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A study on temporal variation of land use pattern in Karnataka through indices

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Abstract
Land use is dynamic process and resources are very essential for all human activities. It is the most important natural resource in a country like India, where the agriculture sectors are fairly more dominant than the manufacturing sectors. Land, as a major factor in agriculture, occupies a significant position among the other tools required for the operation of the agricultural sector. Land Use Pattern (LUP) specifies the quantity of the area under diverse forms of use, for example, the area actually cultivated, the forest, the fallow land, and the area under settlements, etc. The land use area mainly depends on the environmental, physical and population pressures on the land. The study has been made to understand the changes in temporal land use pattern in districts of Karnataka due to industrialization and increase in human population. Herfindahl and Simpson Indices were used to identify the changes in land classification. The Kendall's coefficient of concordance and rank correlation revealed that Dakshina Kannada and Udupi districts showed high changes in land classification whereas, Bijapur, Gadag and Bagalkot showed least changes.

Keywords: Temporal variation, land use pattern, indices

Introduction
Agriculture is the backbone of the Indian economy. As India's largest private enterprise, agriculture contributes almost 15.87 per cent of GDP, which maintains the livelihood security of about sixty-six per cent of the population. And, it is also the backbone of agro-based industries. Natural resources play a substantial role in the development of agriculture and industrialization. Land endowment is a major natural resource, and agriculture is highly dependent on the extent to which it is altered by man and manipulate from it.

Concept of land and land use: FAO (1995) defined land as "A delineable area of the earth's terrestrial exterior, including all features of the biosphere nearly above or below the surface, including those of near-surface climate, soil and soil forms, surface hydrology (including shallow gee-hydrological reserves) of the plant and animal population, settlement patterns by humans and past physical outcomes." In economics, the term 'land' has been given a special meaning. This does not imply soil in the usual context, but it is used in a somewhat wider way. In economics, land means "The resources and powers that nature provides, voluntarily for man's sake, throughout soil and water, in air and light and fire." Land provides all-natural commodities that have an income or an exchange value. This reflects certain natural resources that are, in reality or theoretically, valuable and finite. The Land Use Pattern (LUP) of a country at any specified period is determined through common physical, economical and institutional basis. In other words, the existing pattern of land use has evolved at any time as a result of both the action and interaction of several factors, that are physical features of the land, the structure of other resources, like capital, labour, etc. Land is essential for production of food i.e. pulses, cereals, oil seeds and other numerous crops for consumption, and also for the production of surpluses to meet the increasing demand of the rising population for development of the industrial sector to develop transport network, for connectivity, for the creation of infrastructure and for the planning of its economic use. On the one hand, more production is needed from scarce soil resources to meet the demand of increasing population, whereas on the other hand, cultivable areas are shifted to non-agricultural uses. During the post-independence period, India showed a considerable shift under different land use classes. Until 1949-50, the Indian total area was categorized into five groups known as the Five-fold Land Use Classification.

The following categories were: 1. Forests 2. Area other than cultivation 3. Other uncultivated land, excluding the current fallows 4. Area under current fallows, and 5. Net area sown. This five-fold classification was, however, a very wide overview of land usage. Since it was not suitable to gratify the necessities of the India for agricultural planning and also impossible for the Member States to provide comparative evidence on the basis of this classification owing to the lack of uniformity in the structure and the extent of classification protected by these five specific categories. The Technical Committee with the Coordination of Agricultural Statistics, formed by the Ministry of Food and Agriculture in 1948, proposed the following nine fold classifications for land use to substitute the old five-fold classification and also proposed uniform terms and contents in direction to remove the non-comparability and also to distinct the large categories into smaller components. The nine-fold classification of land use is as follows: 1) Area under forests (F) 2) Barren and uncultivable lands (BAU) 3) Land used for non-agricultural uses (NAU) 4) Permanent pastures along with other grazing lands (PAG) 5) Cultivable wastes (CL) 6) Miscellaneous tree crops, groves (MT) 7) Current fallows (CF) 8) Other fallow land (OF) and 9) Net area sown (NAS). The current classification pattern is considered to be static alignment and adaptation to the other main economic characteristics of the region.

Land utilization in Karnataka

Karnataka has a gross geographical region of 190.49 lakh hectares with a forest area of 30.73 lakh hectares, non-farming region of 14.79 lakh hectares, Barren land of 7.91 lakh hectares, Cultivable waste of 3.39 lakh hectares, permanent pasture of 9.05 lakh hectares, Miscellaneous trees and also groves of 2.71 lakh hectares, Current fallow land of 16.04 lakh hectares, area other than Present fallow land 6.49 lakh hectares. Area planted more than once on 24.88 lakh hectares and total cropped area of 121.70 lakh hectares (Karnataka State at Glance, 2017-18).

Importance of land use studies

Land is the main asset that regulates the financial growth and development. From the available statistics on land use, there seems to be both rare and difficult prospect of a significant and extensive horizontal growth in net area sown due to rise in population growth and variety of human needs, the estimation of the physical property of the land and its pattern of land utilization has assumed large importance in every sector of the economy. This scarce and also non-renewable natural resources should be used judiciously through appropriate supervision.

