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Cluster Analysis Based Approach To Delineate Homogeneous Regions For The Assessment Of Regional Competitiveness: A Case Of Districts Of India

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***Abstract*—In the current context of augmentation of regional economy, the concept of regional competitiveness is becoming highly significant. Competitiveness of a place/firm can be understood as the extent and level of satisfactory socio-economic performance indicators and the subsequent success with which the place/firm compete with one another in attracting capital and workers. Competition occurs at three levels; at the highest level there are countries (macro-economic), at lowest level there are firms (micro-economic) and at the mid-level regions do compete. Regions are treated as an important source of competition in economic geography. In the process of assessment of competitiveness of regions, the issue of identification of suitable regions has not been much emphasized in literature and mostly administrative boundaries are used to define a region. Present study tries to delineate suitable regions in India, for better assessment and augmentation of regional competitiveness. This study uses two layers to define regional boundary. In the first layer, the regional demarcation is based on minimum resource potential and economic viability of different regions. Second layer is based on classification of 531 districts of India, based on homogeneity of their economic structure. Data for Gross Districts Domestic Products (GDDP) for these districts were used under six major sectors of the economy. A series of Hierarchical cluster analysis and k-means cluster analysis were done to assign objects to clusters. Finally, the paper has tried to delineate homogeneous regions based on the overlap of previously mentioned two layers and plot it with the help of Arc Gis for better spatial representation.**

Keywords— Regional Competitiveness, Delineate Regions, District Domestic Product, Cluster Analysis

I. INTRODUCTION

Regional competitiveness can be understood as the extent and level of satisfactory socio-economic performance indicators and the subsequent success with which regions and cities compete with one another in attracting capital and workers. One of the accepted definitions of the competitiveness of a place is the ability of an economy to attract and maintain firms with stable or rising market shares in an activity while maintaining or increasing standard of living for those who participate in it [32].

Competition occurs at three levels [6] distinguish between the highest macro level (competitiveness of a country), the lowest micro level (competitiveness of the individual firm) and the intermediate meso level (competitiveness of local economic systems), where the latter is further divided into industrial districts (or what Porter would call 'clusters') and regions. Out of these three levels, region is an important source of competition, Porter [26, 27] supports this through his argument, 'competitive advantage is created through highly localized processes. Regional externalities or resources that reside outside of individual local firms but which are drawn on directly or indirectly by those firms and which influence their efficiency, innovativeness, flexibility and dynamism: in short, their productivity and competitive advantage [16]. If we want to understand differences in national growth rates, a good place to start is by examining differences in regional growth; if we want to understand international specialization, a good place to start is with local specialization [18]. Paradoxically, then, the enduring competitive advantages in a global economy are often heavily local, arising from concentrations of highly specialized skills and knowledge, institutions, rivals, and sophisticated customers in a particular nation or region [28].

II. NEED OF THE STUDY

Some important studies related to the investigation of regional competitiveness, treat administrative or demographic boundary as regional boundary. For example- Gudgin & Graham [9] analyzed the competitiveness of ten regions of United Kingdom. Lengyle [19] formulated the strategies to improve competitiveness of seven NUTS-2 Hungarian regions. Huggins [11] formed competitiveness index of twelve regions of UK. Bronisz & Heijman [5] formed Polish

regional competitiveness index based on sixteen NUTS-2 Agro clusters. Snieska and Bruneckiene [31] formulated the strategy directions for increasing the competitiveness of the ten NUTS-3 regions of Lithuania.

In the context of competitiveness, the problem of delineation of regional boundary has never been explored. Generally, in the studies of regional competitiveness, entire country is divided in several administrative or demographic regions and each region is treated as having similar strength and opportunities. In a large region, there can be zones, which have different economic or geographic characteristics and potentials. For example- agriculture based regions needs separate policy interventions than industrial or mining based regions.

Hilly regions have different potential than plains. Infrastructure has also different standard for hilly and plain regions. For example, road density of a hilly state, Uttrakhanad in 2008 was 767.37 per 1000 sq.km. and for a plain state Bihar, which were 1275.73 per 1000 sq.km [22]. This data gives an idea that, Uttrakhand is poor performer and Bihar is good performer, in terms of road Infrastructure, but reverse is true. Out of hilly states of India, Uttrakhand has denser network of roads, and out of plain states Bihar has average to lower network of roads.

