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Agriculture Dynamics in Response to Climate Change in Rajasthan

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ABSTRACT

The foremost environmental challenge faced by the world is climate change. All the sectors and societies of world are vulnerable to climate change. But, the developing regions which are scarce on resources and the sectors like agriculture, which are primarily dependent on climate, are among the most vulnerable group. Rajasthan, largest state of India is among the resource scarce regions, although the state is house of many important minerals but lacks in basic resources like fertile land and water resources. The agriculture practiced in the state was mainly subsistence due to lack of resources required to practice agriculture. But, in recent times with advancing technology, canal irrigation and land improvement programmes, the state has achieved better productivity in agriculture sector. The development of agriculture in Rajasthan now faces the challenge of climatic variability. Therefore, in order to maintain the pace of agriculture development in Rajasthan it is important to prioritize the planning, and the regions which are most vulnerable need urgent planning intervention.

Keywords: Climate variability; Cropping Pattern; Farm Management; Crop Efficiency

1. INTRODUCTION

Geographically, Rajasthan being the largest state of India has diversity in the agriculture which is mainly the result of variations in resource endowments, climate, topography and historical, institutional and socio economic factors and the agriculture pattern varies with different agro-

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climatic regions across the state. Rajasthan is among the leading producers of mustard, pearl millet, cumin, coriander and fenugreek (Swain, Kalamkar and Ojha, 2012) which shows the importance of the state in Indian agriculture. The agriculture practices in Rajasthan are very tough due to the harsh dry climate found in majority of the state (Chand and Raju, 2009). The agriculture area has increased manifolds in the state along with production and productivity. The agriculture in the state has also been changing its forms and pattern over last two decades but still the agriculture has not attained the efficiency required for its stability. The state's economy has undergone a considerable transformation in the recent past with growth of manufacturing and services sectors. However, agriculture, with 64.2 per cent of total rural working population is directly dependent on agriculture as cultivators and agriculture labours (Census of India, 2011), continues to play an important role. Agriculture, including animal husbandry, contributed just 24.59 per cent to the State Gross Domestic Product (GDP) during 2012-13 (Directorate of Economics and Statistics, 2013). Growth of the agriculture sector, therefore, has an important impact on the lives of people dependent on agriculture. According to the Planning Department (2012), the challenges faced by the agriculture sector in Rajasthan are increasing gap between demand and availability of water, scanty and uncertain rainfall, deteriorating quality of land and underground water, low value agriculture, large gap between potential and realized yield of crops and high inter-year variation in productivity, low share of vegetable and fruit crops, seed spices and medicinal plants, etc. The vulnerability of agriculture sector increases with changing environmental and socio-economic conditions (Singh, 2000). The low literacy of 61.4 per cent (Census of India, 2011) found among the rural community of Rajasthan is the foremost social reasons for agriculture vulnerability. Agriculture in Rajasthan faces land scarcity not only due to unfavourable topography but also due to competition from industrial sector. The heavy dependence of agriculture in Rajasthan on monsoon rainfall makes it more vulnerable towards the phenomenon of climate change (Singh, 1994; Singh and Kumar, 2013). The rainfall pattern varies for different regions of Rajasthan, similarly the variations in climate are not found uniform across the state and, therefore, single contingency plan for agriculture sustainability cannot be formulated for whole state and a more detailed region wise plan is the need of hour.

