A Comparative Geographical Study Of Crop Combinations In Sivasagar District Using Weaver And Rafiullah Quantitative Methods

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Abstract: Agriculture is one of the most important occupations in most of the states in India. Sivasagar district of Assam also holds agriculture practices as one of the main economic activities. This study explores the crop combination patterns in the Sivasagar district of Assam by applying two quantitative agricultural techniques for measuring crop combination. Weaver's and Rafiullah's quantitative methods were used in this study. The research identifies and classifies cropping patterns to understand the region's agricultural diversity. The findings highlight the dominant and associated crops. The study contributes to agricultural geography and can assist planners and policy makers in optimizing land use and crop planning in the region.**.**

Index Terms - **Crop combination, minimum deviation method, maximum positive deviation.**

I. INTRODUCTION

Agricultural land use studies are crucial for understanding the cropping patterns and optimizing regional agricultural planning of an area. Utilization requires proper planning for being limited resource (Erande et al., 2020). The crop combination technique is one such method, which is developed to examine the distribution and diversity of crops in a given area. Crop combination technique provides a base for agricultural regionalization. This paper applies Weaver's and Rafiullah's methods to Sivasagar district to analyze the crop combinations and compare the results. Crop combination analysis provides insight into the agricultural pattern of a region and helps identify dominant and associated crops. This study uses Weaver's (1954) and Rafiullah's (1956) crop combination techniques to analyze the spatial distribution and concentration of crops in the Sivasagar district of Assam.

The study of crop combinations is a very significant aspect of agricultural geography (Mane et al., 2020). Agriculture is the foundation of the Indian economy for three main reasons. Firstly, since the beginning of the decade of the 1940-1950s, this percentage has increased. Agriculture is the biggest contributor to the country's national income. Secondly, more than half the workforce in India is engaged in the field of agriculture. Third, growth of other sectors and the overall economy depends on the

performance of agriculture to a considerable extent.(Mane et al., 2020). Agriculture is the prime and most important activity for the survival of mankind and his animals.

