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Dynamics of Land Use Pattern in Madurai District of Tamil Nadu in Nexus with Common Property Land Resources

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This paper explores the dynamics of land use in Madurai district as it possesses the largest other fallow lands (48.28 per cent). Time series data on nine-fold classification for the study district of Tamil Nadu was collected from *Season and Crop Reports of Tamil Nadu*. The collected data from 1997-98 to 2017-18 were analysed using Compound Growth Rate, Cuddy Della Instability Index. Retention probability of land use pattern and forecasting was done using Markov Chain Analysis. The results revealed an increasing trend of Common Property Land Resources (CPLRs) due to declining nature of net sown area (-2.24 per cent per annum) and low retention capacity of current fallows. The erratic distribution of rainfall and water stress due to dry climatic conditions extends the current fallows into other fallow lands (4.54 per cent per annum). The predicted land use changes have also reflected the threatening scenario of increasing nature of current fallows and other fallow lands and declining nature of net sown area for the next decade. The study found Socio economic developments like Population growth and urbanization, and climatic conditions are drivers of change in land use pattern in Madurai district. Hence, the study suggest the promotion of less water intensive crops, water harvesting technologies like farm ponds and to give awareness

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about water saving technologies like micro irrigation to increase the productivity and profitability of agricultural lands where water and labour resources are scarce. Afforestation can be done in barren lands. Institutional arrangements should focus on framing Community User Group and women cooperatives to manage and effective utilisation of the increasing CPLRs in a better manner to ensure rainwater harvesting, fodder and fuel security, providing livelihood to rural poor as well as to sustain ecological balance.

Keywords: Land use pattern; CPLR; instability; probability.

ABBREVIATIONS

CPLRs : Common Property Land Resources
CV : Coefficient of Variation
PMKSY: Pradhan Manthri Krishi Sinchayee Yojana

1. INTRODUCTION

Land serves as crucial natural resource for many developmental activities. Like any other resource, land has two dimensions, viz., quality and quantity, and crucial aspects are under serious threat due to intensive and extensive use of land for both agricultural and non-agricultural purposes [1]. Land use pattern includes types of land and how much land is being utilized under different uses. Fertile land should be used for cultivation purposes and infertile land should be used for non agricultural purposes. pattern in the area depends upon the physical, environmental, and pressure of population on land. Dynamics of land use is a complex phenomenon which is affected by several socio economic, agro-climatic, and ecological variables. Both climatic and institutional factors are crucial in determining land use pattern. The extent of land use is also influenced by technological changes over a period of time [2].

A significant proportion of such natural resource is used in common by people who have common user rights (not necessarily ownership rights) is known as Common Property Resources [3]. This includes forests, village lands, grazing lands, streams, rivers, groundwater as well as man-made resources like irrigation tanks, community wells and village roads [4]. In India, out of 330 million ha of total land area, only around 140–147 million ha are being cultivated. The remaining 190 million ha exist in various forms of common properties that support occupations such as forestry and livestock rearing and provide daily requirements like food, fuel, fodder and medicines to pro-poor and poor rural households. Inadequate rural employment opportunities, especially in the slack season, mean that the local commons can make substantial contributions to household incomes. Local CPLRs also act as insurance against uncertainty in the absence of complete contingent markets [5]. Owing to increasing pressure of human and livestock population on the land and ever growing demand of food, fodder and fuel, there is bare need of scientific, rational and economic use of every piece of land in a sustainable manner [6].

According to his study, area put to non-agricultural uses has shown a substantial increase from 7.90 per cent in 1980-81 to 9.70 per cent in 2009-10. The increasing demand of over 23 per cent land per annum during the period 1980-81 to 2009-10, for infrastructural development and urbanization has resulted in the increase of area under non-agricultural uses. These changes are likely to cause severe ecological imbalances, including acute shortages in meeting the rising demand of fuel, fodder and timber in the state and adverse agro-climatic changes [6]. The Land use pattern has changed considerably in state. Net sown area accounted larger share (45% in 1960-61) of land use pattern and the same share to the total geographical area has been continuously declined from 45% in 1960-61 to around 36% in 2013-14. Reasons for many structural changes due to climatic factors includes inadequate rainfall and heavy downpour and technological development. Markov chain analysis revealed retention capacity for land under non-agricultural uses and current fallow land increased after economic reforms, indicating that non-farming activities may slowly absorb farm lands and in turn, may create a vulnerability to the agriculture and allied sector. The projected share of other uncultivated land excluding fallow land is likely to increase its share in future while that of net area sown is likely to lose its share in future. The highest instability was observed in respect of miscellaneous tree crops and groves followed by permanent pasture and cultivable waste. Hence proper land use policy is in need

