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Changing cropping pattern of oilseed crops and its diversification: The case of Thar Desert, Rajasthan (1985–1986 to 2015–2016)

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Abstract – India has been one of the largest producers of oilseeds in the world. Correspondingly, the oilseed sector occupies an important position in the agricultural economy of the country. Oilseeds, especially edible oilseeds, have been an integral part of the cropping system in India till the beginning of monoculture triggered by the implementation of a new agriculture strategy since 1960s. This paper evaluates the cropping pattern of oilseed diversity in the Thar Desert of Rajasthan at district level. This paper also highlights the development programmes launched by state and central governments to promote oilseeds production in dry region of the state. Many statistical techniques are used, for instance, Herfindahl Index, Entropy Index, and Composite Entropy Index, to examine the diversification and specialization in oilseeds.

Keywords: agriculture / cropping pattern / desert / diversification / rainfall

Résumé – Évolution du modèle cultural des oléagineux et de leur diversification : le cas du désert de Thar, Rajasthan (1985–1986 à 2015–2016). L'Inde est l'un des plus grands producteurs d'oléagineux au monde. Donc, le secteur des oléagineux occupe une place importante dans l'économie agricole du pays. Les oléagineux, en particulier ceux destinés à l'alimentation, ont fait partie intégrante du système de culture en Inde jusqu'à l'adoption de la monoculture, liée à la mise en œuvre d'une nouvelle stratégie agricole à compter des années 1960. Cet article évalue le schéma cultural de diversification des oléagineux dans le désert de Thar, au Rajasthan, au niveau des districts. Il met également en évidence les programmes de développement lancés par l'État et le gouvernement central pour promouvoir la production d'oléagineux dans les zones sèches de cette région. De nombreuses techniques statistiques sont utilisées, par exemple l'indice de Herfindahl, l'indice d'entropie et l'indice d'entropie composite, pour examiner la diversification et la spécialisation des cultures oléagineuses.

Mots clés : agriculture / modèle cultural / désert / diversification / précipitations

Highlights

Rapeseed and mustard have been the dominant crops in the Thar Desert. Farmers have started cultivation of castor seed and groundnut oilseed crops. The cropping region of Rajasthan shows moderate oilseed diversification due to changes in policies by the state. Farmers have been facing serious problems related to oilseed cultivation like non-ensured minimum support price (MSP), marketing infrastructure, and transportation.

1 Introduction

A paramount change has been seen in the agricultural sector of Rajasthan in the study period. The Rajasthan Region, previously known to be a land of low-value and low-yield, and had crops for short rotations. It was highly dependent on activities associated with agriculture such as agro-forestry and livestock. But, the changes in the agriculture sector, mainly extension in irrigation facilities, introduction of improved technology and better infrastructure, etc. (Kar, 2014), have significantly improved the agricultural landscape of the state. Due to these changes, economic condition of farmers in the region improved overtime.

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However, the decision for adoption of such modern technologies and over-exploitation of less fertile land have turned into a major problem that is adversely affecting the agriculture and livelihood of farmers (Kar, 2014). The climatic conditions of Rajasthan varied from arid and semi-arid to sub-humid or sub-tropical. Although, it is an integral part of the Indian Monsoon system but because of regional conditions, more variations are seen in the climatic conditions (Saxena, 2019). More than half of Rajasthan receives less than 30 cm of rainfall annually, due to which it is termed as arid region. The wide fluctuation in rainfall often leads to drought-like situations. Drought in the state does not simply represent lack of adequate total rainfall but also its distribution during the monsoon (Sagar, 1995). There has been a rainfall failure in many districts of Rajasthan during 1998 to 2000. Acute drought creates a scarcity of water, food, and fodder (Bokil, 2000). The "Thar Desert" is characterized by low and erratic rainfall, high evapotranspiration, large temperature variation, scanty vegetation, rodent infestation, and absence of perennial rivers, sparse and nomadic population, and dependence of man on animal rearing (Singh and Kumar, 2015).

Agriculture has been the principal occupation of the working population of Rajasthan (Sagar, 1995). Before the commissioning of Indira Gandhi Canal, "Thar Desert" was a barren landscape of sand dunes and subsistence of the masses was based on animal husbandry and allied activities. Rajasthan accounted for 10.70% of livestock and 8.48% of milk production with a population of 5.66% of India (Singh *et al.*, 2014).

The agriculture sector in India, as well in Rajasthan, recorded tremendous progress after independence. Oilseeds have traditionally formed as the backbone of Indian agriculture. India as a whole has been the fourth-largest oilseed producers in the world. It produced 25.14 million tons of oilseeds, which accounted for approximately 8–9% of the world's oilseed production (Singh and Bansal, 2020). Rajasthan is considered as the third largest producer of oilseeds as the farmers of this state have a share of 15.1% in the total production of oilseeds in India. The area under these crops occupies 12.8% of the total area of India, which is an almost 24.01 million hectare. The contribution of Rajasthan to the production of vegetable oil in 2002–2003 amounted to 13% of the total production in India. Groundnuts, soybeans, and rapeseed are the main oilseeds of Rajasthan. The domestic performance of oilseeds is commendable despite changing weather patterns, global price volatility, and increasing domestic demand for the period of time (Jha *et al.*, 2012).

Rajasthan's cropping pattern is diverse in nature. The farmers of Rajasthan cultivated many types of crops like Bajra (Millet), oilseeds (rapeseed and mustard), Taramira (rocket), linseeds, castor seeds, groundnut and sesamum, pulses (gram, moth bean, Moong (green gram), Maah (black gram), Tur (pigeon pea), Chaula (split cow peas), and Urad (split and dehusked black gram lentils)), wheat, maize (corn), barley, cotton, tobacco, sugarcane, Jowar (sorghum), red chillies, Ajwain (carom seed), among others. In a sense, crop diversification means production of different varieties of crop in the same cultivable land. It implies that farmers harvest a variety of crops in a plot of land rather than a single crop. Crop diversification helps to increase farmers' income, generate employment opportunities, and also helps in reduction of poverty (Chand 1996; Ryan and Spencer 2001). Crop diversification is a concept, which is opposite to crop specialization. The level of crop diversification largely depends on the geo-climatic conditions, socio-economic factors, and technological development in a region. In general, higher level of agricultural technology reduces the degree of diversification (Husain, 2010). The meaning of diversification can be elaborated as the movement of resources from low-value commodity to a high-value commodity (Joshi *et al.*, 2004).

This paper will analyze the spatial-temporal pattern of oilseeds cultivation at the district level during the time period of 1985–1986 to 2015–2016. This paper will also find out the districts experiencing oilseed "diversification" as well as oilseed "specialization". The paper focuses on the role of government (both centre and state) in increasing production of oilseeds in the Thar Desert of Rajasthan. To provide the deeper insight, this paper has been categorized into four sections where the Section 2 deals with study area and methodology. Section 3 focuses on the empirical evidence regarding changing spatial-temporal patterns of oilseed cultivation across districts over time. The Section 4 represents the conclusion.

