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STUDY THE SHIFT IN LAND USE PATTERN WITH REGARD TO CHHATTISGARH AS A WHOLE STATE BY USING CLUSTER AND PRINCIPAL COMPONENT ANALYSIS

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ABSTRACT

The present study has been conducted in Chhattisgarh for various land use pattern based on area using secondary data collection from The Directorate of Land Records classify Total reported geographical area of different categories *viz*., land under agriculture, forests, non agricultural uses, barren land, and uncultivated lands and lands put to non-agricultural uses were culturable waste, miscellaneous tree and groves, fallow land and other fallow land etc. The reported geographical area of the state decreased by 7.03 lakh ha during the period under study (i.e. 1970-71 to 2005-06). It was observed that net area sown of land in Chhattisgarh state was increased mainly because area under the land increased considerably, as well as the entire three zones. Culturable wasteland, fallow land and other uncultivated land decreased slightly but forest decreased rapidly. There has been increasing shift in net sown area contributing to 6.59 per cent during the period under study at the state level. The area under forest decreased by 8.61 per cent, at the state level. The culturable wasteland shows increasing trend accounting for 0.65 per cent. There has been an increasing trend in area not available for cultivation contributing 1.9 per cent during period of study. The fallow land shows a decreasing trend contributing for 0.07 per cent during the period under study. There has been a decreasing tendency in other uncultivated land excluding fallow land accounting for 0.54 per cent. The highest sown area was found in the Chhattisgarh plains, while the minimum was found in Bastar Plateau. The zone, which has highest proportionate area under forest, is Bastar Plateau, while the lowest was seen in Chhattisgarh plains. The Bastar plateau has the highest proportionate area under culturable wasteland, while the lowest was seen in Northern hills. The land not available for cultivation was highest in Northern hills, while the minimum was found in Bastar plateau.

Shifts of various land use pattern in Chhattisgarh state as a whole registered a considerable increasing land not available for cultivation followed by net area sown. The results corresponding to the shifts in various land use in Chhattisgarh plains in study years revealed in that culturable waste land and land not available for cultivation recorded considerable positive shifts in the land utilization level of land in the region. Relatively high shift potential for culturable waste land followed by net area sown was observed. This increase was due to the maximum coverage of the Chhattisgarh plains. The shifts of various land use characteristics in northern hills showed that uncultivated land and net area sown increased in positive direction while other categories of lands are shifted in higher negative direction. In the recent years culturable wasteland recorded higher negative shifts than other land. The shifts in the area of various land use of Bastar plateau is positive in these region forest land, net area sown and culturable wasteland showed negative shifts.

KEYWORDS: Shifts, Land Use Pattern, Cluster Analysis, Principal Component Analysis, Agroclimatic Zones

INTRODUCTION

The geographical area of the state is 1.36 lakh sq. km. with about 25.5 million population. The state is having plenty of hills, forests, mineral and ores and other natural land resources. The land use pattern at the state level could be satisfactory, but as compared to the different agro-climatic zones, it is not so. At present various types of wasteland exist in the state *viz.,* degraded forests, leased out mixed area, ravines and other wasteland (water logged and periodically inundated areas). These lands are to be developed to produce crops, fodder, fuel and timber etc. it needs a systematic and scientific study and planning for the optimum land use pattern keeping the long run welfare of the living beings.

The land use classification is concerned with the classification of land according to their capabilities for use and thus according to its use it can be grouped as agricultural and non agricultural land, forest, net sown area, pasture and land not available for cultivation. Forest is to maintain the ecological balance and provide firewood, timber, medicinal herbs and aromatic chemicals to the mankind. It also offers the scope for horticultural plantation, pasture development and help in establishing agro-forestry based industries etc. In fact, it is not possible to think of agriculture without the use of land. Virtually, all types of production depend on this natural resource. In land use capability classification for agriculture purposes, the main consideration is the production capacity of land and thus, the land classes are earmarked. Land is again a key resource, for crops, pastures and grazing lands which feed the growing livestock and help to improve the supply of food to living being.

