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Crop Concentration and Nutritional Challenges in Rajasthan: Need for Nutrition Sensitive Agriculture

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Abstract

The escalating demographic pressure has multiplied the demand for agricultural commodities manifold. The changing environmental scenario and altered climatic conditions have affected agricultural production to a greater extent across the globe. Likewise, the availability of nutrition becomes a great challenge for humanity, - Rajasthan in India, is one such State that faces food and nutrition challenges. The present study focuses on the issue of food scarcity, agricultural production, and nutritional demand in the study area. The objectives of the study include analyzing the crop concentration and nutritional availability and human health in the study area. The crop production has been analyzed in the light of crop concentration index for various crops like pearl millet, jowar, maize, and wheat while nutritional demand has been analyzed in the light of food consumption or utilization. The parameters like underweight conditions and anemic conditions have been analyzed for children and adults (both men and women). The crop concentration index (CCI) has been calculated for mainly food grains jawar, bajra, wheat, and maize in order to understand the crop concentration scenario in the state of Rajasthan. The CCI was coupled with a correlation matrix and regression analysis model in order to analyze the impact of crop concentration on the health of people in the study area. The findings of the study show that though the nutritive value of crops like maize and jowar was high it resulted in iron deficiency among the people of the study area. In addition to this, women are more anemic as compared to their male counterparts in the study area. Similarly, maize and jowar dominant resulted in underweight conditions among the children in the study area. The study concludes with proper suggestions in order to bring agriculture on the lines of sustainability and to find alternative solutions to meet the iron deficiency in the study area. Lastly, the study also makes an appeal to agricultural experts, social scientists, health experts, and nutritionists to highlight such issues for the betterment and welfare of our country.

***Key words*:** Food consumption, Nutritional value, Crop concentration index, Nutrition deficiency diseases

Agriculture occupies the most important position in the Rajasthan's economy, as it is one of the largest private enterprises in Rajasthan, which continues to dominate the change in the economy through its links to various sectors of production and markets. Rajasthan has 14% of India's cultivable land, which accounts for 25.55 million hectares [1]. The State's top agriculture categories by production for 2014-15 include food grains (19.62 million tons), cereals (17.667 million tons), Oilseeds (5.314 million tons), and Pulses (1.952 million tons) [2]. Other major crops include - mustard, cluster bean, coarse cereals, and gram & seed spices.

The role of the agricultural sector in the Rajasthan economy can be seen through its contribution to GDP (Gross Domestic Product) and employment. The agricultural and allied sectors contributed to 31% of GSDP in 2015 (the national average was 20%) [3]. Rajasthan is a leading milk producer, with the fifth-largest cattle population in India and some of the finest breeds of milch and draught cattle. Rajasthan is a strong performer in India in the area of horticulture being the 4th largest producer of oranges and garlic [4]. Agricultural sector also contributes significantly to the sustainable economic development of the state. Rajasthan has about two-thirds of the population living in rural areas with agriculture as its livelihood, in spite of the increasing urbanization that has been taking place for many decades. Therefore, if agriculture goes wrong, it will be really bad for the economy as the falling of agricultural growth not only affects employment but GDP too (thus increasing poverty).

Crop production, food consumption, and nutritional availability are closely interrelated and determined by the climatic conditions prevailing in the region. The ever-increasing demographic pressure has led to looking for more ways to increase crop production [5]. The conditions like soil exhaustion and limited cropland minimize the chances to increase crop production [6]. The other way is to follow agricultural development practices which enable the same piece of land to be used several times in a single year [7]. Similar is the case of Rajasthan which shows diversity in terms of soil and geographical conditions. The geographical conditions of Rajasthan have affected the agricultural production, quality of crops, food supply, and nutritional intake of people. The issue of food scarcity or unavailability in the area can be solved by

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intensifying agriculture. The intensity of cropping can also help in the diversification of crops. The districts of Jhalawar, Baran, Kota, Alwar, Bundi, Chittorgarh, Dausa, Karoli, Pratapgarh, Jaipur etc., experience high intensity of cropping. These districts have fertile soil and irrigation facilities. The intensity of cultivation is low in the districts of Barmer, Jodhpur, Bikaner, Jaisalmer, Pali, Nagaur, and Sawai Madhopur [8].