2. STUDY AREA

The State of Rajasthan lies between 23^{o}04' N to 30^{o}11' N and 69^{o}29' to 78^{o}17' E, occupying 342,239 km^2 and 10.41 per cent of the land area of the country. It is the largest state in India and the one with the highest proportion of land occupied by desert. Rajasthan State has four major physiographic regions, viz. the western desert (Thar Desert), the Aravalli hills, the eastern plains and the south-eastern plateau (Hadoti Plateau). About 62 per cent of the state area consists of sandy plains, which is why it is known as the Desert State of India. The Aravalli hills running diagonally across the state form the geomorphic and climatic boundary of the desert in the east. The western part merges into the Pakistan desert. The Aravalli Range is the major water divide in the state. The area in the east is well drained by several integrated drainage systems, whereas that in the west has only one, the Luni drainage system. The climate is characterized by low rainfall with erratic distribution, extremes of diurnal and annual temperatures, low humidity and high wind velocity. The arid climate has marked variations in diurnal and seasonal ranges of temperature, characteristic of warm-dry continental climates. During summer (March to June), the maximum temperature generally varies between 40^{o}C and 49^{o}C. Night temperatures decrease considerably, to 20^{o}C–29^{o}C. January is the coldest month. During winter (December to February), minimum temperatures may fall to –2°C at night. Occasional secondary Western disturbances, which cross mostly western, northern and eastern Rajasthan during the winter months, cause light rainfall and increased wind speeds which result in a wind-chill effect. The average annual rainfall ranges from less than 100 to 400 mm. The state is divided in 10 agro-climatic zones (TERI, 2010) (Figure 1).