for for proper management of land resource and to ensure sustainable agricultural growth in country [7]. There was a shift in land use pattern is in favour of barren and uncultivable land and fallow lands in recent years [8]. The projected share of land use pattern showed a drastic decline in the case of land under net sown area. This will create a negative impact on the food stability and economic stability of the state in future. Hence, action needed to be taken for effective land management policies [9]. As a normal process of urbanization, industrialization and economic development occurs, certainly it exerts tremendous pressure on the limited natural resource [10]. So a scientific study of land use pattern in general Common Property Resources (CPLRs) in particular is important for the formulation of appropriate land use options and agricultural development policies for balancing natural resources, its sustainability and for food and livelihood security. Hence keeping this view the present study was undertaken to study the temporal change in land use dynamics in Madurai district, one of the largest other fallow lands in the state.

1.1 The Specific Objectives of the Study are

- To study the growth in different land use categories.
- To study the dynamics of different land use categories.
- To measure the instability in different land use categories and
- To predict the future share of different land use categories.

2. METHODOLOGY

2.1 Study Area

The total geographical area of Madurai district is 374173 hectares. About 104827 hectares (28 percent) is under other fallow lands (other fallow lands are those lands which remain fallow for more than one year) whereas the land under net sown area is 102640 hectares accounting for 27.43 per cent during 2017-18. Thus, Madurai district is purposively chosen due to the dominance of other fallow lands, diminishing net sown area, increasing trend of Common Property Land Resources (48.48 per cent in 2017-18) and the socio-economic characteristics of the localist favours the need for this study. Some of the indicators of Madurai district are shown in Table 1.

2.2 Method of Data Collection

The study is based on secondary data regarding land use pattern i.e., nine fold classification obtained from the various issues of Season and Crop Reports of Tamil Nadu, Directorate of Economics and Statistics, Government of Tamil Nadu for the period from 1997-98 to 2017-18 i.e., after its complete separation from Dindugal district. To assess the growth rate and stability, following methodology were adopted in this study.

2.2.1 Tabular analysis

It is used for the presentation of some of the analysed data such as changes in land use classification of the study district. Appropriate percentage analysis was worked to study the land use pattern over three decadal periods and presented in the form of table (Table 2).

2.2.2 Compound growth rate analysis

Growth of any variable indicates its past performance. The analysis of growth is usually used in economic studies to find out the trend of a particular variable over a period of time. It clearly indicates the performance of the variable under consideration and hence it can be very well used for making interpretations and to evolve policy decisions [1].

Hence, the growth in the area under different land use categories was estimated using the exponential growth function of the form

$$Y = ab^t e_t$$

Where,

Y: Dependent variable for which growth rate was estimated
a: Intercept
b: Regression coefficient
t: Years which takes values, 1, 2…, n
e_t: Disturbance term for the year t

The compound growth rate (g) in per centage was then computed from the relationship,

g = (Antilog of b -1) *100

Fig. 1. Map highlighting the study district of Tamil Nadu

Table 1. Socio economic indicators of Madurai district

Particulars	2001	2011
Demography (numbers)		
Population	2578201	3038252
Urban population	1444176	1846801
Cultivators	129240	92719
Agrl.Labourers	228083	372828
Others	295478	841792
Livestock (numbers)		
Sheep	216416	184433
Goat	238588	297052
Total Livestock	698674	703500
Gross District Domestic Product (Rs. In Lakhs)		
Primary Sector	74841	84771
Tertiary Sector	704759	1268355
Rainfall and temperature		
Precipitation(mm)	961.6	875
Maximum Temperature (ºC)	41ºC	
Minimum Temperature (ºC)	25ºC	