In a large country like India, where there is so much diversity in terms of economic & geographic structure and related opportunities & weaknesses. It is very important to delineate a regional boundary, which is homogeneous in geographic and economic characteristics. These regions can be put into intra or inter regional comparison and analysis.

Looking at the methods of delimiting a region, according to Meyer [23], regions can be grouped under three categories based on: homogeneity, nodality, and programming. Homogeneous or formal regions show homogeneity in physical, economic, social or other characteristics. Nodal or Functional regions have polarization around some central urban place. Functional region emphasizes on interdependence. Programming regions have administrative coherence or identity between the area being studied and available political institutions for policy decisions. Regional competitiveness compares the region based on their potential, which has nothing to do with the Functional and Programming regions. Regions with similar characteristics can be compared with each other. Concept of homogeneity is more suitable in the context of comparing competitiveness of regions. Literatures also indicate towards delimitation of a number of regions of a homogeneous type, to understand spatial differentiation in economic development [20]. Hence, this study tries to delineate homogeneous regions in India.

III. METHODOLOGY

Delineation of homogeneous region was performed with the help of two layers. First layer is the established regional classification of the districts of India. For this purpose scheme of Town and Country Planning Organization, 1968, was used as a basis of regional classification. India is divided in thirteen regions in this scheme, based their resource potential. Second layer is the classification of the districts of India, based on their economic structure. This classification is done on the basis of share of six major economic activities in Gross Domestic Products of the districts. Finally, districts are classified in regions, on the basis of homogeneity of the two layers.

In the first layer, entire country was divided in thirteen planning regions, based on the scheme of Town and Country Planning Organization [7]. This scheme of regionalization is based on minimum resource potential of different regions. Planning regions delineated in this manner are to have within them three primary requirements for generating economic activities: (a) land, (b) raw materials for industrial development, and (c) power. These three principal factors will enable each planning region to agriculture and industry. Thus the region will have the basic elements to achieve a degree of economic viability [7].

These macro regions are: (i) South Peninsula (Kerala and Tamilnadu), (ii) Central Peninsula (Karnataka, Goa and Andhra Pradesh), (iii) Western Peninsula (Western Maharashtra, Coastal and interior districts), (iv) Central Deccan (Eastern Maharashtra, Central and Southern Madhya Pradesh), (v) Eastern Peninsular (Odisha, Jharkhand, North-Eastern Andhra Pradesh and Chhattisgarh) , (vi) Gujarat, (vii) Western Rajasthan, (viii) Aravali region (Eastern Rajasthan and Western Madhya Pradesh), (ix) Jammu & Kashmir and Ladakh, (x) Trans Indo Gangetic Plains and Hills (Punjab, Haryana, Himachal Pradesh, Western Uttar Pradesh and Uttaranchal), (xi) Ganga Yamuna Plains (Central and Eastern Uttar Pradesh), (xii) Lower Ganga plains (Bihar and West Bengal Plains) and (xiii) North Eastern Region (Assam and North Eastern States including Sikkim and North Bengal). G.I.S. map was produced for spatial representation of the scheme. Figure 1 shows the above mentioned scheme.

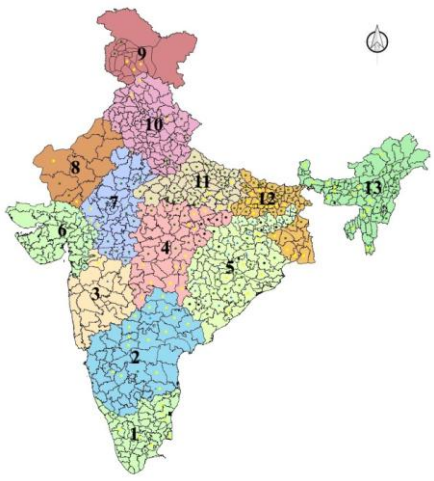

Figure 1: Planning Regions of India (T.C.P.O.)

In the second layer, districts of India were classified, in homogeneous groups, based on the variations in the economic structure. Literature indicates towards, application of structure of national income produced, for differentiation of a number of homogeneous regions and thus zones of different intensity and different features of specific social and economic character [20]. Data for seventeen sectors of economy is available on the website of Planning Commission of India. Data for financial year 2004-05 was selected for the purpose of analysis, because data is available for maximum number of districts for the given financial year.