Material and Methods

The required data for evaluating the objectives of the study were collected from various published sources. Secondary data pertaining to the various aspects under study were obtained from Directorate of Economics and Statistics published by Department of Agriculture, Cooperation and Farmers Welfare, Government of Karnataka. The data collected for classification of total geographical area in Karnataka for the period from 1989-90 to 2018-19. The entire 30 years of data split in to six period's *viz*. Period I (1989-90 to 1993-94), Period II (1994-95 to 1998-1999), Period III (1999-2000 to 2003-04), Period IV (2004-05 to 2008-09), Period V (2009-10 to 2014-15) and Period VI (2014-15 to 2018-19) to study the change in temporal land use pattern across the districts of Karnataka.

Analytical tools and techniques

The methods of analysis employed are presented under the following headings. Herfindahl index (HI), Simpson Index (SI), Kendall's coefficient of Concordance and Rank correlation coefficient.

Herfindahl index (HI)

Herfindahl index is defined as sum of squares of all N proportions. It is a measure of concentration of diversification. With an increase in diversification, the sum of square of the proportion of activities decreases, so also the indices (HI). The mathematical formula for calculating the index is as follows, Herfindahl index (HI) = ΣP_i^2

Where, $P_i = \frac{A_i}{\Sigma A_i}$, is the proportion of the i^{th} activity in acreage and A_i is the i^{th}activity. Herfindahl index is bounded by 'zero' resulting with complete diversification and to 'one' indicating complete specialization. The above index is a measure of concentration and the index which decreases with increase in diversification.

Simpson Index (SI)

Simpson Index is also a measure of diversification and its value ranges from zero to one. Simpson Index increases with increase in diversification. Even though the Simpson index gives the same result like Herfindahl Index, it is used here to get a direct estimation of diversification unlike Herfindahl Index. The estimated value of Simpson Index is 'zero' indicating complete specialization and 'one' indicating complete diversification. Mathematical formula for calculating Simpson Index is(SI) = 1 - ΣP_i^2

Where, $P_i = \frac{A_i}{\Sigma A_i}$, is the proportion of the i^{th} activity in acreage and A_i is the i^{th}activity

Kendall's coefficient of Concordance (W)

If there are 'k' number of variables with 'N' objects and we have to know the association between the 'k' sets of variables, Kendall's coefficient of concordance (W) is used.The ranks will be in the form of k x N table and the formula to calculate W is given by

$$W = \frac{S}{\frac{1}{12}K^2(N^3-N)}$$

Where, S= Sum of squares of the observed deviations from the mean of R_j. This can be calculated from formula,

$$S = \sum_{j=1}^{N}[R_j - \frac{R_j}{N}]^2$$

Where,R_j= Sum of ranks, k = Number of sets ranking, N = Number of variables or individuals ranked, $\frac{1}{12}k^2(N^3-N)$ = Maximum possible sum of the squared deviation.When N is larger than 7, the expression given in formula is approximately distributed as Chi square with degrees of freedom

N-1., $\chi^2 = \frac{S}{\frac{1}{12}kN(N+1)} \sim \chi^2_{(N-1)}$

That is, the probability associated with the occurrence under null hypothesis of any value as large as an observed W may be determined by finding Chi-square by the formula and then determining the probability associated with so large a value of Chi- square by referring Chi-square table.

$$\chi^2 = \frac{S}{\frac{1}{12}kN(N+1)} = k\,(N-1)\,W$$

If the value of Chi-square as computed from the above formula equals or exceeds that the Chi-square table value for a particular level of significance and a particular value of degrees of freedom equal to N-1, then the null hypothesis that the 'k' periods are unrelated may be rejected at that level of significance.

Kendall's Rank correlation coefficient (τ)

The Kendall's Rank correlation coefficient, τ (tau) is suitable as a measure of correlation with the same sort of data for which spearman correlation coefficient is useful. *i.e.*, if at least ordinal measurement of both the X and Y variables has been achieved, so that every subject can be assigned a rank on both X and Y then τ will give a measure of the degree of association or correlation between the two sets of ranks. The sampling distribution of τ under the null hypothesis is known and hence is subject to tests of significance. Kendall's rank correlation coefficient is given by the formula

$$T = \frac{actual\ total}{maximum\ possible\ total} = \frac{S}{\frac{N(N-1)}{2}} = \frac{2S}{N(N-1)}$$

Where, S = actual total =Σ S_i, N= number of objects or individuals ranked on both X and Y When N>10, τ may be approximated by normal distribution with Mean =μ_τ = 0

Standard deviation = $\sigma_\tau = \sqrt{\frac{2(2N+5)}{9N(N-1)}}$,

$$Z = \frac{\tau - \mu_\tau}{\sigma_\tau} = \frac{\tau}{\sqrt{\frac{2(2N+5)}{9N(N-1)}}} \sim SND\ (0,1)$$

Results and Discussion

The results of the investigation are exhibited under the following headings:

To examine the temporal changes in land use pattern

The collected secondary data on classification of total geographical area of Karnataka over a period of 30 years from 1989 to 2018 were utilised in the present study. Land use is determined by many factors like relief features, climate, soil, density of population, technical and socio-economic factors. Land use pattern in Karnataka for the year 2018-19 is presented in Table1.For the purpose of analysis classification of land use are grouped under ten categories. It can be noticed that Net area sown (NAS) occupies 51.84 per cent of the total geographic landscape. Where Forest land (F) accounted for 16.13 per cent of total geographical area. Fallow land was divided in to two categories *i.e.*, Current Fallow (CF) and Other Fallow (OF) represented 8.42 and 3.41 per cent of total geographical area, respectively. Land which is not accessible for cultivation Non agri-uses (NAU) and Barren and Uncultivable Land (BAU) accounted for 7.77 and 4.16 per cent respectively. Uncultivated land exclusive of fallow land i.e., Permanent pastures and Other grazing land (PAG) along with the Miscellaneous tree crops and grooves (MT) occupied 4.75 and 1.42 per cent of total geographical area, respectively. Cultivable waste (CL) land accounts for 2.10 per cent of total geographical area. Area Sown More than Once (ASMO) in a year, can be said that particular plot of agricultural land cultivated more than once in a year occupied over 13.06 per cent of total geographical area.