Source: District profile, office of Deputy Director of Statistics, Madurai (2001 and 2011)

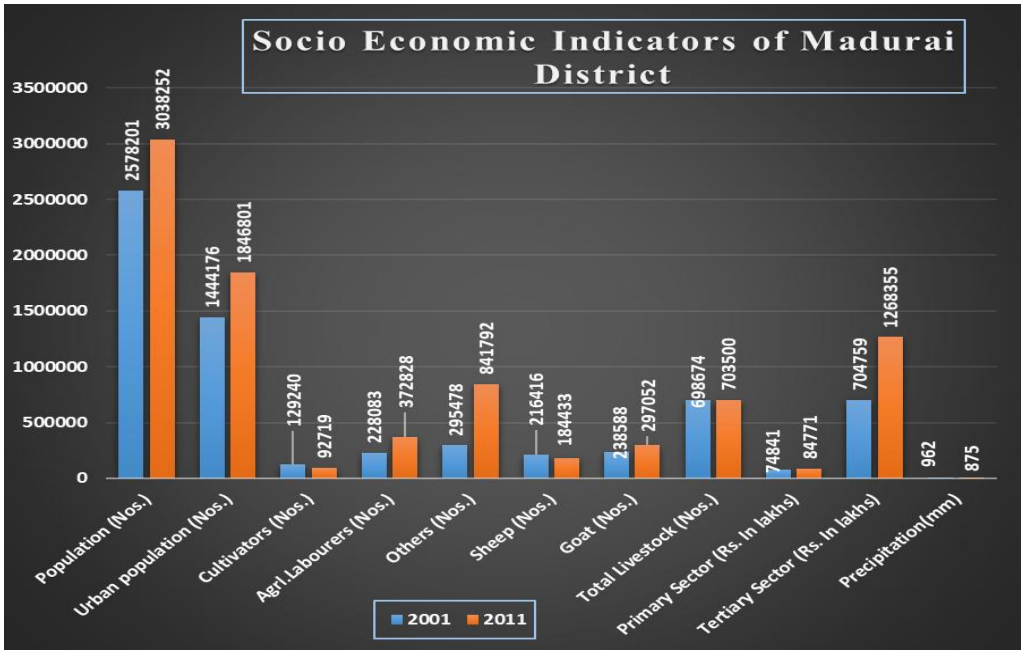

Fig. 2. Socio-economic indicators of Madurai district

Table 2. Extent of changes in various types of CPLRs and other categories during last three decades (Numbers)

Year	1997	2007	2017
CPLRs			
Forest	50452(13.48)	48473(12.95)	48473(12.95)
Barren and Uncultivable lands	15783(4.22)	13160(3.52)	13064(3.49)
Cultivable Waste	4824(1.29)	6498(1.74)	14057(3.76)
Permanent Pastures and other Grazing Land	185(0.05)	233(0.06)	233(0.06)
Other Fallow Lands	25117(6.71)	65167(17.42)	104827(28.02)
Total CPLRs	96361(25.75)	133531(35.69)	180654(48.28)
Others			
Land Put to non-agricultural uses	62583(16.72)	75211(20.10)	75597(20.20)
Land under Miscellaneous Tree crops and Grove	1361(0.36)	3033(0.81)	2514(0.67)
Current Fallows	50792(13.57)	20573(5.50)	12768(3.41)
Net sown area	162776(43.50)	141825(37.90)	102640(27.43)
Subtotal (Others)	277512(74.17)	240642(64.31)	193519(51.72)
Total Geographical Area	374173(100.00)	374173(100.00)	374173(100.00)

(Values in the parentheses indicate the per centage to the respective total)
(Source: Season and Crop Report (1997-98 to 2017-18), Directorate of Economics and Statistics)

2.2.3 Cuddy della instability index (CDII)

Instability index is a simple analytical technique to find out the fluctuations or instability in any time-series data [11]. It is estimated as follows:

(i) Estimate the parameters of a log-linear trend line for the variable (Yt) for which instability is to be estimated.

(ii) If the estimated parameter is statistically significant, then the instability index

(I) is defined as

$$I = CV \times \sqrt{1 - R^2}$$

where CV= coefficient of variation for the time-series calculated as

CV = (S.D/Mean) ×100,

where, S.D. = standard deviation

(iii) If the estimated parameter in the regression equation in step (a) is not significant, then the CV itself is the instability index.