Total five hundred and thirty one districts were taken for analysis out of six hundred districts of India in 2004-05. These districts include, thirteen districts of Andhra Pradesh, thirteen districts of Arunachal Pradesh, twenty seven districts of Assam, thirty eight districts of Bihar, sixteen districts of Chhattisgarh, nineteen districts of Haryana, twelve districts of Himachal Pradesh, twenty two districts of Jharkhand, twenty seven districts of Karnataka, fourteen districts of Kerala, forty five districts of Madhya Pradesh, thirty four districts of Maharashtra, nine districts of Manipur, seven districts of Meghalaya, eight districts of Mizoram, thirty districts of Odisha, seventeen districts of Punjab, thirty two districts of Rajasthan, four districts of Sikkim, thirty districts of Tamil Nadu, ten districts of Telangana, seventy districts of Uttar Pradesh thirteen districts of Uttarakhand, nineteen districts of West Bengal, and two districts of Andaman and Nicobar Islands.

Data for two districts of Goa, twenty four districts of Gujarat, fourteen districts of Jammu and Kashmir, eight districts of Nagaland, four districts of Tripura, one district of Chandigarh, one district of Dadra and Nagar Haveli, one district of Daman and Diu, one district of Lakshadweep, nine districts of NCT Delhi and four districts of Pondicherry was not available, and these sixty nine districts were not included in the analysis.

Data for Gross Districts Domestic Products (GDDP) for districts of India is available for seventeen sectors of economy separately on the website of Planning Commission of India (2004-05). These sectors are 1) Agriculture, 2) Forestry & Logging, 3) Fishing, 4) Mining & Quarrying, 5) Registered Manufacturing, 6) Unregistered Manufacturing, 7) Electricity, Gas & Water Supply, 8) Construction, 9) Trade, Hotels & Restaurants, 10) Railways, 11) Transport by other means, 12) Storage, 13) Communication, 14) Banking & Insurance, 15) Real Estate, Ownership of Dwellings, Building Services & Legal Services, 16) Public Administration and 17) Other Services.

These sectors were clubbed under six major sectors of the economy per as the standard procedure. Agriculture (1), Forestry & Logging (2) and Fishing (3) are clubbed under Agriculture and Allied activities (V_1). Mining & Quarrying (4) is kept as it is (V_2). Registered Manufacturing (5) and Unregistered Manufacturing (6) are clubbed under Manufacturing (V_3). Next group of activities clubbed together are Electricity, Gas & Water Supply (7) and Construction (8) as fourth variable (V_4). Railways (10), Transport by other means (11), Storage (12) and Communication (13) are clubbed under Transportation, Storage and Communication (V_5). Trade, Hotels & Restaurants (9), Banking & Insurance (14), Real Estate, Ownership of Dwellings, Building Services & Legal Services (15), Public Administration (16) and Other Services (17) are clubbed under All Other Services (V_6). Data for identified five hundred and thirty one districts were compiled for these six sectors of economy and converted into percentage.

IV. CLASSIFICATION OF IDENTIFIED DISTRICTS IN HOMOGENEOUS GROUPS OF DISTRICTS

In the present study, cluster analysis is applied as a tool to classify districts in homogeneous groups. It is most frequently employed as a classification tool [29]. According to Mooi & Sarstedt [24], cluster analysis is a method for identifying homogeneous groups of objects called clusters. The objective of this technique is to form homogeneous groups of objects that are described by a variety of characteristics [4]. An object in a certain cluster should be as similar as possible to all the other objects in the same cluster; it should likewise be as distinct as possible from objects in different clusters [24]. This technique is used in very diverse fields for classification of objects in groups. Cluster analysis has been used to identify homogeneous hydrological regions [2, 10, 12, 25, and 33]. Climatic zones of turkey are redefined by using the mathematical methodology of cluster analysis [34]. It is used to develop consumer typologies in domestic marketing [30].Use of cluster analysis was done, for the identification of farms prone to residential development [21]. This tool was used to distinguish German regions according to their economic capabilities [17]. Various stages of cluster analysis are explained below.