2 Study area and methodology

There is a hot desert in western Rajasthan, which is known as the Great Thar Desert of India. It extends to the southern part of Haryana and Punjab and the northern part of the state of Gujarat. The Thar Desert is located between 24°–28°N and 68°–71°E in the western part of Indian subcontinent and covers a total area of about 200 000 km^2. Although, it is the 9th largest desert in the world, it has excellent biodiversity. The average population density of the Thar Desert is 83 persons/km^2, while in other deserts of the world the population density is 7 persons/km^2. In India, more than 60% of the geographical area of the Thar Desert is in the state of Rajasthan. The climate of the Thar Desert is dry and is characterized by low and irregular rainfall, frequent droughts, daily and annual extreme hot temperatures, high wind speeds and low humidity. The highest temperature in summer (March–June) typically ranges between 45 °C to 50 °C, while peak temperature in winter (November–February) ranges between 15 °C to 25 °C. More than 88% of the total annual precipitation (less than 25 cm) in the Thar Desert falls during the rainy season (July–October). The report of the Inter-governmental Panel on Climate Change (IPCC) predicts that the Thar Region will experience warmer days and nights and less rainfall in the 21st century.

This research work is mainly based on secondary data. Different websites and publications provided by the Ministry of Agriculture of the Government of India have been used to collect relevant information regarding crops area. Various issues of Statistical Abstract of Rajasthan have been pressed into service. To look into the policy shift and its effects, the data were divided into three time periods, *i.e.* 1985–1986 to 1995–1996, 1995–1996 to 2005–2006, and 2005–2006 to 2015–2016. The authors used a simple percentage share method to examine the area under oilseed crops across districts of Rajasthan. To analyze the diversification of crops, the authors used statistical techniques like Herfindahl Index (HI),

Entropy Index (EI), and Composite Entropy Index (CEI) (Khatun and Roy, 2014).

Herfindahl Index (HI), Entropy Index (EI), and Composite Entropy Index (CEI) are explained in Sections 2.1–2.3.

2.1 Herfindahl Index (HI)

HI is calculated by taking the sum of the squares of the ratio of the area of each crop to find the total area using the formula:

$$H.I. = \sum_{i=1}^{N} P_i^2,$$

where N is the total number of crops and Pi is the ratio of the area of the ith crop to the total area visited. Its values are capped at 0 and 1. As diversification increases, HI decreases. The index value is 1 in the presence of full specialization and it is close to 0 when crops are fully diversified. It has proved to be the limitation that it cannot assume the theoretical minimum, *i.e.* 0 for smaller values of N (number of crops). HI is a concentration measurement that uses a corrected value (1-HI) instead of HI. To avoid confusion with other indices, (1-HI) is sometimes used as a measure of dispersion instead of HI (Khatun and Roy, 2014).

2.2 Entropy Index (EI)

The measure of entropy is the reciprocal of the logarithmic concentration. By this formula, Entropy can be calculated:

$$E.I. = \sum_{i=1}^{N} P_i log\left(\frac{1}{P_i}\right).$$

The exponent increases with diversification and tends to zero at ideal concentration. That is when $Pi = 1$. Log N is the upper bound of the exponent. Logarithm criterion and the number of crops help in the determination of upper bound of the Entropy Index. If the number of collections is greater than the base log value, then the exponential value will be greater than 1 and it will be less than 1 if the total number of collections is less than the base log value. Thus, it proves to be the major hindrance of EI because it does not provide a standard measure for assessing the degree of diversification (Khatun and Roy, 2014).

2.3 Composite Entropy Index (CEI)

This index has all the desirable properties of the Modified Entropy Index. The CEI is used to compare diversification across different activities because the formula provides the necessary weight for the number of crops. Formula for CEI is given below:

$$C.E.I. = \left(\sum_{i=1}^{N} P_i log_N P_i\right)\left(1 - \frac{1}{N}\right),$$

or

$$C.E.I. = MEI\left(1 - \frac{1}{N}\right).$$

It has two components, *i.e.* distribution and number of crops or diversity. When there is decrease in concentration and increase in number of crops, the CEI values increases. Both components are limited to 0 and 1. Because the index uses log $N\,Pi$ as its weight, it assigns more weight to the smaller set and less weight to the larger set (Khatun and Roy, 2014).

3 Findings and discussion

This paper helps to understand the changing composition of oilseed production in the technological development context of oilseeds, "Oilseed Development Programmes and Projects" initiated by the Indian and Rajasthan governments. The area under oilseeds from 1985–1986 to 2015–2016 is discussed with the help of Tables 1–4 and Figures 1–4.

Table 1 represents the percentage share of areas, which are indulged in oilseed crop production such as rapeseed, sesamum, mustard, linseed, groundnut, and castor seeds in the selected districts of Rajasthan during the period 1985–1986. During 1985–1986, the highest area under sesamum crop was in Barmer District with 65.40% and the lowest was in Hanumangarh with 0.03%. The rapeseed and mustard oilseed played a dominant role in 1985–1986. The 90% share of rapeseed and mustard was from the three districts namely Jhunjhunu with 99.89%, Hanumangarh with 92.49% and Ganganagar with 91.50% and the lowest share of rapeseed and mustard with 29.64% was in Barmer. The share of linseed crop was less than one percent. In the case of groundnut crop, Nagaur ranked highest with a share of 10.80% and eight out of ten districts had less than one percent share. The highest area under castor seed was in Jalore District with 5.56% and lowest area was in the districts such as Bikaner, Churu, Jaisalmer, Jhunjhunu, and Nagaur with 0.00%. The changing pattern in the region over the period of time has been due to various strategies and projects introduced by the central government and state government of Rajasthan after the 1980s. The first strategy in this regard was initiated in 1984–1985 by realigning various centrally funded oilseed development programmes under the banner of National Oilseed Development Project (NODP) to overcome stagnation in oilseed production. Second, the Oil Seed Technology Mission had been launched by the Government of India in the month of May, in 1986, the objective of which is to achieve self-sufficiency in the production of oilseeds and vegetable oil (Sharma, 2014; Marothia *et al.*, 2016). Owing to the changing policy environment, various incentives and institutional support were provided for the development of the oilseeds sector, based on the constitution of Technology Mission on Oilseeds (TMO). With the implementation of these programmes and strategies, India's oilseeds output had crossed 21 million during 1992–1993, which surpassed the target of 18 million fixed for being attained by the end of the Seventh Five-Year Plan. This implies that oilseeds output in India have been increasing at the rate of 6% per annum (Ninan, 1995).

In 1995–1996, the Jodhpur District covered the highest area under the sesamum crop with 52.37%, and Jhunjhunu had the lowest area with 0.24%. Out of twelve districts, three districts namely Jhunjhunu, Ganganagar, and Hanumangarh had a share of 90% in the production of rapeseed and mustard oilseeds and lowest area recorded was in Bikaner district with

Table 1. Percentage share of oilseeds in various districts of Rajasthan in 1985–1986.