2.2.4 Markov chain analysis

The Markov chain analysis with steady-state transitional probability will be used to study the shifts in the land use classification [12,13]. Markov chain analysis involves developing a transitional probability matrix 'P', whose elements, P_{ij} indicate the probability of district land use classification switching from one classification 'i' to another 'j' over time. The diagonal element P_{ij} where i=j, measures the retention probability of respective land use classification.

$$E_{jt} = \sum_{t=1}^{n} (\mathrm{E_{it}} - 1)\mathrm{P_{ij}} + e_{\mathrm{jt}}$$

Where,

E_{jt} = Shift in land use of the district to the j^{th} classification in the year t

E_{it-1} = Shift in land use of the district from i^{th} classification in the year t-1

P_{ij} = the probability that district land use will shift from i^{th} classification to j^{th} classification

e_{jt} = the error term which is statistically independent of E_{it-1}

N = the number of land use classification

3. RESULTS AND DISCUSSION

3.1 Common Property Land Resources

Common Property Land Resources (CPLRs) are the resources accessible to the whole community of a village and to which no individual has exclusive property rights. CPLRs include forest lands, barren and uncultivable lands, cultivable waste land, permanent pastures and grazing lands and other fallow lands. It forms the main thrust of the rural households who depend on the CPLRs to meet household need and ensuring the welfare of the family. This involves collection of fodder for their livestock, fire wood collection, tamper for marketing and self-use, collection of raw materials for rural artisans and collection of traditional medicinal plants for curing minor diseases, harvesting crops and collection of forest product.

3.1.1 Extent of changes in common property land resources during last three decade

The recent two decadal changes in the various categories of land is presented in Table 2. It could be inferred from the table that there had been a marginal decrease in the forest land from 13.48 per cent in 1997 to 12.95 per cent in 2017-18. Among the several categories of Common Property Land Resources, other fallow lands have shown an increasing trend from 6.71 per cent to 28.02 per cent during the last two decades. Reversely, the net sown area has declined from 43.50 per cent to 27.43 per cent. However, the total CPLRs had increased over the years from 25.75 per cent (1997-98) to 48.28 per cent (2017-18). Madurai being in the dry region experiencing erratic distribution of rainfall, abnormal weather conditions (Table 1) led to the reduction of net sown area and led to increase in fallow lands, land put to non-agricultural waste and culturable waste. This certainty puts pressure on the size of the culturable land. So efforts to be made to utilize barren and unculturable land for non agricultural uses. Similarly there is a great scope for expansion of further area under cultivation by diverting culturable wastes and fallow other than current fallow.

3.2 Per Capita Availability of CPLRs in the Study District

Per Capita Availability of CPLRs for the two census periods is presented in Table 3. Though the trend in CPLRs had increased over the years, per capita availability has reduced from 0.06 to 0.05 hectare when comparing the recent two census periods. This is probably due to increasing population (Table 1) and pressure on land especially on CPLRs which may prone to vaporisation of the resource due to overexploitation.

3.3 Compound Growth Rate of Different Land Use Categories of Madurai District

Growth rates were worked out for land use pattern to get a detailed picture of the dynamics of land use classification in the study district. The results indicated that land put to non-agricultural uses was recorded positive growth rate and is significant. This may be due to the rising

urbanization and industrialization (Table 1). Hence, vertical expansion of lands are adviced, so as to protect the cultivable lands. The growth in Culturable wastelands during the past two decades was shown a sharp positive trend and it was very severe in the recent decade (9.31 per cent) than the previous one (3.42 per cent per annum). The latest decadal area of culturable wastes has increased more than 50 per cent over the past decade. It shows that no efforts have been taken to bring that cultivable lands into agricultural uses. Land under miscellaneous trees and grooves had shown the highest positive trend during the previous decade (17.81 per cent). But this trend however shows a negative growth rate of 1.72 per cent per annum during 2007-17. At the same time, the growth of permanent pastures and grazing lands remains stagnant. This might create the feed shocks for the rising livestock population during dry spell. Net sown area had shown a negative trend and it greatly reduced during recent decades to the extent of 4.34 per cent per annum. It is also clear from the Table 2 that the net sown area had drastically reduced from 43.50 to 27.43 per cent. On the contrary, other fallow lands had shown a sharp increasing trend of 4.22 per cent per annum. Thus, the increase in other fallow lands was due to decrease in net sown area and the conversion of current fallows in to other fallows in the long run phenomenon. It might be due to the following reasons. The erratic distribution of rainfall, dry climatic condition, declining nature of population indulging in agricultural activities and labour scarcity due to shifting towards other sectors (Table 1).