Objectives-

1. To identify and classify crop combinations and interpret agricultural land use patterns.

2. To compare results from Weaver's and Rafiullah's methods.

Study area- The study area is Located in Upper Assam, Sivasagar lies between 26.8°N to 27.3°N latitude and 94.3°E to 95.2°E longitude. The region is characterized by fertile alluvial soils, a sub-tropical monsoon climate, and abundant rainfall 2200 mm annually and average temperatures between 15°C and 30°C. Agriculture is the backbone of the district's economy, with rice as the dominant crop, followed by pulses, oilseeds, and vegetables.
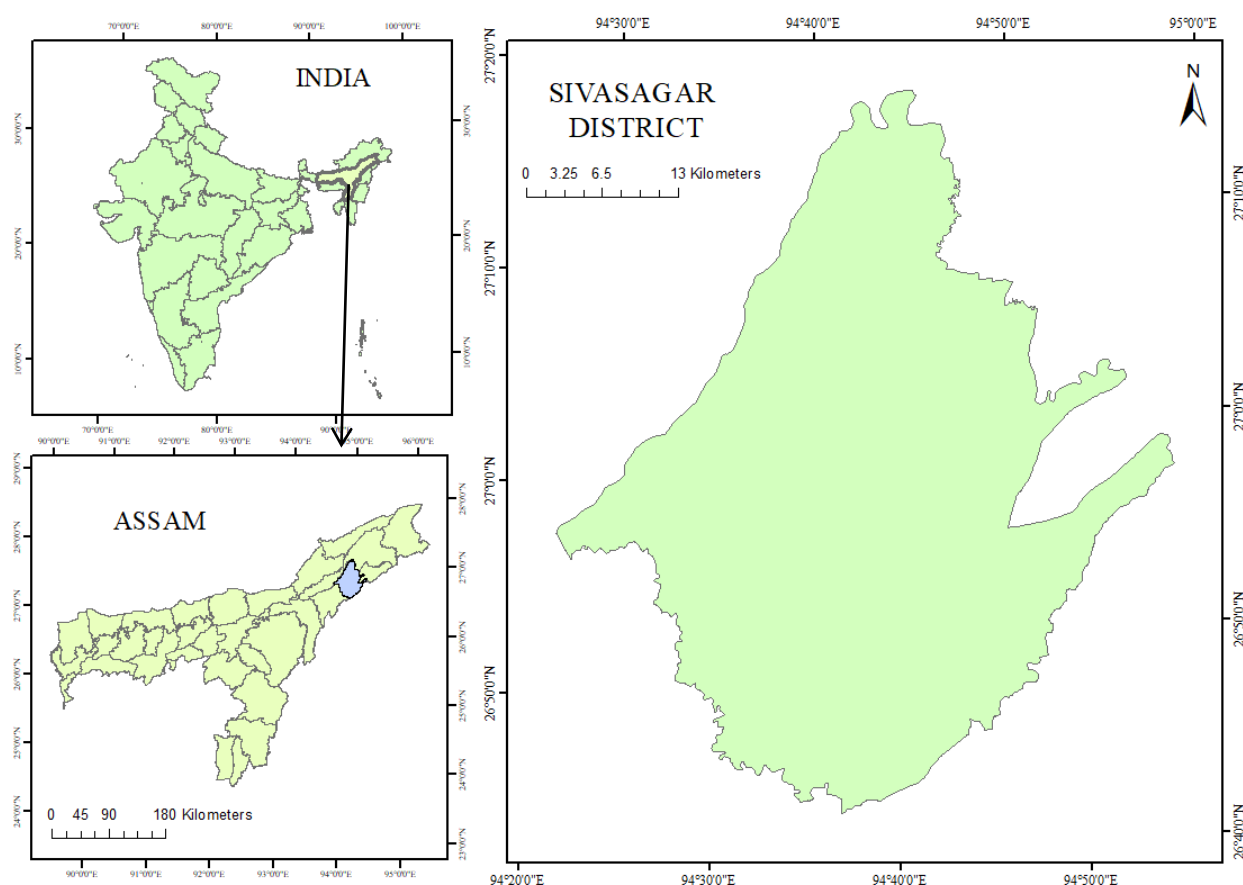

Fig 1- Location map of the study area

Database- District level secondary crop area data has been collected from the Agricultural office of Sivasagar district, Assam. A total of 40 crops area were collected and divided and organised into 7 different crop categories, they are, cereals, pulses, horticulture, oil seeds, fibre, condiments and spices and cash crops. After data collection, the crop combination method of Weaver and Raffiullah was performed.

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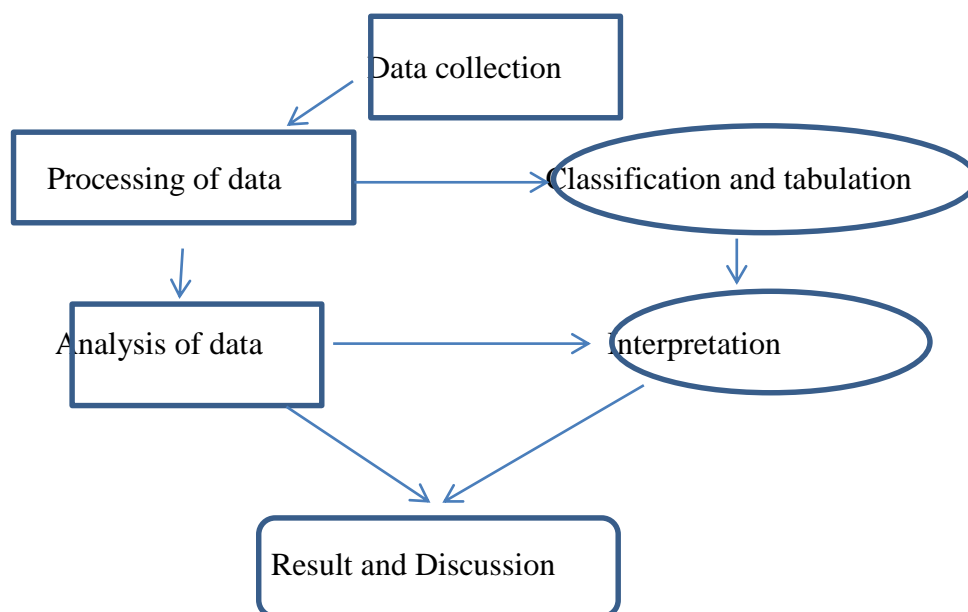
Fig 2- Methodology of the study