MATERIALS AND METHODS

The study was confined to newly formed state Chhattisgarh as a whole with all its agro-climatic zones. There are three agro-climatic zones of Chhattisgarh state namely Chhattisgarh plains, Northern hills and Bastar plateau.

Collection of Data

The study has been undertaken to analyze the land use pattern in Chhattisgarh state for the period of 36 years (i.e. 1970-71 to 2005-06). The data for the analysis are grouped under different categories of land use at the district and state level. The different land uses considered for collection and analysis of data are given below:

- Net sown area
- Forest land (Revenue forest)
- Culturable waste land
- Land not available for cultivation
- Fallow land
- Other un-cultivated land excluding fallows Geographical area (as per village papers)

Analytical Tools

Cluster analysis approach: Study of shifts in the land use pattern is essentially a study of temporal variation in the area under the various categories of land. Hence, these shifts can be studied conveniently by applying the methods of cluster analysis and principal component analysis. Through this analysis, the periods of “similar” land use pattern can be identified instead of arbitrarily selecting them as involved in most of the studies, which apply measures such as averages

and growth rates for studying the level of shifts. The approach of cluster analysis can be defined under the two situations of data as follows:

- **Single Sample Situation:** Let $X_1 \ldots X_n$ be the multivariate measurements on 'n' objects, which are heterogeneous. Suppose that each of these measurements is based on 'k' variables. Then, the observations on these 'n' objects are to be classified into 'g' homogeneous groups i.e., clusters (g<n), which are as distinct as possible.
- **Multi-sample situation:** Suppose that the 'n' objects, which are to be clustered, have each n_j observations (j = 1 to n). These are recorded by drawing a random sample on the objects. Let X_{ij} be the i^{th} observation vector corresponding to the j^{th} object or sample (I = 1…nj; j = 1 to n). In this situation, the data on n samples are to be classified into (g < n) homogeneous groups. Land use pattern of a region refers to the various parameters related to land use. The allocation of area to different land use pattern may vary year wise. Year to year variation could be due to several factors such as the socio-economic factors and the technological innovations in the land use, in addition to the weather parameters.

The year-to-year variations in the area under the land use would normally fluctuate around a mean value. However, the technological impact (if any) would be observed in the forms of sudden 'jumps' (quantal jumps). These jumps are referred as 'shifts'. Whenever a shift occurs in the area of a land, it leads to either an increase or decrease in the area under the other land use, as the total cropped area of the state is fixed. A multivariate approach, which considers collectively the allocation of area under the different land use that defines the land use pattern, would be reasonable. Let 'X' be a random vector consisting of 'p' variables. The variables represent the area under various categories of land. Suppose that time series data for 'n' years are available in k-variate observation vector, and then n x p data matrix is given as:

$$X = Objects(years) \begin{vmatrix} X_{11}, X_{12}, \ldots, X_{1p} \\ X_{12}, X_{22}, \ldots, X_{2p} \\ X_1 n, X_2 n, \ldots, X_{np} \end{vmatrix}$$

Before choosing a clustering method to cluster the objects, proximity matrix would be derived from the data matrices on the basis of choice of proximity measure for particular clustering method. (The n x n proximity matrix from n x p data matrix is derived as)

- **Ward's Minimum Variance Method:** The method of clustering was originally developed by Ward (1963). It was also proposed independently by several authors under the names of "Minimum Variance Clustering", "Sum of Squares'' method (Orloci, 1967) and "Incremental Sum of Squares" method (Burr, 1968 and 1970). The years (i.e. the object) have been clustered on the basis of a criterion, which is assumed to be measuring the similarity between the years. Once the clusters have been formed, the objects and their respective distance are represented in the form of a tree diagram, referred as Dendrogram. Here, on X – axis, the objects are represented in the same order as they are included in the clusters and the 'stem' or links between the clusters (and the objects) are drawn on Y-axis whose height depends on the average distance between the clusters. Ward's method involves fusion of clusters from the matrix of inter-year distances as follows:

To start with, the squared distances of objects ½ d^2_{ij} (ij = l… n) are computed corresponding to all possible pairs of objects. These distances from the matrix D_0 from D_0, the pair of objects having the least ½ d^2ij is grouped to form the initial cluster, say C (l). D1 represents the "increase in the total" within cluster sum of square of the distances from the centroids of the C (1) with the other objects, in addition to the ½ d^2_{ij} values of the objects, which are not clustered. The search for new clusters is again carried out on the basis of the least values of D1.

