TAXONOMIC ANALYSIS OF ZONAL DIFFERENCES IN RELATION TO FACTORS OF CROP PRODUCTION IN INDIA

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ABSTRACT

Taxonomic analysis of inter—and intra—variations of 18 Indian States was done with respect to several agro-economic factors of crops' production classified into five different sets of parameters to examine zonal differences. Reclassification of States of four major geographical zones into larger clusters/groups resulted in different groups for different sets of parameters. The variations noted were not so prominent for southern States as that in case of other three zones. Kerala, Uttar Pradesh, Karnataka, Gujarat, Bihar and Orissa each showed wide diversities from other 17 States for a good number of factors in respective cases. Hill area States of north east and north west regions showed high resemblance for several factors. Punjab and Haryana came out to be highly associated among themselves and they appeared together in same cluster in all the five situations.

Introduction

Adoption of new agricultural technology resulted in augmenting farm production and productivity in India. However, the extent of its implementation differed from one zone to another resulting in differences affecting production as well as productivity. It was, therefore, important that performance-analysis of Indian States be done taking into account their inter—and intra-variations with respect to various factors of crop production analysed simultaneously. In earlier studies conducted by Goel (1990) and Goel and Vasisht (1990), interlinkages were observed among Indian States defying geographical zones.

In the later study, reclassification of States was done into new zones with respect to 38 parameters analysed simultaneously. As pointed out therein, the classification done earlier could differ if factors relevant to land utilisation pattern; rural financing for farming and marketing and storage facilities; fertilizers sale network and their availability and consumption; irrigation potential created and its use pattern; and several production efficiency factors were analysed separately. This study was, therefore, undertaken as an extension of the earlier study by splitting the large number of parameters (38) studied earlier together, into five different sets taking into account their nature and effect on production process. Taxonomy analysis was done

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herein for each of these five sets (of parameters) separately to identify the
broad homogenous zones comprising different States after analysing their differences
with respect to these sets of parameters.

Material and Methods

Similarity Indices (S.I.'s) \(^1\) were calculated with respect to five different sets of
parameters. The S.I.'s, so calculated, were transformed into Z-coefficients using
Fisher and Yates (1963) tables, and termed as Resemblance Indices (R.I.). They
were later subjected to cluster analysis. Weighted Pair Group Method (W.P C.M.)
was used for averaging of indices (R.I. s) at successive stages of clustering. The
methods used here are given by Sokal and Sneath (1973). The resultant clusters were
depicted through dendrograms (Figs. 1 to 5).

Results and Discussion

The Resemblance Indices (R. I.) used here represented only the extent of re-
semblance (or otherwise) in performance pattern of concerned States. The wider the
difference among States, the weaker would be the resemblance and so the lower the
value of R.I. A negative R.I. indicated dissimilarity among the concerned States
which, therefore, could not be grouped together. As such the major clusters (formed)
below the zero-level of R.I. (Figs. 1 to 5) only represented that the respective States
could not be grouped together. The eighteen States, thus, might be grouped at
least into 2 or 3 major clusters (above zero level of R.I.) in the five respective situa-
tions. The decision regarding the number of final (major) clusters in this analysis
was based on the minimum tolerant level of R.I. which ranged from 0.40 to 0.54 in
respective cases (minimum significant value of R.I. was 0.40). However, the R.I.’s
in respective cases varied within the range from —0.37 to 2.56. The results for five
different situations are presented under different sub-heads.

1. Land Use Planning (Set 1)

The eleven parameters included herein related to operated area farms’ size-wise,
rural population pressure on land, area under foodgrain crops, extent of adoption of

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\(^1\) State-wise data (1980-81 to 1986-87) of 18 Indian States for five different sets of parameters
including infrastructural and crops production efficiency factors were analysed using numerical
taxonomy techniques. The data were first standardised by dividing the difference between
individual (State) observation (for each parameter) and parameter-row mean by the respective
parameter-row standard deviation. \((X_{ij} - X_j)/\sigma_j\) where \(X_{ij}\) refer to \(i^{th}\) State and \(j^{th}\) para-