Weaver's Method (1954): Weaver developed a statistical technique to identify the most representative crop combinations using the standard deviation method. J. C. Weaver's crop combination method is one of the simplest and most objective techniques to delineate agricultural regions. Weaver's crop combination formula, proposed by J.C. Weaver in 1954, uses statistical methods to determine the most dominant crop combinations in a region. It relies on variance and standard deviation calculations to identify crop combinations that are representative of a region's natural, cultural, and economic conditions. Crop combination refers to the most dominant group of crops which are being cultivated in a region for a particular time period (mostly year). The basic idea of Weaver's method is that the most dominant crops are representative of the natural, cultural and economic situation of an area. Weaver used quantitative techniques to arrive at the agricultural regions. He calculated dominance with respect to the Gross Cropped Area for a specific crop or crop combination. Weaver used Standard Deviation formula for arriving at the most dominant crop combination.

$$S.D. = \sqrt{\Sigma d2 / n}$$

Whereas, d is the difference between the actual crop percentages in a given area unit and the appropriate percentage in the theoretical curve, n is the number of crops in a given combination of the study area.

As Weaver pointed out. the relative, not absolute value being significant and square roots were not extracted, that's why the following actual formula was used.

The theoretical curve for the standard measurement was employed as follows –

Table 1- Crop combinations and hypothetical percentage of Sivasagar district, Assam.

Monoculture (single/one crop)	100 % of the total harvested crop land in one crop.
Double crop combinations (two crop combination)	50 % in each of the two crops.
Three crop combinations	33.33 % in each of the three crops.
Four crop combinations	25 % in each of the four crops.
Five Crop Combinations	20 % in each of the five crops

Table 2- Total crop category, their area and total percentage.

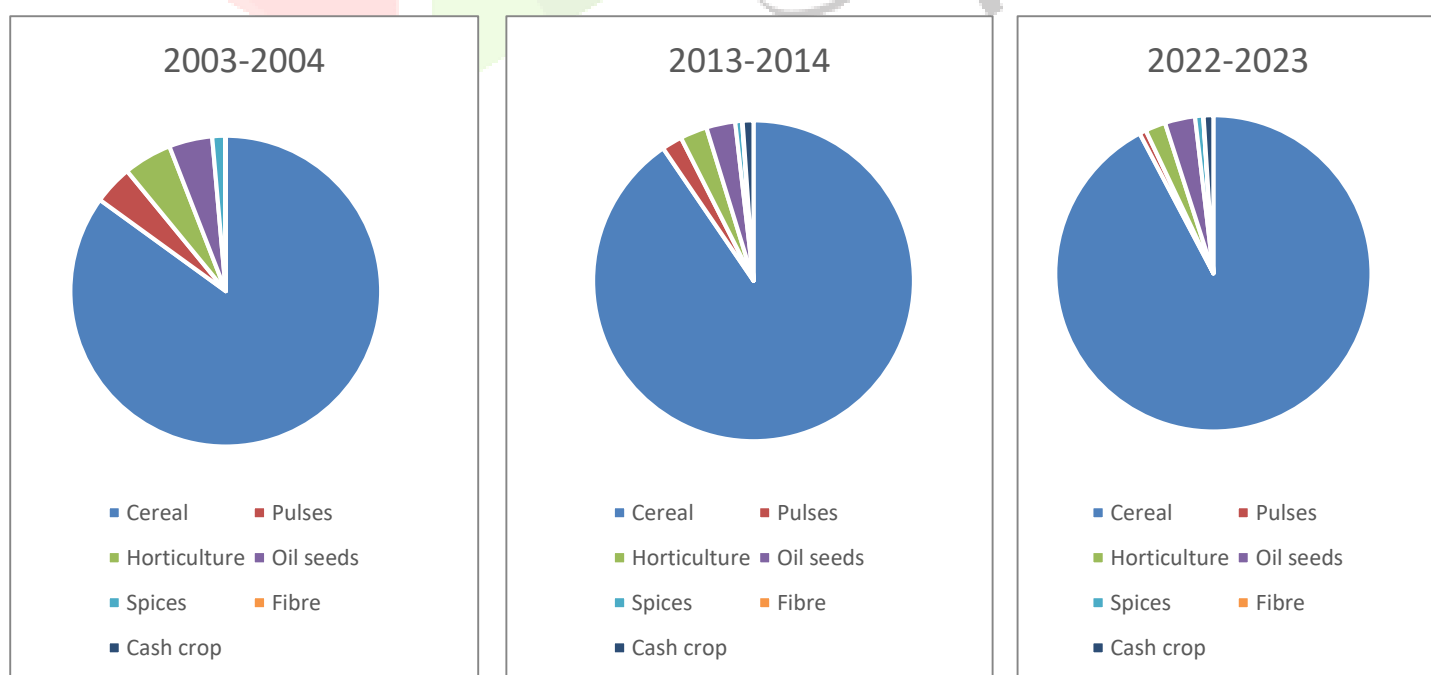| Year and area		Cereal	Pulses	Horticulture	Oil seeds	Spices	Fibre	Cash crop	Total
2003-04	Area in hect	16612	795	985	881	266	3	5	19547
	%	84.98	4.06	5.03	4.50	1.36	0.015	0.025	100
2013-2014	Area in hect	65077	1483	1958	2104	499	36	789	71946
	%	90.45	2.06	2.72	2.92	0.69	0.05	1.09	100
2022-2023	Area in hect	68230	517	1545	2288	620	31	738	73969
	%	92.24	0.69	2.08	3.09	0.83	0.04	0.99	100