A. Validation of sample size

Literature suggest that, a variable that is not related to the final clustering solution, causes a serious deterioration of the performance of all clustering methods, hence there is a need for careful selection of variables for use in clustering [29]. In this study seventeen variables are clubbed together to form only six clustering variables.

Formann [1] recommends a sample size of at least 2^m, where m equals the number of clustering variables. For six clustering variables, minimum sample size should be 64. Sample size (531) is sufficient to perform the cluster analysis.

B. Test of collinearity

Mooi & Sarstedt [24] explain that, if there is a high degree of co linearity between the variables, they are not sufficiently unique to identify distinct segments in clustering process. In this regard, absolute correlation

above 0.9 is always problematic. Other literatures also recommend that variables with a correlation coefficient (r) > 0.9 [8] should be excluded from cluster analysis. The correlations are checked between the variables used, since variables that are highly correlated tend to distort the results [8]. Pearson correlation analysis was done for all six clustering variables. No two clustering variables show high correlation among themselves for the given districts. Highest correlation (r) was observed as 0.438 between Agriculture and Allied activities (V_1) and Manufacturing (V_3).This result shows that data is suitable for cluster analysis.

C. Identification of number of clusters

Hierarchical cluster analysis was performed to determine suitable number of clusters. Single linkage method (Nearest neighbor) based on Euclidean distances was applied. SPSS does not provide Scree plot for cluster analysis. Plotting the distances (coefficient column) against the number of clusters gives a Scree plot in excel (Mooi & Sarstedt, 2011). Figure 2 shows the Scree plot.

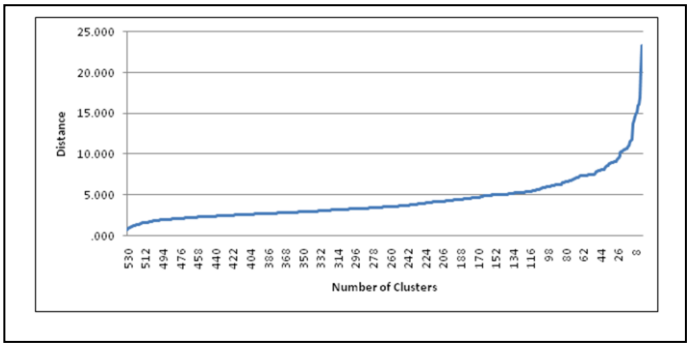

Figure 2: Scree plot

The distinct break (elbow) generally indicates the solution regarding where an additional combination of two objects or clusters would occur at a greatly increased distance [24]. A clear elbow in the graph at the distance of 16.010 (4 clusters), 11.735 (11 clusters), 4.837 (164) and 1.190 (524 clusters) is evident. This analysis provides a rough guidance to the researcher for the number of clusters to be retained [24]. For the purpose of classification of districts based on dominant economic activity, four cluster solution was found better to interpret.

D. Final clustering with k-means clustering technique

K-means cluster analysis was performed in the present study to finally classify districts in cluster. According to Punj & Steward [29] a reasonable amount of evidence suggests that iterative partitioning methods are superior to hierarchical methods. K-means procedures along with other partitioning methods all appear to perform well [29]. K-means is one of the most widely used algorithms for clustering [13, 14, and 15]. This technique is popular because of its ease of implementation, simplicity, efficiency and empirical success [13]. The goal of k-means is to minimize the sum of the squared error over all clusters [13]. In this method, cases are reassigned to minimize the variance within each cluster [29]. K-means clustering was performed with four cluster solution. Final cluster center of the clusters are provided in the Table 1.

Table 1: Cluster centers

	Cluster			
Economic Activities	**1**	**2**	**3**	**4**
1) Agriculture and Allied	20.41	19.42	14.94	38.81
2) Mining and Quarrying	1.41	2.46	36.20	0.93
3) Manufacturing	10.00	28.26	9.54	7.3
4) Electricity, Gas, Water supply and Construction	12.43	8.19	9.96	11.02
5) Transportation, Storage and Communication	8.10	6.66	4.77	5.56
6) All other Services	47.67	35.00	24.60	36.40
Number of districts in each cluster	192	68	18	253

E. Validation of the clusters

K-means clustering in SPSS provides ANOVA, which can be used to interpret the clusters [24].Table 2 shows the details of calculation of ANOVA.