District	Sesamum (percentage share)	Rapeseed and mustard (percentage share)	(Area arable land in thousand hectares) Linseed (percentage share)	Groundnut (percentage share)	Castor seed (percentage share)
			1985–1986		
Barmer	7921	3590	0	1	600
	(65.40)	(29.64)	(0.00)	(0.01)	(4.95)
Bikaner	14 010	12 778	2	559	1
	(51.22)	(46.72)	(0.01)	(2.04)	(0.00)
Churu	1678	1872	0	4	0
	(47.21)	(52.67)	(0.00)	(0.11)	(0.00)
Hanumangarh	65	185 471	541	14 282	171
	(0.03)	(92.49)	(0.27)	(7.12)	(0.09)
Ganganagar	96	174 248	603	15 466	13
	(0.05)	(91.50)	(0.32)	(8.12)	(0.01)
Jaisalmer	137	96	0	0	0
	(58.80)	(41.20)	(0.00)	(0.00)	(0.00)
Jalore	30 452	64 498	1	20	5587
	(30.28)	(64.14)	(0.00)	(0.02)	(5.56)
Jhunjhunu	83	18 029	0	28	0
	(0.46)	(99.39)	(0.00)	(0.15)	(0.00)
Jodhpur	35 703	25 936	7	152	49
	(57.73)	(41.94)	(0.01)	(0.25)	(0.08)
Nagaur	60 135	54 975	8	13 942	3
	(46.59)	(42.60)	(0.01)	(10.80)	(0.00)
Pali	82 338	54 535	102	3126	1744
	(58.05)	(38.45)	(0.07)	(2.20)	(1.23)
Sikar	1054	14 839	0	327	2
	(6.50)	(91.47)	(0.00)	(2.02)	(0.01)

Source: Statistical Abstract of Rajasthan, 1985–1986

34.01%. Figure 2 shows that rapeseeds and mustard oilseeds were a dominant crop than other oilseeds crops (sesamum, linseed, castor seed, and groundnut). Besides, the area under linseed crop was deteriorating over the period of time. But, the area under groundnut was recorded the highest in Bikaner District with 33.66% out of twelve districts. Therefore, the six districts covered less than 2% of the area under groundnut. Highest area under castor seed crop was in the Barmer District with 5.72%, but it is less than one percent in other eleven districts. For instance, Indira Gandhi Canal Project was being executed in the districts of Churu, Hanumangarh, Bikaner, Jaisalmer, Jodhpur, and Barmer to utilize 7.59 MAF (Million Acre Feet) waters out of total 8.6 MAF allocated to Thar Desert, Rajasthan (*Economic Review*, 1996–1997). The maximum area of these districts was under "Barani" land (agricultural area that depends only on rainfall for cultivation) but canal water converted this area into a fully irrigated land. At that time, even in India, the main shift took place from coarse cereals to oilseeds. Due to that, cropped area under oilseeds had been increased by about 8 million hectares and its share in the cropped area increased from 10.92% in 1980–1983 to 15.31% in 1992–1995. Among oilseeds, the area under rapeseed, mustard, and groundnut increased respectively. Besides these crops, the share of remaining crops also increased in the total cropped area (Bhalla and Singh, 1997). The Government of India also setup the Technology Mission on Oilseeds Production in May 1986, the objective of which is to provide plant production umbrella, latest technology, and credit facilities to boost the production of oilseeds in the selected districts of the country. To achieve these objectives, improvements of drainage in heavy rainfall areas, water conservation techniques in low rainfall areas, increase in plant density per unit area and intercropping of oilseeds with some pulses to control pests were recommended (Bansil, 1997).

During 2005–2006, the highest area under sesamum crop was in Pali District with 77.69% and the lowest was in Jhunjhunu with 0.01%. The highest area under rapeseed and mustard was in Jhunjhunu District with 98.51%, followed by Hanumangarh with 98.45%. On the other hand, the Pali District showed the lowest area (18.57%) under this crop. During 2005–2006, the area under the linseed crop did not show any growth because all the 12 districts had area less than one percent share in the linseed production. During this period, the area under this crop stagnated. The highest area under the groundnut crop was in the Bikaner District with 51.24%, and the lowest was in the Ganganagar District with 0.25%. The highest area (28.25%) under castor seed was the Jalore District and the area under Sikar District did show any increment. Production of oilseeds had also increased four-fold in 2006–2007 (11th Five-Year Plan, 2006). The impact of the Integrated Scheme of Oilseeds, Oil Palm and Maize (ISOPOM) had been witnessed during 2004–2014. Due to the initiation of this

Table 2. Percentage share of oilseeds in various districts of Rajasthan in 1995–1996.

District	Sesamum (percentage share)	Rapeseed and mustard (percentage share)	(Area arable land in thousand hectares) Linseed (percentage share)	Groundnut (percentage share)	Castor seed (percentage share)
			1995–1996		
Barmer	10 355 (41.69)	13 049 (52.54)	12 (0.05)	0 (0.00)	1420 (5.72)
Bikaner	23 764 (32.16)	25 131 (34.01)	127 (0.17)	24 872 (33.66)	8 (0.01)
Churu	2026 (12.77)	11 539 (72.76)	0 (0.00)	2273 (14.33)	22 (0.14)
Hanumangarh	1231 (1.50)	79 760 (97.37)	2 (0.00)	412 (0.50)	512 (0.63)
Ganganagar	1299 (0.60)	212 990 (97.92)	2 (0.00)	3207 (1.47)	13 (0.01)
Jaisalmer	944 (10.26)	6316 (68.65)	2 (0.02)	1901 (20.66)	37 (0.40)
Jalore	23 193 (14.18)	131 298 (80.29)	11 (0.01)	45 (0.03)	8991 (5.50)
Jhunjhunu	152 (0.24)	63 687 (98.73)	0 (0.00)	662 (1.03)	3 (0.00)
Jodhpur	64 195 (52.37)	57 442 (46.86)	9 (0.01)	629 (0.51)	296 (0.24)
Nagaur	108 130 (48.86)	107 281 (48.48)	5 (0.00)	5875 (2.65)	6 (0.00)
Pali	89 001 (40.69)	126 342 (57.77)	5 (0.00)	2322 (1.06)	1045 (0.48)
Sikar	1012 (2.58)	34 609 (88.40)	7 (0.02)	3524 (9.00)	0 (0.00)

Source: Statistical Abstract of Rajasthan, 1995–1996

scheme, the area under groundnut, linseed, rapeseed and mustard had increased, which resulted in a significant escalation in production (GOI, 2014).