Table 1: Land classification pattern in Karnataka during 2018-19

Land classification	Area(ha)	Percentage to total geographical area (%)
Forest land (F)	3073376	16.13
Non agri uses (NAU)	1479580	7.77
Barren and uncultivable land (BUL)	791698	4.16
Cultivable waste (CL)	399315	2.10
Permanent pastures and grazing land (PAG)	905072	4.75
Miscellaneous tree crops and groves (MT)	271142	1.42
Current fallow land (CF)	1604383	8.42
Other fallow land (OF)	649742	3.41
Net area sown (NAS)	9874158	51.84
Area sown more than once (ASMO)	2488288	13.06

Temporal changes in land use pattern in Karnataka

In order to study the changes in land pattern that has occurred over the time, land use pattern in the state are compared over different points of time *viz*, 1989-93, 1994-98, 1999-03,2004-08, 2009-2013, 2014-18. The results of the study are presented in Table2.which depict the changing share of area allocated to different land use pattern over the time. The total geographical area of the state is 19049836 hectares. It can be observed from the Table 4.2 that the area shares under Forest land as declined from 16.14 per cent to 16.09 per cent during 1989-93 to 1994-98 and increased marginally up to 16.13 per cent during 2014-18. Similarly, the area under Barren and Uncultivable land and also the Cultivable waste declined from 4.19 to 4.15 per cent and 2.34 to 2.12 per cent, respectively. Area under Miscellaneous Tree crops and Grooves in the year 1989-93 increased slightly from 1.66 to 1. 77 per cent during 1994 -98 and then showed a decline of 1.44 per cent during 2014-18. Area under Net Areas Sown decreased from 55.85 (1989-93) to 52.13 (2014-18) per cent, respectively. Area under Permanent pasture and Other grazing land decreased from 5.55 (1989-93) to 4.75 (2014-18) per cent. Area under Non agri uses experienced an increase during the study period. Non agri uses accounted for 6.29 per cent of total geographical area during the year 1989-93 and it has increased to 7.78 per cent during the year 2014-18. Area under Current follow experienced drastic increase from 5.76 in 1989-93 to 8.09 per cent during 2014-18. Area under Other fallow land also increased from 2.21 to 3.37 per cent. Area under Area sown more than once experienced a steady increase during 1989-93 to 2004-08 with 8.10 to 12.42 per

cent and later on decreased slightly from 2004-08 to 2014-18 and accounted 11.25 per cent of total geographical area. Area under Non agri- uses, Current fallow land, Other fallow land and also the area sown more than once showed an increasing trend during the period of study. The maximum percentage decline in area showed that in permanent pasture and other grazing land whereas maximum per cent increase in area was registered under Other follow land.

Table 2: Area and Percentages share for different districts in each period of five years land classification of area in Karnataka (Area in hectares)

Periods	F	NAU	BAU	CL	PAG	MT	CF	OF	NAS	ASMO
1989-93	3074897 (16.1413)	1196884 (6.2829)	800015 (4.1996)	445044 (2.3362)	1057532 (5.5514)	316571 (1.6618)	1097849 (5.763)	420609 (2.2079)	10640432 (55.8558)	1543360 (8.1017)
1994-98	3065224 (16.0906)	1267160 (6.6518)	800044 (4.1997)	440187 (2.3107)	1017223 (5.3398)	317800 (1.6683)	1327442 (6.9683)	412500 (2.1654)	10402374 (54.6061)	1664017 (8.7351)
1999-03	3069979 (16.1155)	1328927 (6.9761)	789190 (4.1428)	422126 (2.2159)	952004 (4.9974)	301689 (1.5837)	1605461 (8.4277)	455328 (2.3902)	10125129 (53.1507)	1823558 (9.5726)
2004-08	3071525 (16.1236)	1359297 (7.1355)	787780 (4.1354)	416704 (2.1874)	933559 (4.9006)	292405 (1.535)	1361335 (7.1462)	487268 (2.5579)	10341239 (54.2852)	2365468 (12.4173)
2009-13	3072450 (16.1284)	1425794 (7.4845)	786798 (4.1302)	412732 (2.1666)	909785 (4.7758)	284626 (1.4941)	1540846 (8.0885)	503114 (2.641)	10113780 (53.0909)	2288125 (12.0112)
2014-18	3073376 (16.1275)	1482500 (7.7794)	791543 (4.1536)	403561 (2.1177)	905332 (4.7507)	274699 (1.4415)	1542303 (8.0932)	641500 (3.3663)	9934930 (52.1334)	2143116 (11.246)
Rate of change (%)	0.0857	-23.818	1.0948	9.354	14.423	13.2579	-40.433	-52.462	6.6642	-38.8101

Source: Directorate of Economics & Statistics, Bengaluru, Karnataka
Figures in the parenthesis indicate percentage to the total geographical area.