Table 2: Calculation of ANOVA

	Cluster		Error			
Economic Activities	Mean Square	df	Mean Square	df	F	Sig.
1) Agriculture and Allied	16103.72	3	54.30	527	296.56	.000
2) Mining and Quarrying	7101.68	3	12.33	527	575.89	.000
3) Manufacturing	7986.88	3	27.45	527	290.88	.000
4) Electricity, Gas, Water supply and Construction	312.68	3	45.54	527	6.86	.006
5) Transportation, Storage and Communication	256.09	3	7.99	527	32.01	.000
6) All other Services	6844.71	3	43.29	527	158.08	.000

Critical value for degree of freedom (3,527) at level of significance 0.05 is 2.62. All the values in F- table fall in rejection region (> 2.62). Therefore, null hypothesis was rejected for the center of the four clusters, for all the six classes of economic activities. This shows that the districts of all the four clusters differ significantly in term of their economic base.

F. Interpretation of the clusters

To understand the characteristics of these clusters, radar diagram was created in excel.

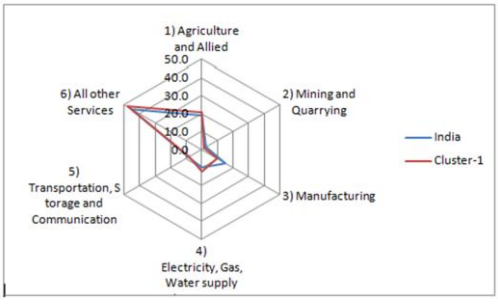

Figure 3: Radar Diagram of India and Cluster-1

Out of all four clusters, only the economic structure of cluster-1 matches with that of India. It has slightly more share of Agriculture and Allied activities. Cluster-1 has less share of Manufacturing than country's average. Only cluster-1 has a similar (to India) share of all other services in all the four clusters (Figure 3). This cluster contains 192 districts of India.

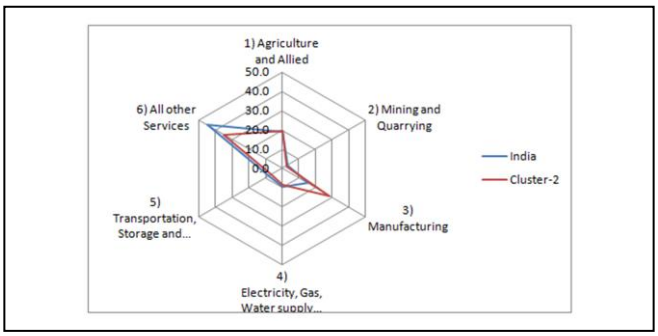

Figure 4: Radar Diagram of India and Cluster-2

Cluster-2 has significant share of manufacturing activities (cluster center-28.26%) This cluster contains 68 districts of India (Figure 4).

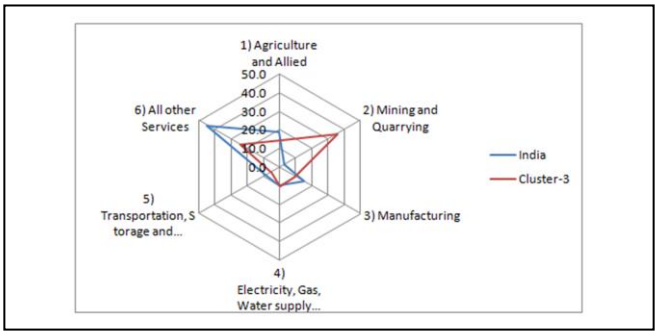

Figure 5: Radar Diagram of India and Cluster-3

Cluster 3 has predominantly mining and Quarrying based economic activities (cluster center-36.20%). This cluster contains only 18 districts of India (Figure 5).

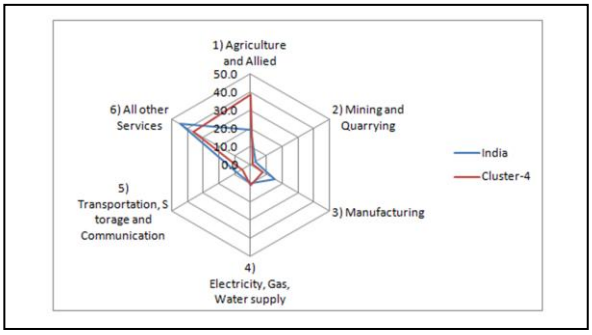

Figure 6: Radar Diagram of India and Cluster-4

Cluster 4 has significant agriculture base (cluster center- 38.81%). This cluster has very small manufacturing base (cluster center- 7.3%).This is the largest cluster with 253 districts (Figure 6).