MATERIALS AND METHODS

The study investigates two main objectives by calculating and analyzing the crop concentration index for main food grains grown i.e., pearl millet, jowar, maize, and wheat in the study area. It also analyzes the nutritional level and its impact on the health of people The present research study is a quantitative study and is based on secondary data collected from various agencies (both governmental and non-governmental). The data has been taken from Agricultural Statistics of Rajasthan 2019, IFPRI (International Food Policy Research Institute) reports, Publications of Indian Council of Medical Research (ICMR). Following methods have been used:

Crop concentration index

Crop concentration refers to the variation in the density of crops cultivated in an area at a given point in time. The concentration of a crop in an area largely depends on its types of soil, terrain, moisture, climate, income and price, government policy, social factors, and many others [9]. The crop concentration index helps to understand the dominance of a crop. This exercise is mainly done on food grains as they occupy most of the area. The study incorporates the Location Quotient Method to understand crop concentration. The following formula has been applied to calculate the crop concentration index:

$$\mathrm{CCI} = \frac{\mathrm{Aij/A}}{\sum_{i}^{n} = 1\ \mathrm{Aij}/\sum \mathrm{A}}$$

Where;
CCI= Crop Concentration Index,
Aij= Area under i^{th} crop in the j^{th} district,
A= Gross cropped area in the j^{th} district, and
$\sum$ A ij = Area in the i^{th} crop in the state

The higher the value higher is the concentration of the crop while the lower value shows low concentration. Crop diversification is a concept that is opposite to crop specialization [10]. It refers to the growing of several crops in the holdings in an agricultural year [11]. To understand the crop concentration in the study area, the three different ranges were selected viz. <0.50 (less concentrated), 0.51 - 1.00 (moderately concentrated), and >1 (highly concentrated).

To understand food consumption and nutritional level of people two set of data has been used i.e. Number of Anaemic people and underweight i.e. wasting population. To carry out the analysis of anemic children, five categories have been designed viz. very low (40-48 percent), low (49-56 percent), medium (57-64 percent), high (65-72 percent), very high (73-85 percent). The statistical techniques use of correlation matrix and regression analysis model for the variables like crop concentration index and health conditions of people like underweight and anemic conditions. ArcGis 10.1 and STRATA software has been used for mapping in the research outcomes.

RESULTS AND DISCUSSION

Crop concentration index has been calculated for the crops like pearl millet, jowar, maize, and wheat. The (Fig 1a) shows that Pearl millet i.e. Bajra is moderately concentrated in districts of Pali, Tonk, and Bharatpur (0.51 - 1.00). The number of districts is more under the category 'less concentrated (<0.50)' namely Ganganagar, Hanumangarh, Sikar, Ajmer, Sawai, Madhopur, Bhilwara, Rojsamadd, Bundi, Kota, Baran, Jhalawar, Chittorgarh, Udaipur, Pratapgarh, Dungarpur, Banswara while the districts which fall under the category of 'highly concentrated (>1)' include Bikaner, Churu, Jhunjhunu, Nagaur, Jodhpur, Jaisalmer, Barmer, Jalor, Sirohi, Jaipur, Alwar, Dausa, Karauli, Dhaulpur. In other words, Bajra is highly concentrated in the western and north-western parts of the study area. Bajra cultivation requires less water. It is generally grown in areas of high temperature and less rainfall. It is concentrated in drought-prone areas and in areas with high salinity in the soil. Rajasthan is in fact the largest Bajra producing state in India. Bajra has been considered staple nourishment for a section of society that is not rich. According to a manual by the Indian Council of Medical Research, 100 grams of Bajra contains 201 grams of calories, 6-gram protein, 1.7-gram fat, 40-gram carbohydrate, 2 grams of fiber, 286 grams of sodium, and 6 percent iron [12]. Nowadays, Bajra is considered to be having lots of health benefits but since it isn't available everywhere so it is mainly consumed in this part of the state. It is rich in magnesium and fiber.

