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Dynamics of land use pattern in Tamil Nadu

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Abstract

The paper examines the dynamics of land use pattern in Tamil Nadu for the past five decades using secondary data from official sources. To understand the structural changes and future transistions, the analysis integrates trend analysis, decadal compound growth rate and markov chain analysis. The results reveal that there is a significant decline in the net sown area from 61.35 lakh hectares in the 1970's to 48.34 lakh hectares in the 2020's, reflecting shrinkage in the agricultural land. In contrast, land under non-agricultural uses has increased gradually, reflecting urbanisation. Further decadal growth rate also confirms the same result. It is projected that net sown area will decline to 47.37 lakh hectares by 2050-51, accompanied by an increase in fallow lands which highlights the threat for food security. The study emphasizes the urgent need for effective land use policies focusing on protection of agricultural land, reclamation of fallow lands and sustainable resource management to ensure long-term food security and ecological balance.

Keywords: decadal compound growth rate, markov chain analysis, urbanisation, fallow lands, food security

1. Introduction

India's "Green Revolution" in 1960's initially stabilised agricultural production, but in later stages drastic increase in urban population have restructured rural-urban gradients ^[1]. India's one of the most urbanized state is Tamil Nadu because 49 per cent of the population resides in Urban areas, which is currently facing issues in transition of land due to rapid industrialisation, demographic shifts and changes in agricultural practices which exerts unprecedented pressure on finite land resources. Growth in urban population lead to 75 per cent expansion in built-up area from the year 2000 to 2020. These land use and land cover changes are the important drivers of environmental transformation not only at regional level but also in the global level because it has an impact on the ecological integrity, hydrological cycles and climate resilience ^[2].

Similarly climate change also act as an important factor in land conversion. Rainfed regions in Tamil Nadu are vulnerable to rising temperatures, ranges from 28.2-32.2 °C in 1954 to 29.8 - 33.6°C in 2014 ^[3]. Similarly in Southern river basin areas nearly 10 per cent decrease in annual rainfall and a 32.3 per cent decrease in rainy days were noted ^[4]. These factors combined with biophysical constraints like soil erosion and salinity have contributed significantly for the expansion of fallow lands ^[5, 6]. This swift from agricultural land to fallow land and built-up area is a threat to food security and livelihood of farmers.

Moreover, Tamil Nadu has lengthiest coastline of 1076 km which frequently affected by extreme weather events including cyclones and floods in turn it leads to

deterioration of fertile soil through sand and silt deposition ^[7]. By 2050, it is projected that there will be a rise in mean maximum temperature by approximately 0.4°C. This can further endanger crop yields and farmer livelihoods ^[8]. If this situation persist farmers will be forced to shift their occupation permanently and there will be a permanent conversion of agricultural lands which will cause food insecurity ^[9, 10]. Understanding these shifts through systematic analysis is essential for formulating sustainable land use policies that can balance development with food security. Based on the critical need to address these shifts, this research is structured with the following objectives,

1. To analyse the long-term trends in land use pattern in Tamil Nadu
2. To identify the acceleration of land conversion towards non-agricultural uses
3. To project the future land use pattern for the year 2030 and 2050 to support climate-adaptive planning.

2. Materials and Methods

This study was carried out for India's one of the major agrarian state Tamil Nadu which is characterised by diverse agro-climatic conditions and currently facing pressure on land resources due to urbanisation. Secondary data was used for the study, collected from various official government sources like Season and Crop Report published by the Department of Economics and Statistics, Govt of Tamil Nadu, and Statistical Handbook of Tamil Nadu. The dataset spans a long time period from 1970-71 to 2023-24, which is further aggregated into decadal averages (1970's, 1980's,

1990's, 2000's, 2010's and 2020's) for trend analysis purpose. For projection analysis, the triennium ending (TE) 2023-24 values are calculated and used as the base year value to estimate future land use pattern for 2030 and 2050. The econometric methods used for the study include, trend analysis, decadal compound growth rate and markov chain analysis.

(i) Trend Analysis

The trend analysis was conducted using the descriptive statistics and percentage distributions for the period 1970-71 to 2023-24. This method allows us to know about the directional shifts in eleven land use categories. By quantifying these changes, the study highlights the phases where agricultural land was most rapidly diverted to other uses^[11]

(ii) Decadal Compound Growth Rate

To measure the average annual rate of change while smoothing out short-term fluctuations, the compound growth rate was calculated^[11]. This approach is robust for evaluating the speed of urbanization and the expansion of fallow lands.