Land Diversification Index

Different types of indices are used to find out the change in land use pattern. Index provides single value for each district which can be easily compared across districts. The two indices used in the present study are Herfindahl index (HI) and Simpson Index (SI) which were computed for all the periods. Herfindahl index (HI) for different districts are presented in Table 3 and Fig.1. The decrease in Herfindahl indicates the increase in the diversification of land classification pattern which implies that shift in land classification within the districts. The index takes a value one when there is a complete single land classification and approach zero as diversification indicates uniform spread of all the types of land classification. The value of a index for state indicates that the Karnataka state as highly diversified land use pattern. This is evident from the fact that value of a Herfindahl index is around 0.35 in 1989-93 and it shows decrease with the value around 0.32 during 2014-18 which indicates the increasing diversification of land use. Across the districts the value of Herfindahl index falls in the range of 0.19 to 0.69 during 1989-93 and 0.20 to 0.71 during 2014-18 which clearly indicates in some of the districts there is shift in area under different land classification. Herfindahl index (HI) presented in Table 3. for districts of Karnataka indicate that, Dakshina Kannada district has shown highest changes of land classification during first five periods. But during the last period, Udupi has got Herfindahl index (HI) value with 0.19 and indicates that this district has spread over all types of land classification compared with all other districts during 2014-18. Bijapur district has shown high value of HI ranging from 0.55 (period III) to 0.75 (period VI) indicates complete single land classification that is majorly for agricultural purposes which may be due to the climatic condition of the region and lack of urbanization and industrialization. Bagalkot, Belgaum, Bellary, Bidar, Chamarajanagar, Chitradurga, Davanagere, Dharwad, Hassan, Haveri, Kolar, Mandya, Mysore, Raichur, Ramnagar, Uttara kannada, Yadgir districts shows moderate diversification of land area due to changes in increasing population, socio-economic factors, environmental effects *etc.* But Chikkamagalur, Koppal, Shimoga, Tumkur districts remains same throughout the study period. Remaining all districts indicates complete single land classification.

Table 3: Computed values of Herfindahl index of different land use areas for different districts of Karnataka

Herfindahl Index						
Districts	**Period I (1989-93)**	**Period II (1994-98)**	**Period III (1999-03)**	**Period IV (2004-08)**	**Period V (2009-13)**	**Period VI (2014-18)**
Bagalkot	0.5725	0.5172	0.4707	0.5195	0.5222	0.5212
Bangalore (Rural)	0.2437	0.3010	0.2927	0.3334	0.3287	0.2702
Bangalore (Urban)	0.2760	0.2741	0.3147	0.3298	0.3504	0.3730
Belgaum	0.4773	0.4567	0.3883	0.4147	0.3691	0.3750
Bellary	0.4219	0.3718	0.3439	0.3543	0.3227	0.3094
Bidar	0.4677	0.4917	0.4803	0.4340	0.4356	0.4356
Bijapur	0.6877	0.6393	0.5563	0.6466	0.6465	0.7074
Chamarajanagar	0.3203	0.3246	0.3207	0.3420	0.3418	0.3175
Chikkaballapur	0.2521	0.2351	0.2295	0.2410	0.2585	0.2909
Chikkamagalur	0.2643	0.2679	0.2555	0.2674	0.2694	0.2620
Chitradurga	0.3498	0.3350	0.3262	0.3226	0.3117	0.2924
Dakshina Kannada	0.1860	0.1885	0.1932	0.1917	0.1922	0.2073
Davanagere	0.4484	0.4240	0.4116	0.4503	0.4563	0.4160
Dharwad	0.6498	0.6128	0.6095	0.5654	0.5075	0.5902
Gadag	0.5782	0.6406	0.7032	0.6687	0.6574	0.6702
Gulbarga	0.5870	0.5926	0.6092	0.6203	0.6704	0.6111
Hassan	0.3335	0.3481	0.3595	0.3612	0.3375	0.3062

Haveri	0.5803	0.5632	0.5489	0.5803	0.5788	0.5626
Kodagu	0.2545	0.2498	0.2562	0.2726	0.2873	0.2834
Kolar	0.3236	0.3210	0.2699	0.2536	0.2689	0.2507
Koppal	0.5056	0.4443	0.4132	0.4734	0.4847	0.5079
Mandya	0.3487	0.2917	0.2549	0.2717	0.2493	0.2148
Mysore	0.3292	0.3559	0.3115	0.2938	0.3006	0.3034
Raichur	0.5257	0.4602	0.4807	0.4856	0.4208	0.3643
Ramnagar	0.3090	0.2961	0.3201	0.2695	0.2691	0.2585
Shimoga	0.2215	0.2215	0.2224	0.2257	0.2293	0.2278
Tumkur	0.3262	0.3205	0.3183	0.3326	0.2825	0.2613
Udupi	0.2038	0.1928	0.1998	0.2013	0.1995	0.1969
Uttara Kannada	0.6687	0.6516	0.6451	0.6447	0.6444	0.6442
Yadgir	0.4632	0.4514	0.4300	0.4240	0.4098	0.4132
State	0.3515	0.3392	0.3254	0.3364	0.3254	0.3162

The magnitude of Simpson Index provides direct estimation of the extent of diversification, unlike Herfindahl Index. It makes the interpretation much simpler compared to Herfindahl Index.

