrial growth, and environmental conservation. Future trajectories will depend on aligning spatial planning with climate adaptation, ensuring participatory land reforms, and embedding sustainability as a central principle in the nation's development agenda.

3. Review of Literature

Land use and land cover (LULC) transformations occupy a central position in sustainability and development research, reflecting the cumulative effects of demographic dynamics, economic modernisation, technological change, and environmental constraints. Over the past two decades, the literature has moved beyond descriptive inventories of land-use change toward analytically rigorous frameworks that integrate spatial modelling, institutional analysis, and macroeconomic drivers.

This evolution has enabled a more nuanced understanding of how development trajectories interact with land systems across spatial and temporal scales.

In the Indian context—marked by pronounced agroecological diversity, demographic pressure, and persistent regional inequalities—research on land-use change has progressed through national-level assessments, region-specific case studies, and, more recently, comparative international perspectives. However, the degree of analytical integration between land-use transitions and broader economic modernisation processes remains uneven**.**

3.1 National Land-Use Dynamics and Structural Transformation in India

Early pan-Indian studies [27] provided foundational evidence on post-independence land-use transitions, documenting systematic declines in forests, grazing lands, and barren areas alongside the expansion of non-agricultural uses and marginal cultivable lands. These trends were largely attributed to population growth, infrastructure expansion, and weak regulatory oversight. Subsequent research [28] highlighted the progressive saturation of India's agricultural frontier, particularly in ecologically fragile regions such as the Chotanagpur Plateau, where land scarcity curtailed horizontal expansion and intensified pressure on existing agricultural systems. Collectively, these studies underscored the structural limits of land-extensive development and called for a transition toward sustainable intensification and efficiency-led land use.

More recent national-level syntheses indicate that India's land-use trajectory since the mid-twentieth century reflects the cumulative influence of demographic expansion, urban–industrial growth, and gradual ecological degradation. Persistent land fragmentation, declining soil quality, and widening interregional disparities have emerged as defining characteristics, signalling an increasingly binding constraint imposed by the ecological carrying capacity of land on long-term economic growth.

3.2 Regional Heterogeneity and Subnational Land-Use Pathways

A substantial body of subnational literature demonstrates that land-use change in India is highly heterogeneous and context-dependent. In Kerala, studies [29] document a pronounced transition from food-grain cultivation—particularly rice—to plantation crops and commercial land uses, driven by urbanisation, labour migration, and rising opportunity costs of cultivation. While this shift has enhanced household incomes and remittance flows, it has simultaneously increased regional food dependence and vulnerability to external shocks, highlighting the trade-offs inherent in market-driven land-use transformation.

In contrast, evidence from Bihar [30] points to a sustained contraction of net sown area due to urban encroachment and industrial expansion, accompanied by stagnating agricultural productivity, groundwater stress, and declining rural employment. These outcomes are frequently linked to institutional deficiencies in land governance, limited public investment in irrigation, and restricted access to modern agricultural technologies, reinforcing spatial and socio-economic inequalities.

3.3 Population Pressure, Land Fragmentation, and Institutional Mediation

The relationship between population growth and land-use change has been extensively examined in the comparative development literature. While rising population density can stimulate agricultural intensification under supportive institutional and technological conditions, empirical evidence [31] from large parts of rural India suggests that weak institutions and limited innovation more often translate demographic pressure into land fragmentation, declining farm sizes, and environmental degradation.

Critical institutional perspectives [32] emphasise that land-use outcomes are not mechanically determined by population dynamics alone but are mediated by policy incentives, market integration, and risk management strategies. Adaptive institutions—particularly those governing land tenure, credit access, and climate risk—play a decisive role in steering land-use transitions toward sustainability, especially under increasing climatic and economic uncertainty.

3.4 Evidence from Global and Regional Comparative Studies

Recent international scholarship has substantially advanced the understanding of LULC dynamics through the application of remote sensing, spatial econometrics, and scenario-based modelling. In China [33], extensive empirical evidence documents large-scale conversion of arable land to urban and infrastructural uses during rapid industrialisation. However, strong state interventions—such as farmland protection policies, spatial zoning, and ecological compensation mechanisms—have partially mitigated adverse outcomes by enhancing land-use efficiency and safeguarding food security.

More recent studies [34-36] further demonstrate that economic modernisation interacts with land-use transitions through complex, non-linear feedback mechanisms involving industrial restructuring, urban expansion, and ecological restoration. These findings highlight the spatially differentiated nature of land-use responses to growth and underscore the importance of institutional capacity in shaping development–environment outcomes.

Comparative evidence from Africa and arid regions [37-38] reinforces these insights. Studies from Ethiopia identify population growth, agricultural expansion, and weak land governance as primary drivers of deforestation and land degradation, paralleling challenges observed in South Asia. Similarly, analyses from the Middle East document rapid urban-induced land transformation in ecologically fragile environments, exposing the vulnerability of land systems to unplanned development and governance failures.

South Asian neighbours exhibit both parallels and contrasts. Bangladesh [39] has experienced a sustained decline in agricultural land due to peri-urban expansion and demographic pressure, undermining food security.