The procedure of revising the matrix D_i [i = l …] on the basis of D(1) and the search for the fusion of clusters is continued till at the fusion of clusters are combined into a single cluster. The values of D_i during each step of fusion provide 'links' or distances between the clusters and the object through which the dendrogram can be constructed. During every step of fusion, the matrix D is revised in terms of an Index I which can compute as follows:

$$I\left[C(i), C(j)\right] = \frac{n(i)n(j)}{n(i) + n(j)}\left[\left|x(i) - x(j)\right|\right]^2$$

Where, x (i) and x (j), are respectively the centroids of the clusters C (i) and C (j) which consists of n (i) and n (j) objects. This method of clustering has been used in present study.

Principal Component Approach: This approach is also commonly applied in regional classification studies. The approach has the characteristic property that it identifies the distant objects more 'faithfully' then the closer ones (Rohlf, 1970). This property would be useful in identifying the shifts in the land use pattern. In the context of studying the shifts in the land use pattern, the approach can be formulated as follows:

It is found to be convenient to apply the principal component approach for clustering the objects (i.e. the years) with the same (n x p) data matrix, used earlier for cluster analysis approach, given as follows:

$$X = \begin{pmatrix} \overset{\text{Variables or land use parameter}}{X_{11,}\ X_{12}\ ,\ldots,\ X_{1p}} \\ X_{21,}\ X_{22,}\ \ldots,\ X_{2p} \\ X_{n1},\ X_{n2}\ ,\ldots,\ X_{np} \end{pmatrix}$$

Data matrix represents same database of observations for an year on each of 'p' variables X_1, $X_{2,}$ …, X_P, these 'p' variable represents a land use characteristics (area) corresponding to the 'p' land use variable that define the land use pattern of the region.

The time series data on 'p' variables in the data matrix can be then subjected to the principal component analysis. The analysis provides a dimension space in the form of principal component and principal component scores. So, the complete procedure of obtaining these principal components starts with determining a new variable Z_1 that can be used to account for the variation in the p X variables. The result can be used to provide a matrix approximation for data matrix X. the principle component Z_1 is given by a linear combination of p X variables as:

$Z_1 = v_{11}X_1+v_{21}X_2+ \ldots\ldots+ v_{p1}X_p$

RESULTS & DISCUSSIONS

The analytical results obtained by analyzing the data collected for a period of thirty-six years (from 1970-71 to

2005-06) for three agroclimatic zones of the Chhattisgarh state has been discussed in this chapter. The results obtained so far have been divided into several sections i.e., covering the existing land use pattern along with the shift in the land use pattern at agroclimatic zone level. The results have been arranged, covering full time span with chronological break up, in terms of dimensions of land use and relative changes over time.

Existing Land Use Pattern of Chhattisgarh State

The existing land use pattern of the state of Chhattisgarh during the period under reference (i.e. from 1970-71 to 2005-06) has been discussed at the state level in the following section.

The State Level

The existing land use pattern of Chhattisgarh state for the period from 1970-71 to 2005-06. The absolute area under forest in 2005-06 was 18.19 lakh ha, which is 10.07 lakh ha lower than the reported area of 1970-71 which shows that there is a gradual decline due to deforestation authorized by the forest department and un-noticed destruction of plants by the public in general.

The net sown area in 2005-06 was 47.63 lakh ha which is 2.8 lakh ha higher than the reported area of 1970-71. This increase was due to growing population pressure and expansion in demand of land for multiple uses. During this period, the net sown area increased by 6.24 per cent of the reported area in the base year (1970-71).