Simpson index was calculated for all districts for six periods, is presented in Table 4. and Fig.2. If the calculated value is nearer to one then it indicates that there is a complete or perfect land diversification. From the Table 4. it is clear that state shows diversification period to period from 0.65 to 0.68 between first and last period. Which indicates there is a land shifts within the districts. During the year 2014-18, Udupi district has highest Simpson index value which was accounted as high as 0.80 indicating shifts in land classification during last period. This is clear from the descriptive statistics provided in Table 2 that the forest area has increased and land under Miscellaneous trees, groves, non-agri uses, barren land, cultivable waste, pasture land has decreased. Whereas, Bijapur district has got Simpson index value which around 0.30 in all six period shows highly single land use classification that is mainly agricultural related which may be as inferred earlier lack of industrialization and hence urbanization. Both Herfindahl index and Simpson index depict similar change in land use pattern across different districts of Karnataka during the study period. These results are in close confirmation with the findings of Goswami and Challa (2004) [15] and Beegum (2014) [23]. Further, Kendall's coefficient of concordance (W) and Rank correlation coefficient (τ) is computed to know whether there has been shift in the land use pattern in different districts of Karnataka. Coefficient of concordance (W) is calculated separately for districts and land areas for six periods 1989-93, 1994-98, 1999-03, 2004-08, 2009-13, 2014-18. The results are presented in Table 5. Ranking is given to the Herfindahl index calculated for each districts of Karnataka. Calculated test statistics value which follows Chi square distribution is more than the critical value for the study years. Hence it is inferred that there is significant change in land use pattern over periods in the districts of Karnataka during the study period which also supports the inference drawn from Herfindahl and Simpson index.