The growth rate was calculated using the exponential function:

$$Y_t = ab^t$$

Transformed into log-linear form:

$$\ln Y_t = \ln a + t \ln b$$

Where,

Y_t = Area under land use category at time t

$b = (1+r)$, where r is the compound growth rate

The final CGR is calculated as $r = (\text{antilog } b - 1) \times 100$

(iii) Markov Chain Analysis

It was used to project future land use dynamics for the years 2030-31 and 2050-51. This stochastic modelling technique utilises a transition probability matrix (P) derived from cross-tabulating land use data between two base years. The model assumes the "Markov property", where the land use state at time $t+1$ depends solely on its state at time t .

The transition Probability matrix is as follows,

$$P = \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1n} \\ P_{21} & P_{22} & \dots & P_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \dots & P_{nn} \end{bmatrix}$$

Where P_{ij} represents the transition probability and each row must sum to 1 ($\sum P_{ij} = 1$). These probabilities are derived by cross-tabulating land use maps from two distinct periods to capture the rate of conversion.

The future land use distribution is then projected using the formula:

$$S_{t+1} = S_t \times P^n$$

Where S_t is the current land use status and S_{t+1} is the projected state^[12]

3. Results and Discussion

3.1 Land Use Pattern

The developmental objectives such as increasing food production and achieving food security largely depend on the land use pattern. The pattern of land use is determined by various physical (properties of the soil, rainfall, temperature, water resources availability etc), economic (capital, labour resources, infrastructure development etc) and institutional (financial institutions, policies of the state etc) factors at any particular time.

Tamil Nadu state has witnessed significant changes in the land use. The land which is not available for cultivation includes land put to non-agricultural uses and barren and uncultivable lands. The area under barren and uncultivable land has decreased over the three decades. It decreased from 4.9 lakh hectares in 1990s to 4.7 lakh hectares in 2010s and beyond (Table.1). In percentage terms, the barren and uncultivable land is around 3.8 per cent to the total geographical area. Its counterpart, the land put into non-agricultural uses, has increased from 19.1 lakh hectares (14.7 per cent) during 1990s to 22.3 lakh hectares (17.1 per cent) during 2020s. This confirms that certainly there is a shift in land use from barren and uncultivable land to non-agricultural uses over the years. The other drivers may be increasing demand for non-agricultural purposes, increase in population, implementation of various development programmes etc.

The fallow lands include fallow lands other than current fallows and current fallows increased over the years. The other fallows increased from 10.9 lakh hectares during 1990s to 17.8 lakh hectares during 2010s and 18.61 lakh hectares during 2020s. Lands that are kept fallow out of the net area sown during the previous year are classified as current fallow for the reporting year. Though various efforts taken by both the Central and State governments, the area under current fallows is around 8.86 lakh hectares. The net area sown has significantly declined over a period of five decades. It declined from 61.35 lakh hectares during 1970s to 48.34 lakh hectares during 2020s. Similarly, the gross sown area has also declined significantly.

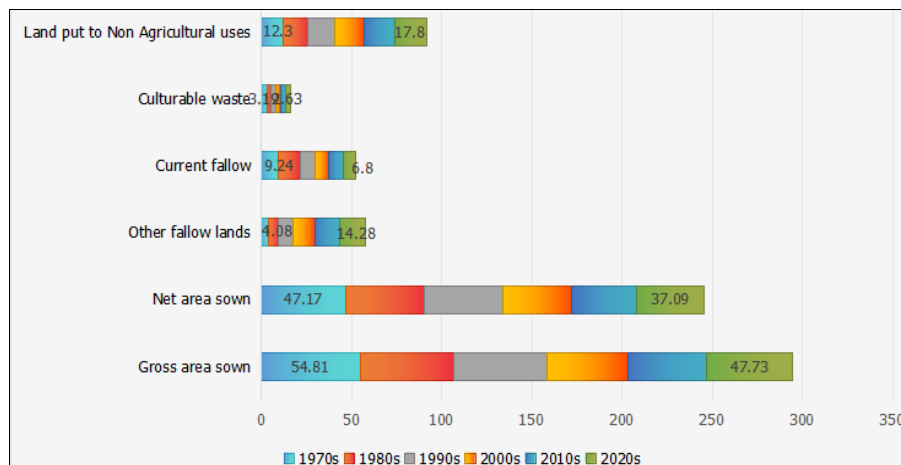
Table 1: Trend in Land use Pattern in Tamil Nadu (Lakh hectares)

