International Journal of Engineering, Science and Mathematics
Vol. 6 Issue 1, March 2017,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

STUDY OF SHIFTS IN CROPPING PATTERN OF KHARIF SEASON CROPS IN HARYANA USING CLUSTER ANALYSIS

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Abstract

For the better understanding of the assessment of technological impact on crops and cropping systems, it is always better to study the shifts in cropping pattern with respect to area, production and productivity. Agricultural scientists generally analyze the shifts in cropping pattern on some pre defined periods but this does not give a clear picture being n arbitrary selection of the time period. In this paper an attempt has been made to study the various methods of cluster analysis .It has been found that Wards minimum variance method of cluster analysis is most appropriate for the identification of the shifts in cropping pattern of various crops in Haryana as a whole and in various agro-climatic zones of Haryana. This has been done for the data from 1976-77 to 2010-11 on various crops in kharif season.

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Introduction:

Haryana is predominantly an agricultural state where 51.56 percent population depends upon agriculture directly or indirectly. Basically Haryana is an agrarian state and about 31 percent of the total income of the state comes from agriculture including livestock. Haryana has set all time record in food grains production during 2010-2011 and emerged as a major contributor of food grains to the Central food pool (Economic Survey, 2012-13). But the alarming rate of increasing population, depleting natural resources and attaining plateau in productivity in the state necessitated the identification of suitable cropping patterns, which are productive, profitable and stable over a period of time .

The cropping pattern is the outcome of internal farm resource restrictions within the external frame-work of socio-economic aid physical environments (Kahlon and Johl, 1965). The planning of cropping pattern thus means the selection of crops, crop combinations and rotations programs consistent with frame work of internal and external envisaged and followed over a period, on individual farm units or on the aggregate area of a village, district, state or the country as a whole.

Therefore it would be interesting to analyze statistically the shifting distribution of land among various crops. This type of problem is more important as land holdings are becoming the most limited resources. Moreover, simple analysis of the shift in cropping pattern alone is not sufficient. With this background in view, the present paper deals to study the shifts in area, production and productivity levels of various crops grown in Haryana state as a whole and the

three zones of Haryana *viz.*, Arid, Semi-Arid, Sub-Humid under kharif season. The study has been based on 35 years of data (1976-77 to 2010-11) on the three zones of Haryana and Haryana state as a whole.

The time-series data of the 'n' years was subjected to cluster analysis (corresponding to the years). Each cluster, thus represent a period of years with similar year-to-year fluctuation i.e., each cluster represents a certain level of "shift" in the cropping pattern.

A review of earlier attempts revealed that the principal component approach could also be applied under certain classification studies. However, the approach has the limitation of subjectivity in the cluster formation. Further, when the dimension space exceeds two, the plotting of scores was not convenient. Hence, a modification was proposed to deal with the present situation. To reduce the complexity in plotting the scores in p-dimensions, the data on p-variable z_j (j = 1, p) was subjected to cluster analysis, by applying the Ward's method.

Material & Methods :

Study of shifts in the cropping pattern is essentially a study of temporal variation in the area under the crops. Hence, these shifts can be conveniently studied by applying the methods of cluster analysis. Through this analysis, the periods of "similar" cropping pattern can be identified instead of arbitrarily selecting them as is involved in most of the studies which apply measures such as averages and growth rates for studying the levels of shifts.

The approach of cluster analysis can be defined under the two situations of data as follows:

1. Single Sample situation:

Let X_1, ..., 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.

2. Multi-Sample situation:

Suppose that the 'n' objects, which are to be clustered, have each nj observations(j = 1...n). These are recorded by drawing a random sample on the objects. Let Xij be the ith observation vector corresponding to the jth object or sample (i = 1... nj; j =1,..,n). In this situation, the data on n samples are to be classified into g (<n) homogeneous groups.

Cropping Pattern of a region refers to the various crops raised on a given area during the season. The allocation of area to different crops may vary year-wise. This year-to-year variation could be due to several factors such as the socio-economic factors and the technological innovations in the crop, in addition to the weather. The year-to-year variations in the area under the crops would normally fluctuate around a mean value. However, the technological impact (if any) would be observed in the form of sudden 'jumps' (quantal jumps). These jumps are referred as shifts. Whenever a shift occurs in the area of a crop, it leads to either an increase or decrease in the area under the other crop(s), as the total cropped area during the season is fixed. The area allocation under the crops during a year is therefore not an independent process. In the light of this inter-dependent structure, study of shifts independently with regard to any specified crop(s) may not attribute to the study of "shifts in cropping pattern".