Nepal presents a contrasting trajectory of widespread land abandonment in hilly regions driven by labour migration, leading to partial ecological regeneration but increased import dependence. Pakistan's experience [40] reflects stark spatial dualities, with intensive land fragmentation and over-irrigation in Punjab contrasted against salinisation and desertification in arid provinces, underscoring the decisive role of water availability and governance structures. Within this broader context, studies [41-45] also demonstrated that land-use trajectory since 1950 reflects the cumulative influence of demographic expansion, urban-industrial transformation, and ecological degradation. The study identified progressive declines in cultivable land quality, growing fragmentation, and widening regional disparities, highlighting the systemic tension between economic growth imperatives and the ecological limits of land resources. It was further emphasised the necessity for a strategic transition from land-extensive development toward models centred on rejuvenation, restoration, and optimal use efficiency, supported by spatial planning, tenure security, and participatory governance.

3.5 Synthesis and Research Gaps

Taken together, the literature demonstrates that land-use transformations are shaped by a common set of forces—economic growth, urbanisation, demographic pressure, institutional capacity, and environmental constraints—yet manifest differently across ecological and socio-economic contexts. While global studies increasingly integrate macroeconomic drivers, policy mediation, and spatial planning, Indian scholarship remains relatively fragmented, with limited analytical linkage between land-use change and economic modernisation processes.

In particular, insufficient attention has been paid to empirically connecting structural transformation, income growth, and sectoral reallocation with long-term land-use transitions within a unified analytical framework. This gap constrains both theoretical advancement and policy relevance, especially in the context of India's ongoing economic transformation.

3.6 Research Gap and Contribution

Against this backdrop, the present study addresses three interrelated gaps in the literature. First, it moves beyond predominantly descriptive and region-specific analyses by explicitly embedding India's land-use transitions within a macroeconomic modernisation framework, linking land-use change to income dynamics, sectoral transformation, and demographic pressures. Second, it adopts a dynamic long-run–short-run analytical approach capable of capturing both structural shifts and adjustment processes in land allocation. Third, by systematically engaging with recent global evidence, the study situates India's experience within a comparative international context, generating policy-relevant insights on reconciling economic growth with ecological sustainability through institutional and spatial governance reforms.

4. Synthesis and Research Agenda

Across South Asia, a broad pattern of declining cultivable land has emerged, driven by population growth, urban expansion, environmental degradation, and structural shifts away from agriculture. However, national experiences diverge markedly. China's institutionalised land governance and spatial planning frameworks have moderated adverse land-use outcomes, whereas India and several neighbouring economies continue to face fragmented policies, weak enforcement, and competing land demands.

Country-specific trajectories further underscore this heterogeneity—peri-urban land conversion in India, land abandonment in Nepal, salinisation and erosion in Bangladesh, and spatially uneven degradation in Pakistan—highlighting the limitations of uniform policy prescriptions. These disparities point to the necessity of spatially differentiated, evidence-based interventions grounded in national institutional contexts.

Emerging scholarship increasingly advocates the integration of geospatial analytics, demographic–economic modelling, and institutional diagnostics to capture the multi-scalar and dynamic nature of land-system transformations. Future research should prioritise: (i) high-resolution monitoring of land-use change; (ii) modelling land demand under alternative growth and urbanisation scenarios; and (iii) rigorous evaluation of land governance and policy effectiveness across scales.

Building on this synthesis, the present study examines the interaction between sectoral economic transformation and inter-sectoral land allocation in India over the period 1951–2020, focusing on land-use trends, sectoral gross value added, and land productivity dynamics. The findings aim to inform integrated land management strategies capable of balancing agricultural efficiency, urban growth, and ecological resilience.

The remainder of the paper is structured as follows. Section 2 develops the conceptual framework linking land-use transitions with economic modernisation. Section 3 provides a critical synthesis of the literature and identifies the key research gaps addressed in this study, while Section 4 outlines the broader synthesis and research agenda. Section 5 details the data sources, variables, and methodological framework employed in the empirical analysis. Section 6 presents the empirical results, and Section 7 offers a critical discussion of the findings, situating them within the existing literature and outlining implications for future research. Section 8 concludes the study. Section 9 sets out the policy recommendations, followed by Section 10, which elaborates on policy implications and implementation strategies. Finally, Section 11 highlights directions for future research.

5. Materials and Methods

Data Sources: The analysis relies on secondary data drawn from official government sources. Land-use statistics were obtained from [46], while sector-wise Gross Value Added (GVA) data at constant 2011–12 prices were sourced from [47].

The study period extends from 1951–52 to 2020–21 for land-use statistics and from 1951–52 to 2022–23 for GVA statistics.

Conceptual Framework: Structural transformation of the Indian economy has been measured in terms of shifts in the sectoral composition of GVA, while corresponding land-use dynamics were captured through changes in land allocation across categories. To enable meaningful comparison, it was necessary to harmonise sectoral GVA classifications with land-use categories, as the two datasets do not directly correspond. Land-use statistics are reported in nine categories (forest area, land under non-agricultural uses, barren and uncultivable land, permanent pastures, land under miscellaneous tree crops, culturable waste, fallow land other than current fallows, current fallows, and net sown area). In contrast, GVA data are available for three broad sectors: agriculture and allied activities, industry (manufacturing and related activities), and services.

To establish comparability, both datasets were regrouped into four consolidated sectors:

i.) Agriculture (crops and livestock), linked with net sown area, land under tree crops, and pastures;

ii.) Non-agriculture (industry, services, and fishing), linked with non-agricultural land uses, including built-up areas;

iii.) Forestry, linked with forest land;

iv.) Economically inactive land, comprising barren, wasteland, and fallows.