Fig 3- Percentage of major crops area under total cropped area in Sivasagar district in different years.

Table 3- Combination of crops.

Crop combination	Monoculture	Two crop com	Three crop combination	Four crop combination	Five crop combination
2003-04	Cereal	Cereal, horticulture	Cereal, horticulture, oil seeds	Cereal, horticulture, oil seeds pulses	Cereal, horticulture, oil seeds pulses spices
2013-2014	Cereal	Cereal, oil seeds	Cereal, oil seeds, horticulture	Cereal, oil seeds horticulture and pulses	Cereal, oil seeds horticulture and pulses, cash crop
2022-23	Cereal	Cereal, oil seeds	Cereal, oil seeds, horticulture	Cereal, oil seeds, horticulture, cash crops	Cereal, oil seeds, horticulture, cash crop, spices

Table 4- Crop combination according to Weaver method

Years	2003-2004		2013-2014		2022-23	
Types of crop combination	Σ d2	d = Σ d2 / n	Σ d2	d = Σ d2 / n	Σ d2	d = Σ d2 / n
Mono- Single crop	225.60	225.60	91.20	91.20	60.21	60.21
Double crop	3245.9	1622.95	3852.72	1926.36	3984.75	1992.37
Triple crop combination	4299.17	1433.05	5124.42	1708.14	5361.39	1787.13
Four crop combination	3855.13	963.78	5793.85	1448.46	6103.05	1525.76
Five crop combination	5288.27	1057.65	6232.93	1246.58	6554.53	1310.90

Raffiullah method - Considering the weakness of Weaver's method Rafiullah developed a new deviation method in his work entitled A New Approach to the Functional Classification of Towns. Rafiullah revised the technique and expressed it as

$d = (\sum Dp^2 - \sum Dn^2) / N^2$

Where, d is the positive deviation, Dp is the positive difference and Dn is the negative difference from the medium value of the theoretical curve value of the combination, and N is the number of crops in the combination.