During 2015–2016, the highest area under sesamum crop was in Pali District with 90.60% and the lowest was in Jhunjhunu with 0.15%. The highest area under rapeseed and mustard was in Jhunjhunu with 97.84% and lowest area under this crop was in the Pali District with 6.50%. In 2015–2016, the linseed crop did not show any growth over the period of time, the area under this crop stagnated. The highest area under the groundnut crop was in the Bikaner District with 69.59%, and the lowest was in the Pali District with 0.98%. The castor seed grown only in Barmer with 50.38% but the six districts namely Churu, Sikar, Bikaner, Jhunjhunu, Nagaur and Hanumangarh had a share of less than one percent. Figure 4 indicates that rapeseed and mustard was the foremost crop in this time period. The central government launched a new mission, *i.e.* National Mission on Oilseeds and Oil Palm (NMOOP) during 12th Five-Year Plan (2012–2017). To implement this mission, certain strategies have been taken into consideration such as increasing coverage area for oilseeds production from 26 to 36%; increasing Seed Replacement Ratio (SRR) with emphasis on varieties replacement and diversification of area from cereals to oilseeds production. The cost of carrying on the strategies in the mission would be shared by the state and central government in the ratio of 25:75, except in few cases such as supply of seed minikits, purchase of breeder seeds, development of infrastructure for production of seed through public sector entities like State Farms Corporation of India (SFCI), National Seeds Corporation (NSC), State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), Front Line Demonstrations (FLDs), procurement support to National Agricultural Cooperative Marketing Federation of India Limited (NAFED), Tribal Cooperative Marketing Development Federation of India Limited (TRIFED), Research and Development (R&D) support for Programme (*Economic Review*, 2015–2016; 12th Five-Year Plan, 2012–2017).

There were various factors that led to increase or decrease in the growth of area under oilseeds in Rajasthan. An overall decline of 14% can be seen in the area used for cultivating sesamum crop during the period of 1995–1996 to 2005–2006 (Fig. 5). The reasons for this decline were poor production due to water stress and infestation and poor post-harvest price. It gives a clear understanding that irrigation facilities play a significant role in the cropping pattern. These facilities also play a vital role if the nature of variability is analyzed in cultivation of oilseeds. Even though rainfall remained at alarming level in Rajasthan over the years, the development of irrigation facilities in the state were quite beneficial to the farmers (Swain, 2013).

Table 5 elaborates the changing cropping pattern of the Thar Desert from 1985–1986 to 2015–2016. The area under

Table 3. Percentage share of oilseeds in various districts of Rajasthan in 2005–2006.

District	(Area arable land in thousand hectares)				
	Sesamum (percentage share)	Rapeseed and mustard (percentage share)	Linseed (percentage share)	Groundnut (percentage share)	Castor seed (percentage share)
	2005–2006				
Barmer	6851	17 086	0	96	1702
	(26.62)	(66.39)	(0.00)	(0.37)	(6.61)
Bikaner	3145	36 850	0	42 229	192
	(3.82)	(44.71)	(0.00)	(51.24)	(0.23)
Churu	860	23 547	60	9501	308
	(2.51)	(68.70)	(0.18)	(27.72)	(0.90)
Hanumangarh	1234	303 138	470	2215	862
	(0.40)	(98.45)	(0.15)	(0.72)	(0.28)
Ganganagar	6201	163 084	0	449	10 354
	(3.44)	(90.56)	(0.00)	(0.25)	(5.75)
Jaisalmer	416	44 167	4	4728	487
	(0.84)	(88.69)	(0.01)	(9.49)	(0.98)
Jalore	27 429	77 678	0	915	41 744
	(18.56)	(52.57)	(0.00)	(0.62)	(28.25)
Jhunjhunu	10	113 745	0	1658	56
	(0.01)	(98.51)	(0.00)	(1.44)	(0.05)
Jodhpur	38 145	65 439	0	12 318	9079
	(30.52)	(52.36)	(0.00)	(9.86)	(7.26)
Nagaur	40 147	132 749	0	14 416	164
	(21.41)	(70.81)	(0.00)	(7.69)	(0.09)
Pali	148 944	35 609	1	3028	4126
	(77.69)	(18.57)	(0.00)	(1.58)	(2.15)
Sikar	504	61 823	0	28 557	3
	(0.55)	(68.02)	(0.00)	(31.42)	(0.00)

Source: Statistical Abstract of Rajasthan, 2005–2006

sesamum crop has been sharply declining in Bikaner, Barmer, Churu, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Sikar districts. But, the positive growth of area under sesamum crop was found in Pali District with 32.55%, followed by Ganganagar District with 6.32% and Hanumangarh District with 1.42%. The rapeseed and mustard were declined in Pali District with a negative of 32%. On the contrary, the highest increase was found in Jaisalmer with 33.95% over the thirty years' time period. The farmers shifted from sesamum to rapeseed and mustard because sesamum crop was attacked by many pests. During 1985–1986 to 2015–2016, linseed crop did not undergo major changes over the three decades. The area under groundnut increased in Bikaner District by 67.55%, Churu District by 58.9%, Jodhpur District by 24.94%, Sikar District by 24.76%, Jaisalmer District by 20.02%, and Nagaur District by 6.67%. Hanumangarh, Ganganagar, and Pali districts had faced a minor decline of area by (−4.86%, −3.75%, and −1.22%) respectively under groundnut during this time period. The area under castor seed did not decrease over the period of thirty years. The area under castor seed had increased in the study area during 1985–1986 to 2015–2016. India has emerged as the largest exporter of castor oil with 86.1% share in the world market during the year 2018. India had exported more than 690 000 (0.69 million) tons of castor oil worth Rs 67.3 billion during the year 2017–2018 (Gondalia *et al.*, 2020).

3.1 Crop diversification and specialization

Table 6 shows the index values of 12 districts of Rajasthan from the time period of 1985–2016. These calculations help us to understand the level of diversification in a particular area of a specific crop. These values are calculated with the use of Herfindahl, Entropy, and Composite Entropy Indexes. These indexes were required for understanding the diversification level, as the reader cannot estimate this level by a mere glance at the percentage share of a specific crop in an area. For instance, in 1985–1986, total area used for production of oilseeds in Barmer District was 12 112 (area in thousand hectares). The area used for the production of sesamum, rapeseed and mustard, linseed, groundnut, and castor seed were 7921, 3590, 0, 1, 600, respectively. After making the calculations using the Herfindahl Index, we get a score of 0.52 which lies at the centre of (0) and (1). This shows a moderate diversification of oilseed crops in Barmer District. All other calculations are made in the similar manner by using the three listed indexes. The interpretation of the results is based on these index values.

Herfindahl Index is a method that is used here to describe the oilseed diversification of the Thar Desert, Rajasthan from 1985–1986 to 2015–2016. Churu, Jaisalmer, Jalore, and Nagaur districts fall under moderate crop diversification. Hanumangarh, Ganganagar, Sikar, and Jhunjhunu fall under a

Table 4. Percentage share of oilseeds in various districts of Rajasthan in 2015–2016.