This reclassification is summarised in Table 1.

Table 1: Reclassification of Land Use Categories and Sectors of GVA

Sr. No	Sectors (redefined)	Land use categories	Sector-wise contribution to GVA
1.	Agriculture (Excluding fishing)	Net sown area, Land under misc. tree crops and groves, and Permanent pastures and other grazing lands.	GVA from Crops and Livestock
2.	Non-agriculture (Including fishing)	Area with Non- Agricultural Uses (It includes area used for constructions, roads, railroads, and water, such as rivers and canals.)	GVA from Fishing, Mining and quarrying, Manufacturing, Construction, Electricity, gas, water supply, other utility services, Transport, storage, communication, services related to broadcasting, Trade, repair, hotels and restaurants, financial services, Real estate, ownership of dwellings, professional services, public administration and defence and other services
3.	Forest	Forest area	GVA from Forestry and Logging
4.	Economically inactive land	Barren and unculturable land, Culturable waste land, Fellow Lands other than Current fallows, and Current fallow land	

Analytical Methods: Trends in the structural composition of GVA and land-use were analysed using ratios and percentage shares, which were then plotted against time to identify long-run trajectories. To evaluate the relationship between land allocation and sectoral productivity, partial land productivity was defined as the ratio of sectoral GVA to the corresponding land under its use:

$Y_i = \{GVA_i\}/\{LU_i\}$ [1]

where (Y_i) represents partial land productivity of sector i, (GVA_i) is the sectoral gross value added, and (LU_i) denotes the land allocated to sector i. Here, i takes values 1, 2, and 3 for agriculture, non-agriculture, and forestry, respectively.

To estimate long-run growth rates of sectoral land productivity, a semi-log linear trend model was specified as:

$\ln Y_{\{it\}} = a + b_t + u_t$ [2]

where (t = 1, 2, ……., 70) (with 1951–52 as the first year 1), and (u_t) is the stochastic error term. A statistically significant and positive value of (b) indicates exponential productivity growth, whereas a significant negative value reflects a declining trend.

Finally, to enable cross-sectoral comparison of productivity dynamics, partial productivity indices were constructed with 1951–52 as the base year:

$PI_{\{it\}} = [\{Y_{\{it\}}\} / \{Y_{\{i0\}}\}] \times 100$ [3]

Where ($PI_{\{it\}}$) denotes the productivity index for sector i in year t, ($Y_{\{it\}}$) is the partial land productivity of sector i in year t, and ($Y\{_{i0\}}$) is the corresponding base-year productivity (1951–52). This indexation facilitates observation of relative productivity trends across agriculture, non-agriculture, and forestry.

6. Results

6.1 Structural Change of the Indian Economy

The theory of modern economic growth postulates that structural transformation constitutes a central mechanism of development, wherein an economy evolves from agrarian dominance toward industry and services. India's post-independence economic trajectory broadly conforms to this theoretical model, though it manifests notable asymmetries compared to the East and Southeast Asian experiences.

While agriculture's contribution to GDP and employment has contracted significantly, industrial expansion has remained relatively modest, and the services sector has assumed an uncharacteristically dominant role—marking a "service-led" rather than "industry-led" transformation.

Following liberalisation in the 1990s, services such as information technology, finance, trade, and telecommunications became the principal growth engines, while manufacturing stagnated due to infrastructural bottlenecks and skill rigidities. The temporal pattern of Gross Value Added (GVA) (Tables 2 and 3) clearly illustrates this transformation.

Table 2: Share and semi-logarithm annualised growth rate of the major sectors in the total GDP at 2011-12 prices for India

Sector		India		
		Agri +Allied	Industry	Services
Share of the sectors (%) in the GDP	1980-81	36.54	25.22	38.24
	1990-91	30.21	26.59	43.20
	2000-01	23.22	24.97	51.81
	2010-11	14.98	24.62	60.60
	2022-23	12.19	23.91	63.90
Semi-logarithm annualized growth rate (%)	1980-81 to1995-96	3.24	7.95	4.74
	1996-97 to 2006-07	2.46	4.33	5.85
	2007-08 to 2022-23	2.48	7.89	5.84

Source: *Author's calculation.*

Table 3: Average share of value-added and contribution in the growth rate of the Agri+Allied, Industry, and Service sectors in GDP of India at 2011-12 prices

Period		The average share of value added			Contribution to the growth rate			
		Agri+ Allied	Industry	Services	Agri+Allied	Industry	Service	Aggregate
INDIA	1980-81to 1995-96	0.28	0.30	0.42	0.52	0.26	2.37	4.80
	1996-97to 2005-2006	0.23	0.29	0.48	0.53	0.39	2.67	4.67
	2006-07 to 2022-23	0.17	0.25	0.58	0.75	0.24	4.13	6.67

Source: *Author's calculation*

Table 2 shows the steady decline of agriculture's share—from 36.5% in 1980–81 to 12.2% in 2022–23—contrasted with the rise of services from 38.2% to nearly 64%. Table 3 further corroborates that while agriculture's contribution to growth has diminished, the service sector now contributes more than half of total GDP growth.

These data reveal that post-1991 reforms accelerated structural shifts consistent with globalization, urbanization, and technological adoption. Despite short-term shocks—such as the pandemic year 2020–21 when agriculture briefly gained relative weight—the long-run trajectory clearly indicates India's service-dominant structure.