Table 1 Crop concentration in Rajasthan: District wise

District	Crop Concentration Index			
	Bajra	Jowar	Maize	Wheat
Ajmer	0.49	5.14	0.99	0.54
Alwar	1.14	0.00	0.11	1.28
Banswara	0.00	0.01	5.70	1.01
Baran	0.01	0.00	0.36	2.81
Barmer	2.25	0.05	0.00	0.05
Bharatpur	0.76	1.78	0.00	1.53
Bhilwara	0.01	1.14	4.82	1.11
Bikaner	1.14	0.01	0.00	1.47
Bundi	0.01	0.00	1.42	2.19
Chittorgarh	0.00	0.46	4.94	0.46
Churu	2.04	0.00	0.00	0.28
Dausa	1.26	0.28	0.02	1.21
Dhaulpur	1.29	0.01	0.00	1.29
Dungarpur	0.00	0.04	5.28	0.94
Ganganagar	0.01	0.00	0.00	2.50
Hanumangarh	0.23	0.00	0.00	2.32
Jaipur	1.26	0.66	0.05	0.84
Jaisalmer	1.95	0.24	0.00	0.40
Jalore	2.05	0.11	0.00	0.29
Jhalawar	0.00	0.08	1.76	2.45
Jhunjhunu	1.64	0.00	0.00	0.78
Jodhpur	1.86	0.89	0.00	0.34
Karoli	1.35	0.01	0.00	1.22
Kota	0.00	0.11	0.14	2.73
Nagaur	1.72	1.12	0.00	0.41
Pali	0.67	5.06	0.68	0.61
Pratapgarh	0.00	0.01	4.49	1.68
Rajasmand	0.01	0.82	5.98	0.89
Sikar	0.47	0.00	0.04	1.65
Sirohi	0.07	6.56	0.00	0.72
Sawai madhopur	1.86	1.04	0.32	0.13
Tonk	0.54	3.86	0.66	1.03
Udaipur	0.00	0.31	6.90	0.80

Unlike Bajra, Jowar is concentrated in very few districts in the study area. The districts falling under the category of 'highly concentrated (>1)' includes Nagaur, Sikar, Ajmer, Pali, Tonk, Bharatpur, Bhilwara, Sirohi while it is 'moderately

concentrated (0.51-1.00)' in the districts of Jodhpur, Jaipur, and Rajsamadd. The number of districts falling under the category of 'less concentrated (<0.50)' were Jaisalmer, Bikaner, Ganganagar, Hanumangarh, Churu, Jhunjhunu, Alwar, Dausa, Karauli, Dhaulpur, Sawai Madhopur, Bundi, Kota, Baran, Jhalawar, Chittorgarh, Udaipur, Pratapgarh, Dungarpur, Banswara, Jalor, Barmer.

Jowar also known as Sorghum, is also a drought resistant crop and is found in arid and semi-arid conditions. It is a rabi crop and requires a mean monthly temperature of 26°-33°C. It grows in the area where rainfall is moderate to low. It is highly concentrated in Ajmer, Pali, Bhilwara, Tonk etc. In Rajasthan the yield of the jowar crop is very low, i.e. 180q/ha with India's average of 761 kg/ ha. Jowar is considered to have good nutritive value. It is also used for livestock. In 100 grams of jowar, there are 349 calories, 10.4-gram protein, 1.9-gram fat, 72.6-gram carbohydrate, 9.7-gramfiber, 672 grams of potassium, and 3 mg of iron [13]. It has many health benefits. It is rich in fiber and is considered to be good for the heart and to maintain blood sugar levels [14].