G. Mapping of the Cluster classes

To understand the spatial distribution visually, final cluster classes were mapped with the help of Arc GIS 9.3. These maps were superimposed on the map of planning region of India. Figure 7 to Figure 17 show the cluster classification of identified 531 districts in different planning regions of India.

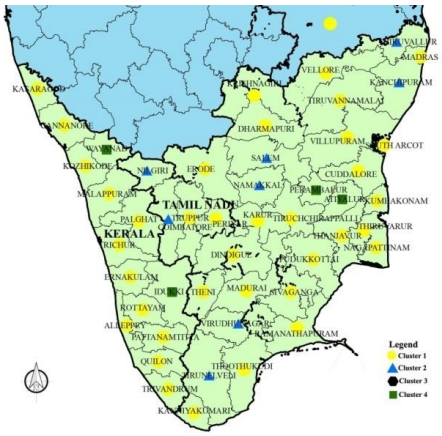

Figure 7: cluster classification of districts in planning region 1

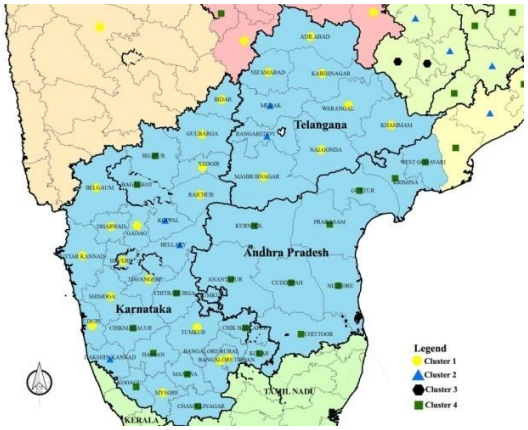

Figure 8: cluster classification of districts in planning region 2

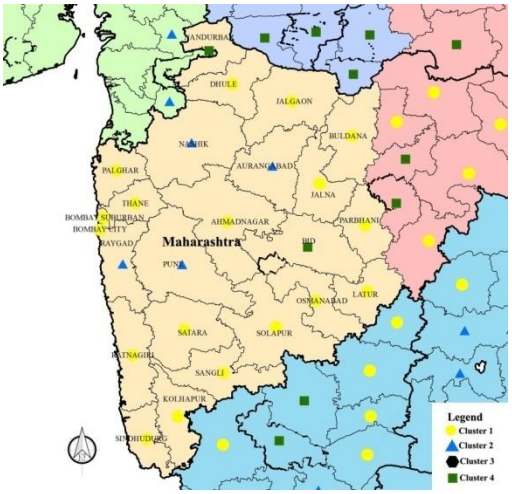

Figure 9: cluster classification of districts in planning region 3

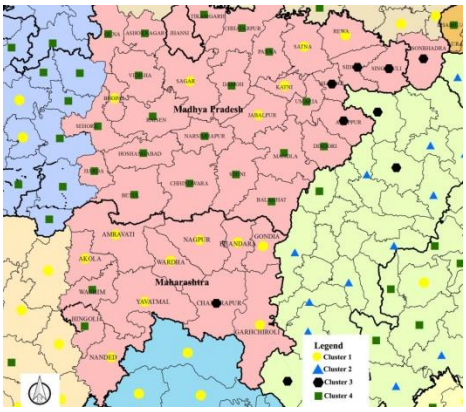

Figure 10: cluster classification of districts in planning region

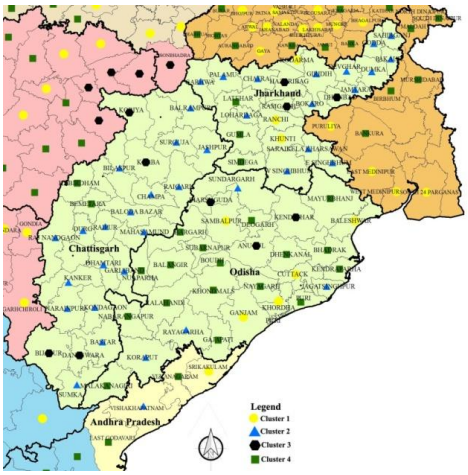

Figure 11: cluster classification of districts in planning region

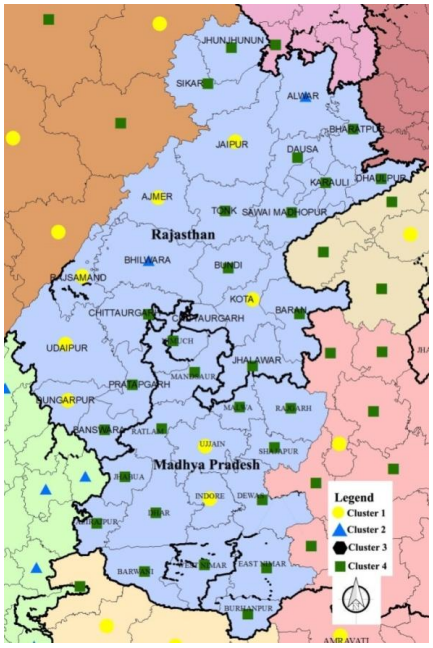

Figure 12: cluster classification of districts in planning region 7

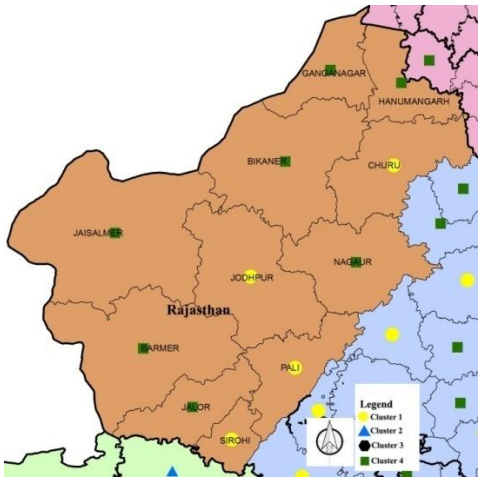

Figure 13: cluster classification of districts in planning region 8

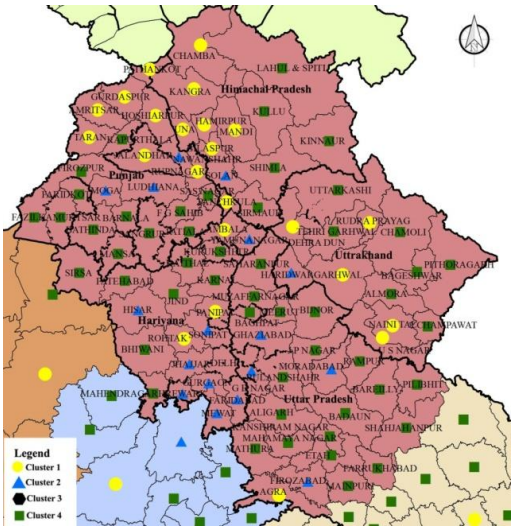

Figure 14: cluster classification of districts in planning region 10

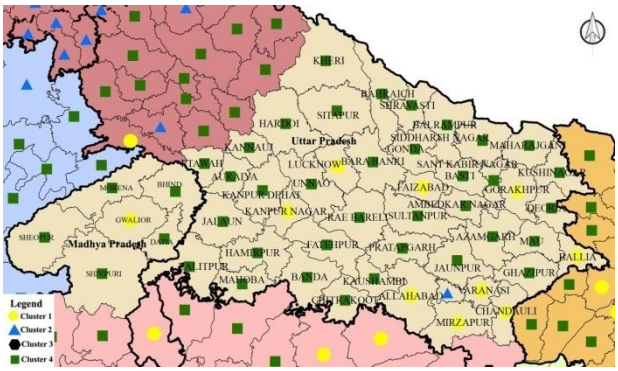

Figure 15: cluster classification of districts in planning region 11

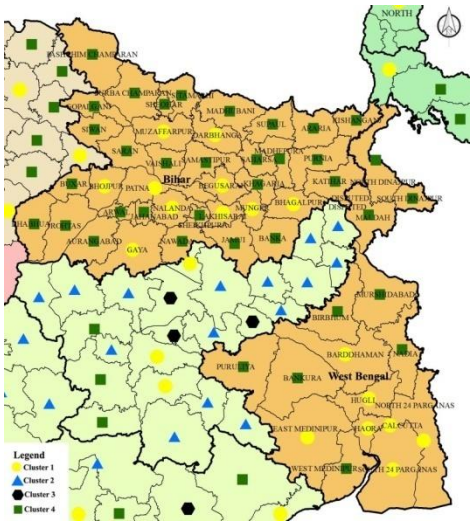

Figure 16: cluster classification of districts in planning region 12

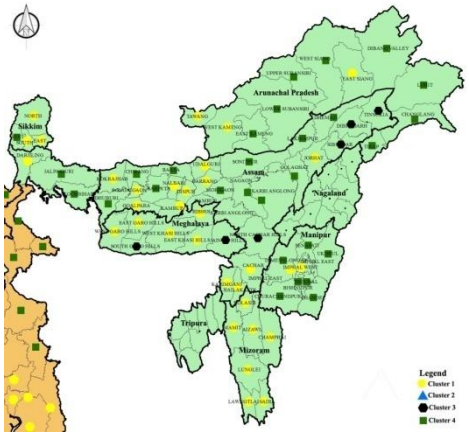

Figure 17: cluster classification of districts in planning region 13

H. Regionalization of districts

Identified districts were divided into regions based on two criteria

1. Homogeneity in Resource base (T.C.P.O.'s scheme)
2. Homogeneity in Economic Structure