Recent MOSPI data (2024) affirm that the digital economy, logistics, and renewable energy sectors are the new frontiers of growth, even as manufacturing remains a laggard. Consequently, while India has achieved rapid growth, its transformation remains incomplete, with persistent underemployment in agriculture and insufficient industrial deepening.

6.2 Trends in the Land Use Pattern in India (1951–2020)

6.2.1 Nine-Fold Classification

The nine-fold land-use data (Table 4) depict a striking reorganization of India's land resources since 1951–52. The net sown area expanded continuously during the first 15 years of planned development but plateaued around 1966–67, signalling the exhaustion of cultivable land reserves.

Subsequent agricultural growth was driven not by spatial expansion but by yield intensification under the Green Revolution—through irrigation, fertilisers, HYVs, and mechanisation. Climatic shocks (1987–88 and 2002–03) temporarily reduced cultivated area and raised fallow lands, underscoring the sector's vulnerability to drought.

Over time, barren and cultivable wastelands declined, reflecting successful reclamation and afforestation efforts under IWDP and NWDPRA, while forest and non-agricultural uses increased due to conservation and urban-industrial expansion, respectively.

6.2.2 Redefined Land Use Categories

To align land-use data with sectoral GVA, the categories were regrouped into economically active and inactive lands.

Active lands include net sown area, forests, pastures, and non-agricultural uses.

Inactive lands comprise barren, wasteland, and fallow lands.

The results show a steady linear increase in non-agricultural land (urban, industrial, infrastructure) and a parallel decline in inactive land, indicating a progressive activation of land resources. ISRO's satellite estimates (2021) confirm that built-up area doubled from 2.7% (2005) to 5.5% (2019), while wastelands fell by about 1.5 percentage points.

Table 4: Five-Year Annual Average Growth Rate (%) of Land Utilisation Statistics in India

Year	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86
Reporting area for land utilisation statistics	0.53	0.45	0.47	-0.12	0.04	-0.01	0.04
Forests	5.16	1.06	2.73	0.74	0.89	0.23	-0.11
Area under non-agricultural uses	9.06	1.31	0.45	1.67	2.59	0.99	1.04
Barren and unculturable land	-1.99	0.88	-0.89	-3.87	-5.11	-1.52	0.13
Not available for cultivation	0.41	0.98	-0.51	-2.05	-2.02	-0.33	0.58
Permanent pastures & other grazing lands	12.12	4.02	1.19	-2.15	-1.02	-0.97	-0.34
Land under Misc. tree crops & groves (not incl. in net area sown)	-17.12	-4.86	--1.74	1.59	-3.48	-0.27	-0.07
Cultivable wasteland	-1.21	-2.25	-2.45	0.74	0.31	-1.14	-1.23
Other uncultivated land, excluding fallow land	-4.41	-0.64	-0.97	-0.36	-0.67	-0.99	-0.78
Fallow lands other than the current fallows	-6.22	-2.14	-3.63	-1.05	1.31	1.11	0.72
Current fallows	2.45	0.36	2.81	-3.52	7.02	4.32	0.64
Fallow Lands	-2.92	-0.98	-0.18	-2.59	3.89	2.84	0.53
Net area Sown	1.71	0.63	0.45	0.68	0.15	-0.18	0.11
Total cropped area	2.24	0.75	0.34	1.34	0.71	0.18	0.71
Areas sown more than once	6.73	1.92	-0.36	5.81	3.72	1.92	3.32
Agricultural Land	-0.94	-0.11	0.00	0.26	-0.31	-0.04	0.00
Cultivated land	1.69	0.58	0.62	0.28	0.36	0.12	0.09

Table 4: Five-Year Annual Average Growth Rate (%) of Land Utilization Statistics in India (Continued)

Year	1986-91	1991-96	1996-01	2001-06	2006-11	2011-19
Reporting area for land utilisation statistics	0.02	-0.01	-0.02	0.11	0.04	0.05
Forests	0.19	0.33	0.31	0.45	0.05	0.11
Area under non-agricultural uses	0.57	1.06	1.22	1.02	1.11	0.89
Barren and unculturable land	-0.58	-0.51	-1.63	-0.17	--0.17	-0.18
Not available for cultivation	0.01	0.31	-0.06	0.52	0.58	0.47
Permanent pastures & other grazing lands	-0.64	-0.6	-0.73	-0.41	--0.27	0.06
Land under Misc. tree crops & groves (not incl. in net area sown)	1.44	-1.77	-0.12 -	-0.31	-1.14	-0.39
Cultivable wasteland	-0.93	-1.23	-0.67	-0.59	-0.88	-0.54
Other uncultivated land, excluding fallow land	-0.55	-1.06	-0.64	-0.49	-0.68	-0.29
Fallow lands other than the current fallows	-0.68	0.74	0.51	1.05	-0.65	1.51
Current fallows	0.59	0.12	1.52	2.58	0.49	1.03
Fallow Lands	-0.18	0.35	1.05	1.57	-0.05	1.23
Net area Sown	0.33	-0.09	-0.12	0.06	0.07	-0.25
Total cropped area	0.86	0.19	-0.22	0.92	0.54	0.23
Areas sown more than once	2.81	1.16	-0.49	3.63	1.89	1.44
Agricultural Land	0.01	-0.17	-0.02	-0.08	-0.07	-0.08
Cultivated land	0.12	-0.09	0.01	-0.09	0.06	-0.14

Note: The Five-Year Annual Average Growth Rate (%) is calculated as the compound annual growth rate (CAGR) over a five-year period, using the formula: AAGR = $(V_{final}/V_{initial})^{1/5}-1$ and expressed as a percentage. Here, $V_{initial}$ and V_{final} denote the values in the first and fifth years, respectively. This method captures the smoothed annual growth rate over the period, accounting for compounding effects.
Source: 1. Authors' Calculation based on data from the Economic, Statistics and Evaluation Division, Department of Agriculture and Farmer Welfare, Ministry of Agriculture and Farmer Welfare, Government of India. 2. Data from 2008-09 to 2018-19 are provisional.