District	Sesamum (percentage share)	Rapeseed and mustard (percentage share)	(Area arable land in thousand hectares) Linseed (percentage share)	Groundnut (percentage share)	Castor seed (percentage share)
			2015–2016		
Barmer	4315 (9.80)	16 854 (38.27)	0 (0.00)	684 (1.55)	22 185 (50.38)
Bikaner	3953 (3.50)	30 279 (26.83)	2 (0.00)	78 547 (69.59)	93 (0.08)
Churu	1225 (3.19)	14 546 (37.84)	3 (0.01)	22 664 (58.96)	0 (0.00)
Hanumangarh	3216 (1.45)	212 656 (95.82)	90 (0.04)	5007 (2.26)	965 (0.43)
Ganganagar	6514 (6.37)	89 818 (87.88)	45 (0.04)	4468 (4.37)	1355 (1.33)
Jaisalmer	1026 (2.22)	34 680 (75.15)	0 (0.00)	9241 (20.02)	1201 (2.60)
Jalore	25 281 (17.66)	62 612 (43.74)	1 (0.00)	3029 (2.12)	52 220 (36.48)
Jhunjhunu	118 (0.15)	78 412 (97.84)	0 (0.00)	1555 (1.94)	61 (0.08)
Jodhpur	36 066 (20.70)	74 197 (42.58)	0 (0.00)	43 892 (25.19)	20 101 (11.54)
Nagaur	18 811 (23.06)	46 544 (57.05)	1936 (2.37)	14 251 (17.47)	46 (0.06)
Pali	146 665 (90.60)	10 528 (6.50)	0 (0.00)	1587 (0.98)	3098 (1.91)
Sikar	541 (0.66)	59 702 (72.47)	0 (0.00)	22 064 (26.78)	76 (0.09)

Source: Statistical Abstract of Rajasthan, 2015–2016

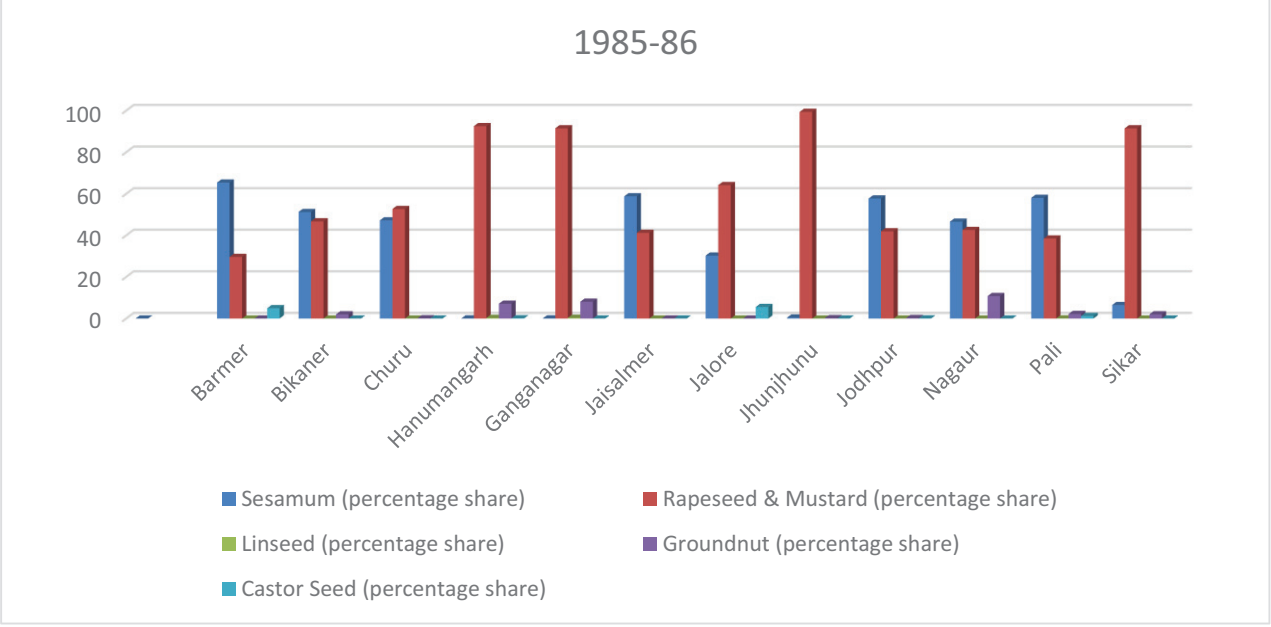

Fig. 1. Percentage share of oilseeds in various districts of Rajasthan in 1985–1986.

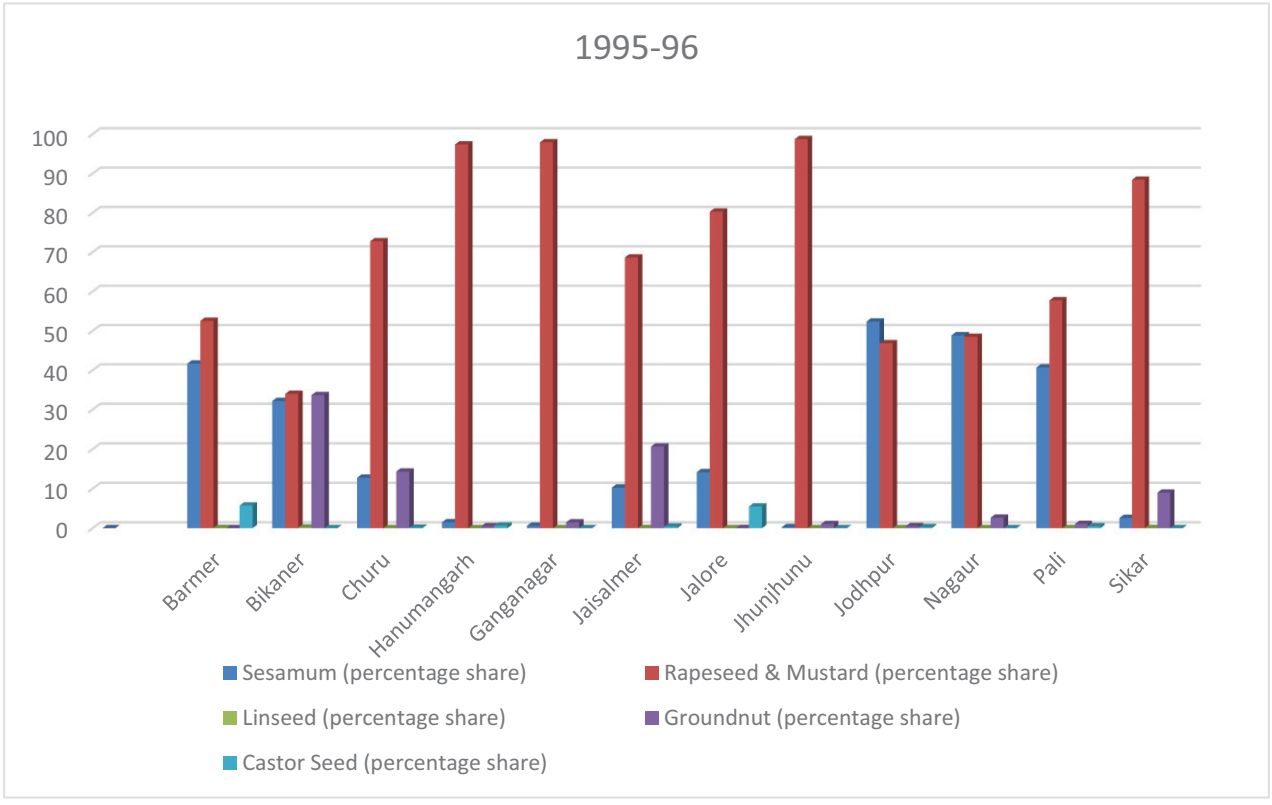

Fig. 2. Percentage share of oilseeds in various districts of Rajasthan in 1995–1996.