A multivariate approach, which considers collectively the allocation of area under the different crops that define the cropping pattern, would be reasonable. Studying the shifts is hence a study of temporal variations in the area under the crops.

- **Cluster analysis approach.**

Let X be a random vector consisting of p variables. The variables represent the area under crops raised in the region during a season. Suppose that time series data for n years are available in k-variate observation vector, then n×p data matrix is given as

Variables
(crop characteristics)

$$\mathbf{X} = \begin{pmatrix} X_{11} & X_{12} \cdots\cdots\cdots & X_{1p} \\ X_{21} & X_{12} \cdots\cdots\cdots & X_{2p} \\ X_{n1} & X_{n2} \cdots\cdots\cdots & X_{1p} \end{pmatrix}$$

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×n proximity matrix from n×p data matrix is derived as:

- <u>**Proximity Matrices Derived from Data Matrices:**</u>

A proximity matrix is an (n × n) matrix that summarizes the degree of similarity or dissimilarity among all possible pairs of profiles in X. The p columns of X are usually referred to as variables whereas the n rows are commonly called the profiles or patterns of the observational units. A profile is simply a vector or measurements whose elements are to be compared. Here the profiles are the n (1×p) vectors that constitute X. This matrix is denoted by D with elements dr s, r,s = 1, 2 …., n. The elements drs denotes the proximity measure between the observational units r and s, the matrix XX' is an example of a proximity matrix.

Objects (years)

$$D = \mathbf{X}\,\mathbf{X}' = \begin{pmatrix} d_{11} & d_{12} & \cdots & d_{1s} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2s} & \cdots & d_{2n} \\ \vdots & & & & & \\ d_{r1} & d_{r2} & \cdots & d_{rs} & \cdots & d_{rn} \\ \vdots & & & & & \\ d_{n1} & d_{n2} & \cdots & d_{ns} & \cdots & d_{nn} \end{pmatrix}$$

A variety of measures of proximity are introduced in the study of cluster analysis, which constitute the proximity matrix, are given as:

- **THE MEASUREMENT OF PROXIMITY BETWEEN OBJECTS (YEARS IN THE PRESENT STUDY):**

Proximity measures usually reflect the degree of similarity or the degree of dissimilarity. As two objects become more similar, the value of a similarity measure increases whereas the corresponding dissimilarity measure declines in value. The two types of proximity measures have been used in this study.

- **Similarity and Dissimilarity**

A proximity measure drs is a measure of dissimilarity if drs satisfies the following:

1. drs > 0 for all objects r, s;
2. drs = 0 if objects r and s are identical;
3. drs = dsr.

The most commonly used measure of dissimilarity is the Euclidean distance. At alternative measure of dissimilarity is the Mahalanobis distance between two observations. Dissimilarity measures are commonly referred to as distance-type measures. Proximity matrix is based on any one of the following measures of dissimilarity and similarity depending upon the choice of particular cluster analysis techniques.

- Euclidean Distance
- Using Mean Centered Variables
- Euclidean Distance in Matrix Form
- Standardized Euclidean Distance
- Mahalanobis Distance and Multivariate Distance

▪ **Correlation Type Measures of Similarity:**

An alternative approach, to the measurements of proximity between two points "r and s" in a p-dimensional space, is to use the angle between the two (px1) vectors of observations xr and xs. The two points can be viewed as tips of vectors drawn from the origin with an angle between the two vectors. A useful measure of similarity is the cosine of the angle.

In general, the cosine of the angle between the vectors xr and xs is given by

$$C_{rs} = \frac{\sum_{j=1}^{p} x_r x_s}{\sqrt{\sum_{j=1}^{p} x_{rj}^2 \sum_{j=1}^{p} x_{sj}^2}}$$

C_{rs} does not depend on the lengths of the two vectors, and hence proportional changes in the coordinates x_r and/or x_s will not change C_{rs}. The resulting correlation coefficient of similarity measures is equal to

$$Q_{rs} = \frac{\sum_{j=1}^{p}(x_{rj} - \bar{x}_r)(x_{sj} - \bar{x}_s)}{\sqrt{\sum_{j=1}^{p}(x_{rj} - \bar{x}_r)^2 \sum_{j-1}^{p}(x_{sj} - \bar{x}_s)^2}}$$

The measures *Crs* and *Qrs* are often called Q type measures of similarity.

