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Dynamics of Land Use Pattern in Kerala – A Temporal Analysis

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This study aims to assess the dynamic changes of land use pattern in Kerala for which panel data of land use pattern was used from 1970-71 to 2016-17. The collected data was analysed using Markov chain analysis. The transition probability matrix revealed that the area under miscellaneous tree crops and non-agricultural land had the highest retention probability which were 76% and 70% respectively while barren and uncultivable land and cultivable waste land were failed to retain their previous year's area share. Estimated land use share during 2006-07 to 2015-16 revealed that the shift in land use pattern is in favour of barren and uncultivable land and fallow lands in recent years. The net sown area was found to be losing its shares. The projected share of land use pattern showed a drastic decline in the case of land under net sown area.

Key words: Dynamic changes, Land use pattern, Markov chain, Transition probability.

Land is a vital input among all the resources. Land use is a highly dynamic process and is affected by several socio-economic and biological variables. One poorly understood area in Indian agriculture is the impact of the structural change in agricultural land use on the long term socioeconomic- ecological viability of agriculture (Seema and Sham, 2010). 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 (Mouzam *et al.,* 2015).

The extent of land use is also influenced by technological changes over a period of time. The technological changes in agricultural ignited intensive cultivation resulting in conversion of marginal lands in to productive agricultural lands through capital intensive cultivation (Gairhe *et al.,* 2010). According to FAO, land use pattern is the study of identification of different purposes of land according to their role and importance. From the point of view of agriculture, land available for cultivation is the most important among different land use patterns.

Kerala is having a highly dynamic history of land use. The most predominant change is the shrinkage of area under cultivation of food crops. Land put to non- agricultural purposes had increased gradually from 7.12 per cent in 1970-71 to 11.37 per cent in 2016-17 of the total geographical area of the state. The total area under food grains during 2016-17 was 1,73,386 Ha (Directorate of Economics and Statistics, Kerala). The net sown area experienced a decline of 10.32 per cent during the same period. The area under paddy was also found to be losing its share. The decrease is 34.96 per cent during the last 10 years. This will not only to create threat on food security, but also create ecological problems due to conversion of low lying paddy fields for non-agricultural purposes after filling the land. In this context it is vital to know the changing scenario of land use pattern and in Kerala.

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Material and Methods

Secondary data on land use pattern and area under food grain production were collected from government reports published by the Directorate of Economics and Statistics (DES), Reports on Land Use and Statistics from Kerala Land Use Board and the Annual Economic Review of the State Planning Board for all the districts for the period of 47 years from 1970-71 to 2016-17. Statistics on land use pattern were collected for Kerala state in the form of nine-fold classification. They are Area under Forest (FO), Land put to Non–Agricultural use (NAU), Barren and uncultivable land (BL), Permanent pastures and other grazing land (PP), Land under miscellaneous tree crops (MTC), Cultivable waste (CW), Fallow other than current fallow (OF), Current fallow (CF) and Net Area Sown (NAS).

Markov chain analysis

Markov chain analysis was used to study the shifts in the land use pattern and thereby gain an understanding of the dynamics of the changes (Paramasivam *et al*., 2017). It is the application of dynamic program to the solution of a stochastic decision process that can be described by a finite number of states (Adhikari and Sekhon, 2014). A first order Markov chain is characterised by the transition probability matrix and each element in the transition probability matrix is expressed by P_{ij}, where P_{ij} is the probability that if for any time t, the process is in state 'i', it moves to state 'j' on the time t+1. Also it should be noted that each element in the transition probability matrix is non-negative and the sum of the elements in any row is 1 (Moody and DuCloux, 2014)

In the present study, P_{ij} represents the conditional

probability of the area under a particular land use category in time 't' given its share in time 't-1'. The transition matrix of this study was 8×8 matrix resulting in 64 probabilities, P_{ij}, i, j =1,2,3…..,8 which would be estimated further. The diagonal elements indicates the probability of retention of the previous year's area by the respective land use category. The off-diagonal elements are the probabilities of transiton between the categories.

Estimation of transition probability matrix

Estimation of transition probability matrix in the matrix form can be expressed as

$$Y_j = X_j P_j + U_j$$

Where, Y_j is a (T×1) vector of observations reflecting the proportions in land use pattern j in time t, X_j is a (T × R) matrixes of realized values of the proportion in land use pattern/cropping pattern j in time t-1, P_j is a (R×1) vector of unknown transition parameters to be estimated and U_j as a vector of random disturbances (Paramasivam *et al*., 2017).