\(X_j\) is the \(j^{th}\) parameter-row mean (over 18 States) and \(\sigma_j\) is the \(j^{th}\) parameter-row

standard deviation. The standardised values so obtained were then used to calculate correla-
tion coefficients \((18C_2 = 153)\) between different States which were used as similarity coefficients
between the two respective States in each of 153 (combination) pairs of States.
high yielding varieties of crops, and cropping intensity, etc. Resemblance Index (R.I.) came out to be highest (1.69) for Punjab and Haryana (Fig. 1) followed by that between Madhya Pradesh and Rajasthan (1.44) and between Karnataka and Maharashtra (1.26). Assam, Jammu & Kashmir, Bihar and Tamil Nadu also showed quite good resemblance (at 1.17 and 0.92 levels, respectively) at initial stages of clustering. The respective States in different cases belonged to the same or different geographical zones. The number of clusters formed at different stages reduced from 12 (at 1.10 level) to 8 (at 0.59 level). However, at the lowest significant level (0.45 in this case) the eighteen States could be grouped into six (final) major clusters. Kerala and Uttar Pradesh were the two States which did not join any of the four

**Fig. 1.** Dendrogram representing clusters of 18 Indian States based on resemblance indices for 11 parameters. (P₁ to P₁₁ Set I : Table 1)

NEFR includes Manipur, Meghalay, Sikkim, Tripura and Nagaland. For sets and parameters see Table 1.
major clusters formed by the other 16 States (at 0.45 R.I). This indicated wide diversities in the performance levels of each of them (with respect to factors studied) with other States. The other south zone States, viz., Karnataka and Andhra Pradesh joined a cluster with the four west zone States, while Tamil Nadu showed closeness with Bihar and NEFR. Similarly, States of north and east zones also showed much diversities among themselves and fell under different clusters. Punjab and Haryana stayed together in a separate cluster all through; they joined another cluster only at negative values of R.I. indicating extreme divergence in their performance pattern as compared to other States.

2. Farm Financing, Storage and Market Facilities (Set II)

Loans advanced by credit/cooperative societies and commercial banks, and
market network established in rural areas formed the five parameters analysed in this case. Jammu and Kashmir and NEFR, both hilly areas but located in two extreme geographical corners, showed (Fig. 2) highest resemblance (2.56). Himachal Pradesh and Assam also registered closeness to this group but joined it at lower levels (at 1.88 and 1.39, respectively) forming a still broader group of these four States. This indicated similarities in the pattern of availability of these factors of production in the hilly areas of north east and north west parts of the country. Considering the clusters at levels higher to 1.0, eleven States fell under three different clusters while 7 other States stood independent, thus resulting in 10 clusters in all. This number was reduced to seven at 0.73 (level of R.I.) and to five major (final) clusters at the minimum significant level of 0.53 (in this case). Bihar and West Bengal, falling under one cluster, showed extreme divergence with the other 16 States (they joined them only at negative values of R.I.). Similarly, Karnataka also did not show any worthwhile closeness with any other state. But it was interesting that Tamil Nadu, Andhra Pradesh and Kerala, the other three southern States, went along with Orissa and hilly areas States of north and east zones. Among the west zone States, Madhya Pradesh remained apart from the other three sister States which fell together in the same cluster.

3. Irrigation Potential and its Use (Set III)

Five parameters analysed herein included irrigation potential created through major, medium and minor irrigation projects, and pump sets/tubewells generated, and the extent of its utilization. Orissa and West Bengal registered largest (Fig. 3) resemblance (2.27). Assam, NEFR and Himachal Pradesh again showed close similarities (at 1.08) with respect to these parameters. The eighteen States might be grouped into 9 different clusters at 1.08 level (of R.I.) and into 6 major (final) groups at the minimum significant level (0.54). Gujarat, however, did not join any of the remaining five clusters at this stage. Assam, NEFR and Bihar remained apart from Orissa and West Bengal, the other two east zone States. Kerala showed wide divergence from the other three southern States and Uttar Pradesh and Himachal Pradesh also did not show any resemblance with the rest of the three States of the north zone. In all these cases the respective States joined their sister States of the same respective zone only at negative values of R.I.s.
RESEMBLANCE INDICES 0.40 = 1 CM

Fig. 3. Dendrogram representing clusters of 18 Indian States based on resemblance indices for 5 parameters (P17 to P21—Set III; Table 1).