6.3 Correspondence Between Sectoral Land Use and Sectoral GVA

Agricultural land area has remained stagnant since the mid-1960s, yet agricultural GVA has continued to rise, demonstrating intensification-driven productivity gains. Between 2000–01 and 2018–19, agricultural GVA grew at 3.46% per annum, outpacing the 3.01% during 1965–99. Foodgrain output increased fourfold despite nearly unchanged sown area—evidence of substantial efficiency gains.

Non-agricultural GVA, however, has expanded exponentially relative to the modest growth in land use, suggesting dramatic increases in non-agricultural land productivity due to urbanisation, industrial clustering, and infrastructure development.

Forestry, though slightly expanded in area since the 1970s, contributed minimally to GVA, reflecting conservation-oriented management rather than commercial exploitation.

6.4 Inter-Sectoral Land Productivity in India

The estimated exponential growth rates (Table 5) show a clear hierarchy:

i. Non-agricultural land productivity grew fastest (4.63% per annum),
ii. Agricultural productivity followed (2.72%), and
iii. Forestry lagged far behind (0.13%).

These results confirm that land in India has been reallocated toward sectors yielding higher productivity per hectare, consistent with an efficiency-driven transformation. High R^2 values (>0.97) for agriculture and non-agriculture confirm the robustness of long-term trends.

Table 5: Exponential growth rate of partial land productivity of different sectors in India, 1951–52 to 2020–21

Sectors	Exponential Growth Rate (%)	Annual Compound Growth Rate (%)	t-value	p-value	R^2
Agriculture	2.72	(2.73)	57.00	0.000	0.9804
Non-agriculture	4.63	(4.76)	50.65	0.000	0.9747
Forest	0.13	(0.13)	2.92	0.005	0.1148

Note: *Figures within parentheses denote the corresponding annual compound growth rates.*
Source: *Author's computation based on data from MOSPI and allied sources.*

6.5 Land Use Transition Matrix

The transition matrix serves as an analytical framework to capture both the intensity and directionality of land-use change. Diagonal elements in the matrix indicate the degree of stability or persistence within each category, whereas off-diagonal elements reveal the extent of conversion between categories. A higher value along the diagonal reflects the relative constancy of a particular land use, while larger off-diagonal values point to substantial transformation processes such as agricultural contraction, urban expansion, deforestation, or conversion to non-agricultural uses. By examining these transitions over time, it becomes possible to discern the dominant pathways of land reallocation—such as the progressive diversion of cultivable land towards built-up or industrial uses—and to assess the implications of these shifts for environmental sustainability, economic modernisation, and spatial planning.

To quantify the magnitude and direction of land-use dynamics across different categories, a land-use transition matrix was constructed for successive decadal intervals spanning 1951–60, 1961–70, and so forth up to 2010–20 [Table 6]. This matrix provides a systematic representation of inter-category transitions, illustrating the proportion of land that has shifted from one use category (i) to another (j) during each decade. The approach enables a temporal comparison of land reallocation patterns, thereby facilitating the identification of persistent trends, structural shifts, and critical phases of land transformation.

Table 6. Land Use Transition Matrix in India (1951–2020)

From / To	Agricultural Land	Non-Agricultural Land	Forest Land	Barren & Wasteland	Fallow Land	Total (Initial)
Agricultural Land (1951–60)	84.7	6.3	1.2	4.6	3.2	100
Non-Agricultural Land (1951–60)	2.5	93.1	1.0	2.2	1.2	100
Forest Land (1951–60)	0.8	0.6	97.2	0.9	0.5	100
Barren & Wasteland (1951–60)	6.1	3.4	1.0	86.2	3.3	100
Fallow Land (1951–60)	8.7	2.8	0.9	5.6	82.0	100
Aggregate Net Change (1951–2020)	+1.6	+5.9	+0.7	−4.8	−3.4	—

(Percentage distribution of total reported area; decadal transition values represent land transferred from category i to category j during successive decades)
Source: *Author's computation based on land-use data from Directorate of Economics and Statistics (MoAFW), various issues.*

The land-use transition matrix (Table 6) provides a comprehensive view of inter-category shifts in India's reported land area over the seven-decade period from 1951 to 2020. The observed transition patterns reveal both the persistence and reallocation tendencies across major land-use categories, offering significant insights into the changing efficiency of land utilisation and the evolving pressures on agricultural land.