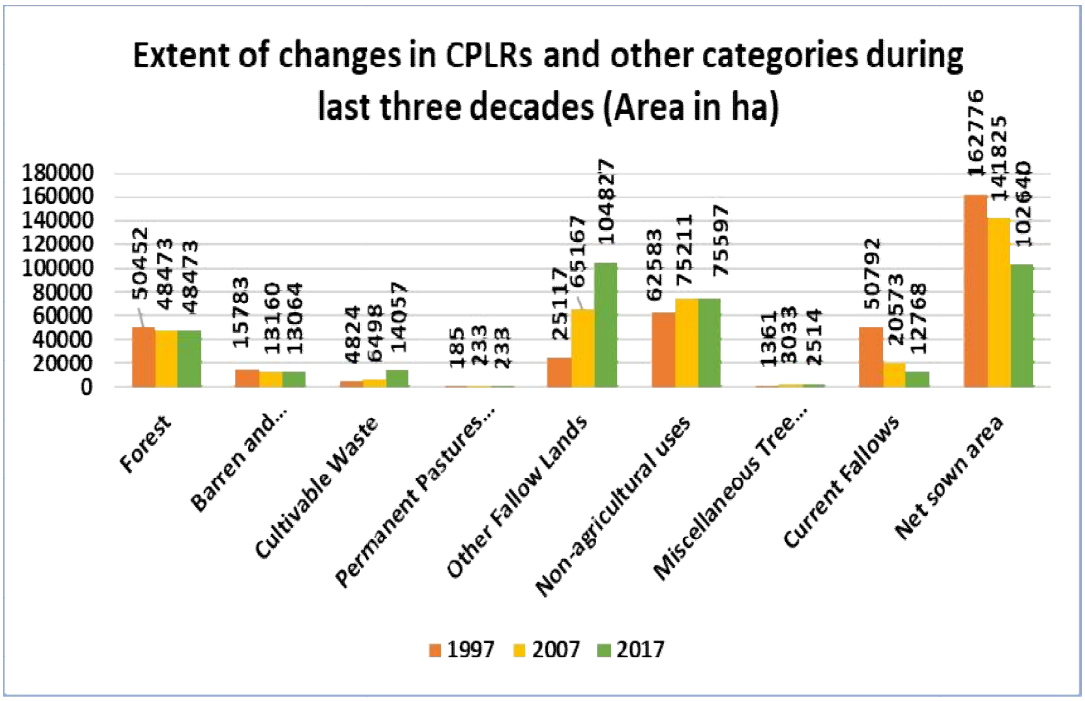

Fig. 3. Extent of changes in land use pattern during last three decadal periods

Table 3. Percapita availability of CPLRs and PPLRs in the study district

Year	2001	2011
Population (numbers)	25,78,201	30,41,038
Total CPLRs (hectares)	152871	153756
Percapita Availability	0.060	0.050

Source: 1. Population details collected from Records of office of the Registrar General and Census Commissioner of India, 2001 and 2011
2. Data on CPLRs collected from Season and Crop Report, Directorate of Economics and Statistics, 2001 and 2011

3.4 Instability Index of Land Use Pattern in Madurai District

Instability index is a measure of the extent of variability or the absence of stability in time-series data. Thus, the instability index for the land use categories was worked out and are represented in Table 5. It could be observed from the table that the highest instability index for the period 1997-2017 was recorded for current fallow. It showed high year to year fluctuations due to variations in rainfall as most of the agricultural lands were under rainfed conditions (Table 1). It is followed by cultivable wastelands which showed more fluctuation and instability was increasing over the decades. However, the forestlands have stabilized their area during the recent decade. Hence institutional arrangements should bring the idle culturable wasteland near the urban areas in to cultivation thereby preventing it from indulging in speculative purposes.