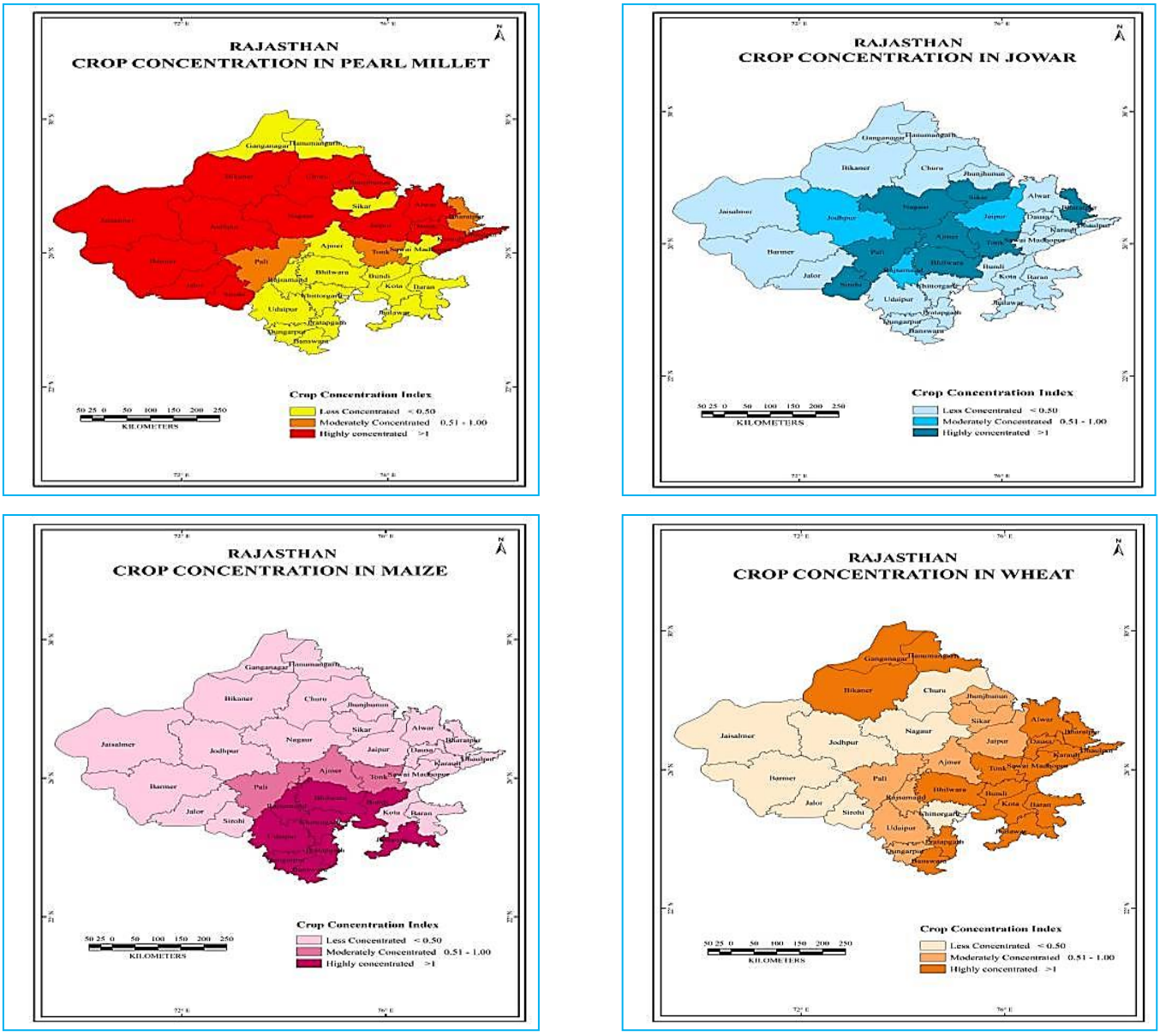

Fig 1 Crop concentration of pearl millet, jowar, maize and wheat, 2017-18, Rajasthan

The (Fig 1) shows that the concentration of maize is basically in the southern part of the study area. Likewise, the districts falling under the category of 'highly concentrated (>1)' includes Banswara, Dungarpur, Pratapgarh, Udaipur, Chittorgarh, Rajasamadd, Bhilwara, Bundi, and Jhalawar while the districts under the category 'moderately concentrated (0.5-1.00)' were Tonk, Ajmer, and Pali. The districts falling under the category of 'less concentrated (<0.50)' includes Ganganagar, Hanumangarh, Bikaner, Churu, Jhunjhunu, Sikar, Alwar, Jaipur, Bharatpur, Dausa, Dhaulpur, Karauli, SawaiMadhopur, Kota, Baran, Nagaur, Jodhpur, Jaisalmer, Barmer, Jalor, Sirohi, Kota, Baran. In India, after wheat and rice, maize is considered to be the third most important food grain**.** Rajasthan has one of the highest productions of maize in India. It contributes around 9 percent of the total maize area of India. It is mainly concentrated in the districts of Udaipur, Banswara, Dungarpur, Jhalawar, Pratapgarh, etc. It is highly concentrated in southern Rajasthan which has humid climatic conditions. Maize has low nutritive value. In 100 grams of maize, there are 381 calories, 91 gm of carbohydrates. Maize is considerably low in fibre, protein, fats, sodium, and iron. It does not have magnesium, calcium, potassium and vitamin C [15].