Final regions were identified. For example, in planning region 12, twenty eight districts of Bihar and nine districts of West Bengal form a homogeneous region. Their economy majorly depends upon agriculture (cluster-4).

Ten districts of Bihar and seven districts of West Bengal form a homogeneous region. They have large share of tertiary activities and a substantial share of agriculture (cluster-1) in their economy. In total, thirty regions were identified.

I. Conclusion

Out of three levels of competition, regions are becoming an important source of competition. In the presently available literature, administrative or demographic boundaries are treated as regional boundary. This system of delineation of regions is efficient in terms of data availability. In a large region, there can be zones, which have different economic or geographic characteristics and potentials. Concept of homogeneity is more suitable in the context of comparing competitiveness of regions. Literature also indicate towards delimitation of a number of regions of a homogeneous type, to understand spatial differentiation in economic development [20].Hence, this study tries to delineate homogeneous regions in India. Delineation of homogeneous region was performed with the help of two layers. First layer is the established regional classification of the districts of India. For this purpose scheme of Town and Country Planning Organization, 1968, was used as a basis of regional classification. India is divided in thirteen regions in this scheme, based their resource potential. Second layer is the classification of the districts of India, based on their economic structure. This classification is done on the basis of share of six major economic activities in Gross Domestic Products of the districts. Finally, districts are classified in regions, on the basis of homogeneity of the two layers.

In the present study, cluster analysis is applied as a tool to classify districts (531 out of 600) of India in homogeneous groups for the second layer. Hierarchical cluster analysis was performed to determine suitable number of clusters. Single linkage method (Nearest neighbor) based on Euclidean distances was applied. Scree plot was constructed with the help of excel. Four cluster solution was found better to interpret. Finally, k-means cluster analysis was performed classify districts in cluster. Out of all four clusters, only the economic structure of cluster-1 matches with that of India. It has slightly more share of Agriculture and Allied activities. Cluster-1 has less share of Manufacturing than country's average. This cluster contains 192 districts of India. Cluster-2 has significant share of manufacturing activities (cluster center-28.26%) This cluster contains 68 districts of India. Cluster 3 has predominantly mining and Quarrying based economic activities (cluster center-36.20%). This cluster contains only 18 districts of India. Cluster 4 has significant agriculture base (cluster center- 38.81%). This cluster has very small manufacturing base (cluster center- 7.3%).This is the largest cluster with 253 districts.

To understand the spatial distribution visually, final cluster classes were mapped with the help of Arc GIS 9.3. These maps were superimposed on the map of planning region of India. Finally, these districts were divided into regions based on two criteria of homogeneity in resource base as well as economic structure.

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