Table 5- Crop combination according to Raffiullah's method

Type of crop combination	2003-04 $(\sum Dp^2 - \sum Dn^2) / N^2$	2013-14 $(\sum Dp^2 - \sum Dn^2) / N^2$	2022-23 $(\sum Dp^2 - \sum Dn^2) / N^2$
Mono crop	1223.60	1636.20	1784.21
Double crop combination	652.5	949.04	1010.29
Triple crop combination	486.12	561.52	589.70
Four crop combination	316.39	366.86	376.80
Five crop combination	218.28	249.06	259.50

Result and discussion-

Monoculture- Monoculture is the most dominant crop combination in both the quantitative techniques. The dominant crop in this category is cereal, it includes summer rice, winter rice, autum rice, maize, wheat and other types of cereals. In the year 2003-04 cereals cover 16612 hectares of area which increased to 65077 in 2013-14 and 68230 hectares in 2022-23. Which is increased from 84.98 % to 92.24 % in two decades. In Raffiulah's method cereal is the most dominant crop category among all the 7 crop categories in all the selected years.

Two crop combination- Two crop combinations denote the increases in the number of crops with comparative diversification in crop combination. In this combination for both the quantitative techniques, cereal and horticulture were taken in the year 2003-04 and cereal and oil seeds in the years 2013-14 and 2022-23. In horticulture all types of fruits and vegetables are included that were grown in the district. Crops were papaya, banana, watermelon, orange, etc and vegetables crops like potato, tomato, onion, sweet potato, tapioca, etc were included as vegetables. Just like cereals the horticulture category is also increasing in the time being. It went from 985 hectares 5.03 % in 2003 to 1958 hectares in 2013-14 but in the year 2013 it's just 2.72 % of the entire cropland. Again it decreased to 1545 hectares in 2022-23. Also in the year 2013 cereals and oil seeds were taken in a two crop combination according to Weaver's quantitative techniques of minimum deviation.

Three crop combination- The triple crop combinations includes three crop combination which includes, cereals, horticulture and oil seeds. Oil seeds include crops like sesame seeds, Lin seeds, Castor oil, Rapeseed and mustered, Nizer and Coconut. The oil seed category went from 881 hectares in 2003 to 2104 in 2013-14 to 2288 hectares in 2022-23.

Four crop combination- Four crop combination includes all the crop categories mentioned above with adding crop categories of pulses and cash crops in different years. In both the years 2003-04 and 2013-14 pulses were included as a fourth crop for crop combination but in the year 2022-2023 cash crop were included to measure crop combination. Pulses were another important crop category in the region pulses included crops like Gram, Green gram, Black gram, Red gram, Red Lentil, Peas, other types of pulses. The area of pulses increased from 795 hectares in 2003-04 to 1483 hectares in 2013-14 but again it decreased in the year 2022-23 to 517 hectares.

Five crop combination- Five crop combination included the crops categories of cereal, oil seeds, horticulture, cash crops and condiments and spices. Cash crop included crops like Tobacco, Areca nut. Also condiments and spices included crops like Chili, Turmeric, Black paper, Ginger.

Conclusion This study reveals that Sivasagar district predominantly practices rice-based cropping. The application of Weaver's and Rafiullah's methods to crop combination analysis across the years 2003–04, 2013–14, and 2022–23 reveals important trends in agricultural practices in the Sivasagar district of Assam. Where Weaver's method consistently identifies monoculture, specifically cereal cultivation which involves paddy, as the most dominant and representative cropping pattern, indicating a growing reliance on a single crop type over the decades. This may reflect the market demands, policy preferences, or efforts to maximize yield and efficiency in the region.

In contrast, Rafiullah's method, which emphasizes the deviation from the theoretical balance of crop diversity, highlights five-crop combinations as more representative. This underscores the underlying diversity in agricultural systems that may not be immediately visible through dominance-based analysis. Weaver's method is better for highlighting dominance, while Rafiullah's method is suited to reflect crop diversity.

Together, the two methods provide a comprehensive picture: while monoculture dominates in terms of area, multiple crops still contribute to the region's agricultural identity and pattern. The decline in the share of pulses and horticulture and the modest rise in cash crops and oil seeds point to a gradual but noticeable shift in cropping patterns. This highlights the need for balanced agricultural policies that support both high-yield crops and crop diversity.

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