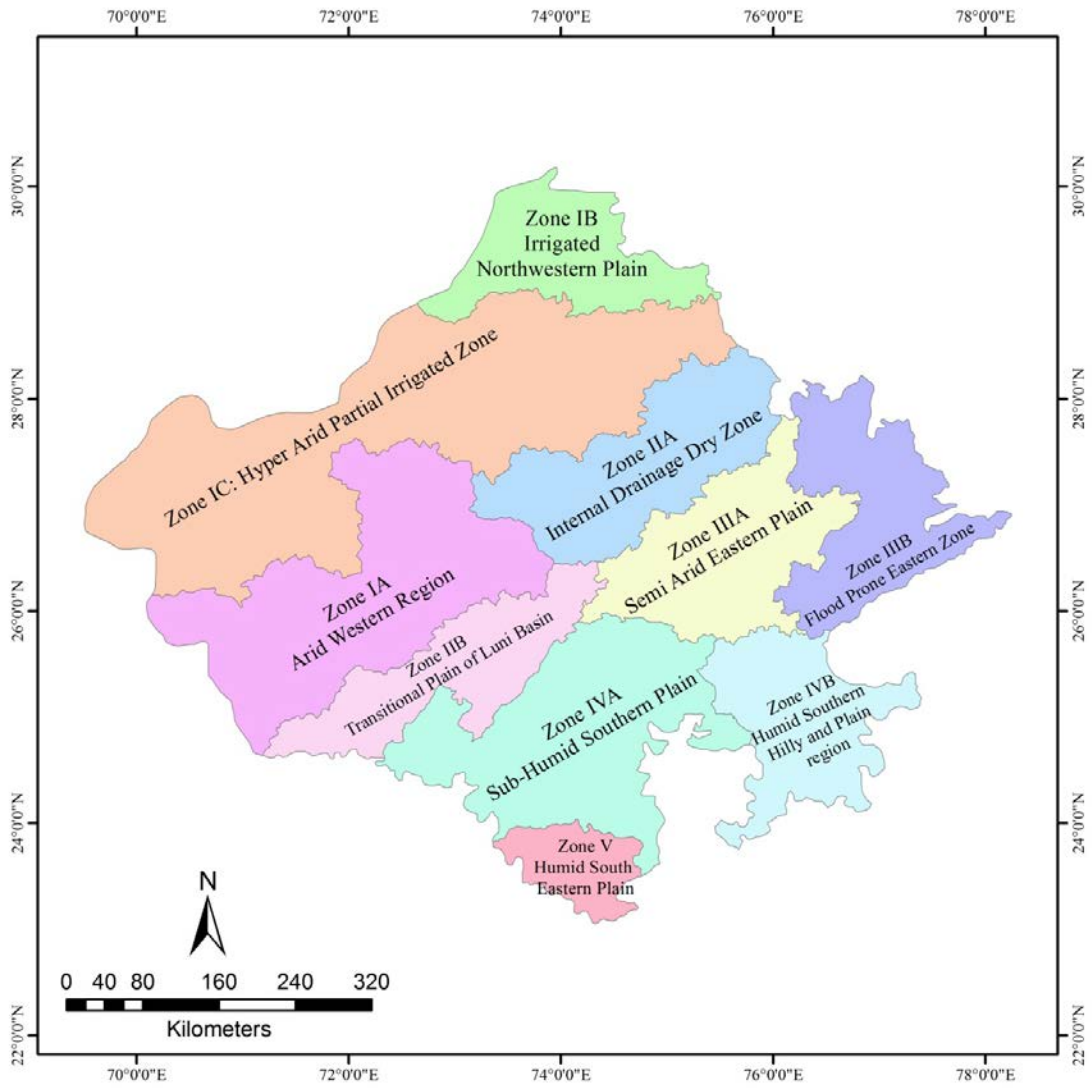


Figure 1: Agro-climatic Divisions of Rajasthan

3. RESEARCH METHODOLOGY

The study has used secondary database which includes historical data of 60 years from 1951 to 2010 of WMO standard in respect of rainfall, maximum temperature, minimum temperature and rainy days from India Meteorological Department (IMD). The land use/ cover data has been extracted from satellite images acquired by Indian Remote Sensing Satellites available with National Remote Sensing Agency (NRSA), Hyderabad available at BHUVAN open Data Portal. The cartosat image has also been acquired from BHUVAN. Data on food production growth rate has been taken from District Agriculture Statistics Handbook. Information about Ground water position has been sourced from Ground Water Commission. Data related to poverty, per capita income and income source has been taken from website of Government of

Rajasthan. The climate variability is analyzed on both temporal and spatial scales. Moving averages has been used to determine the trend of climatic parameters over past 60 years. The spatial change in climate parameters has been deduced through combination of interpolation and change detection technique using GIS software. Similarly, the shifts in climate regions as propounded by Thornthwaite are determined using the same set of software. The database has also been represented and analyzed using tables, graphs and charts. Techniques like regression and correlation has also been used wherever necessary. For such analysis SPSS software has been used.

4. ANALYSIS AND FINDINGS

4.1 Climate Change

With an overall rise in temperature over the region and changing precipitation trends the humidity provinces as defined by Thornthwaite have shifted eastward. The arid climate zone during 1951-1980 consisted of the western region along with some pockets in the eastern as well as the southern part of Rajasthan. The region along the Aravali was in the semi-arid zone. The southern and south-eastern part of Rajasthan consisted of the sub-humid zone. The climate zones shifted in during 1981-2010 compared to 1951-1980. The arid zone engulfed the semi-arid regions of Jalore, Pali and sub-humid zone of Sirohi. The north-western part along with the south-western part now lies in the semi-arid region. The main reason behind the shift is attributed to advent of canal irrigation in north-western part of the state. The sub-humid region extended along the Aravali range in the north part (Figure 2).