The land put to non-economical uses such as culturable wasteland and area not available for cultivation revealed upward trend i.e. culturable wasteland increased from 2.86 lakh ha to 3.39 lakh ha which is 18.53 per cent of the reported area in the base year (1970-71). Similarly, the area not available for cultivation which includes the barren land and land put to non-agricultural uses i.e. the land under roads, railways, houses, rivers etc increased from 9.05 to 9.91 which is 9.50 per cent increased of the reported area in the base year 1970-71. Whereas, the land under fallow which includes old and current fallow, land excluding fallow land revealed slightly change over the period of study. It was mainly due to increasing population pressure on land and growing concern about the economizing the use of land resources. Moreover, the fallow land remaining same from 4.84 lakh ha to 4.85 lakh ha. The situation can be remedied by enhancing the irrigation facilities, provided proper drainage, following optimum use of fertilizers and also pursuing dry farming techniques in the rain fed area.

The comparative picture of land use pattern, during the period 2005-06 for the state of Chhattisgarh and India is presented in Table 1, which reveals the relative position in each category of land use at the State and National level.

Table 1: Comparative Land Use Pattern between Chhattisgarh and India during Year 2005-06

S. No.	Particulars	Area Under Different Categories of Land (lakh ha)		Percentage of Geographical area	
		India	Chhattisgarh	India	Chhattisgarh
1.	Geographical area	3287.26	92.56	100.00	100.00
2.	Forest land	696.72	18.19	21.19	19.65
3.	Area not available for cultivation includes area under non agricultural uses, barren and uncultivated land	274.17	9.91	8.34	10.70

4.	Other uncultivated land excluding fallow land this includes permanent pastures and miscellaneous tree crops	104.30	8.56	3.17	9.24
5.	Culturable waste land	131.86	3.39	4.01	3.66
6.	Fallow land which includes old and current fallow land	249.41	4.85	7.50	5.23
7.	Net area sown	1413.19	47.63	42.98	51.45

Cluster Comparison Tables

Table 2: Shifts in Area under Land Use Pattern in Chhattisgarh State

Clusters	Cluster Analysis	Principal Component Analysis
I	1970-71 to 1975-76	1970-71 to 1975-76
II	1984-85 to 1995-96	1984-85 to 1995-96
III	1976-77 to 1983-84	1976-77 to 1983-84
IV	1996-97 to 2005-06	1996-97 to 2005-06

Table 3: Comparisons of Both the Approach Based on Percentage of Area

Data base	No. of Clusters by		No. of Similar Clusters	Percentage of Similarity
	Cluster Analysis	Principal Component Approach		
Chhattisgarh state	4	4	4	100

Shifts in the Land Use Pattern Corresponding to Chhattisgarh State

The results of shifts in the area under the different land use pattern over 36 years for the state as a whole are represented with 4 clusters in Table 4.8 & Figure 4.1. Dendogram obtained for Chhattisgarh state using Ward's minimum variance using cluster analysis approach is given in Figure 4.2. It can be observed that on aggregates level of the entire state of Chhattisgarh the net area sown recorded an increase in the period I to II, the increase was 5.79 percent, from period III to IV the increase was corporately marginal 3.02 percent, but for period II to III a decrease of 3.13 percent.

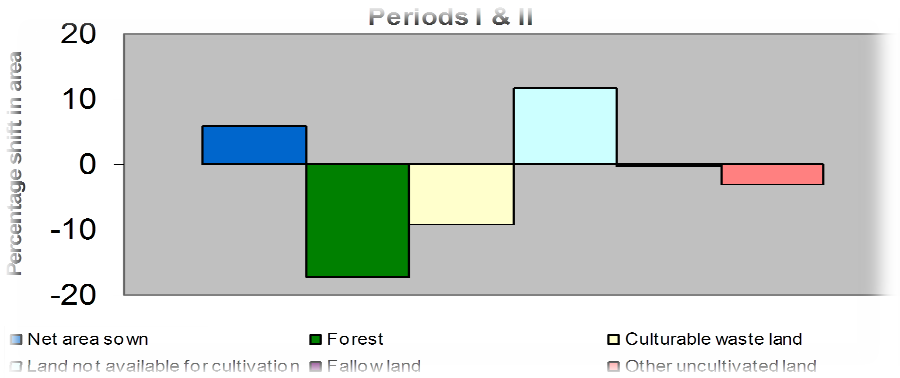
Forest and culturable waste land register a decrease of 17.10 and 9.24 percent respectively in area during the period II over period I, then in the period III an increase of 8.58 and 11.46 percent respectively which was relatively low. Land not available for cultivation showed an increase of 11.69 percent in area during II over period I and in period IV an increase of 3.96 percent over period III. But in period III over period II decrease of 3.81 percent was observed.