Once settled on the choice of an appropriate similarity or dissimilarity measures, the n×n proximity matrix can be obtained from these measures, after this a particular method of cluster analysis can be applied to this proximity matrix of the objects (i.e. the years) to cluster them in different clusters which are homogenous within and heterogeneous between. This analysis would provide clusters with years of similar.

The method for clustering was selected from the methods described as follows:

- **Methods of cluster analysis:**

Everitt (1974) classified the different methods of clustering into the following approaches.

1. Optimization/Partitioning Methods
2. Hierarchical Methods
3. Density Search Methods
4. Clumping Methods
5. Ordination Methods
6. K-mean clustering method

In this study, since we have used Hierarchical Methods , they are described below:

- **Hierarchical Methods:**

The hierarchical methods were developed mostly for describing taxonomic structures. These methods involve computation of ‘distances’ or similarities between the pair of objects, which are to be clustered. A comparison of such similarity coefficients among the pairs of objects finally leads to a tree diagram referred as “Dendrogram”. From this “Dendrogram”, the clusters of homogeneous units are identified.

The different methods that are grouped under the hierarchical approach are

i) Single Linkage Method (Nearest Neighbour Method):

ii) Complete linkage or the furthest neighbour method:

iii) Average Linkage method:

iv) Centroid Method:

v) Divisive Method:

vi) Ward's Minimum Variance Method:

- **Choosing a 'Best' Clustering Techniques:**

The increasing number of cluster analysis methods available has led several authors to consider the perplexing problem of choosing a 'best' method in some sense. Fisher and Van Ness (1971), for example, while not considering this problem to be defined well enough for a complete solution, suggest various admissibility conditions which they suggest will eliminate obviously bad clustering algorithms. Jardine and Sibson (1968) made some recommendations regarding which techniques are acceptable and which are not. Whilst such theoretical approaches to this problem may be illuminating in various respects, they have not led to results acceptable in practice, and it appears unlikely that the relations between different methods and data types will be untangled solely by formal analysis and argument. An alternative and very promising approach to understanding and evaluating the variety of clustering techniques available is to compare the effectiveness of different methods across a variety of data sets

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, 1970). The years (i.e. the objects) 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 distances are represented in the form of a tree diagram, referred as dendogram. 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 d2ij (i,j = 1, ...,n) are computed corresponding to all possible pairs of objects. These distances form the matrix D0. From D0, the pair of objects having the least ½ d2ij is grouped to form the initial cluster, say C(1). 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 d2ij 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 Di [i = 1, ...] on the basis of D(1) and the search for the fusion of clusters is continued till al the fusion of clusters are combined into a single cluster. The values of Di during each step of fusion provide 'links' or distances between the clusters and the objects 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 computed as follows:

$$\left|C_{(i)}. - C_{(j)}\right| = \frac{n_{(i)}n_{(j)}}{n_{(i)} + n_{(j)}}\left|x_{(i)} - x_{(j)}\right|^2$$

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.

Area of study:

For the present study, the Haryana State has been divided into three agro climatic zones viz. arid, semiarid and sub-humid zones (Gupta et al., 1989). A brief description of these zones is given in the table below. It may be mentioned here that the districts having maximum area similar to adjacent zone has been included in that zone for administrative as well as operational convenience.

S. No.	Zone	Districts	Rain fall	Imp. Crops
1	Sub humid zone	Pan h ul a,Amba la , Yamuna Nagar	100 cm	Rice, Maize, Wheat, G. Nut, Sugar cane
2	Semi-arid zone	Kurukshetra, Karnal , Kaithal, J ind, S onepat,pan ipat , Gurgaon, Faridabad, Rohtak, Jhajjar	40-100 cm	Cereals, Pulses, Cotton, Oilseed, Veg. And Fruit. Crops
3	Arid-zone	S irsa , Fatehabad,H isar, Bhiwani, Mahindargarh, Rewari	40 cm	Cereals, Cotton, Pulses, Oilseed Veg. And Fruit crops

Analysis of crop data has been carried out corresponding to the data on the kharif (Rainy) season. The observation vector, which represent the cropping pattern is defined with 7 variables representing the area under 7 crops during kharif season. The crops are considered as Rice, Jowar, Bajra, Maize, Moong , Groundnut and Cotton. The crops were selected with respect to their relative importance.

- **Data Collection and Data analysis:**

The study was based on the data covering 1976-77 to 2010-2011 for the three agro-climatic zones of Haryana state. The relevant crop wise data and season wise data on total area of crops, crop production and crop productivity (kg/ha) have been collected from the statistical Abstracts of Haryana. The analysis of data has been carried out with the help of SYSTAT and WINDOSTAT package.

- **Results and Discussion:**
- **Shifts in the crop characteristics under kharif season.**

It may be mentioned that for obtaining the clusters corresponding to the crop characteristics (i.e., area, production and productivity), the time-series data on different crops was standardized to account for the differences in the range of the values of the crop variables.

- **Shifts in area under the crops:**

The results of shifts in the area under the different crops over the years under study are represented with 4 clusters in **Table 1**. It can be observed that on the aggregate level of the entire state of Haryana the rice crop recorded an increase in area in all the periods as from periods I to II, the increase was 87.02 per cent, from period II to III the increase was comparatively marginal (11.88 percent) and for period IV there was 47.69 percent increase in area under rice.

Jowar and bajra registered a decrease of 30.16 and 14.07 percent respectively in area during the period II over period I, then in the period III a decrease of 14.00 and 25.33 percent respectively and finally again there was a decrease in period IV i.e. 0.40 and 1.20 percent respectively which was relatively low. Maize recorded a decrease of 44.83, 40.30 and 28.62 percent in period II, III and IV respectively. Moong exhibited a different trend. This crop has recorded an increase in area in all periods except for the period II where it showed a decrease of 57.02 percent. In periods III and IV there was an increase of 13.91 and 64.93 percent respectively. Groundnut has shown a decrease of 35.84 percent from period I to II, then a decrease of 53.98 percent from period II to III and finally a decrease of 44.444 percent from period III to IV. Whereas cotton exhibited an increase in area in all periods i.e. 49.72 percent from period I to II, 33.41 percent from period II to III and 22.57 percent in period IV. It can also be seen that the rice crop in period IV had relatively maximum area with an average 918.69 thousand hectares whereas, ground nut crop in the period IV has recorded relatively low area with an average of 1.70 thousand hectare **(Table 1)**.

Table 1: Shifts in area under the kharif crops in Haryana (1976-77 to 2010-11)

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	297.28	195.78	908.31	106.88	14.14	10.36	241.91
II	% Shift	87.02	-30.16	-14.07	-44.83	-57.02	-35.84	49.72
III	% Shift	11.88	-14.00	-25.33	-40.30	13.91	-53.98	33.41
IV	% Shift	47.69	-0.40	-1.02	-28.62	64.93	-44.44	22.57

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1988-89, 1990-91
II	1989-90, 1991-92 to 1996-97, 1998-99
III	1997-98, 1999-2000 to 2002-2003
IV	2003-2004 to 2010-11

Shifts in Production of the kharif crops:

The results of temporal variation in the production of crops as identified through the cluster analysis are presented in **Table 2**.

Table 2: Shifts in production of the kharif crops in Haryana (1976-77 to 2010-11)

Cluster		Rice	Jowar	Bajra	Maize	Moong	G. Nut	Cotton
I	Mean	453.18	46.18	474.64	122.36	7.81	9.98	401.30
II	% Shift	181.71	-33.05	-8.95	-47.29	-54.22	-33.55	69.86
III	% Shift	45.89	19.68	6.29	-23.77	1.17	-73.36	83.52
IV	% Shift	33.86	-27.93	41.51	-12.20	16.59	-36.79	0.53

* % shift refers to the shift over the earlier period.

Cluster	Period
I	1976-77 to 1986-87
II	1987-88 to 1998-99
III	1999-2000 to 2003-2004, 2005-06
IV	2004-2005, 2006-07 to 2010-11

It can be observed that certain crops like rice and cotton recorded a continuous increase in the production levels from period I to IV. Production of rice recorded an increase of 181.71, 45.89 and 33.86 percent in periods II, III and IV respectively; whereas cotton recorded an increase of 69.86, 83.52 and 0.53 percent in periods II, III and IV respectively.

Maize and groundnut recorded a continuous decrease in production in all the periods as from period I to II the decrease was 47.29 and 33.55 percent respectively, from period II to III decrease recorded was 23.77 and 73.36 percent respectively and from period III to IV the decrease in production of these crops were 12.20 and 36.79 respectively.

In case of the crop jowar, bajra and moong a different trend was observed. Production of jowar first decreased (33.05 percent) in period II, then increased (19.68 percent) in period III and then again there was a decrease of 27.93 percent in period IV. Production of bajra first decreased (8.95 percent) in II period, then it was increased continuously in III and IV period (6.29 and 41.91 percent). Similarly production of moong was decreased from period I to II and the decrease was of 54.22 percent. There after there was a continuous increase in production from II to III period (1.17 percent) and from III to IV period (16.57 percent). It can be observed that rice crop in the period IV has relatively maximum production level with an average of 2493.17 thousand tonnes; whereas groundnut in the same period recorded relatively minimum production level with an average 1.12 thousand tonnes. This crop registered continuous decrease in the production level from period I to IV.

Table 3: Shifts in productivity of the kharif crops in Haryana

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	1654.58	215.33	519.42	1021.75	410.00	899.17	587.50
II	% Shift	55.14	6.95	2.81	7.59	76.05	7.10	3.15
III	% Shift	6.85	28.91	81.27	38.12	-32.44	-21.25	-35.61
IV	% Shift	-14.27	-29.77	-2.09	39.03	-55.19	-6.97	-8.90

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1985-86, 1989-90, 1997-98
II	1986-87 to 1988-89, 1990-91 to 1996-97
III	1998-99 to 2004-05, 2006-07, 2007-08
IV	2005-06, 2008 –09 to 2010-11

Table 4: Shifts in area under the kharif crops in Arid Zone

Cluster		Rice	Jowar	Bajra	Maize	Moong	G. Nut	Cotton
I	Mean	19.32	34.73	564.96	3.90	14.55	0.35	179.02
II	% Shift	145.10	-62.65	-9.37	-45.70	-68.41	342.09	67.99
III	% Shift	51.11	-38.28	-23.38	-60.33	70.25	-36.49	42.81
IV	% Shift	18.95	41.04	0.82	26.04	8.01	-64.79	29.47

* % shift refers to the shift over the earlier period.

Cluster	Period
I	1976-77 to 1987-88
II	1988-89 to 1996-97, 1998-99
III	2005-06, 2006-07
IV	1997-98, 1999-2000 to 2004-05, 2007-08 to 2010-11

Table 5: Shifts in production of the kharif crops in Arid Zone

Cluster		Rice	Jowar	Bajra	Maize	Moong	G. Nut	Cotton
I	Mean	36.19	7.50	276.50	3.78	6.50	0.39	341.80
II	% Shift	287.47	-60.29	-8.89	-63.90	-53.29	259.38	89.21
III	% Shift	63.59	-7.72	18.57	-53.68	3.95	-72.86	66.98
IV	% Shift	23.73	14.05	64.48	67.41	20.23	23.87	19.12

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1987-88
II	1988-89 to 1998-99, 2007-08, 2008-99
III	1999-2000 to 2001 -02, 2003-04, 2005-06, 2009-10, 2010-11
IV	2002-03, 2004-05, 2006-07

Table 6: Shifts in productivity of the kharif crops in Arid zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	737.38	197.43	468.35	448.48	304.75	722.43	381.51
II	% Shift	92.32	16.96	18.74	-27.31	7.92	14.97	24.28
III	% Shift	1.21	-25.57	-6.41	-13.81	23.05	-27.54	-46.25
IV	% Shift	0.96	6.92	95.47	-19.66	-23.79	-14.51	5.99

* % Shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1984-85, 1989-90
II	1985-86 to 1988-89, 1990-91 to 1995-96
III	1996-97, 1997-98, 1999-2000, 2001-02, 2003-04, 2005-06
IV	1998-99, 2000-01, 2002-03, 2004-05, 2006-07 to 2010-11

Table 7: Shifts in area under the kharif crops in Sub – Humid Zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	46.81	0.67	5.42	40.17	0.05	9.62	2.29
II	% Shift	45.51	-77.13	-34.65	-16.02	71.15	-39.87	12.48
III	% Shift	55.35	-9.15	-5.95	-29.21	46.07	-69.64	-61.87
IV	% Shift	22.15	-13.67	-31.29	-27.76	15.38	-76.54	-87.28

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1987-88, 1997-98
II	1988-89, 1992-93, 1994-95 to 1996-97, 1998-99
III	1993-94, 1999-2000 to 2006-07
IV	2007-08 to 2010-11

Table 8: Shifts in production of the kharif crops in Sub – Humid Zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	78.53	0.01	2.53	43.47	0.06	8.08	2.74
II	% Shift	124.12	0.00	-7.75	-2.62	50.82	-57.69	3.51
III	% Shift	63.64	100.00	0.81	-8.66	-54.35	-66.34	-87.36
IV	% Shift	25.81	50.00	78.87	-7.33	7.14	-56.78	-89.39

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1989-90, 1991-92, 1992-93, 1997-98
II	1990-91, 1993-94 to 1996-97, 1998-99
III	1999-2000, 2003-04, 2005-06
IV	2004-05, 2006-07 to 2010-11

Table 9: Shifts in productivity of the kharif crops in Sub – Humid Zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	1167.20	113.00	530.70	1109.80	255.46	888.40	50.00
II	% Shift	67.31	-55.75	0.92	2.84	-16.67	18.80	0.00
III	% Shift	33.24	0.00	20.86	25.18	0.68	-28.18	69.92
IV	% Shift	13.34	0.00	49.22	37.77	-2.79	-7.11	-41.15

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1984-85, 1989-90
II	1985-86 to 1988-89, 1990-91 to 1992-93
III	1993-94 to 2001-02, 2003-04, 2005-06, 2008-09
IV	2002-03, 2004-55, 2006-07, 2007-08, 2009-10, 20100-11

Table 10: Shifts in area under the kharif crops in Semi – Arid Zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	209.59	169.51	331.80	66.41	1.27	0.62	43.65
II	% Shift	89.06	-26.28	-3.70	-52.76	-7.58	67.32	4.74
III	% Shift	16.99	-6.05	-39.15	-48.36	-39.62	-41.01	20.95
IV	% Shift	43.80	10.87	-11.52	-70.70	48.51	71.99	33.58

* % shift refers to the shift over the earlier period.

Cluster	**Period**
I	1976-77 to 1987-88
II	1988-89 to 1994-95
III	1995-96 to 2001-02
IV	2002-03 to 2010-11

Table 11: Shifts in production of the kharif crops in Semi – Arid Zone

Cluster		**Rice**	**Jowar**	**Bajra**	**Maize**	**Moong**	**G. Nut**	**Cotton**
I	Mean	333.14	39.10	219.70	69.80	1.31	0.58	50.36
II	% Shift	185.27	-21.98	-14.28	-59.47	-38.02	24.14	28.68
III	% Shift	43.21	5.42	-12.96	-57.67	-17.61	-26.90	64.87
IV	% Shift	31.95	-23.11	23.27	-45.28	-59.04	6.42	5.59

* % shift refers to the shift over the earlier period.

Cluster **Period**

I 1976-77 to 1985-86

II 1986-87 to 1994-95, 1996-97 to 1998-99

III 1995-96, 1999-2000 to 2005-06

IV 2006-07 to 2010-11

Table 12: Shifts in productivity of the kharif crops in Semi – Arid Zone

Cluster		Rice	Jowar	Bajra	Maize	Moong	G. Nut	Cotton
I	Mean	1411.76	236.20	636.96	879.81	188.00	575.61	213.86
II	% Shift	47.17	23.30	7.47	-27.66	66.30	11.13	-28.25
III	% Shift	3.58	-21.24	18.54	8.76	17.66	-60.94	11.44
IV	% Shift	21.52	14.61	16.63	27.45	14.72	14.09	9.64

* % shift refers to the shift over the earlier period.

Cluster **Period**

I 1976-77 to 1985-86, 1989-90

II 1986-87 to 1988-89, 1990-91 to 1995-96, 1998-99

III 1996-97 to 1999-2000, 2005-06, 2008-09 to 2010-11

IV 2000-01 to 2004-05, 2006-07, 2007-08

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