3.5 Markov Chain Analysis

Transitional probability matrix is matrix that calculate the probability changing of each types of land cover into another types of land cover based on Markov Chain Analysis [12,13]. The probability describes in a range of value between 0 and 1 in which zero value indicates that the retaining capacity is impossible and 1 represents highest stability.The results from Table 6 indicated that the forest cover and permanent pastures and other grazing lands had shown the highest stability (100 per cent) which is followed by net sown area (92 per cent), miscellaneous trees and groves (83 per cent), land under non-agricultural uses (74 per cent) cultivable wastelands (71 per cent), other fallow lands (66 per cent) and barren and uncultivable lands (26.10 per cent). Current fallows have shown poor retention capacity of about 2.2 per cent. The great fluctuations seen in area under current fallows was mainly due to fluctuating nature of rainfall. This leads to transformation of such idle lands into other fallows category. This could be evidenced that 76.6 per cent of current fallows have transformed to Other fallow lands over the past two decades (Table 6).

3.5.1 Projection of land use changes

The forecasting of land use was done based on the transitional probability matrix shown in Table 7. The predicted results showed an alarming nature of gradual reduction in net sown area and an increasing trend would be observed in current fallows and other fallow lands for the next decade. Another threatful trend is the increasing nature of barren and uncultivable lands which can be use for afforestation programme. With the increasing population, the demand for non agricultural land for settlement and food grain requirement also increases. The only prospect of increase food grains and meeting the need of food lie in expansion of cultivated area, reduction of fallow, increase in net sown area and enhancing productivity. Therefore, Various factors such as population growth, urbanization, infrastructure development, demand of land for settlement purpose, demand for food grains are responsible for change in land use pattern.

Table 4. Compound growth rate (Percentage per annum) of land use categories of Madurai District

Particulars	1997-98 to 2006-07	2007-08 to 2017-18	1997-98 to 2017-18
Forest	-0.58**(-4.62)	-	-0.23**(-5.49)
Barren and Uncultivable Land	-11.38(-1.51)	-0.03(-1.19)	0.71**(-3.84)
Land put to non-agricultural uses	1.89**(7.94)	0.05**(12.69)	0.89**(7.72)
Cultivable Waste	3.42**(5.25)	9.31**(3.44)	6.77**(8.67)
Permanent Pastures and other Grazing Land	1.35(1.95)	-	0.34(2.04)
Land under Miscellaneous Tree crops and Groves	17.81**(7.04)	-1.72**(-7.58)	2.86*(2.31)
Current Fallows	-23.71*(-3.30)	1.81(0.25)	-1.75(-0.55)
Other Fallow Lands	15.09*(2.80)	4.22**(8.29)	4.54**(3.36)
Net Area sown	-1.62(-1.05)	-4.34**(-3.37)	-2.24**-4.36

Values in the parenthesis represent the t-value
** and ** indicate significance of growth rates at 5 and 1 per cent respectively*

Table 5. Instability index for land use pattern in Madurai district

Particulars	1997-98 to 2006-07	2007-08 to 2017-18	1997-98 to 2017-18
Forest	2.06	0.00	1.87
Barren and Uncultivable Land	9.00	0.30	7.17
Land put to non-agricultural uses	5.99	0.17	6.12
Cultivable Waste	11.98	31.37	46.69
Permanent Pastures and other Grazing Land	6.53	0.00	4.52
Land under Miscellaneous Tree crops and Groves	50.34	6.20	33.14
Current Fallows	81.85	68.12	73.51
Other Fallow Lands	46.46	14.44	31.75
Net Area sown	13.74	18.88	18.70

Table 6. Transitional probability matrix for land use categories in Madurai district during 2007-2017