The (Fig 1) shows that wheat is majorly concentrated in the northern part, northeastern part, and southern parts of the study area. The districts in the category of 'highly concentrated (>1)' includes Bikaner, Ganganagar and Hanumangarh in the northern part of the study area while northeaster part covers districts like Alwar, Bharatpur, Dausa, Dhaulpur, Karauli,

SawaiMadhopur, Tonk, Bundi, Kota, Baran, Jhalawar, Bhilwara. Pratapgarh and Banswara in the southern part. The districts under the category of 'moderately concentrated (0.51-1.00)' includes Jhunjhunu, Sikar, Jaipur, Ajmer, Pali, Rajasamadd, Udaipur, Dungarpur in the central region of the study area. The districts falling under the category 'less concentrated (<0.51)' includes Churu, Nagaur, Jodhpur, Jaisalmer, Barmer, Jalor, and Sirohi.

Wheat called. e *gehu* grown in Rajasthan contributes to 8 percent of the total wheat production of India. Wheat is a Rabi crop. It needs moderate temperature and rainfall. It is mainly grown in alluvial soil [16]. It is highly concentrated in Hanumangarh, Ganganagar, and Bikaner in the north and Alwar, Bundi, Tonk, Kota, Baran, and other districts of the south or southeast Rajasthan. These areas receive plenty of rainfall and have alluvial soil. The irrigation system is also good in these areas. Wheat has good nutritive value. 100 gm of wheat contains 346 calories, 11.8 g of protein, 1.5 gm of fat, 12.5 g of fibre, 2.4 g of sodium, and 20% of iron [17]. Food and nutrition insecurity is ultimately related to its consumption and health impacts. If People are not healthy or suffer from nutrition deficiency, diseases, then it is commonly interpreted that they have inadequate consumption of food. To analyze food consumption several indicators were taken into consideration, namely the proportion of underweight children below five years of age, anemic children (0-5 years), anemic men, and anemic women. The selection of indicators was also based on the data available.

Though the problem of anemia is quite common in the people of Rajasthan it is more prevalent in women as compared to their male counterparts [18]. The districts with more number of females as anemic patients were Jalor, Pali, Ajmer, Tonk, Bundi, Kota, Baram, Jhalawar, Chittaurgarh, Banswara, Dungarpur, Udaipur and Sirohi. The districts with a comparatively lesser number of females as anemic patients were Ganganagar, Hanumangarh, Bikaner, Churu, Jhunjhunu, Jaipur, Karauli, SawaiMadhopur, Nagaur, Jodhpur, Barmer, Jaisalmer. In districts of Dungarpur, Banswara, Pratapgarh, Udaipur, Jhalawar, Bundi, Kota, SawaiMadopur, Ajmer, Bhilwara, Pali have more than 50 percent of women suffer from anemia. Only Jaipur and Dausa the percentage is less than 30, though it is still very high and reflects concern about female health. In Banswara and Sirohi districts men have high iron deficiency i.e. above 40 percent. Other districts with more than 20 percent of men population suffering from anaemia are Udaipur, Dungarpur, Chittorgarh, Kota, Tonk, Baran, Rajasmad and Pratapgarh (Fig 2).