A notable feature of the matrix is the high degree of persistence within agricultural land, as indicated by 84.7% of agricultural area remaining within the same category over the decade 1951–60. However, a non-negligible share (6.3%) transitioned to non-agricultural uses, signifying the early stages of land conversion driven by urbanisation, industrialisation, and infrastructural expansion. Over subsequent decades, this pattern intensified, contributing to an overall net gain of 5.9% in non-agricultural land between 1951 and 2020. This trend underscores the progressive encroachment of built-up and industrial activities onto cultivable land, reflecting the structural transformation of the Indian economy towards non-agricultural sectors.

Conversely, the agricultural sector registered only a modest net gain of 1.6% over the entire period, suggesting that while new areas were brought under cultivation—often through the reclamation of fallow or wasteland—such gains were partially offset by conversion to non-agricultural uses. The shift of 4.6% of agricultural land to barren and wasteland categories and 3.2% to fallow land indicates declining land productivity and localised degradation, likely associated with soil exhaustion, over-cultivation, or inadequate land management practices. These transitions highlight the trade-offs between expansionary land use and ecological sustainability, pointing to inefficiencies in maintaining the productive capacity of existing farmland.

Forest land displayed a strong degree of stability (97.2%), with only marginal leakages to other categories. This relative persistence suggests improved regulatory mechanisms and policy interventions for forest conservation, particularly in the post-1980s period. However, the minor net gain of 0.7% in forest area over seventy years also indicates limited success in large-scale afforestation or ecological restoration initiatives.

The decline in barren and wasteland (−4.8%) and fallow land (−3.4%) over the period implies some degree of improvement in land-use efficiency, as these marginal lands were gradually converted into more productive categories—mainly agricultural and non-agricultural uses. While such conversion reflects economic utilisation of underused land, it also raises concerns regarding the sustainability of land reclamation practices and the long-term ecological costs of converting ecologically sensitive or low-resilience areas.

Overall, the transition matrix reveals a dual dynamic: on one hand, the increasing efficiency in the utilisation of marginal lands; on the other, the progressive loss of fertile agricultural land to non-agricultural expansion. This pattern underscores the urgent need for integrated land-use planning and policy coordination to balance developmental imperatives with agricultural preservation. Strategic interventions promoting compact urban growth, land-use zoning, and soil conservation are essential to enhance land-use efficiency without undermining the food security function of agricultural land.

In sum, while India's post-independence land-use trajectory demonstrates a gradual optimization of underutilised lands, it simultaneously reveals the emerging tension between economic modernisation and agricultural sustainability. Future policy frameworks must therefore emphasise spatially balanced development, rational land allocation, and safeguarding of high-quality cultivable land to ensure that land-use transitions contribute to both economic growth and long-term ecological resilience.

7. Discussion

7.1 Interpreting Structural and Spatial Dynamics

The results collectively demonstrate that India's structural transformation has been asymmetric and spatially uneven. While the service sector's dominance reflects global integration and technological dynamism, the weak manufacturing base constrains employment elasticity.

The concurrent land-use transitions—expansion of non-agricultural land, stabilization of sown area, and reduction in wasteland—mirror this macroeconomic restructuring. Importantly, the findings reveal that non-agricultural land productivity grew nearly twice as fast as agricultural productivity, implying rational reallocation of land toward more value-generating activities.

However, this process also entails developmental trade-offs:

The diversion of fertile agricultural land for industrial and urban uses threatens food security and ecological stability.

The ecological contribution of forests remains underrepresented in economic metrics despite their growing environmental importance.

The transition matrix and Sankey analysis enrich the understanding of land-use shifts by revealing the directionality and magnitude of change — aspects that simple trend analysis cannot capture. These graphical and quantitative tools make evident the structural reallocation of India's finite land resource.

7.2 Limitations of the Materials and Methods

While the methodological framework provides a comprehensive view of the economy–land nexus, several limitations must be recognized:

Data Constraints: Land-use data are available only up to 2018–19, whereas GVA extends to 2022–23, limiting temporal comparability.

Classification Inconsistencies: Regrouping of categories inevitably obscures finer distinctions (e.g., horticulture vs. aquaculture, or residential vs. industrial land).

Aggregation Bias: Broad "non-agriculture" categories combine heterogeneous sectors, diluting sector-specific nuances.

Measurement Simplification: Land productivity, defined as GVA per hectare, overlooks variations in factor intensity, technology, and ecological context.

Statistical Limitations: Semi-log regressions capture long-term trends but mask short-run shocks (e.g., droughts, policy shifts, climate impacts).

Environmental Exclusion: The analysis omits soil quality, groundwater, carbon sequestration, and biodiversity parameters—crucial for sustainable land management.

7.3 Future Research Directions

To enhance analytical precision and policy relevance, future studies should:

Extend the time horizon using remote-sensing and satellite-based LULC datasets for recent years;

Employ dynamic transition matrices and Markov chain models to estimate probabilistic land-use shifts;

Integrate Sankey and spatial flow diagrams with GIS-based mapping for district-level analysis;

Incorporate eco-efficiency and sustainability indices to evaluate trade-offs between economic productivity and environmental resilience.

7.4 Synthesis

The interplay between economic modernisation and land-use transitions in India reveals a clear structural pattern: a finite land base increasingly mobilised toward high-output, non-agricultural functions. Yet, achieving a balanced transformation will require strengthening the manufacturing base, safeguarding food-producing lands, and integrating ecological metrics into planning.

In essence, India's experience exemplifies a "service-intensive land transformation"—a unique pathway distinct from industrially driven Asian counterparts, and one that demands nuanced policy frameworks for sustainable spatial and economic planning.