Projections

After estimating transition probability matrix (P), proportion of area under land use categories was predicted using the following equation:

$$Y'_{(t)} = Y'_{(0)} P^t$$

Where, $Y_{(t)}$ is a (R×1) vector of proportion of area under land use categories/crops in year t, $Y_{(0)}$ is a (R×1) vector of proportion of area under land use categories/crops in year 0,P^t = (R×R) transition probability matrix to the power of time (t), and $Y'_{(t)}$ and $Y'_{(0)}$ are transpose of vector $Y'_{(t)}$ and $Y'_{(0)}$ respectively (Selvi, 2015).

Results and Discussion

Land use pattern in Kerala

The total geographical area of Kerala state was 38.59 lakh hectares during 2016-17. Net area sown occupies the maximum share. But a gradual decline could be observed from 21.72 lakh ha in 1-970-71 to 20.15 lakh ha in 2016-17 (Table 1).

Table 1. Land use pattern in Kerala (Area in lakh ha)

Classification	1970-71	1980-81	1990-91	2000-01	2010-11	2016-17
Forest land (FO)	10.55 (27.33)	10.82 (27.83)	10.82 (27.83)	10.82 (27.83)	10.82 (27.83)	10.82 (27.83)
Land put to non-agri. Uses (NAU)	2.75 (7.12)	2.69 (6.94)	2.97 (7.65)	3.81 (9.82)	3.84 (9.88)	4.42 (11.37)
Barren and uncultivable land(BL)	0.72 (1.86)	0.85 (2.20)	0.58 (1.50)	0.29 (0.75)	0.19 (0.50)	0.12 (0.30)
Permanent pastures and other grazing lands (PP)	0.28 (0.72)	0.05 (0.13)	0.02 (0.04)	0.001 (0.01)	0.002 (0.01)	0.00 (0.00)
Miscellaneous tree crops and groves (MTC)	1.32 (3.42)	0.63 (1.64)	0.34 (0.88)	0.15 (0.39)	0.037 (0.09)	0.025 (0.06)
Cultivable waste (CW)	0.79 (2.04)	1.29 (3.32)	0.96 (2.48)	0.59 (1.52)	0.91 (2.35)	1.01 (2.60)
Current fallows (CF)	0.22 (0.62)	0.26 (1.12)	0.26 (1.13)	0.34 (2.00)	0.51 (1.95)	0.55 (1.85)
Other fallows(OF)	0.24 (0.57)	0.43 (0.69)	0.44 (0.68)	0.77 (0.87)	0.76 (1.33)	0.72 (1.42)
Net area sown (NAS)	21.72 (56.28)	21.72 55.88)	22.47 (57.81)	22.06 (56.77)	20.72 (53.30)	20.15 (51.86)
Total geographical area	38.59 (100)	38.85 (100)	38.85 (100)	38.85 (100)	38.86 (100)	38.86 (100)

Source: Economic Review (1970-71 to 2016-17) of the Government of Kerala

Note: Figures in parentheses are percentage to total area

In terms of percentage, the share of net sown area has decreased from 56.28 per cent (1970-71) to 51.86 per cent (2016-17). At the same time, the share of land under non-agricultural use has increased from 7.12 per cent (2.75 lakh ha) in 1970-71 to 11.37 per cent (4.42 lakh ha) in 2016-17. Forest land showed a marginal increase from 1970-71 to 1980-81 but became consistent thereafter. All categories except cultivable waste and fallow lands showed decreasing trend over the decades. Current and other fallow land categories showed a gradual increase over the years.

Dynamic changes of land use categories

The dynamic changes of land use categories of Kerala were studied by estimating Markov transitional probability matrix and is presented in Table 2. The Markov chain analysis was carried out for the period from 2006-07 to 2016-17. The stability of previous year's area share of different land use categories were analysed using the matrix. In the table, Fallow

land (FL) includes both current fallow (CF) and other fallow (OF).