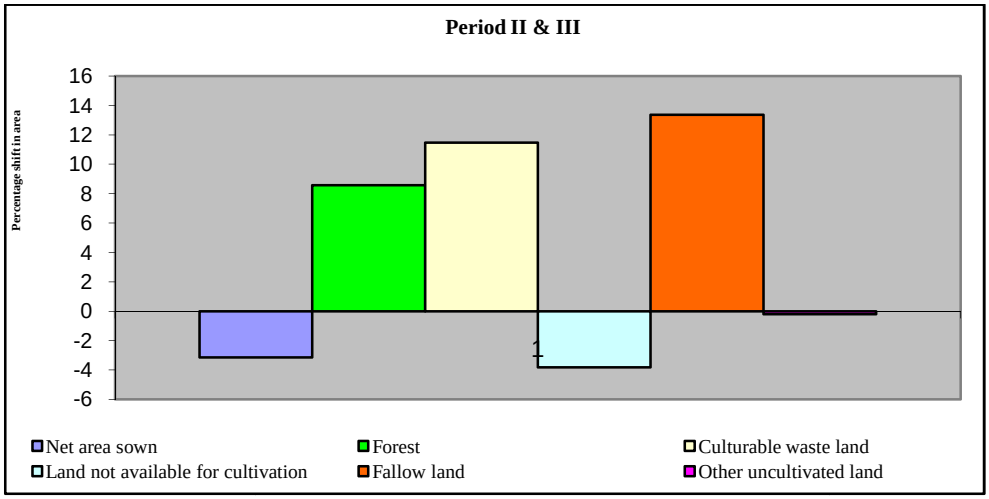
In case of fallow land a different trend was observed, area of fallow land decrease slightly (0.21 percent) in period II over I, then increased (13.36 percent) in period III and then again there was a decrease of 10.04 percent in period IV. Other uncultivated land recorded a decrease of 2.94 percent, 0.21 percent and 6.73 percent in period II, III and IV respectively.

Table 4: Shifts in Area under Land Use Pattern in Chhattisgarh State (1970-71 to 2005-06)

Clusters		Net Area Sown	Forest	Culturable Waste Land	Land Not Available for Cultivation	Fallow Land	Other Uncultivated Land
I	Mean	45.40	27.83	3.46	9.16	4.65	9.51
II	Mean	48.03	23.07	3.14	10.23	4.64	9.23
	% Shift	5.79	-17.10	-9.24	11.69	-0.21	-2.94
III	Mean	46.53	25.05	3.50	9.84	5.26	9.21
	% Shift	-3.13	8.58	11.46	-3.81	13.36	-0.21
IV	Mean	47.93	18.40	3.33	10.23	4.73	8.59
	% Shift	3.02	-26.54	-4.86	3.96	-10.04	-6.73

Clusters	Periods
I	1970-71 to 1975-76
II	1984-85 to 1995-96
III	1976-77 to 1983-84
IV	1996-97 to 2005-06