Land Use Pattern	1970s	1980s	1990s	2000s	2010s	2020s
Forest	20.05 (15.42)	20.77 (15.9)	21.44 (16.48)	21.20 (16.28)	21.41 (16.43)	21.57 (16.55)
Barren and uncultivable land	7.05 (5.42)	5.58 (4.29)	4.94 (3.80)	4.93 n(3.79)	4.73 (3.63)	4.57 (3.51)
Land put to Non Agricultural use	16.00 (12.30)	17.95 (13.80)	19.08 (14.67)	21.05 (16.17)	21.94 (16.83)	23.20 (17.80)
Culturable waste	4.15 (3.19)	3.09 (2.37)	3.25 (2.50)	3.61 (2.77)	3.25 (2.50)	3.42 (2.63)
Permanent Pasture	1.98 (1.52)	1.45 (1.11)	1.23 (0.95)	1.14 (0.87)	1.08 (0.83)	1.08 (0.83)
Miscellaneous Tree Crops	2.15 (1.65)	1.82 (1.40)	2.31 (1.78)	2.69 (2.07)	2.37 (1.82)	1.81 (1.39)
Current fallow	12.02 (9.24)	16.18 (12.44)	10.55 (8.11)	10.09 (7.75)	10.71 (8.22)	8.86 (6.80)
Other fallow	5.31 m(4.08)	7.03 (5.41)	10.93 (8.41)	15.24 (11.71)	17.67 (13.56)	18.61 (14.28)

Net area sown	61.35 (47.17)	56.22 (43.22)	56.32 (43.30)	50.22 (38.58)	47.16 (36.18)	48.34 (37.09)
Area sown more than once	9.95 (7.65)	11.38 (8.75)	10.97 (8.44)	7.83 (6.01)	10.07 (7.72)	13.86 (10.64)
Gross area sown	71.30 (54.81)	67.60 (51.97)	67.29 (51.73)	58.05 (44.59)	57.22 (43.90)	62.20 (47.73)
Total Geographical Area	130.07 (100.00)	130.06 (100.00)	130.06 (100.00)	130.17 (100.00)	130.33 (100.00)	130.33 (100.00)

Figures in Paranthesis indicate percentage to total geographical area

Source: Season and Crop report of Tamil Nadu, Department of Economics and Statistics, Government of Tamil Nadu, Chennai. (Various issues)



Source: Author Estimate

Fig 1: Percentage of Different Types of Land Use in Tamil Nadu

The percentage share of net sown area and gross sown area to the total geographical area has been declining over the years (Fig.1). Hence, there is need arises for effective land use strategies particularly for effectively utilising the fallow lands, increasing net sown area and gross sown area.

3.2 Growth Rate Dynamics

The decadal compound growth rates indicates long-term reconfiguration of land use in Tamil Nadu between 1970–71 and 2023–24. Land put to non-agricultural uses shows a consistently positive growth over most of the decades, underscoring sustained expansion of urbanisation and

infrastructure, while net area sown and gross area sown exhibit negative growth in the long run, reflecting shrinking agricultural land availability. Forest area shows positive overall growth, suggesting gradual conservation gains, whereas permanent pastures, culturable waste and miscellaneous tree crop areas have declined steadily, pointing to erosion of common and ecological lands. The recent increase in area sown more than once suggest that increased cropping intensity as an adaptive response to land constraints, but the overall trends insist the need for strategic land-use planning to balance development, agriculture and ecological sustainability (Table. 2).

Table 2: Decadal Compound Growth Rates of Major Land Use Category in Tamil Nadu (1970-71 to 2023-24)

Year	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-2000	2000-01 to 2009-10	2010-11 to 2019-20	2020-21 to 2023-24	1970-71 to 2023-24	2000-01 to 2023-24
Forest	0.09	0.85	-0.09	-0.12	0.22	0.00	0.14	0.093
Barren and uncultivable land	-4.11	-1.44	-0.94	0.35	-1.00	-0.02	-0.86	-0.415
Land put to Non Agricultural use	1.69	0.45	0.86	1.13	0.14	-1.80	0.78	0.522
Culturable waste	-4.46	-2.03	2.16	-1.51	-0.33	2.68	-0.28	-0.571
Permanent Pasture	-4.74	-2.80	0.11	-1.20	-0.25	-0.05	-1.30	-0.416
Miscellaneous Tree Crops	-2.48	-4.46	0.31	-0.57	-1.57	-3.65	0.24	-1.859
Current fallow	4.90	-4.00	-0.80	-1.45	-0.68	3.33	-0.73	-0.331
Other fallow	-3.04	8.65	1.45	1.05	2.39	-0.06	3.02	1.357
Net area sown	-0.03	0.33	-0.48	-0.07	-0.68	-0.63	-0.58	-0.349
Area sown more than once	-9.91	-3.94	-2.35	-2.60	4.23	0.74	-0.04	2.824
Gross area sown	-1.36	-0.49	-0.79	-0.45	0.10	-0.33	-0.49	0.183