(Fig 3) shows higher percentage of anemic children exists in the districts namely Rajsamad (75.9 percent), Udaipur (79.1 percent), Pratapgarh (75.8 percent), Dungarpur (76.0 percent), Banswara (84.1 percent), Tonk (74.3 percent), Bundi (80.0 percent), Kota (73.8 percent), Baran (76.0 percent), Jhalawar (76.6 percent). The districts falling in the category of 'high (65-72 percent)' were Ajmer (68.7 percent), Bhilwara (71.7 percent), Chittaurgarh (71.7 percent), Sirohi (69.8 percent), and Jalor (67.0 percent). The districts falling in the 'medium (57-64 percent)' includes Barmer (60.0 percent) and Jodhpur (63.6 percent). The districts falling in the category of 'low (49-56 percent)' includes Bikaner (51.2 percent), Nagaur (50.8 percent), Pali (53.4 percent), Karauli (52.8 percent), Alwar (54.0 percent), Dhaulpur (50.0 percent), Jaipur (49.8 percent). The districts in the category 'very low (40-48 percent)' include Ganganagar (40.0 percent), Churu (42.2 percent), and Jaisalmer (42.5 percent).

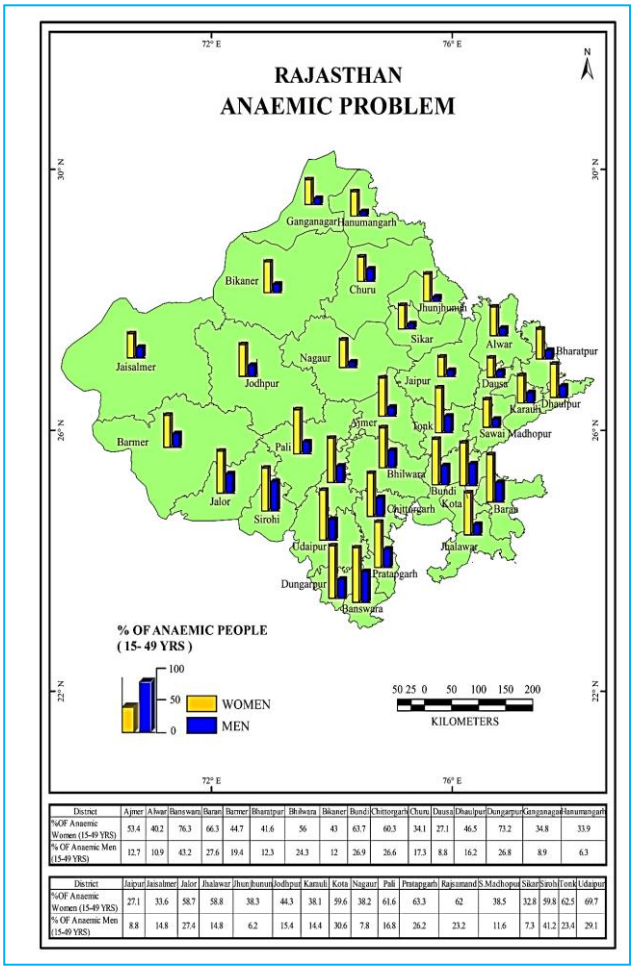

Fig 2 Anaemic problem in Rajasthan

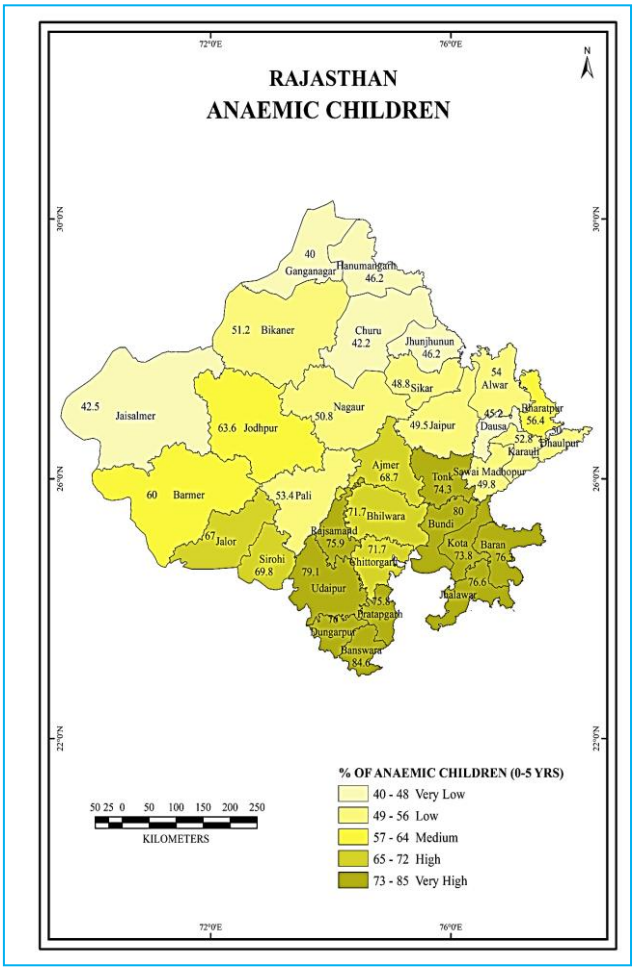

Fig 3 Anaemic children in Rajasthan

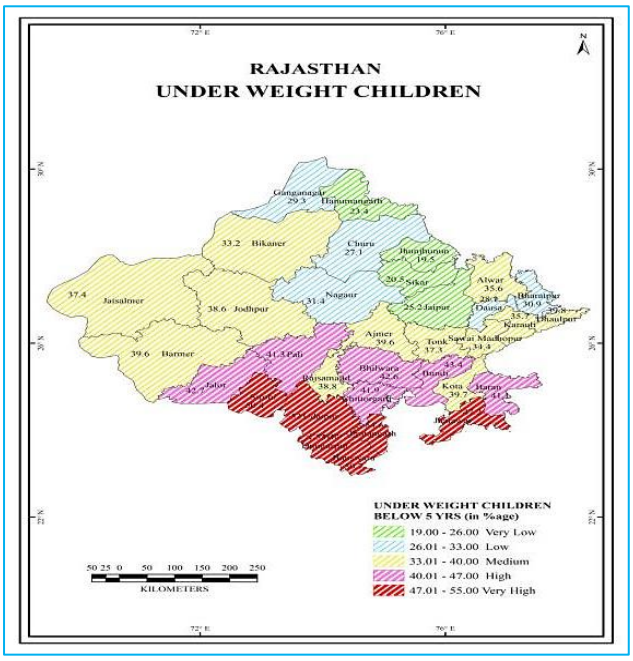

Fig 4 Underweight children

(Fig 4) shows that Children between 0- 5 years of age, the districts having more anemia are Banswara, Dungarpur, Pratapgarh, Udaipur, Baran, Tonk, Bundi, etc. These districts have a very high percentage of anaemic population i. e. more than 70 percent. Inthedistricts of Ganganagar, Hanumangarh, Jaisalmer, Churu, and Jhunjhunun the percentage of anemic children is below 40. Considering the lowest percentage, it can be interpreted that iron deficiency is a major challenge