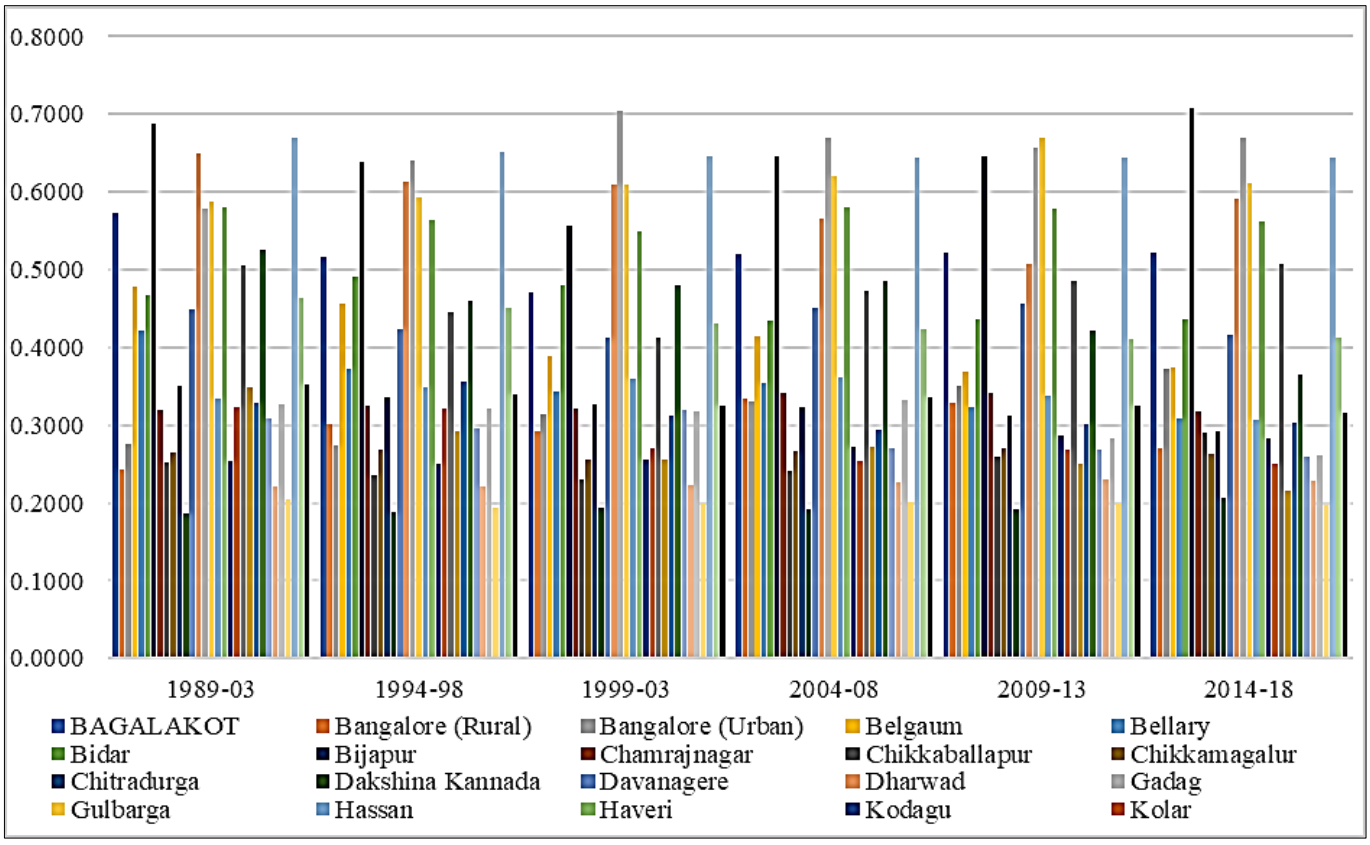

Fig 1: Herfindahl index for different districts of Karnataka

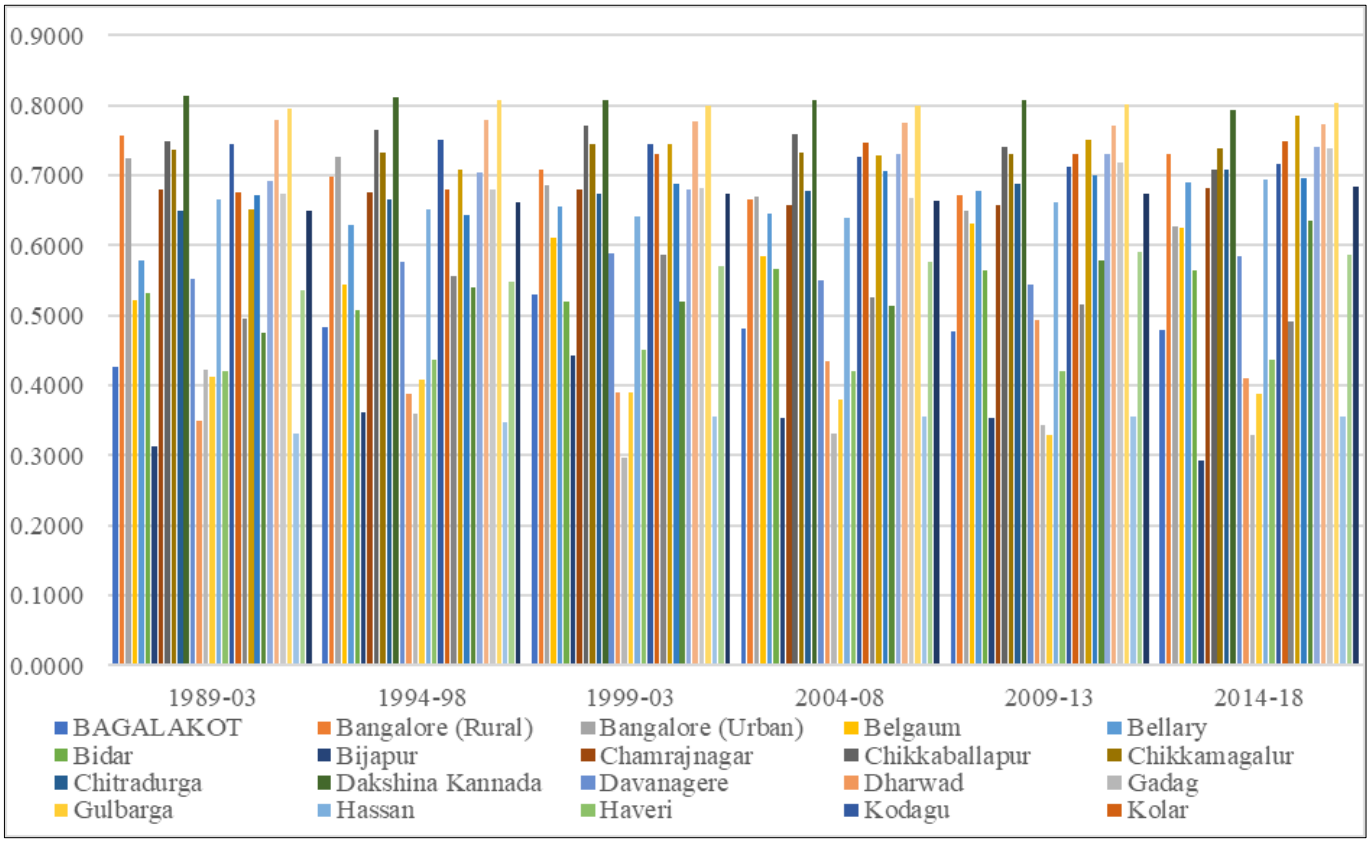

Fig 2: Simpson index for different districts of Karnataka

Table 4: Computed values of Simpson Index of different land use areas for different districts of Karnataka

Simpson Index						
Districts	**Period I (1989-93)**	**Period II (1994-98)**	**Period III (1999-03)**	**Period IV (2004-08)**	**Period V (2009-13)**	**Period VI (2014-18)**
Bagalkot	0.4275	0.4828	0.5293	0.4805	0.4778	0.4788
Bangalore (Rural)	0.7563	0.6990	0.7073	0.6666	0.6713	0.7298
Bangalore (Urban)	0.7240	0.7259	0.6853	0.6702	0.6496	0.6270
Belgaum	0.5227	0.5433	0.6117	0.5853	0.6309	0.6250
Bellary	0.5781	0.6282	0.6561	0.6457	0.6773	0.6906
Bidar	0.5323	0.5083	0.5197	0.5660	0.5644	0.5644
Bijapur	0.3123	0.3607	0.4437	0.3534	0.3535	0.2926
Chamarajanagar	0.6797	0.6754	0.6793	0.6580	0.6582	0.6825
Chikkaballapur	0.7479	0.7649	0.7705	0.7590	0.7415	0.7091
Chikkamagalur	0.7357	0.7321	0.7445	0.7326	0.7306	0.7380
Chitradurga	0.6502	0.6650	0.6738	0.6774	0.6883	0.7076
Dakshina Kannada	0.8140	0.8115	0.8068	0.8083	0.8078	0.7927
Davanagere	0.5516	0.5760	0.5884	0.5497	0.5437	0.5840
Dharwad	0.3502	0.3872	0.3905	0.4346	0.4925	0.4098
Gadag	0.4218	0.3594	0.2968	0.3313	0.3426	0.3298
Gulbarga	0.4130	0.4074	0.3908	0.3797	0.3296	0.3889
Hassan	0.6665	0.6519	0.6405	0.6388	0.6625	0.6938
Haveri	0.4197	0.4368	0.4511	0.4197	0.4212	0.4374
Kodagu	0.7455	0.7502	0.7438	0.7274	0.7127	0.7166
Kolar	0.6764	0.6790	0.7301	0.7464	0.7311	0.7493
Koppal	0.4944	0.5557	0.5868	0.5266	0.5153	0.4921
Mandya	0.6513	0.7083	0.7451	0.7283	0.7507	0.7852
Mysore	0.6708	0.6441	0.6885	0.7062	0.6994	0.6966
Raichur	0.4743	0.5398	0.5193	0.5144	0.5792	0.6357
Ramnagar	0.6910	0.7039	0.6799	0.7305	0.7309	0.7415
Shimoga	0.7785	0.7785	0.7776	0.7743	0.7707	0.7722
Tumkur	0.6738	0.6795	0.6817	0.6674	0.7175	0.7387
Udupi	0.7962	0.8072	0.8002	0.7987	0.8005	0.8031
Uttara Kannada	0.3313	0.3484	0.3549	0.3553	0.3556	0.3558
Yadgir	0.5368	0.5486	0.5700	0.5760	0.5902	0.5868
State	0.6485	0.6608	0.6746	0.6636	0.6746	0.6838