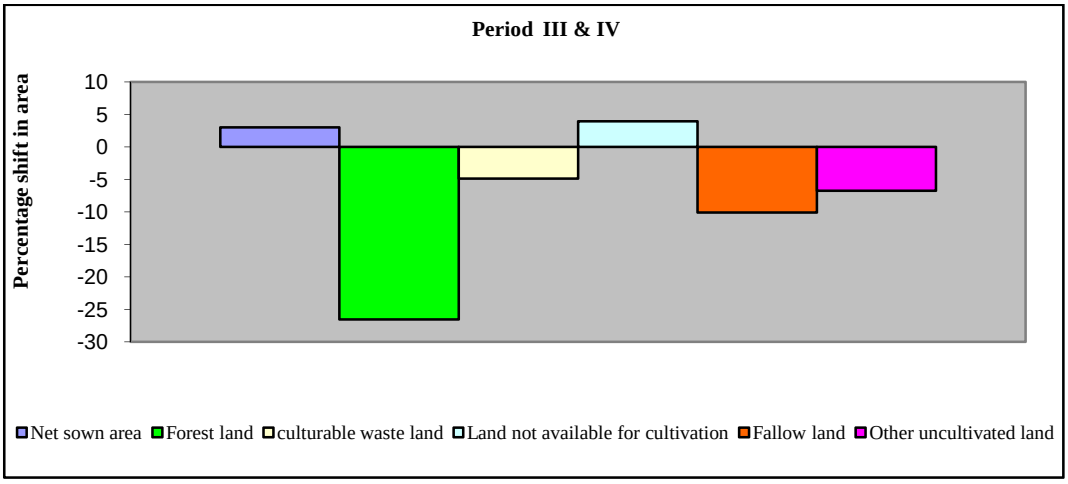


Figure 1: Shifts in Area of Land Use Pattern in Chhattisgarh State (1970-71 to2005-06)

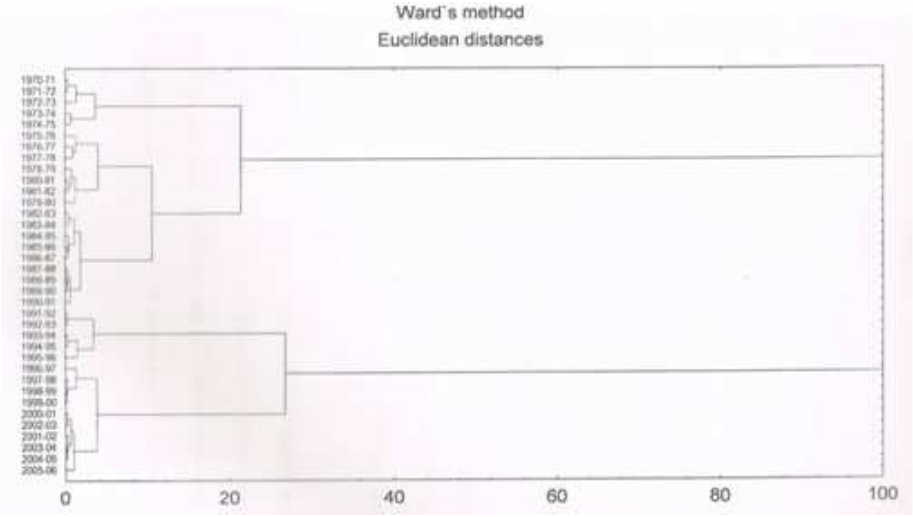


Figure 2: Dendogram Obtained Using Ward's Method for Chhattisgarh State

CONCLUSIONS

The following summary and conclusions are from drawn in the present study on periods of shifts in land and various land use parameters corresponding to Chhattisgarh state:

In the context of the shifts in land use pattern the procedure of cluster analysis, in particular, Ward's method and principal component method can be applied. The shifts identified under the corresponding situation in the present study using cluster analysis are same as those obtained with principal component analysis. Both the approaches found to be suitable in classifying the years, in view of the homogeneity of clusters within themselves. Forest recorded decrease (35.63%)in the recent years in Chhattisgarh state as a whole. Shifts of various land use pattern in Chhattisgarh state as a whole registered a considerable increasing (0.86%) land not available for cultivation followed by net area sown.

The results corresponding to the shifts in various land use in Chhattisgarh plains under study years, the culturable waste land (18.53%) and land not available for cultivation recorded considerable positive shifts in the land utilization level

of the region land relatively high shift potential for culturable waste land followed by net area sown (increase 2.8 lakh ha.) was observed. This increase was due to the maximum coverage of the Chhattisgarh plains. The shifts of various land use characteristics in northern hills the uncultivated land and net area sown increased in positive direction while categories of lands are shifted in negative direction. In the recent years culturable wasteland recorded negative shifts is more than other land. The shifts in the area of various land use of Bastar plateau is positive in these region, Forest land, net area sown and culturable wasteland showed negative shifts in these regions.

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