in Rajasthan. The districts having underweight children under the category of 'very high (47.01-55.00 percent)' includes Sirohi (50.4 percent), Udaipur (52.1 percent), Jhalawar (47.2 percent), Pratapgarh (54.0 percent), Banswara (50.7 percent), Dungarpur (53.0 percent). The districts in the category 'high (40.01-47.00 percent)' includes Baran (41.0 percent), Bundi (43.4 percent), Chittorgarh (41.9 percent), and Pali (41.3 percent), Jalor (42.7 percent). The districts falling in the medium category includes Kota (39.7 percent), Dhaulpur (39.8 percent), Karauli (35.7 percent), Ajmer (39.6 percent), SawaiMadhopur (34.4 percent), Jodhpur (38.6 percent), Barmer (39.6 percent), Jaisalmer (37.4 percent), Bikaner (33.2 percent). The districts in the category 'low (26.01-33.00 percent)' Churu (27.1 percent), Nagaur (31.4 percent), Bharatpur (30.9 percent). The districts in the category of 'very low (19.00-26.00 percent)' includes Sikar (20.5 percent) and Jaipur (25.2 percent).

(Fig 4) shows underweight children below 5 years of age is also high in districts of Banswara, Dungarpur, Sirohi, Udaipur, Pratapgarh, and Jhalawari.e above 47 percent whereas the districts of Hanumangarh, Sikar, Jaipur Jhunjhunun it is between 19 -26 percent. Underweight children reflect the undernourishment that both child and mother must be having. According to a study conducted by Mulu and Mengistie [19] in Western Ethiopia Food insecurity influences children's nutritional status by limiting the quantity and quality of dietary intake. Studies conducted across different parts of the world revealed controversial evidence about the relationship between household food insecurity and child nutritional status [19].