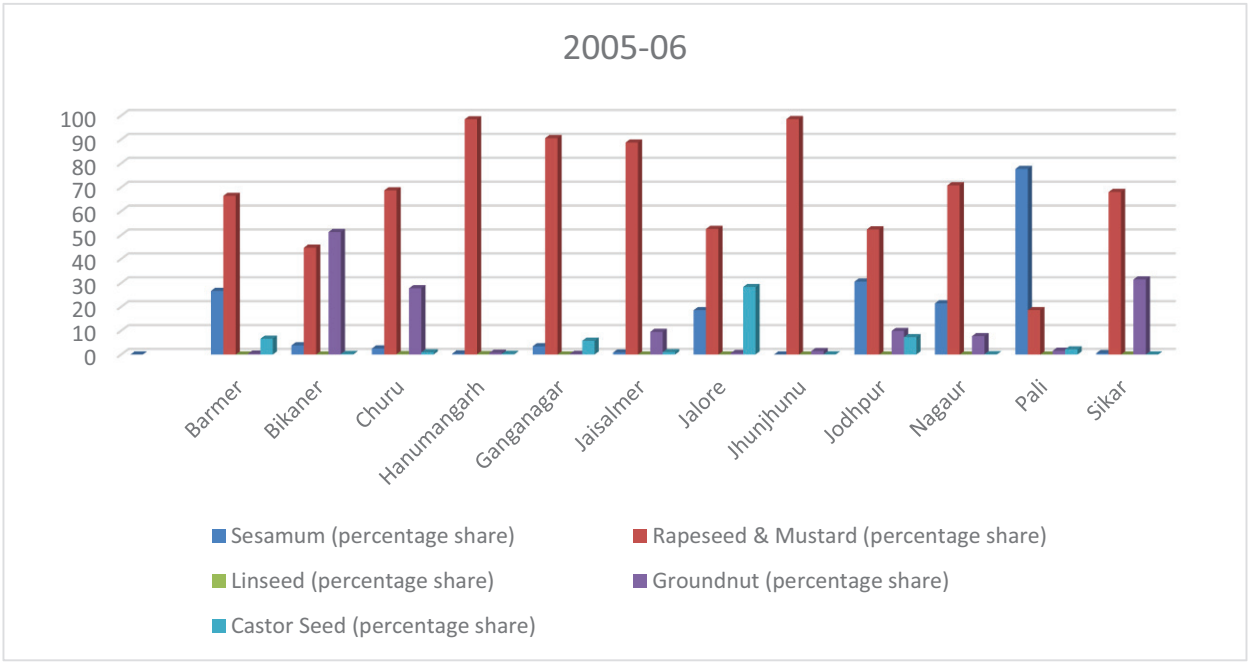

Fig. 3. Percentage share of oilseeds in various districts of Rajasthan in 2005–2006.

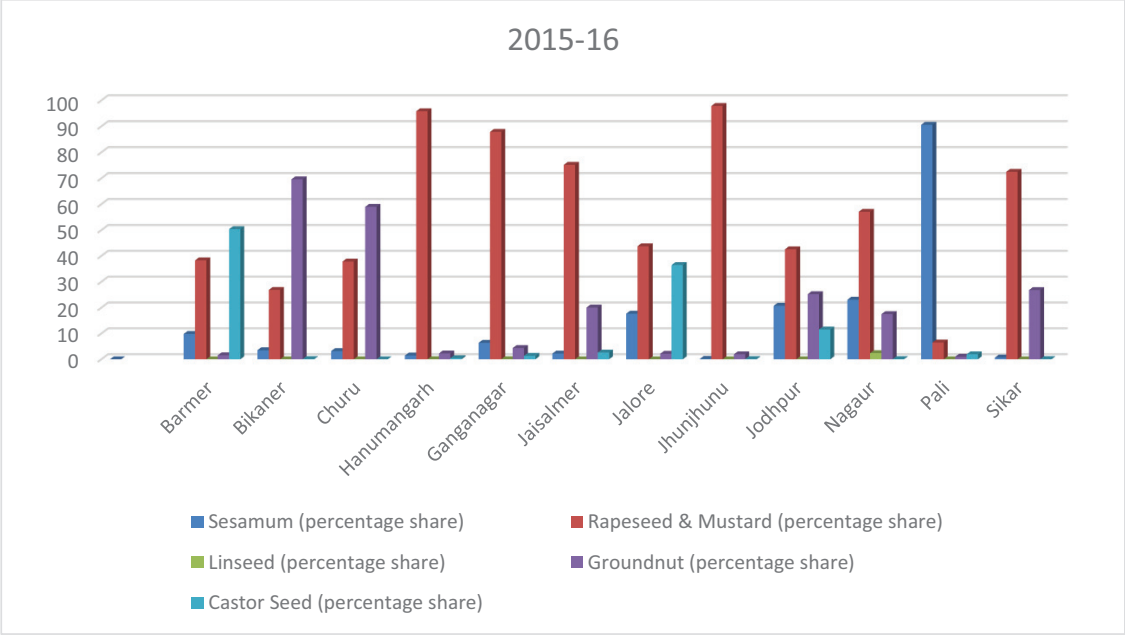

Fig. 4. Percentage share of oilseeds in various districts of Rajasthan in 2015–2016.