Table 5: Kendall's coefficient of concordance for different districts by using Herfindahl Index

Herfindahl index (HI)						
Districts	**Period I (1989-93)**	**Period II (1994-98)**	**Period III (1999-03)**	**Period IV (2004-08)**	**Period V (2009-13)**	**Period VI (2014-18)**
Bagalkot	0.5725 (7)	0.5172 (7)	0.4707 (9)	0.5195 (7)	0.5222 (6)	0.5212 (7)
Bangalore (Rural)	0.2437 (27)	0.301 21)	0.2927 (22)	0.3334 (17)	0.3287 (17)	0.2702 (22)
Bangalore (Urban)	0.276 (23)	0.2741 (24)	0.3147 (20)	0.3298 (19)	0.3504 (14)	0.3730 (13)
Belgaum	0.4773 (10)	0.4567 (10)	0.3883 (13)	0.4147 (13)	0.3691 (13)	0.375 (12)
Bellary	0.4219 (14)	0.3718 (14)	0.3439 (15)	0.3543 (15)	0.3227 (18)	0.3094 (16)
Bidar	0.4677 (11)	0.4917 (8)	0.4803 (8)	0.4340 (11)	0.4356 (10)	0.4356 (9)
Bijapur	0.6877 (1)	0.6393 (3)	0.5563 (5)	0.6466 (2)	0.6465 (3)	0.7074 (1)
Chamarajanagar	0.3203 (21)	0.3246 (18)	0.3207 (17)	0.3420 (16)	0.3418 (15)	0.3175 (15)
Chikkaballapur	0.2521 (26)	0.2351 (27)	0.2295 (27)	0.2410 (27)	0.2585 (26)	0.2909 (20)
Chikkamagalur	0.2643 (24)	0.2679 (25)	0.2555 (25)	0.2674 (25)	0.2694 (23)	0.2620 (23)
Chitradurga	0.3498 (15)	0.3350 (17)	0.3262 (16)	0.3226 (20)	0.3117 (19)	0.2924 (19)
Dakshina Kannada	0.1860 (30)	0.1885 (30)	0.1932 (30)	0.1917 (30)	0.1922 (30)	0.2073 (29)
Davanagere	0.4484 (13)	0.4240 (13)	0.4116 (12)	0.4503 (10)	0.4563 (9)	0.4160 (10)
Dharwad	0.6498 (3)	0.6128 (4)	0.6095 (3)	0.5654 (6)	0.5075 (7)	0.5902 (5)
Gadag	0.5782 (6)	0.6406 (2)	0.7032 (1)	0.6687 (1)	0.6574 (2)	0.6702 (2)
Gulbarga	0.5870 (4)	0.5926 (5)	0.6092 (4)	0.6203 (4)	0.6704 (1)	0.6111 (4)
Hassan	0.3335 (17)	0.3481 (16)	0.3595 (14)	0.3612 (14)	0.3375 (16)	0.3062 (17)
Haveri	0.5803 (5)	0.5632 (6)	0.5489 (6)	0.5803 (5)	0.5788 (5)	0.5626 (6)
Kodagu	0.2545 (25)	0.2498 (26)	0.2562 (24)	0.2726 (22)	0.2873 (21)	0.2834 (21)
Kolar	0.3236 (20)	0.3210 (19)	0.2699 (23)	0.2536 (26)	0.2689 (25)	0.2507 (26)
Koppal	0.5056 (9)	0.4443 (12)	0.4132 (11)	0.4734 (9)	0.4847 (8)	0.5079 (8)
Mandya	0.3487 (16)	0.2917 (23)	0.2549 (26)	0.2717 (23)	0.2493 (27)	0.2148 (28)
Mysore	0.3292 (18)	0.3559 (15)	0.3115 (21)	0.2938 (21)	0.3006 (20)	0.3034 (18)
Raichur	0.5257 (8)	0.4602 (9)	0.4807 (7)	0.4856 (8)	0.4208 (11)	0.3643 (14)
Ramnagar	0.3090 (22)	0.2961 (22)	0.3201 (18)	0.2695 (24)	0.2691 (24)	0.2585 (25)
Shimoga	0.2215 (28)	0.2215 (28)	0.2224 (28)	0.2257 (28)	0.2293 (28)	0.2278 (27)
Tumkur	0.3262 (19)	0.3205 (20)	0.3183 (19)	0.3326 (18)	0.2825 (22)	0.2613 (24)
Udupi	0.2038 (29)	0.1928 (29)	0.1998 (29)	0.2013 (29)	0.1995 (29)	0.1969 (30)
Uttara Kannada	0.6687 (2)	0.6516 (1)	0.6451 (2)	0.6447 (3)	0.6444 (4)	0.6442 (3)
Yadgir	0.4632 (12)	0.4514 (11)	0.4300 (10)	0.4240 (12)	0.4098 (12)	0.4132 (11)
STATE	0.3515	0.3392	0.3254	0.3364	0.3254	0.3162