Table 2. Transitional probability matrix

Land use category	FO	NAU	BL	PP	MTC	CW	FL	NAS
FO	0.12	0.42	0.05	0.02	0.18	0.04	0.05	0.11
NAU	0.09	0.70	0.05	0.02	0.12	0.01	0.00	0.00
BL	0.73	0.00	0.00	0.00	0.00	0.20	0.00	0.07
PP	0.00	0.36	0.00	0.64	0.00	0.00	0.00	0.00
MTC	0.00	0.24	0.00	0.00	0.76	0.00	0.00	0.00
CW	0.97	0.00	0.00	0.00	0.00	0.00	0.03	0.00
FL	0.00	0.00	0.34	0.00	0.00	0.00	0.66	0.00
NSA	0.21	0.00	0.06	0.00	0.00	0.03	0.00	0.69

It can be inferred from the Table 2 that different land use categories considered in the study indicated some stability except for the barren and uncultivable land and cultivable waste land.The area under miscellaneous tree crops and non-agricultural land had the highest retention probability which were 76% and 70% respectively. It clearly indicates that a major share of cultivable waste land (97%) and barren and uncultivable land (73%) have been converted to land under forest over the period even if the retention probability of forest was comparatively low (12%). Net sown area retained 69 per cent of the previous period's share and lost 21 per cent to forest , 6 per cent to barren and uncultivable land and 3 per cent to cultivable waste land categories. However, it gained 11 per cent of the area share from forest and 7 per cent from barren and uncultivated land.

Table 3. Estimated land use categories (Percentage)

Year	FO	NAU	BL	PP	MTC	CW	FL	**NAS**
2006-07	18.72	19.81	6.37	0.88	6.67	3.08	3.89	40.90
2007-08	18.67	19.99	6.36	0.88	6.70	3.07	3.89	40.66
2008-09	18.71	19.96	6.36	0.88	6.62	3.07	3.88	40.72
2009-10	18.94	18.39	6.42	0.84	6.33	3.08	3.99	42.06
2010-11	18.27	18.99	6.28	0.85	7.04	3.00	3.99	40.11
2011-12	18.19	19.07	6.34	0.85	6.44	2.97	4.16	39.55
2012-13	18.24	19.11	6.35	0.86	6.43	2.97	4.15	39.69
2013-14	20.55	19.17	6.38	0.86	6.44	3.59	4.19	39.96
2014-15	18.19	19.69	6.37	0.87	6.53	2.94	4.19	39.24
2015-16	18.29	19.41	6.39	0.86	6.48	2.95	4.20	39.59
2016-17	18.19	19.82	6.41	0.87	6.55	2.92	4.57	39.10

Table 4. Projected share of land use area (Percentage)

Year	FO	NAU	BL	PP	MTC	CW	FL	NAS
2017-18	19.28	17.69	5.44	1.25	8.49	3.34	2.30	42.22
2018-19	20.13	23.07	5.13	1.60	12.20	3.34	2.69	31.83
2019-20	18.29	28.22	4.97	1.96	15.85	3.00	3.02	24.69
2020-21	16.57	32.05	4.84	2.25	18.94	2.69	3.14	19.52
2021-22	15.22	34.85	4.69	2.47	21.45	2.45	3.14	15.73
2022-23	14.16	36.92	4.54	2.64	23.47	2.26	3.07	12.94
2023-24	13.34	38.46	4.41	2.77	25.07	2.11	2.97	10.88
2O24-25	12.70	39.62	4.29	2.86	26.33	2.00	2.86	9.35
2025-26	12.20	40.49	4.19	2.93	27.32	1.91	2.76	8.20
2026-27	11.82	41.15	4.11	2.97	28.10	1.84	2.66	7.35

Estimated land use pattern

The proportion of land use pattern in Kerala under different categories of usage are estimated

and presented in Table 3. The results found that the shift in land use pattern is in favour of barren & uncultivable land and fallow lands in recent years. The net sown area was found to be losing its shares. All other categories were stable over the years from 2006-07 to 2016-17.

Projected share of land use area

The area under different land use categories in Kerala were predicted for the next ten years (2017-18 to 2026-27) using transition probability matrix and the results are presented in Table 4. The results revealed that the land under net sown area is likely to lose its share in the coming years. The land under forest, barren land, cultivable waste are also having a decreasing trend. A gradual increase in the area has predicted in the case of non-agricultural uses, permanent pastures and grazing land, miscellaneous tree crops and fallow land. All the results are indicating a downward growth of agriculture land area in Kerala in the future.

Conclusion

Total geographical area of 38.59 lakh hectares of the state, net area sown occupies the maximum share. But a gradual decline could be observed through the decades from 21.72 lakh ha in 1970-71 to 20.15 lakh ha in 2016-17. At the same time, the share of land under non-agricultural use has increased. Results of Markov analysis revealed that the area under miscellaneous tree crops and non-agricultural land had the highest retention probability which were 76% and 70%, respectively while barren and uncultivable land and cultivable waste land were failed to retain their previous year's area share. There was a shift in land use pattern is in favour of barren and uncultivable land and fallow lands in recent years. 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.

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