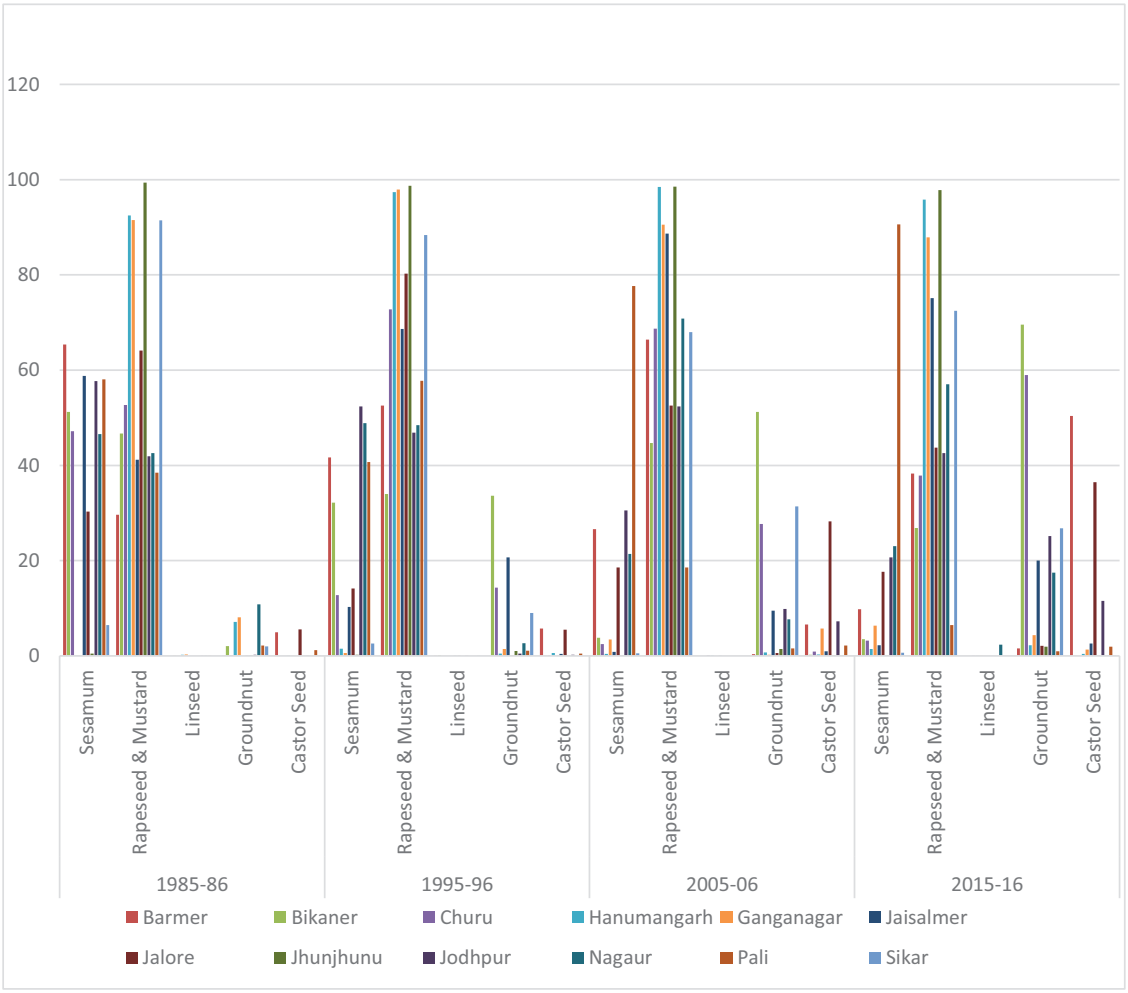

Fig. 5. Graphical representation of the evolution of total area under oilseed crops from 1985–1986 to 2015–2016.

Table 5. Changing composition of cropping pattern of Thar Desert (1985–1986 to 2015–2016).

District	Barmer	Bikaner	Churu	Hanumangarh	Ganganagar	Jaisalmer	Jalore	Jhunjhunu	Jodhpur	Nagaur	Pali	Sikar
Crops	**1995–1996 over 1985–1986**											
Sesamum	−24	−19.06	−34.4	1.47	0.55	−48.54	−16.1	−0.22	−5.36	2.27	−17.4	−3.92
Rapeseed	22.9	−12.71	20.1	4.88	6.42	27.45	16.15	−0.66	4.92	5.88	19.32	−3.07
Linseed	0.05	0.16	0	−0.27	−0.32	0.02	0.01	0	0	−0.01	−0.07	0.02
Groundnut	−0	31.62	14.2	−6.62	−6.65	20.66	0.01	0.88	0.26	−8.15	−1.14	6.98
Castor seed	0.77	0.01	0.14	0.54	0	0.4	−0.06	0	0.16	0	−0.75	−0.01
	2005–2006 over 1995–1996											
Sesamum	−15	−28.34	−10.3	−1.1	2.84	−9.42	4.38	−0.23	−21.85	−27.5	37	−2.03
Rapeseed	13.9	10.7	−4.06	1.08	−7.36	20.04	−27.72	−0.22	5.5	22.33	−39.2	−20.4
Linseed	−0.1	−0.17	0.18	0.15	0	−0.01	−0.01	0	−0.01	0	0	−0.02
Groundnut	0.37	17.58	13.4	0.22	−1.22	−11.17	0.59	0.41	9.35	5.04	0.52	22.42
Castor seed	0.89	0.22	0.76	−0.35	5.74	0.58	22.75	0.05	7.02	0.09	1.67	0
	2015–2016 over 2005–2006											
Sesamum	−17	−0.32	0.68	1.05	2.93	1.38	−0.9	0.14	−9.82	1.65	12.91	0.11
Rapeseed	−28	−17.88	−30.9	−2.63	−2.68	−13.54	−8.83	−0.67	−9.78	−13.8	−12.1	4.45
Linseed	0	0	−0.17	−0.11	0.04	−0.01	0	0	0	2.37	0	0
Groundnut	1.18	18.35	31.2	1.54	4.12	10.53	1.5	0.5	15.33	9.78	−0.6	−4.64
Castor seed	43.8	−0.15	−0.9	0.15	−4.42	1.62	8.23	0.03	4.28	−0.03	−0.24	0.09
	2015–2016 over 1985–1986											
Sesamum	−56	−47.72	−44	1.42	6.32	−56.58	−12.62	−0.31	−37.03	−23.5	32.55	−5.84
Rapeseed	8.63	−19.89	−14.8	3.33	−3.62	33.95	−20.4	−1.55	0.64	14.45	−32	−19
Linseed	0	−0.01	0.01	−0.23	−0.28	0	0	0	−0.01	2.36	−0.07	0
Groundnut	1.54	67.55	58.9	−4.86	−3.75	20.02	2.1	1.79	24.94	6.67	−1.22	24.76
Castor seed	45.4	0.08	0	0.34	1.32	2.6	30.92	0.08	11.46	0.06	0.68	0.08

Source: Statistical Abstract of Rajasthan, 2015–2016 over 1985–1986

high specialization. The state and the central government launched new projects like the Indira Gandhi Canal and high yielding variety of seeds. These programmes played a pertinent role in the farming practices. Therefore, farmers adopted a new farming system like a wheat-rice cropping pattern and oilseed traditional farming practices.

According to Entropy Index, Barmer, Bikaner, Churu, Jaisalmer, Jalore, Jodhpur, and Nagaur fall in the category of moderate crop diversification from 1985–1986 to 2015–2016. Hanumangarh, Ganganagar, Jhunjhunu, and Sikar districts fall under high diversification from 1985–1986 to 2015–2016. The state government initiated the new Programme (Technology Mission on Oilseeds) for increasing the area under production.

Composite Entropy Index finds out that Barmer, Bikaner, Churu, Jaisalmer, Jalore, Jodhpur, Pali, and Nagaur districts fall in the category of moderate diversification from 1985–1986 to 2015–2016 whereas Hanumangarh, Ganganagar, Jhunjhunu, and Sikar districts fall under high specialization from 1985–1986 to 2015–2016.

3.2 Policy initiatives regarding for oilseed crops

Oilseeds, especially edible oilseeds, have been an integral part of the cropping system in India before the beginning of monoculture triggered by modern technologies. Rajasthan is known to be one of the top four oilseed producing states in India, contributing about 10 to 15% of total oilseed production (Nethrayini *et al.*, 2015). Subsequently, oilseed crops were reduced to limited area and deprived of all investments such as inputs, irrigation and capital, and investment in oilseeds research was also stagnated (Chandel and Rao, 2003). In this context, the mission was a resounding success. It is generally assumed that the increase in vegetable oil production after the introduction of Technology Mission on Oilseeds (TMO) was due to increase in inputs, acreage and price incentives (Rao, 1991; Gulati *et al.*, 1996). There were number of strategies that were implemented initially to overcome the sluggishness in the production of oilseeds such as promotion of new technologies for production and processing oilseeds with the help of centrally funded programmes. A project was also initiated in 1984–1985 namely, National Oilseed Development Project (NODP), but it went down and but revived again in 1985–1986 by realigning different centrally funded oilseed development programmes. The Oil Seed Technology Mission has been launched by the Government of India in May 1986, the purpose of which is to increase oilseed production and achieve vegetable oil self-sufficiency in the country. The Oil Palm Development Programme (OPDP) was also launched in 1991–1992 under the "Oil Seeds and Nuts Technology Mission" after considering the potential of domestic palm oil with respect to regional expansion in Tamil Nadu, Gujarat, Orissa, Goa, Karnataka, and Andhra Pradesh. In the 10th Five-Year Plan, various combinations of programmes took place such as Palm

Table 6. Oilseeds diversification and specialization across districts.