4. Fertilizers Availability and their Consumption (Set IV)

State-wise despatch of fertilizers (nutrients-wise), their sale outlets and consumption constituted the eight parameters of this set. Here again (as for Set III), Orissa and West Bengal had the highest (Fig. 4) resemblance (1.70) between themselves. This was closely followed by that between Punjab and Haryana (1.63) and Kerala and Tamil Nadu (1.56). In all these cases, the respective States belonged to the same geographical zone. At 1.0 level (of R.I.), the 18 States might be grouped into eleven different clusters. But on reducing this limit to 0.69, the number of resulting clusters came down to eight. At the minimum significant level (0.40) five major (final) clusters were formed. However, even at this stage Bihar stood apart from the other four major clusters. This showed its wide differences from other
States regarding fertilizers' availability and their consumption pattern. Andhra Pradesh and Assam did not show any affinity with any other State of their respective geographical zones (as they joined them only at negative levels of R.I. indicating wide diversities).

5. Production and Productivity of Major Crops (Set V)

State-wise production and average productivity of cereals, pulses, oilseeds and sugarcane (cane) and adoption of high yielding varieties programme formed this set of nine parameters. High similarities were noted (Fig. 5) for Madhya Pradesh and Rajasthan (1.70), for Karnataka and Tamil Nadu (1.32), and for Punjab and Haryana (1.37). All the States in respective cases belonged to the same geographical
zones. But these three different miniclusters, formed at initial stages, did not come anywhere close to each other up to the minimum significant level (0.55). This indicated wide diversities in the performance pattern of the respective States belonging to different geographical groups. However, at this stage (0.55), the 18 States were grouped into six major (final) clusters. Orissa did not join any of the remaining five major clusters and it also registered extreme diversities with other east zone States (which it joined only at a negative value of R.I.). Similar pattern was noted in case of Kerala vis-a-vis the other three southern States. Uttar Pradesh and Himachal Pradesh also did not come anywhere near the other three north zone States for similar reasons.

Fig. 5. Dendrogram representing clusters of 18 Indian States based on resemblance indices for 9 parameters. (P_31 to P_3D —Set V; Table 1)
Conclusions

The above analysis brought out clearly the differences among different States/zones with regard to availability and use pattern of various factors of crop production highlighting the zonal differences. Reclassification of States into different clusters/groups lead to 5 or 6 groups at lower, but significant, levels (0.40 to 0.55 in respective cases) and 9 to 14 groups at higher levels (above 1.0) of resemblance indices. It also clearly brought out the risks in reducing the number of broader groups (by increasing the size of resultant groups by adding additional States) to less than 5 or 6 in respective cases as the resultant resemblance indices (R.I.s) had then declined to very low (unacceptable) levels. It also cautioned not to classify the 18 States into very few (2 or 3) large groups which resulted in negative R.I.'s indicating extreme dissimilarities among respective States, and were hence not found suitable to be clubbed together in the same cluster/zone. The broad clusters obtained herein were different from those formed in the earlier studies confirming the observation of Goel and Vasisht (1990) that the classification might change with change in parameters. The analysis has thus demonstrated the fruitfulness of numerical taxonomy and cluster analysis in objective assessment of the extent of zonal differences as well as in handling problems of classification while dealing with agro-economic data pertaining to large number of factors of production which may vary in their nature, utilisation pattern and effect on production system.

Acknowledgements

The author wishes to express his sincere thanks to Shri R.S. Rai, Technical Assistant, for his assistance in computational work.

References

Goel, S.K. (1990). "Comparative performance of Indian States with respect to crops' production and related infrastructural and other resources factors." Agricultural Situation in India, 44(10), 803-808.