Figure in the parenthesis indicate ranks, Kendall's coefficient of concordance (W) = 0.950
Calculated Chi square =165.217, Critical value of Chi square for 29 degrees of freedom is 42.557 at 5 per cent and 49.588 at 1 per cent.

Table 6: Kendall's coefficient of concordance for different land use areas (Areas in hectares)

Land use areas	**Period I (1989-93)**	**Period II (1994-98)**	**Period III (1999-03)**	**Period IV (2004-08)**	**Period V (2009-13)**	**Period VI (2014-18)**
F	3074897 (2)	3065224 (2)	3069979 (2)	3071525 (2)	3072450 (2)	3073376 (2)
NAU	1196884 (4)	1267160 (5)	1328927 (5)	1359297 (5)	1425794 (5)	1482500 (5)
BAU	800015 (7)	800044 (7)	789190 (7)	787780 (7)	786798 (7)	791543 (7)
CL	445044 (8)	440187 (8)	422126 (9)	416704 (9)	5812732 (9)	403561 (9)
PAG	1057532 (6)	1017222 (6)	952004 (6)	933559 (6)	909785 (6)	905332 (6)
MT	316571 (10)	317800 (10)	301689 (10)	292405 (10)	284626 (10)	274699 (10)
CF	1097849 (5)	1327441 (4)	1605460 (4)	1361334 (4)	1540846(4)	1542303 (4)
OF	420609 (9)	412500 (9)	455328 (8)	487268 (8)	503114 (8)	641500 (8)
NAS	10640432 (1)	10402375 (1)	10125129 (1)	10341239 (1)	10113780 (1)	9934930 (1)
ASMO	1543360 (3)	1664017 (3)	1823558 (3)	2365468 (3)	2288125 (3)	2143116 (3)

Figure in the parenthesis indicate ranks, Kendall's coefficient of concordance (W) = 0.991 and Calculated Chi square = 53.579, Critical value of Chi square for 9 degrees of freedom is 16.920 at 5 per cent and 21.670 at 1 per cent

Coefficient of concordance (W) is calculated for different land use areas for the same period of time and it is represented in Table 6. It may be inferred from the test statistic compared with Chi square distribution for respective degrees of freedom at specified level of significance value that the rankings given to the area under each classified land use over study periods are related, hence it may be inferred that there is significant change in land use pattern over years in the state.

Table 7: Rank correlation coefficient for the periods 1989-93 and 2014-18 (Areas in hectares)

Land use areas	1989-93	2014-18
F	3074898 (2)	3073376 (2)
NAU	1196885 (4)	1482500.2 (5)
BAU	800015 (7)	791543.2 (7)
CL	445044.8 (8)	403561.8 (9)
PAG	1057532 (6)	905332 (6)
MT	316571 (10)	274699.8 (10)
CF	1097849 (5)	1542303.4 (4)
OF	420609.4 (9)	641500.8 (8)
NAS	10640433 (1)	9934930.4 (1)
ASMO	1543360 (3)	2143116.6 (3)

Figure in the parenthesis indicate ranks, Kendall's rank correlation coefficient (τ) = 0.911

P = 0.0001, 2p = 0.0002 < alpha, there is a significant agreement between two years.

Rank correlation coefficient (τ) is computed for two periods *viz*., 1989-93 and 2014-18 is presented in Table7. Its significance p value is less than 0.0001, which is one tailed probability. Therefore, 2p is calculated and is less than specified alpha value (i.e., 2p = 0.0002). So, it is inferred that there is a significant agreement between two periods. The state showed diversified land use pattern during last thirty years and the inference was supported by Kendall's coefficient of concordance and rank correlation coefficient. The major changes in the utilization of land use might occur due to the changes in climatic condition, change in topology, change in industrialization and urbanization or any combinations of the above. The results obtained were in concordance with Bhat *et al.* (1989) [6], Jessy *et al.* (1990) [19] and Parmer *et al.* (1995) [26].

Conclusion

Karnataka state has a diversified Land Use Pattern (LUP). Extent of diversification fluctuates considerably across the districts, while some of the districts comes under hilly and coastal zones have highly diversified land use pattern. Certain other districts in dry zones have exposed leaning towards single land classification. However, the ecological factors are more congenial to diversify the land in some of the districts, but socio-economic aspects do act as a barrier in adopting diversified land use pattern. The results confirmed that there is shifting of land under Forest (F) and Other Fallow land (OF) highly and other areas are slightly changing in different agro climatic zones.

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