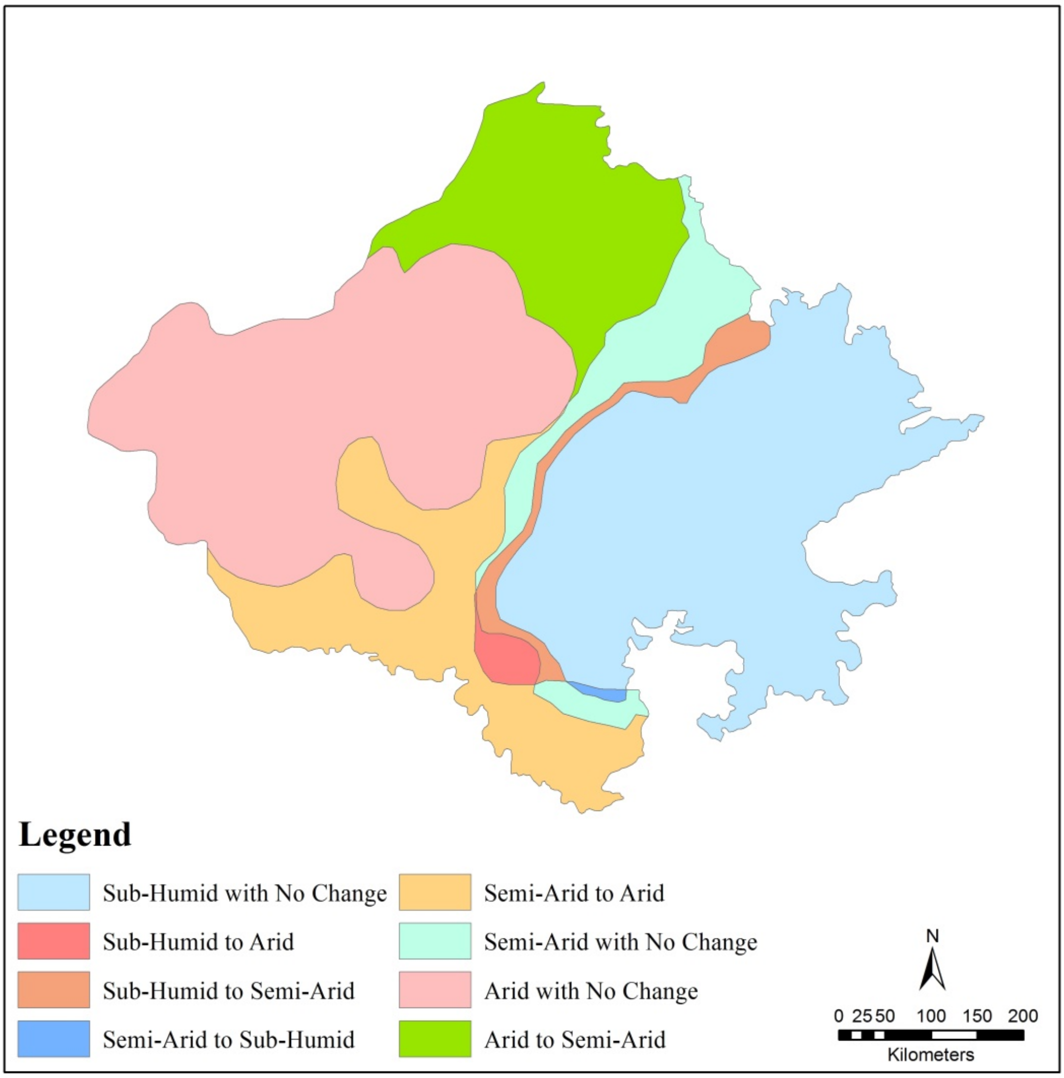


Figure 2: Change in Climate Zones based on Thornthwaite (1948)

The region has experienced changes in moisture index, but the changes are not homogenous all over the region. Increase in aridity i.e. fall in index values have been noticed over major part of the state whereas, the north-western part of the state has experienced decrease in aridity. The increase in aridity ranges from a maximum of 15 points. The increase in aridity is mainly concentrated in the eastern part of the region. The increase is prominent in the Dhaulpur. The increase in aridity is also observed in the Hadoti region and the Dungarpur district. The decrease in aridity has also been observed in the districts of Nagaur, Sikar, Jhunjhunu and northern part of Jodhpur along with Ganganagar, Hanumangarh and Bikaner. The region along the Aravali in the western side has experienced no change in the moisture index (Figure 3).