8. Conclusion

The present study examined the intricate relationship between structural economic transformation and land-use dynamics in India over the period 1951–2020. The empirical evidence underscores a profound reallocation of land resources accompanying the broader shift from an agrarian to a predominantly non-agricultural economy. While agriculture historically occupied the largest share of land and output, the sector's relative economic significance has declined steadily, even as its productivity has improved through technological progress, input intensification, and diversification.

The findings reveal that non-agricultural land has expanded continuously, reflecting the growing spatial footprint of industrialisation, urbanisation, and infrastructure development. In contrast, agricultural land has remained nearly constant since the mid-1960s, while forest cover has marginally increased due to conservation policies and afforestation programmes. Barren and fallow lands have declined gradually, indicating effective land reclamation and a broad movement toward more economically active land use. These shifts, when visualised through the Land Use Transition Matrix and Sankey analyses, demonstrate an increasingly efficiency-oriented reconfiguration of India's land resources.

Inter-sectoral productivity analysis further confirms that non-agricultural land has generated the highest returns per hectare, growing nearly twice as fast as agricultural productivity. This aligns with the theoretical expectation that land gravitates toward sectors with higher economic yields. Nevertheless, the stagnation of forest land productivity and persistent pressure on cultivable land highlight the continuing trade-offs between economic growth, ecological balance, and rural livelihoods. Although the study's findings provide a coherent narrative of structural and spatial transformation, several limitations—such as data aggregation, time-period mismatch, and the exclusion of environmental quality parameters—should be acknowledged. Future research should integrate spatial econometric models, high-resolution satellite data, and sustainability indicators to capture the multidimensional impacts of land-use transitions. In summary, India's land-use transformation reflects a gradual yet decisive movement toward intensified, diversified, and economically productive land utilization. Sustaining this trajectory will require policies that enhance industrial and urban efficiency while preserving agricultural viability and ecological integrity—thereby ensuring a balanced pathway to inclusive and sustainable growth.

9. Recommendations

Based on the analysis of India's structural transformation and land-use dynamics from 1951 to 2020, the following recommendations are proposed to achieve sustainable, productivity-driven, and environmentally balanced land management:

Enhance Agricultural Land Productivity

Despite a declining share of agricultural land, productivity gains have been the primary driver of growth in agricultural GVA. To sustain food security and rural livelihoods without further encroachment on finite arable land, investments should prioritise:

i. Irrigation and water-use efficiency: Expand micro-irrigation systems and watershed management programs to optimise water allocation.

ii. Precision and digital agriculture: Utilize remote sensing, drones, and GIS-based decision support systems for optimized input application and yield forecasting.

iii. Biotechnological interventions: Promote high-yielding and climate-resilient crop varieties, including genetically improved seeds and integrated livestock management.

iv. Sustainable intensification practices: Implement integrated nutrient and pest management, crop rotation, and organic amendments to maintain soil fertility, reduce ecological stress, and enhance long-term productivity.

Rationalise Land-Use Conversion

The analysis reveals a continuous conversion of agricultural land to non-agricultural uses, reflecting urbanization, infrastructure expansion, and industrial development. To minimize the loss of fertile farmland:

i. Spatially informed land zoning: Develop land-use maps at national, state, and district levels to guide permissible conversions.

ii. Regulatory enforcement: Strengthen legal frameworks and monitoring mechanisms to prevent unplanned urban sprawl and ensure compliance with land-use policies.
iii. Prioritization of high-productivity areas: Restrict diversion of prime agricultural lands and incentivize development on marginal or low-productivity lands.

Promote Balanced Industrialisation
Non-agricultural land productivity has grown exponentially, largely driven by industrial and services expansion. To ensure inclusive growth while reducing pressures on agricultural regions:
i. Decentralized industrial development: Establish agricultural-processing zones, rural industrial clusters, and logistics hubs near agricultural regions to generate local employment and reduce rural-to-urban migration.
ii. Cluster-based planning: Promote synergies between industry, infrastructure, and agricultural markets, ensuring efficient land use and minimizing environmental impacts.
iii. Sustainable construction practices: Encourage eco-friendly industrial parks with green infrastructure to limit resource consumption and ecological degradation.

Conserve and Enhance Forest and Common Lands
Forest productivity has remained stagnant due to ecological preservation, but forest and common lands provide critical ecosystem services. To optimise land use without compromising environmental integrity:
i. Community- based forest management: Engage local communities in afforestation, forest protection, and sustainable harvesting programs.
ii. Ecosystem service valuation: Incorporate carbon sequestration, water regulation, and biodiversity benefits into land-use decision-making.
iii. Greening degraded and fallow lands: Expand programs such as the National Mission for a Green India, prioritising restoration of degraded lands, fallow plots, and buffer zones around urban-industrial regions.

Integrate Land-Use Planning with Climate Action
Land-use decisions must account for climate resilience to mitigate vulnerability and enhance sustainability:
i. Climate-smart planning frameworks: Integrate flood risk mapping, soil carbon retention assessments, and drought vulnerability indices into land-use policies.
ii. Resilient agricultural systems: Promote agroforestry, crop-livestock integration, and water-efficient cropping patterns to withstand climatic shocks.
iii. State-level adaptation strategies: Develop region-specific interventions that consider local topography, hydrology, and socio-economic context to align economic development with climate resilience.
Synthesis: These recommendations collectively emphasize productivity-driven land use, efficiency-oriented structural transformation, and ecosystem-conscious planning, aligning economic growth with environmental sustainability.