Correlation between Crop Concentration and nutritional challenges - Areas with a higher concentration of Bajra do not reflect higher values of underweight children and anemic populations. Areas with a higher concentration of maize definitely reflect higher underweight children and higher anemic children and women.

Table 2 Correlation matrix between crop concentration and nutritional challenges in Rajasthan

Crop	Bajra	Jowar	Maize	Wheat	Barley	Underweight children	Anaemic children	Anaemic women
Bajra	1							
Jowar	-0.14281	1						
Maize	-0.58386	-0.11295	1					
Wheat	-0.61771	-0.2839	-0.06895	1				
Barley	-0.19462	0.710179	0.202393	-0.29829	1			
Underweight children	-0.29338	-0.17967	0.632648	-0.01218	-0.08379	1		
Anaemic children	-0.51917	-0.03163	0.681336	0.129896	0.014193	0.798493486	1	
Anaemic women	-0.50601	0.001544	0.689026	0.089975	-0.11755	0.849668464	0.916346007	1

Multiple regression analysis has been used to test whether there is an association between variables that suggest malnutrition among children and women, and crop concentration index for bajra, jowar, wheat, and maize. The variables suggesting malnutrition are the dependent variables for regression models and the crop concentration indices for the various crops serve as the independent variables.

Table 3 Regression analysis between CCI and nutritional challenges, 2017-18

	Regression coefficient (t stat, p values) of independent variables				Regression Model		
Dependent variable	Bajra CCI	Jowar CCI	Wheat CCI	Maize CCI	Adjusted R square	F value	Significance of F (P Value)
Percent of anemic children (6-5yrs)	9.74 (1.01,0.32)	4.38 (1.94,0.06)	13.02 (1.6,0.12)	6.84 (2.74,0.01)*	0.532	10.12	0
Percent of underweight children below 5 years	12.59 (1.77,0.09)	4.16 (2.5,0.02)*	11.34 (1.9,0.07)	5.83 (3.18,0)*	0.447	7.47	0
Percent of anemic women (15-49 years)	11.74 (1.22,0.23)	5.47 (2.44,0.02)*	14.29 (1.77,0.09)	7.6 (3.07,0)*	0.575	11.85	0

CCI - Crop Concentration Index

The regression models show that there is a significant association between:

- Percentage of Anemic Children (6-5 years) and Maize CCI
- Percentage of Underweights Children Below 5 years and Jowar CCI as well as Maize CCI
- Percentage of Anemic Women (15-49 years) and Jowar CCI as well as Maize CCI

No significant association has been found between wheat CCI and Bajra CCI. The significance of the models shows that the concentration of maize and to an extent, jowar explains the high percentage of anemic children, underweight children, and anemic women in the districts of Rajasthan.

CONCLUSION

The proportion of underweight children and anaemic people (children, men and women) is considerably high in the state of Rajasthan. The percentage of anaemic women was 'less than 30' only in Jaipur and Dausa leaving aside these two districts all other have high percentage of anaemic population. The regions dominated by Bajra crop do not have higher percentage of underweight and anaemic population while areas with Maize as dominant crop have higher percentage of underweight and anaemic population. To meet the nutritional challenges, it is important to promote the regrowing of indigenous crops which have been replaced by the maize and wheat so that nutritional requirements can be met. Iron fortification in crops like maize and jowar in the region where it is the main staple crop or combining it with other iron-rich vegetables can help address the problem of anemia among women and children as well as the problem of children being underweight at ages below 6 years. Moreover, dairy farming practices can also meet the nutritional supply. Our diets need to be nutrition sensitive which means incorporating nutrition objectives, concerns and considerations to enable communities to achieve food and nutrition security by avoiding negative impacts of consuming one form of food. The study underscores the importance of understanding the regional distribution of crops and its implications for nutrition and health outcomes. It highlights the need for promoting indigenous crops, fortifying staple crops, and adopting nutrition-sensitive diets to address nutritional challenges in Rajasthan.

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