Source: Authors Estimate

3.3 Future Land Use Pattern

For informed and sustainable development planning, we need future land use pattern projection. Because urbanisation and agriculture are competing with the limited land resources. Systematic projections will provide policymakers with a strong analytical basis to evaluate the long-term consequences of existing land use pattern. The land use projection for Tamil Nadu state was carried out

using Markov Chain Analysis. This model assumes that future land use transition depend primarily on the current land use state and the observed probabilities of conversion which is helpful for appropriate planning of medium and long term land use. By systematic quantification, the model enables a transparent and evidence-based assessment of how land resources are likely to evolve under prevailing development trajectories.

The forecast shows a gradual yet persistent decline in the net sown area from 48.34 lakh hectares in TE 2023-24 to 47.37 lakh hectares by 2050-51 which reflects sustained pressures arising from land conversion, fragmentation of land and the increasing fallow lands due to climate change (Table. 3). Land put to non agricultural uses, although shows a marginal moderation by 2030-31, continues to occupy a substantial share of the total geographical area, highlighting the influence of urbanisation and peri-urban growth. Forest area is projected to remain stable throughout the forecast period, indicating that existing conservation

policies are highly effective in Tamil Nadu.

At the same time, current and other fallow lands signals stress on the agricultural lands, potentially due to water scarcity, climate variability, declining groundwater availability, rising production cost, labour scarcity. All together, these trends highlight the need for proactive land-use governance, protection of agricultural lands, promotion of sustainable agricultural practices and reclamation of fallow and wastelands to ensure long-term food security, rural livelihoods and ecological sustainability in Tamil Nadu.

Table 3: Projected Land Utilization pattern in Tamil Nadu for the Year 2030-31 and 2050-51 (Area in Lakh ha)

Year	TE 2023-24	% to TGA	2030-31	% to TGA	2050-51	% to TGA
Forest	21.57	16.36	21.54	16.53	21.46	16.46
Barren and uncultivable land	4.57	3.47	4.59	3.52	4.55	3.49
Land put to Non Agrl.use	23.59	17.89	22.34	17.14	22.73	17.44
Culturable waste	3.49	2.65	3.32	2.55	3.19	2.44
Permanent Pasture	1.08	0.82	1.08	0.83	1.07	0.82
Miscellaneous Tree Crops	1.78	1.35	1.99	1.53	2.13	1.63
Current fallow	8.84	6.70	9.27	7.11	9.23	7.08
Other fallow	18.59	14.10	18.61	14.28	18.60	14.27
Net area sown	48.34	36.66	47.59	36.52	47.37	36.35
Total Geographical Area (TGA)	130.33	100.00	130.33	100.00	130.33	100.00

Source: Author Estimate

4. Conclusion

The study clearly indicates that land use pattern in Tamil Nadu has undergone a substantial transformation over the last five decades. The decrease in net sown area and gross cropped area reflects the shrinkage of agriculture land and continuous increase of land under non agriculture use highlight the expansion of urbanisation and population growth. The expansion of fallow lands indicates the constraints in agriculture like labour scarcity, water scarcity, climate fluctuation and increase in cost of cultivation. The decadal compound growth rate further confirms the long-term structural shift from agriculture land to non agricultural land. Although area sown more than once increased due to farmers intensive agricultural practices in their available land, its not sufficient to overcome the loss of cultivable land. The markov chain projections also indicate there is a decline in the net sown area and increase in fallow lands by 2030-31 and 2050-51. Forest area alone shows stable growth, because of effective conservation policies and afforestation efforts by the government. Overall, these findings highlight that the current trajectory of changes in the land use poses a serious threat to food security, farmer livelihoods and ecological sustainability. Therefore, there is an urgent need for integrated land use planning that prioritises the protection of agricultural land, promotes the reclamation of fallow lands and encourages climate resilient agricultural practices. Strengthening policy interventions in these areas will be crucial to achieve a balanced and sustainable land use system in the future.

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