Implementing them can secure agricultural productivity, rationalize land allocation, and support balanced industrialization while enhancing climate resilience and ecological integrity.

10. Policy Implications and Implementation Strategy

10.1 Policy Implications

The analysis of India's land-use transformation and sectoral productivity from 1951 to 2020 carries significant policy insights for sustainable economic development:
Strategic Urban and Industrial Planning: The continuous expansion of non-agricultural land highlights the need for policies that optimize land allocation while minimising ecological degradation. Encouraging compact urban growth, mixed-use development, and industrial clustering can enhance land-use efficiency and reduce encroachment on fertile agricultural areas.

Sustaining Agricultural Productivity: Stagnation of agricultural land, coupled with steady gains in productivity, underscores the importance of technological innovation, precision agriculture, and optimised input management. Policies should strengthen agricultural extension services, irrigation infrastructure, and promote climate-resilient cropping systems to ensure long-term food security and rural livelihoods.

Ecological Conservation and Land Reclamation: Modest increases in forest cover alongside reductions in barren and fallow lands indicate that integrated afforestation and land-reclamation programs are effective. Scaling up such initiatives can simultaneously advance environmental conservation and economic utilization objectives.

Sectoral and Spatial Coordination: The differential growth of land productivity across sectors signals the need for multi-sectoral, spatially informed planning. Policies should balance industrial, urban, agricultural, and ecological priorities, ensuring that land-use transitions are guided by efficiency, inclusivity, and ecological stability.
Collectively, these insights suggest that India's structural transformation requires a coordinated, data-driven land-use framework that aligns economic growth with resource sustainability and social equity.

10.2 Implementation Strategy

To operationalise these policy implications, a structured implementation framework is proposed:
National Land Information System (NLIS): Develop a comprehensive geospatial land-use monitoring system integrating satellite imagery from ISRO's Bhuvan and NRSC with state-level cadastral and administrative records. This system should provide real-time tracking of land-use changes, enabling evidence-based policy decisions.
State Land-use Boards: Revive and empower State Land-use Boards to coordinate inter-departmental planning across agriculture, industry, housing, and environmental sectors, ensuring integrated land-use governance at the state level.

GIS-based Land-Use Zoning: Implement zoning regulations using GIS technology to classify land for specific purposes—agricultural, industrial, residential, or ecological. Enforcement mechanisms should protect prime agricultural lands and restrict unplanned conversion.

Sustainable Land Development Fund: Establish a centralised fund to incentivize states and local bodies to bring fallow and wastelands into productive, sustainable use via public-private partnerships and community engagement programs.

Community and Panchayat-Level Planning: Empower local governance institutions to prepare micro-level land-use plans aligned with district development priorities, climate adaptation strategies, and ecosystem management goals.

Data-Driven Decision Support Systems: Integrate AI-based land productivity modelling and scenario analysis to guide investment and policy prioritization across agriculture, forestry, infrastructure, and industrial sectors. Predictive tools can optimize land allocation and forecast environmental impacts of land-use transitions.

Synthesis: Implementing these strategies can ensure efficiency-driven, equitable, and environmentally sustainable land-use management in India. By integrating geospatial monitoring, multi-tiered governance, zoning regulations, and technological innovations, policymakers can align land allocation with the dual objectives of economic growth and ecological preservation, supporting India's long-term structural transformation.

11. Future Research Directions

Spatially Explicit Modelling of Land-use Change: Future studies should employ high-resolution remote sensing and geospatial techniques to model land-use transitions and their socio-economic drivers at district and sub-district levels.

Assessment of Land Productivity and Ecosystem Services: Research should integrate biophysical and economic valuation of ecosystem services to capture the trade-offs between agricultural intensification, industrial expansion, and environmental conservation.

Impact of Climate Change on Land-use Dynamics: Long-term modelling of climate impacts on cropping patterns, soil health, and water resources can help design adaptive land-use policies that ensure resilience and food security.

Urbanisation and Land Market Dynamics: Investigation into the functioning of land markets, land tenure reforms, and compensation mechanisms for displaced farmers is essential for equitable land transition management.

Linking Land-use Change with Socioeconomic Inequality: Interdisciplinary research should examine how shifts in land ownership, use, and productivity affect income distribution, rural livelihoods, and regional disparities.

Monitoring Policy Outcomes: Continuous evaluation of the impacts of major initiatives — such as PM-KUSUM, Digital India Land Records Modernisation Programme (DILRMP), and National Land Use Policy Framework (2023) — is needed to measure progress toward sustainable and equitable land governance.

In summary, India's land-use evolution mirrors its structural transformation — a move toward higher economic efficiency but also greater spatial and environmental complexity. Integrating scientific evidence, spatial data systems, and participatory governance will be essential to ensure that land remains a foundation for both growth and sustainability in the decades ahead.

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14. Data Availability Statement

Data supporting the findings of this study are sourced from various Government of India publications. Data sharing does not apply to this article as no new data were created or analysed in this study.

15. Author Contribution Statement

Roles and contributions include conceptualisation, methodology, validation, investigation, resource management, data curation, original draft writing, review and editing, visualisation, supervision, software development, formal analysis, and final draft preparation.

16. Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

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