Table 1. Sets/Parameters (P’s) included for analysis

**Set I  ** *Land availability/use pattern for crops production*

<table>
<thead>
<tr>
<th>Parameter (P)</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>P₁</td>
<td>State’s share (%) in total area of operational holdings.</td>
</tr>
<tr>
<td>P₂ to P₅</td>
<td>State-wise percentage of total operated area holdings' size-wise: 0—2 h; 2—4 h; 4—10 h; and above 10 h, respectively.</td>
</tr>
<tr>
<td>P₆</td>
<td>State’s share (%) in total gross cropped area.</td>
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<tr>
<td>P₇</td>
<td>Percentage of State’s total cropped area under foodgrain crops.</td>
</tr>
<tr>
<td>P₈</td>
<td>Cropping intensity (%) in a State.</td>
</tr>
<tr>
<td>P₉</td>
<td>Percentage of State’s total cropped area under high yielding variety programme.</td>
</tr>
<tr>
<td>P₁₀</td>
<td>Percentage of State’s total available cultivable area net sown.</td>
</tr>
<tr>
<td>P₁₁</td>
<td>Pressure of rural population on land i.e. Number of persons per unit of net area sown.</td>
</tr>
</tbody>
</table>

**Set II  ** *Cooperatives/institutional banking credit/storage/marketing facilities pattern for farming purposes*

<table>
<thead>
<tr>
<th>Parameter (P)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₁₂</td>
<td>State’s share (%) in total number of regulated markets (Principal+Sub.).</td>
</tr>
<tr>
<td>P₁₃</td>
<td>State’s share (%) in total loan advanced by credit and cooperative societies plus monetary value of goods distributed (seeds, fertilizers, pesticides, implements, etc.).</td>
</tr>
<tr>
<td>P₁₄</td>
<td>State’s share (%) in (all India) average godown capacity (tonnes) warehousing (State Govts. + Central Govt.) plus F.C.I. plus Cooperatives.</td>
</tr>
<tr>
<td>P₁₅ and P₁₆</td>
<td>State’s share (%) in total short-term and long-term loans disbursed (direct financing), respectively, by commercial banks.</td>
</tr>
</tbody>
</table>

**Set III  ** *Irrigation potential and its use pattern*

<table>
<thead>
<tr>
<th>Parameter (P)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₁₇</td>
<td>State’s share (%) in total irrigation potential (hectares) created through major, medium and minor irrigation projects.</td>
</tr>
<tr>
<td>P₁₈</td>
<td>Percentage of State’s gross cropped area under irrigation.</td>
</tr>
<tr>
<td>P₁₉</td>
<td>State’s share (%) in total number of pump sets/tubewells emerged.</td>
</tr>
<tr>
<td>P₂₀ and P₂₁</td>
<td>State-wise per cent utilization of irrigation potential under major and medium; and minor irrigation project respectively.</td>
</tr>
</tbody>
</table>

**Set IV  ** *Fertilizers availability and consumption pattern*

<table>
<thead>
<tr>
<th>Parameter (P)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₂₂ to P₂₅</td>
<td>State’s share (%) in total despatch (tonnes) of fertilizers (nutrients-wise): i.e. for Nitrogen (N); P₂O₅; K₂O, respectively.</td>
</tr>
</tbody>
</table>
**Table 1—Continued**

<table>
<thead>
<tr>
<th>PM</th>
<th>Description</th>
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<tbody>
<tr>
<td>P26</td>
<td>State's share (%) in total number of sale points for fertilizers.</td>
</tr>
<tr>
<td>P27</td>
<td>State's share (%) in total consumption of fertilizers (N + P₂O₅ + K₂O).</td>
</tr>
<tr>
<td>P28</td>
<td>State-wise average consumption of fertilizers (nutrients-wise) i.e.: N, P, K₂O per hectare of gross cropped area, respectively.</td>
</tr>
<tr>
<td>P29</td>
<td>States average yield versus all India average for cereals; pulses; oilseeds; and sugarcane (cane), respectively.</td>
</tr>
<tr>
<td>P30</td>
<td>State's share (%) in total area under high yielding varieties programmes.</td>
</tr>
</tbody>
</table>

**Notes:**

**Sources of Information**


The four geographical zones included the following States:


