

Changes In Crop Combination Regions In Rajasthan: A Geographical Analysis

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ABSTRACT:

The significance of combinational analysis in geography increasing day by day. Because these through light on the nature of cropping pattern of region/state/nation, whether is of diversified or specialized. Secondly, it helps for delineate the agricultural regions. The major objective of the present study is to demarcate the crop combinations of Rajasthan and highlight the changes in crop combination regions. It is of threefold. First part deals with crop combination regions of 1994-95 and 2014-15. While, in second part changes in crop combinations and reasons responsible are discussed. Whereas, in third part conclusions are drawn. The study has found that in 1994-95, there were 26 crop combinations which are grouped into 13 on the basis of first two crops. While, in 2014-15 the number of crops has remained same. Crop combinations of two time periods reveals that cropping pattern of Rajasthan is of highly diversified. During study period, there was change in the nature of crop combinations. Because in 1994-95, the overall crop combination of Rajasthan was bajra-pulses-oilseeds-wheat-grams. But in 2014-15, it has changed to oilseeds- guar- bajra- pulses-wheat. Similar in the case with crop combinations at district levels. All these changes are the result of changes in socio-economic-technological and organisational factors. The present study is based on secondary sources of data, for deriving the crop combinations Doi's method is used. For presenting the results cartographic techniques are used. The unit of study is district. Two time periods are taken i.e. 1994-95 and 2014-15. Three years' averages are taken for each time period.

Keywords: *Crop combination, cropping pattern, diversification, technological, irrigation.*

INTRODUCTION:

Combinational analysis refers to the geophysical investigation of agriculture that aims to select various crops or agricultural elements to be studied collectively in an area. Combinational analysis identifies the spatial characteristics of an agricultural element such as spatial distribution of crops with their arrangement in the cropping pattern (Singh & Dhillon, 1994). Crops are commonly grown in combination and the study of crop combination prepares the ground for the demarcation of agricultural regions. It provides adequate knowledge about the geo-climatic conditions of the individual crops of existing cropping pattern of a region. Moreover, the study of crop combination is also helpful to arrange the individual crops in ranking order among the cropping pattern of a region. Raghunathan (2019) mentioned that the crop combination is a scientific study which defines the

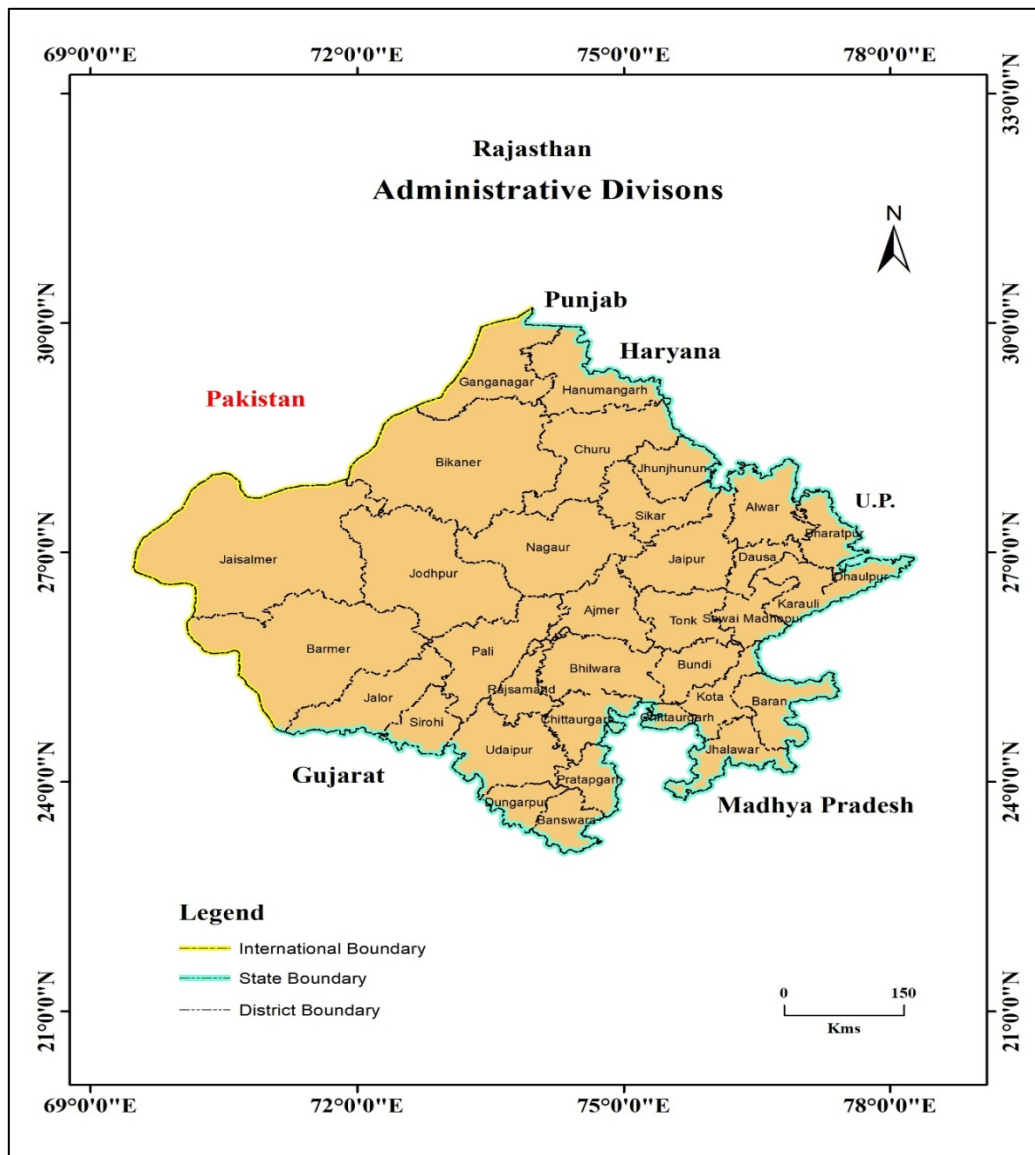
characteristic features of existing crops as well as of agricultural land use. It develops the understanding of the dominating

agricultural activities of a region which are the basic requirements for planning and development of agriculture. While, Deshmukh (2017) found that association among the crops indicate whether food crops are dominant or non-food crops in a prevailing region and thus, forms a basic understanding for delineation of agricultural regions. Sharma and Tiwari (2012) in his study stated that a crop combination region provides significant features for agricultural geography and also gives an idea about the agronomic topology. Sharma & Sharma (2015) has deduced that study of crop combination not only helps in demarcation of agricultural regions but also frames basic understanding for planners for further development. Crop combinational study has gained more importance in the field of agriculture in recent years and importance of this study is increasing day by day. Husain (1997) has highlighted the significant position of crop combinational study in agriculture. He further revealed that a systematic study of crop combinations provides strong and ample understanding of the agricultural mosaic of an agro-climatic region and for the development and planning. Thus, crop combinational regions are useful in many ways. Firstly, it provides adequate knowledge about the geography of specific crops existing in the cropping pattern of a region. secondly, it indicates the relationship among crops. thirdly, helpful in demarcation of agricultural regions which further useful for complex studies. Fourthly, crop combination regions can be used to determine whether a particular combination will result in dietary adequacy or inadequacy. Originally, the study of crop combinations was introduced by Weaver in 1954 while doing study of crop combinations in Midwestern United States. Individual systematic components of geography are frequently researched individually and for themselves alone, as weaver correctly noted. Similar to how defining and interpreting a geographic pattern of soils without taking climate and soils into account only results in a partial structure of integrated understanding, observing one specific crop without taking into account its immediate cultivated companion can only eliminate a small portion of the larger mosaic of land use. Characteristically, crops are grown in association and for the successful understanding of agricultural features and geographical patterns the best is to do the combinational analysis of crops i.e crop combinational analysis. The present study deals with spatial patterns of crop combinations of Rajasthan of 1994-95 and 2014-15.

STUDY AREA:

Rajasthan is situated in the north- western part of India. It extends from $23^{\circ} 3' N$ to $30^{\circ} 12' N$ latitudes and $69^{\circ} 30' E$ to $78^{\circ} 17' E$ longitudes, covering an area of about 342,274 square kilometres. It forms international boundary with Pakistan in the West, while neighbouring states are Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Gujarat. The Thar desert of Rajasthan is part of great plains while rest of Rajasthan belongs to peninsular India. Here, average annual rainfall is 50 cms and maximum temperature reaches up to $51^{\circ} C$ in Sri Ganganagar district. The coefficient of variability in annual rainfall is over 65 per cent. There are two climatic zones; arid and semi-arid.

Fig. 1



Source: Census of India, 2011.

Here, soils vary from sandy to clayey. Its total population is 68,548,347 persons, of which male and female are 35,550,997 and 32,997,440 respectively, according to 2011 census. The average density of Rajasthan is 200 persons per sq. kilometres in 2011. The number of districts in Rajasthan are 33 in 2014-15.

HYPOTHESIS:

1. The geo-climatic conditions often affect the nature of crop combinations.
2. Increased irrigational facilities stimulates the process of agricultural modernization, which leads to changes in crop combination regions.

OBJECTIVES:

1. To demarcate crop combination regions and changes.
2. To highlight the factors responsible for changes in crop combination regions.
3. To examine the patterns of dominance of cereal and non-cereal crops.

METHODOLOGY:

The paper in hand is empirical in nature and is based on secondary sources of data which is obtained from economic and statistical organisation, Rajasthan. The unit of study is district. Three time periods of 1994-95, 2004-05 and 2014-15 are selected and for each time period three year's average is taken like 1993-94, 1994-95 and 1995-96, etc. Simple statistical methods and simple choropleth technique are applied.

DOI'S METHOD:

This approach relates to the minimum deviation family. Doi suggested a small change to Weaver's formula by replacing d^2/n with d^2 or the sum of the squared differences in order to get around Weaver's overgeneralization. The major crop combinations match the weaver's process exactly. In Doi's technique, the crop combination is actually determined by consulting a one-sheet table that presents critical values for various factors at higher rankings for an agricultural geographer; elements include crops, animals, or enterprises. It is necessary to add up real percentages and theoretical distributions when using a one-sheet table. Table is an abridged format of one sheet table of Doi's method.

$$\sigma = (\sum d^2)$$

Thus, the crop combination is actually established by a single sheet table that compares critical values for various elements at various ranks to cumulative percentages of

elements at higher ranks, therefore with this technique it is not necessary to calculate ($\sum d^2$) for each combination. Later on, he introduced sheet table for deriving the crop combinations which is as follows;

An abridged part of the deviation analysis table (one sheet table)

Table:1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| 95 | | | | | | | | | | 6.98 | 6.27 | 95 |
| 90 | | | | | | | 8.84 | 7.60 | 6.67 | 5.94 | 5.35 | 90 |
| 85 | | | | 12.93 | 10.00 | 8.17 | 6.91 | 5.99 | 5.29 | 4.73 | 4.29 | 85 |
| 80 | | | 13.83 | 10.00 | 7.85 | 6.46 | 5.49 | 4.78 | 4.23 | 3.79 | 3.33 | 80 |
| 75 | | 16.67 | 10.57 | 7.75 | 6.13 | 5.06 | 4.32 | 3.76 | 3.33 | 2.99 | 2.71 | 75 |
| 70 | 27.64 | 12.25 | 7.93 | 5.96 | 4.65 | 3.85 | 3.29 | 2.87 | 2.55 | 2.29 | 2.08 | 70 |
| 65 | 18.38 | 8.66 | 5.63 | 4.19 | 3.34 | 2.77 | 2.37 | 2.07 | 1.84 | 1.65 | 1.50 | 65 |
| 60 | 11.27 | 5.46 | 3.59 | 2.68 | 2.14 | 1.78 | 1.52 | 1.33 | 1.18 | 1.06 | 0.97 | 60 |
| 55 | 5.38 | 2.68 | 1.73 | 1.29 | 1.04 | 0.86 | 0.74 | 0.64 | 0.57 | 0.52 | 0.47 | 55 |
| 50 | .000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Source: Doi, Kikukazu, “The industrial structure of Japanese Prefectures”, Tokyo, Proceedings of the International Geographical Union Section on Human Geography, Regional Conference in Japan, 1957.

DISCUSSION:

1. Spatial pattern of crop combinations :1994-95
2. Spatial patterns of crop combinations:2014-15
3. Changes in crop combinations:1994-95 to 2014-15

CROP COMBINATION REGIONS AFTER DOI’S METHOD: 1994-95

According to Doi’s method, there was registered 26 crop combinations which collected into 13 major crop regions on the basis of first two crops for discussion purpose. These major crop combinations were;

1. Maize- wheat crop combinations:

This major combination was found in southern parts and had four sub- crop combinations namely; maize-wheat, maize-wheat-pulses, maize-wheat-pulses-jowar, maize-wheat-pulses-rice. These were maize –wheat crop combination in Rajasmand, maize-wheat-pulses crop combination in Udaipur district, maize-wheat-pulses-rice crop combination in Bhilwara and maize-wheat-pulses-jowar crop combination in Chittaurgarh district. Main reasons for maize-wheat crop combination in Rajasmand district were high rainfall during summers followed by irrigation which can be provided to wheat in winters. In Bhilwara district, on

highlands or rain shadow areas pulses were grown, while on low lands rice was grown. In case of Udaipur and Chittaurgarh districts, pulses were grown in areas of low rainfall without irrigation facilities and in Chittaurgarh district pulses and jowar were grown in areas of low irrigation facilities and high lands. Pulses were grown in kharif as well as well in rabi season.

2. Bajra-guar crop combination:

Bajra-guar crop combination had its existence in extreme western parts of Rajasthan, covering two districts of Jaisalmer and Barmer with 6.06 per cent of the total occurrences. Bajra was leading crop in the cropping pattern of these districts followed by guar. Owing to high temperature, low rainfall, frequent occurrence of sand dunes, sandy soils with low fertility, inadequate irrigational facilities, etc. farmers preferred to cultivate these crops as major crops. Moreover, bajra and guar were drought prone crops and had potentiality to survive in these hot and dry climatic conditions. Also guar crop belongs to leguminous crop family and play significant role to increase the soil fertility by fixing nitrogen content. Hence, bajra-guar combination was exiting and these crops had combinedly over 80 per cent area under their cultivation in each district in 1994-95.

3. Pulses-bajra crop combination:

Pulses-bajra crop combination region had covered two districts Bikaner and Churu which belong to arid Rajasthan. In these districts, pulses and bajra were the predominant crops owing to favourable physical and socio-economic conditions. While, guar was another crop of this combination which introduced sub- crop combination region of pulses-bajra-guar. As a two crop combination region, it comprised district of Bikaner and had a one sub -crop combination region of pulses-bajra-Guar which covered the district of Churu.

4. Maize-pulses crop combination:

It laid in extreme southern parts of the study region, comprising three districts namely; Dungarpur, Banswara and Partapgarh. These are areas of high rainfall, high extent of irrigation, variety of soils (red & yellow, mixed red & black, ferruginous red soils), etc. These reasons are responsible for cultivation of number of crops which resulted into three sub-crop combinations which are maize-pulses-rice-wheat crop combination in Banswara and Partapgarh districts, maize-wheat-rice-wheat crop combination in Dungarpur district. Here on slanting slopes farmers grew maize, rice

in comparatively low lying areas, wheat in plain areas and pulses wherever rainfall is comparatively less owing to rain shadow areas.

5. Pulses-oilseeds crop combination;

This crop combination was found in only Jhalawar district, where though soils were fertile with medium black color, high rainfall, high extent of irrigation but being a part of Deccan lava topography was mainly of stoniness. Thus, wherever some patches of soils were found, farmers grew crops such as pulses, oilseeds, jowar, maize and spices, etc. intensively. Moreover, these soils were not so fertile and farmers selected those crops which can grow in less fertile soils. Hence, pulses-oilseeds-jowar-maize-spices crop combination was existing.

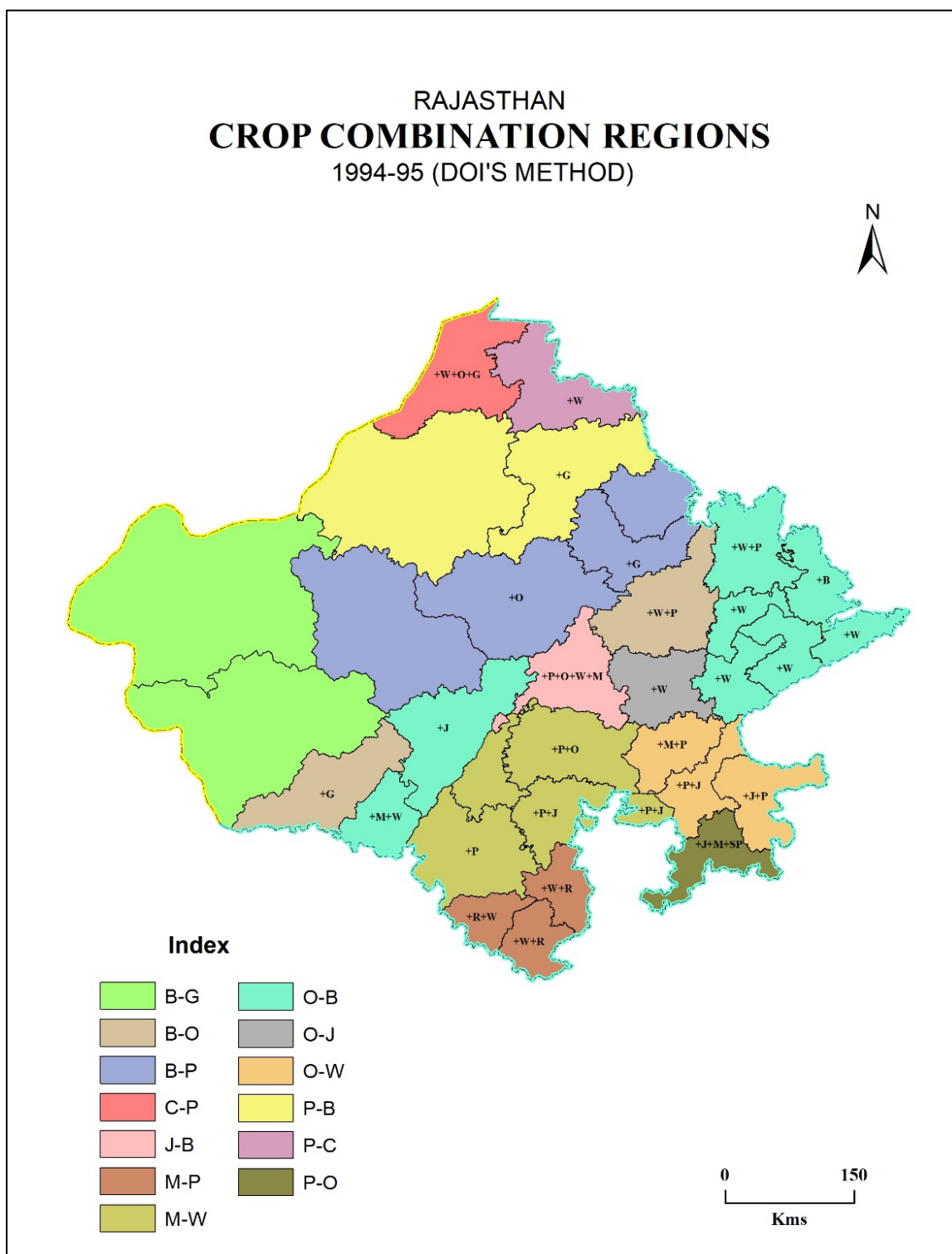
6. Pulses-cotton crop combination:

Pulses-cotton crop combination had only one crop combination namely; pulses-cotton-wheat which was found in district of Hanumangarh, lying in the northern tip of Rajasthan. Wheat was third ranking crop and all other crops were far away in respect of per cent area. Thus, pulses-cotton-wheat crop combination had emerged due to due to high extent of irrigation, soils with moderate in fertility, developed agricultural infrastructure, awareness among farmers, higher economic returns, etc. All these factors made the farmers conscious about the right choice for the selection of crops to be grown and hence, pulses-cotton-wheat crop combination was noted.

7. Cotton-pulses crop combination:

Ganganagar district, covering the extreme northern part of state had cotton-pulses-wheat-oilseeds-guar crop combination. Cotton was the major crop of this district and having more than 20 per cent area under its cultivation. The responsible factors were high temperature, alluvial to sandy soils, availability of adequate canal irrigation, risk oriented and well awakened migrated Punjabi farmers, etc. Additional major crops with cotton were pulses, wheat, oilseeds and guar. Moreover, Ganganagar district had comparatively developed agricultural infrastructure, which resulted into major share of market oriented crops rather than food crops.

Fig. 2



Source: Economic and Statistical Organisation of Rajasthan, Jaipur.

Crop combinations after Doi's Method

Table:2

| Sr. no. | Districts | 1994-95 | 2014-15 | Changes |
|---------|--------------|----------------|----------------|---------|
| 1. | Ajmer | J-B-P-O-W-M(6) | P-J-B-O-W-M(6) | - |
| 2. | Jaipur | B-O-W-P(4) | B-P-O-W(4) | - |
| 3. | Dausa | O-B-W(3) | B-O-W(3) | - |
| 4. | Tonk | O-J-W(3) | O-P-W(3) | - |
| 5. | Sikar | B-P-G(3) | B-G-W-P-O(5) | +2 |
| 6. | Jhunjhunu | B-P(2) | B-G-P-W-O(5) | +3 |
| 7. | Nagaur | B-P-O(3) | P-B-G-O(4) | +1 |
| 8. | Alwar | O-B-W-P(4) | B-O-W(3) | -1 |
| 9. | Bharatpur | O-B-J(3) | O-W-B(3) | - |
| 10. | Dhaulpur | O-B-W(3) | B-O-W(3) | - |
| 11. | S.Madhupur | O-B-W(3) | O-W-B(3) | - |
| 12. | Karauli | O-B-W(3) | B-O-W(3) | - |
| 13. | Bikaner | P-B(2) | G-P(2) | - |
| 14. | Churu | P-B-G(3) | P-G-B(3) | - |
| 15. | Jaisalmer | B-G(2) | G-P(2) | - |
| 16. | Ganganagar | C-P-W-O-G(5) | G-W-O(3) | -2 |
| 17. | Hanumangarh | P-C-W(3) | G-W-C(3) | - |
| 18. | Jodhpur | B-P(2) | B-O-G-P-SP(5) | +3 |
| 19. | Barmer | B-G(2) | B-G-P(3) | +1 |
| 20. | Jalore | B-O-G(3) | B-O-P-G(4) | +1 |
| 21. | Pali | O-B-J(3) | O-P-J-G-B(5) | +2 |
| 22. | Sirohi | O-B-M-W(4) | O-W-G-M(4) | - |
| 23. | Kota | O-W-P-J(4) | O-W(2) | -2 |
| 24. | Baran | O-W-J-P(4) | O-W-SP-F(4) | - |
| 25. | Jhalawar | P-O-J-M-S(5) | O-SP-W(3) | -2 |
| 26. | Banswara | M-P-W-R(4) | M-W-O-P(4) | - |
| 27. | Dungarpur | M-P-R-W(4) | M-W-P(3) | -1 |
| 28. | Udaipur | M-W-P(3) | M-W(2) | -1 |
| 29. | Partapgarh | M-P-W-R(4) | O-W-M(3) | -1 |
| 30. | Bhilwara | M-W-P-O(4) | M-W-P-O(4) | - |
| 31. | Chittaurgarh | M-W-P-J(4) | O-W-M(3) | -1 |
| 32. | Rajsamand | M-W(2) | M-W(2) | - |
| 33. | Bundi | O-W-M-P(4) | O-W-P(3) | -1 |
| 34. | Rajasthan | B-P-O-W-G(5) | O-G-B-P-W(5) | - |

Source: Economic and Statistical Organisation of Rajasthan, Jaipur.

8. Bajra-pulses crop combination:

This crop combination had its position in central parts of Rajasthan, comprising the districts of Jodhpur, Nagaur, Sikar and Jhunjhunu. Among these districts, Jodhpur had only two crop combination i.e. bajra-pulses while, Nagaur and Jhunjhunu districts had bajra-pulses-oilseeds and bajra-pulses-guar crop combination respectively. Here owing to arid climatic conditions such as high temperature, less rainfall, low to moderate fertile soils (desert to grey & brown) with low extent of irrigation, less developed agricultural infrastructure, etc., farmers had grown a variety of crops for their survival and as a result, these three sub- crop combinations had emerged namely; bajra-pulses, bajra-pulses-oilseeds and bajra-pulses-guar.

9. Bajra-oilseeds crop combination:

Two districts of Jalore and Jaipur had bajra-oilseeds as major crop combination with two sub- crop combinations, which were bajra-oilseeds-guar in Jalore district and bajra-oilseeds-wheat-pulses in Jaipur district. These districts fall in semi-arid transitional plains and having moderate rainfall, patches of moderate fertile soils with low irrigational facilities, moderately developed agricultural infrastructure, etc. Owing to these reasons farmers selected arid to semi-arid crop combination in kharif and rabi season. Wheat was grown mainly in Jaipur district, where irrigational facilities were developed.

10. Oilseeds-jowar crop combination:

This crop combination was existing only in district of Tonk, where oilseeds were grown as major crop. It was situated in mid-eastern part of Rajasthan and belong to semi-arid eastern plain zone. Here river Banas was the life line of the district which irrigated about 28 per cent of the net sown area and had moderate rainfall with variety of soils. Owing to these reasons, in most of the areas of this district farmer preferred oilseeds and wheat crops in rabi season and jowar in kharif season. Thus, all this led to oilseeds-jowar-wheat crop combination.

11. Oilseeds-bajra crop combination:

Districts of Sirohi, Pali, Alwar, Bharatpur, Dausa, Bharatpur, Dhaulpur, Karauli and S.madhopur belonged to this major crop combination of oilseeds-bajra with two minor crop combinations i.e oilseeds-bajra-maize-wheat and oilseeds-bajra-jowar. Except Pali district, all the prevailing districts in this category had oilseeds-bajra-wheat crop combination. While Pali had oilseeds-bajra-jowar crop combination. Factors responsible for these crop combinations were red & yellow soils which were

moderate in fertility, moderate to high rainfall, low to moderate extent of irrigation, moderately developed agricultural infrastructure, etc.

12. Oilseeds-wheat crop combination:

It included three districts of Kota, Bundi and Baran. This major crop combination had three sub- crop combinations namely; oilseeds-wheat-pulses-jowar crop combination in Kota district, oilseeds-wheat-maize-pulses crop combination in Bundi district and oilseeds-wheat-jowar-pulses crop combination in Baran district. Here owing to high rainfall, comparatively high extent of irrigation, medium black soils with moderate in fertility, semi- developed agricultural infrastructure, etc. farmers preferred to grow wheat, oilseeds and pulses during winters and jowar in summers. Thus, these three crop combinations had emerged which are the discussed under the heading of oilseeds-wheat crop combination.

13. Jowar-bajra crop combination:

This crop combination existed only in Ajmer district which was lying in the centre of Rajasthan. Pulses (gram, moong, cowpea), oilseeds (mustard, sesam, groundnut), wheat and maize were the other crops grown in this district. Here low to moderate annual rainfall generally receive from monsoons, grey to brownish soils which were moderate in fertility if there was availability of moisture, moderate extent of irrigation, inadequate developed agricultural infrastructure, etc. were the factors responsible for this crop combination.

CROP COMBINATION REGIONS AFTER DOI'S METHOD:2014-15

1. Bajra-guar crop combination:

This major crop combination has contained three districts of Jhunjhunu, Barmer and Sikar which are dispersed into one belt and small patch, comprising 9.09 per cent of the total occurrences. It has three sub-crop combinations namely; bajra-guar-pulses in Barmer district, bajra-guar-wheat-pulses-oilseeds in Sikar district, bajra-guar-pulses-wheat-oilseeds in Jhunjhunu district. These districts lie in western sandy plains and have high temperature, presence of sand dunes, desert soils with low fertility, nearly absence of irrigational facilities, inadequate developed agricultural infrastructure, etc. All these elements collectively account for the existing crops combinations in these areas.

2. Bajra-oilseeds crop combination:

Bajra-oilseeds as a major crop combination has captured 18.18 per cent of the total occurrences, covering six districts which have two belts. First belt belongs to western sandy plains, including districts of Jalore and Jodhpur. While second belt lays in eastern plains and having four districts namely; Alwar, Dausa, Dhaulpur and Karauli. This major crop combination has further three sub-combinations of bajra-oilseeds-pulses-guar crop combination in Jalore district, bajra-oilseeds-guar-pulses-spices crop combination in Jodhpur district and bajra-oilseeds-wheat in Alwar, Dhaulpur and Karauli districts. In Jalore and Jodhpur districts, owing to high temperature, very low rainfall, nearly absence of irrigational facilities, less developed agricultural infrastructure, etc. drought resilient crops such as bajra, oilseeds, pulses and guar have dominant position in the cropping pattern. Whereas in case of remaining districts, moderate rainfall with moderate extent of irrigation, etc. are responsible reasons for bajra-oilseeds-wheat crop combination.

3. Bajra-pulses crop combination:

Bajra-pulses crop combination has only one sub-crop combination i.e. bajra-pulses-oilseeds-wheat and is lying in Jaipur district which is part of semi-arid transitional plains. Here owing to grey & brown soils with moderate fertility, moderate rainfall supplemented by moderate extent of irrigation and semi-developed agricultural infrastructure and as a result, number of crops can be grown during kharif and rabi seasons in an agricultural year. Therefore, there are four major crops belonging to both seasons existing in the cropping pattern of Jaipur district which is further recognised as bajra-pulses-oilseeds-wheat crop combination.

4. Pulses-bajra crop combination:

Pulses-bajra as a major crop combination is covering the district of Nagaur including sub-crop combination of pulses-bajra-guar-oilseeds. Nagaur district belongs to arid region of Rajasthan and having high temperature, less rainfall which receives mainly during monsoons, moderate to low fertile soils, less developed irrigational facilities, etc. Here mostly crops are grown during kharif season, among them most significant crops are bajra, guar and kharif pulses. While important crops of rabi season are

oilseeds and rabi pulses. Thus, pulses-bajra-guar-oilseeds crop combination is recorded.

5. Pulses-guar crop combination:

This major crop combination is found in Churu district of the state, lying in northern parts of Rajasthan. Here due to arid geo-climatic conditions, drought prone crops such as pulses, guar and bajra have predominant position in the cropping pattern. These crops are more assured and have high potentiality to survive in these climatic conditions. Hence, pulses-guar-bajra crop combination is existing.

6. Pulses-jowar crop combination:

Ajmer district lying in the centre of Rajasthan, comprising of six major crops in the cropping pattern of 2014-15 owing to these prevailing geo-climatic conditions which are moderate rainfall, moderate fertile soils supplemented by adequate irrigation and semi-developed agricultural infrastructure, etc. This district generally receives rainfall in monsoon season, consequently, proportion of kharif crops is high in the total cropped area, while rabi crops cover comparatively low proportion of area and mainly grown in irrigated soils. Therefore, pulses-jowar-bajra-oilseeds-wheat-maize crop combination is noted.

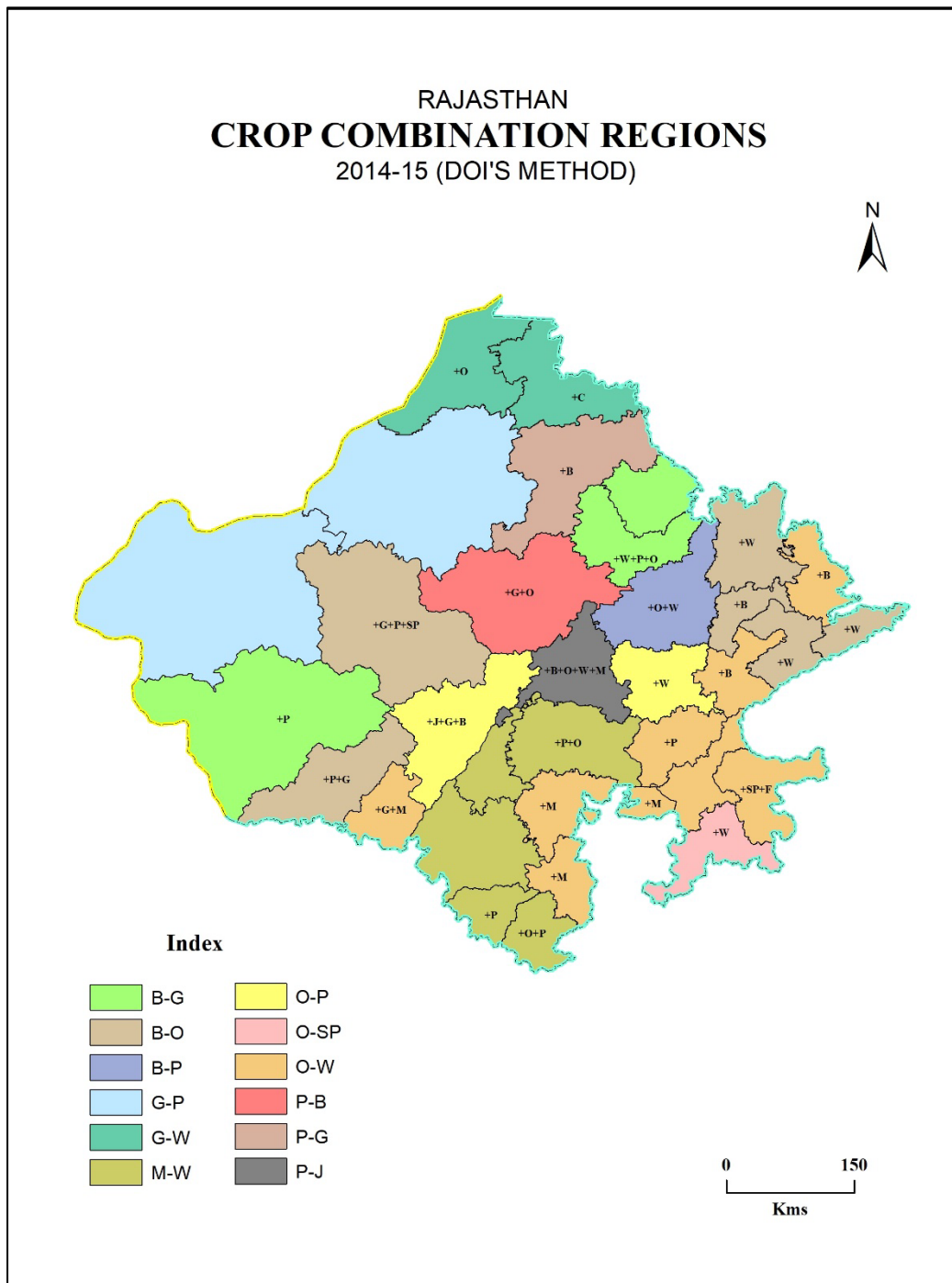
7. Guar-pulses crop combination:

This major crop combination of guar-pulses is found in extreme western parts of Rajasthan, covering two districts of Jaisalmer and Bikaner. Here adverse geo-climatic conditions such as high temperature, existence of sand dunes, desert soils with low fertility, absence of irrigational facilities, etc. enthruse farmers to grow subsistence crops. As a result, guar-pulses crop combination is existing.

8. Guar-wheat crop combination:

It covers northern tips of the state, including Ganganagar and Hanumangarh districts with two sub-crop combinations i.e. guar-wheat-oilseeds and guar-wheat-cotton crop combinations, respectively. Here moderate extent of irrigation, semi-developed agricultural infrastructure, risk oriented migrated Punjabi farmers with progressive attitude, etc. become responsible factors for cultivation of number of crops on commercial scale.

Fig.3



Source: Economic and Statistical Organisation of Rajasthan, Jaipur.

9. Oilseeds-wheat crop combination:

Oilseeds-wheat as a major crop combination occupies one belt and two small patches. The belt lying in south-eastern part includes six districts namely; Partapgarh, Chittaurgarh, Kota, Baran, Bundi and S.Madhupur. In these districts, owing to moderate to high rainfall supplemented by high extent of irrigation, a variety of crops are grown and further these crops formed sub-crop combinations which are oilseeds-wheat-maize in Chittaurgarh district, oilseeds-wheat-maize in Partapgarh district, oilseeds-wheat-pulses in Bundi district, oilseeds-wheat in Kota district and oilseeds-wheat-spices-fodder in Baran district and oilseeds-wheat-bajra in S.madhupur district. Remaining two small patches belonging to this major crop combination, cover districts of Bharatpur and Sirohi with sub-crop combinations of oilseeds-wheat-bajra and oilseeds –wheat-guar-maize-pulses, respectively.

10. Oilseeds-pulses crop combination:

This major crop combination belongs to Pali and Tonk districts and has further two sub-crop combinations which are; oilseeds-pulses-jowar-guar-bajra in Pali district and oilseeds-pulses-wheat in Tonk district. In these districts oilseeds and pulses occupy more than 50 per cent of the total cropped area individually.

11. Oilseeds-spices crop combination:

Oilseeds-spices crop combination exists in Jhalawar district which is covering the south-eastern end of Rajasthan. Jhalawar has heavy rainfall, extensive irrigation and stoniness relief, therefore, wherever patches of soils are found farmers grow crops such as soybean, sorghum, groundnut, wheat, chickpea, coriander, mustard, garlic, etc. Additionally, these soils are not very fertile, that's why farmers choose crops that could develop in less fertile soils. Hence, a crop combination of oilseeds-spices-wheat is recorded.

12. Maize –wheat crop combination:

Southern parts of Rajasthan, covering five districts of Banaswara, Udaipur, Rajasmand, Dungarpur and Bhilwara have this major crop combination. It contains further four sub-crop combinations which are; maize-wheat-oilseeds-pulses in Banswara district, maize-wheat in Rajasmand district, maize-wheat-pulses-oilseeds in Bhilwara district, maize-wheat-pulses in Dungarpur district. Here owing to relatively low temperature, high rainfall, developed irrigational facilities and developed agricultural infrastructure, etc., crops are grown in both

seasons. Therefore, maize-wheat major crop combination is favourable among farmers of these districts.

CHANGES IN CROP COMBINATIONS IN RAJASTHAN: 1994-95 TO 2014-15

Any kind of modification in physical environment or upgrading in socio-economic phenomenon or innovation in technological & organisational infrastructure lead to changes in cropping structure of an area or region. Akhtar and Rekha (2015) also mentioned that no cropping pattern is perfect or ideal for all the time. There are number of factors which either enthruse or compel the farmers to bring changes in cropping system. A change in the cropping structure affects the areal strength of individual crops which in turn affects the association among the existing crops (Siddique & Afzal, 2018). Some crops have gained or some have lost area under their cultivation. During 1994-95 to 2014-15, the study region has witnessed improvements in the physical & socio-economic environment in respect of land by levelling the sand dunes especially in north-western parts of Rajasthan, reclamation of kallar soils, expansion in sources of irrigation, introduction of high yielding variety of seeds, development in mechanization of agriculture, development of agricultural infrastructure, liberal credit facilities, govt. policies, etc. The action, reaction and interaction among physio-socio-economic factors have their controls on the crop combinations of the Rajasthan which has been proved by the changes in crop combinations of 1994-95 to 2014-15. During 1994-95, Rajasthan as a whole experienced bajra-pulses-oilseeds-wheat-guar crop combination but in 2014-15 noted crop combination is oilseeds-guar-bajra-pulses-wheat.

According to Doi's method, overall crop combination of Rajasthan in 1994-95 was bajra-pulses-oilseeds-wheat-guar which has changed to oilseeds-guar-bajra-pulses-wheat. But changes in this overall crop combination are not evenly distributed throughout the study region. Though the number of crops in the crop combination of Rajasthan almost has remained same in both time periods. Following points are emerged from figs. 1 and 2.

1. District wise, there was noted 13 crop combination regions in Rajasthan in 1994-95 but during present investigation period, the number has reduced to 12 crop combination regions.
2. Bajra-oilseeds major crop combination had its existence in only two districts i.e. Jalore and Jaipur during 1994-95. While in 2014-15, this crop combination has changed from bajra-oilseeds to oilseeds-bajra crop combination, covering Alwar,

Dausa, Karauli and Dhaulpur districts. Because more area has come under oilseeds in 2014-15 as compare to 1994-95.

3. The major crop combination of bajra-pulses had four districts which accounted for 12.12 per cent of the total occurrences in 1994-95 and these districts were Nagaur, Jodhpur, Sikar and Jhunjhunu. In 2014-15, this crop combination has disappeared from these districts and emerged in Jaipur district whereas it was not prevailing in 1994-95.
4. There were two districts namely; Jaisalmer and Barmer which comprised 6.06 per cent of the total occurrences with bajra-guar crop combination during 1994-95. Though this crop combination lost its position in Jaisalmer district in 2014-15 yet the number of districts has increased from 2 to 3 and these districts are; Barmer, Jhunjhunu and Sikar.
5. Pulses-cotton crop combination had covered only single district of Hanumangarh in 1994-95 but during 2014-15, this crop combination has disappeared in the state and no district is noted with this crop combination, because of area under cotton has declined in 2014-15. Moreover, farmers put more land under guar cultivation in Hanumangarh district which requires less water and other inputs as compare to cotton.
6. In 1994-95, Bikaner and Churu districts had pulses-bajra crop combination but during present investigation period, these districts have been captured by either guar-pulses or pulses-guar crop combination. During 2014-15, this crop combination has shifted to Nagaur district where in 1994-95, bajra-pulses crop combination was existing but pulses gained more area and became first ranking crop thus, resulted into pulses-bajra major crop combination.
7. Pulses-guar crop combination did not cover single district in the study region, during 1994-95, but it has emerged in Churu district in 2014-15, because of increase in area under guar cultivation owing to its high demand followed by higher economic returns and easy marketing. Thus, now Churu district has pulses-guar as major crop combination.
8. Cotton crop was favourable among the farmers of Ganganagar district which resulted into the existence of cotton-pulses crop combination in this district in 1994-95. But during 2014-15, cotton has lost its significant position owing to decline in irrigation facilities, high demand of guar with higher economic returns,

etc. which make the farmers to grow guar in place of cotton and as a result, guar-wheat crop combination has emerged in 2014-15 in Ganganagar district.

9. Oilseeds-bajra crop combination had covered largest area with 24.24 per cent of the total occurrences in 1994-95 and included districts of Sirohi, Pali, Alwar, Dausa, Karauli, Dhaulpur and Bharatpur. But during 2014-15, it has been disappeared and replaced by crop combinations of either bajra-oilseeds in Alwar, Dausa, Karauli and Dhaulpur districts or oilseeds-wheat in Sirohi district or oilseeds-pulses in Pali district.
10. Ajmer and Tonk districts had jowar-bajra and oilseeds-jowar crop combinations in 1994-95, while during 2014-15 these crop combinations replaced to pulses-jowar and oilseeds-pulses crop combinations, respectively.
11. Except Jhalawar district, there were three crop combinations existing in extreme southern and south-eastern districts of Rajasthan in 1994-95 which were namely; maize—wheat in Udaipur, Chittaurgarh, Rajasmand and Bhilwara districts, maize-pulses in Dungarpur, it Partapgarh and Banswara districts and oilseeds-wheat in Bundi, Kota and Baran districts. During 2014-15, maize-pulses crop combination has disappeared from these districts and existed only two crop combinations either maize-wheat in Banswara, Dungarpur, Udaipur, Rajasmand and Bhilwara districts or oilseeds –wheat in Chittaurgarh, Bundi, Kota, Baran and S.Madhupur districts.

From the preceding discussion, it is found that the present investigation period has experienced significant changes in crop combinations either by losing or by capturing the area. There are 6 crop combinations which have disappeared from the study region in 2014-15 and these are bajra-guar, pulses-oilseeds, oilseeds-jowar, cotton-pulses, maize-pulses and oilseeds-bajra. Whereas, 7 new crop combinations have emerged in the study region during 2014-15 which include bajra-wheat, pulses-guar, pulses-jowar, guar-pulses, guar-wheat, oilseeds-pulses and oilseeds-spices. It shows that the study region has witnessed marked changes in the agricultural scenario.

CONCLUSION:

The following conclusions are drawn:

1. In 1994-95, there were existing 13 crop combination regions on the basis of first two crops. Out of 13 crop combinations, in 6 crop combinations, largest area was registered under bajra-pulses crop combination. In north-western bajra-pulses, bajra-guar, bajra- oilseeds, pulses-bajra, pulses-oilseeds and pulses-cotton crop

combinations were prevailing, which shows that bajra and pulses were dominant crops of these areas and were occupying either first or second ranks in the cropping pattern, owing to suitable climatic (hot & dry) conditions with low to moderate developed irrigational facilities. While in south- eastern parts of Rajasthan, oilseeds, maize and wheat were having predominant positions which further resulted into oilseeds-wheat, oilseeds-jowar, maize-wheat and maize-pulses crop combinations. Here, moderate to high rainfall supplemented by availability of irrigational facilities collectively accounted for the occurrence of these crop combinations.

2. During 2014-15, in the cropping pattern of Rajasthan a variety of crops are prevailing, ranging from less water- intensive to water-intensive crops. These crops are namely; guar, bajra, pulses, oilseeds, spices, jowar, cotton, maize, wheat, rice, etc. which mirrors the diversified picture of state's cropping pattern. It is also found that there are 12 crop combinations existing, out of 12, in 5 crop combinations bajra has either first rank or second rank. It is also found that upper half of the study region has bajra, guar and pulses as major crops in the cropping pattern and as a result, bajra-guar, bajra-pulses, guar-pulses, bajra-oilseeds, pulses-bajra and pulses-oilseeds crop combinations are recorded. Whereas, lower half of the state has maize, oilseeds and wheat as main crops in the cropping structure and consequently, maize-wheat and oilseeds-wheat crop combinations are registered. These prevailing contrasts in the crop combinations are due to the differences in magnitude of physio-socio-economic factors.
3. From 1994-95 to 2014-15, the study region has experienced significant changes in crop combinations either by losing or by capturing the area. There are 6 crop combinations which have disappeared from the study region in 2014-15 and these are bajra-guar, pulses-oilseeds, oilseeds-jowar, cotton-pulses, maize-pulses and oilseeds-bajra. Whereas, 7 new crop combinations have emerged in the study region during 2014-15 which include bajra-wheat, pulses-guar, pulses-jowar, guar-pulses, guar-wheat, oilseeds-pulses and oilseeds-spices. It shows that the study region has witnessed marked changes in the agricultural scenario.

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