	FOR	BUL	NAU	CW	PPGL	MTG	CF	OF	NAS
FOR	**1.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BUL	0.000	**0.261**	0.739	0.000	0.000	0.0	0.000	0.000	0.000
NAU	0.000	0.091	**0.740**	0.035	0.000	0.000	0.000	0.134	0.000
CW	0.000	0.000	0.041	**0.710**	0.000	0.000	0.000	0.249	0.000
PPGL	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000
MTG	0.000	0.054	0.000	0.000	0.000	**0.083**	0.551	0.312	0.000
CF	0.000	0.015	0.042	0.003	0.000	0.015	**0.022**	0.766	0.136
OF	0.000	0.013	0.045	0.000	0.000	0.007	0.275	**0.660**	0.000
NAS	0.000	0.010	0.042	0.013	0.000	0.014	0.000	0.000	**0.920**

(FOR: Forest, BUL: Barren and Uncultivable Land, NAU: Land put to non-agricultural uses, CW: Cultivable Waste, PPGL: Permanent Pastures and other Grazing Land, MTG: Land under Miscellaneous Tree crops and Groves not included in Net Area Sown, CF: Current Fallows, OF: Other Fallow Lands, NAS: Net Area sown)

Table 7. A projected change in land use pattern (in Hectares)

YEAR	FOR	BUL	NAU	CW	PPGL	MTG	CF	OF	NAS
2020-21	48473	13140	75882	13629	233	2614	30763	106113	83325
2024-25	48473	13192	76074	13312	233	2572	32336	111172	76810
2029-30	48473	13256	76338	12930	233	2527	33982	116427	70009

(FOR: Forest, BUL: Barren and Uncultivable Land, NAU: Land put to non-agricultural uses, CW: Cultivable Waste, PPGL: Permanent Pastures and other Grazing Land, MTG: Land under Miscellaneous Tree crops and Groves not included in Net Area Sown, CF: Current Fallows, OF: Other Fallow Lands, NAS: Net Area sown)

4. CONCLUSION AND POLICY RECOMMENDATIONS

Results revealed that there was a significant decline in the forest lands and barren and uncultivable lands. In this view, efforts should be made to implement afforestation program to protect the forest lands and utilize the barren and uncultivable lands which is projected to increase in the future decades. The other fallow lands have shown a critical increasing trend from 6.71 per cent to 28.02 per cent during past twenty years. At the same time, the net sown area has sharply declined from 43.50 per cent to 27.43 per cent. It is probably due to the erratic distribution of rainfall, abnormal weather conditions and lack of availability of seasonal irrigation water leading to the reduction of net sown area and increasing trend of other fallow lands, land put to non-agricultural waste and culturable waste. Secondly, it might be due to labour scarcity for the agricultural sector.

The instability index for the study district was seen highest in the current fallow lands which might be due to the variations in rainfall. The Markov chain analysis has also supported the above findings that the current fallows has shown a poor retention capacity of 2.2 per cent. The predicted land use pattern has also reflected the

threatening scenario of increasing nature of current fallows and other fallow lands and declining nature of net sown area for the next decade. These necessitates the pressing need for preserving agricultural lands. Hence, the institutional sector should focus on promotions to cultivate less water-intensive crops, establish water harvesting technologies like farm ponds among farming communities.

Besides, there is a great scope for expansion of further area under cultivation by diverting culturable wastes and other fallow lands. This may help in achieving food security of the district. Awareness programmes on government schemes like PMKSY promoting water saving technologies like drip irrigation may be promoted. Capacity building should be encouraged. Thereby facilitating better adoption of technology and increasing the productivity and profitability of agricultural lands where water and labour resources are scarce. Diversification of agriculture should be encouraged in the district because it not only enhances income but also protects from risks, enhances soil properties and prevents degradation of land.

The serious challenge of increasing nature of non-agricultural lands needs an immediate attention which is ultimately due to the rapid urbanization and industrialization. This could be alleviated by vertical expansion of lands for non-agricultural uses rather than horizontal expansion. The stagnant growth of permanent pastures and grazing lands calls for the need of pastoral and fodder management to support the livelihood of pastoral communities during dry spell. In this regard, strong policies become the need of the hour to device Community User Groups and women cooperatives who help manage and effectively utilize the increasing CPLRs in a better way to ensure rainwater harvesting, fodder and fuel security, livelihood to rural poor and to sustain ecological balance. To sum up, desirable land use pattern could be achieved by framing appropriate land use policies by promoting suitable institutional mechanisms for scientific management, conservation and development of land resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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