District	Barmer	Bikaner	Churu	Hanumangarh	Ganganagar	Jaisalmer	Jalore	Jhunjhunu	Jodhpur	Nagaur	Pali	Sikar
Herfindahl Index												
1985–1986	0.52	0.48	0.50	0.77	0.84	0.52	0.51	0.99	0.51	0.41	0.49	0.84
1995–1996	0.45	0.33	0.57	0.95	0.96	0.52	0.67	0.97	0.49	0.47	0.50	0.79
2005–2006	0.52	0.46	0.55	0.97	0.82	0.80	0.39	0.97	0.38	0.55	0.64	0.56
2015–2016	0.41	0.56	0.49	0.92	0.78	0.61	0.36	0.96	0.30	0.41	0.83	0.60
Entropy Index												
1985–1986	0.34	0.34	0.30	0.27	0.13	0.29	0.35	0.02	0.31	0.42	0.36	0.15
1995–1996	0.38	0.48	0.34	0.06	0.05	0.37	0.27	0.03	0.32	0.35	0.33	0.18
2005–2006	0.36	0.37	0.33	0.04	0.17	0.18	0.45	0.03	0.49	0.34	0.29	0.28
2015–2016	0.54	0.36	0.43	0.11	0.24	0.39	0.56	0.06	0.7	0.53	0.21	0.34
Composite Entropy Index												
1985–1986	0.43	0.39	0.42	0.24	0.15	0.49	0.40	0.02	0.35	0.48	0.41	0.18
1995–1996	0.47	0.55	0.42	0.07	0.06	0.42	0.31	0.04	0.37	0.40	0.38	0.23
2005–2006	0.45	0.46	0.38	0.05	0.21	0.21	0.56	0.04	0.61	0.42	0.33	0.35
2015–2016	0.54	0.36	0.43	0.11	0.24	0.39	0.56	0.06	0.7	0.53	0.21	0.34

Author's calculations

***Note: H.I.: (0)** represents crop diversification and **(1)** represents complete specialization; **E.I.: (0)** represents perfect specialization and **(1)** represents crop diversification; **C.E.I.: (0)** represents complete specialization and **(1)** represents crop diversification.

Table 7. Launched by the centre government alone or by centre and state governments jointly.

Year	Scheme(s)	Launched by the central government alone or by central and state governments jointly
1984–1985	The National Oilseed Development Project (NODP)	centre and state
1985–1986	Technology Mission on Oilseed (TMO)	centre and state
1986	Oil Seeds Production Programme	centre
1991–1992	Oil Seeds and Nuts Technology Mission	centre
2004	Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM)	centre and state
2004–2014	Integrated System for Oilseeds, Nuts, Palm Oil and Corn (ISOPOM)	centre and state
2012–2017	National Mission on Oilseeds and Oil Palm (NMOOP)	centre and state

Source: Economic Review and Five-Year Plan, 2017

Oil Development Programme (OPDP), National Pulses Development Programme (NPDP), Maize Development Acceleration Programme (AMDP) and Oil Seed Production Programme (OPP).

In most of the districts of Rajasthan, the expansion of oilseeds have been promoted through various programmes like National Food Security Mission (NFSM), Integrated Scheme for Oilseeds, Nuts, Oil Palm and Maize (ISOPOM), Agricultural Technology Management Agency (ATMA), etc. With the help of these programmes, schemes and agencies, farmers were getting the inputs at subsidized rates and in right quality and quantity. This led to the expansion of the area under oilseed crops in comparison to the previous years in the state (Swain, 2013) (Tab. 7).

The centre and state governments launched many development programmes/schemes, which led to an increase in area under oilseed crops and production. Recognizing the importance of oilseeds, various oilseed development programmes such as the Intensive Oilseed Development Programme (1974–1984), National Oil Palm Seed Development Project 6 Oil Seed Status Papers (1984–1990), Oil Seed Production Acceleration Project (1987–1991), Oil Seed Production Programme (1991–2004) and Oil Palm Development Programme (1991–2004) under the Mission and Integrated Oilseed, Palm Oil and Corn Seed Oil Technology (2004–2014) were funded by the central government for the development of oilseeds and palm oil in the country. The implementation of these programmes had also increased the availability of vegetable oil in the country. Numerous efforts and opportunities have been explored by the central and the state governments to boost the production of agricultural crops, including oil-producing crops. For oilseeds, the centrally sponsored Integrated System for Oilseeds, Nuts, Palm Oil and Corn (ISOPOM) has been implemented since 2004–2014 with the overall objective of increasing oilseed production and productivity (GOI, 2014).

4 Conclusion

Oilseed crops have been one of the most important crops of the Thar Desert in Rajasthan. This data reveals that rapeseed and mustard play a dominant role in this region. The authors have analysed the significance of oilseeds and the changes in the area under oilseed crops. The different time periods have been taken in this study, which tells us about the real condition of oilseed crops in Rajasthan. Indian and Rajasthan governments have initiated many development programmes, which resulted in an increase in the area under oilseed crops. Rapeseed and mustard was the dominant crop in the Thar Desert. But gradually, the farmers started to cultivate castor seed and groundnut oilseed crops. Figures 1–5, which have been used in this research paper, elaborate the increase and decrease in oilseed crop production in the last decades in the Thar Desert. The diversity methods, which have been used in this research paper such as Herfindahl Index, Entropy Index, and Composite Entropy Index, describe the moderate diversity in oilseed crops in the deserted area of Rajasthan. The data explored the fact that even after the availability of so many programmes and schemes, there has been a moderate oilseed diversification in this region. The area in question has been highly suitable for oilseed cultivation. Both the Indian and Rajasthan governments have launched many programmes for increasing area and production under oilseed crops. But still, farmers are facing many problems related to oilseed cultivation like non-ensured MSP (Minimum Support Price), and non-availability of marketing and transportation. This area had also faced many natural disasters in the past such as scarcity of rainfall and thunder and lightning. There is a need to understand oilseed cultivation in a holistic perspective as an important aspect for agricultural development in the region.

Conflict of interest

The authors declare that there is no financial or commercial relationship that could be elucidated in this research as a conflict of interest.

Author's contributions

Shivjeet Kaur: Conceptualization, writing review, editing, supervision and writing original draft. Jasvir Singh: Formal analysis and interpretation, methodology and writing original draft.

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