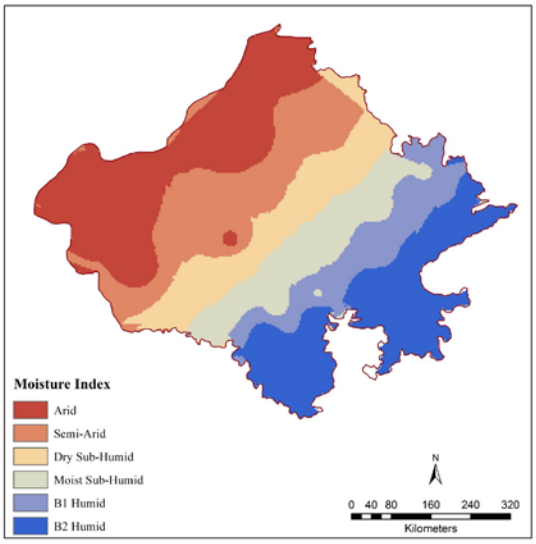


Figure 3(a): Thornthwaite's Humidity Provinces during 1951-2010 (Based on Thornthwaite (1948))

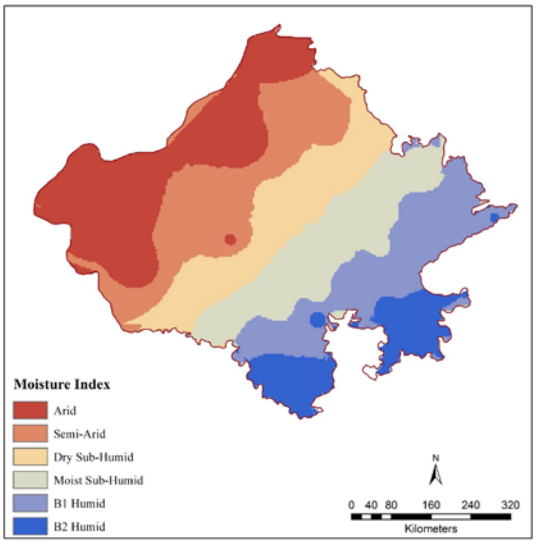


Figure 3(b): Thornthwaite's Humidity Provinces during 1981-2010 (Based on Thornthwaite (1948))

4.2 Trend Productivity in Agriculture

The area, production and productivity of agriculture in Rajasthan showed a continuous rise over last four decades and the kharif crops maintain a plateau in majority of agro-climatic zones after mid 1970's (Chand, Garg and Pandey 2009). The rabi crops on the other side are showing an ever increasing trend of area under cultivation. The first district wise analysis of performance of agriculture covering whole country was attempted by Bhalla and Alagh (1979). This was a pioneering work which not only prepared estimates of productivity but also provided detailed analysis of agriculture growth at disaggregates level of crops. This analysis covered the period upto 1970-73. The second major attempt on district level analysis of agricultural productivity at national level was made by Bhalla and Singh (2001) which extends to early 1990s. Lot of changes have been experienced in Indian agriculture after early 1990s. These changes have influenced different parts of the country in different ways (Chand et. al. 2007).

It has been observed that productivity of major kharif crops has shown decline from 1951-60 to 2001-10. Productivity of kharif pulses have declined invariably across the state, with sharp decline in IIB (2008.53 to 853.97), IVA (1056.16 to 327.20) and IV (2121.13 to 16.10). Besides, productivity of Maize have also shown a downward trend in almost all region, exception being IVA, IV B and V, which have registered a quite decent rise in productivity owing to suitable physical conditions of the region. Pearl Millet is the only crop registering growth in productivity in IB, IIA, IIB and IIIA. Productivity in IIIB has doubled between 1951-60 to 2001-10. Region wise trends show that productivity of all major crops has declined in IA and IC. In IVB and V, only productivity of Maize crop has increased significantly. In IIB and IIIA, productivity of Sorghum and Pearl Millet has increased (Table 1).

TABLE 1

CROP EFFICIENCY OF MAJOR KHARIF CROPS

	Sorghum		Pearl Millet		Maize		Kharif Pulses	
	1951-60	2001-10	1951-60	2001-10	1951-60	2001-10	1951-60	2001-10
IA	103.76	94.68	3220.17	2566.34	5.94	0.16	218.53	132.99
IB	599.33	0.83	965.46	1175.03	47.89	0.45	65.73	23.45
IC	65.63	13.52	1664.33	1215.42	0.24	0.00	184.64	46.78
IIA	488.23	179.38	3063.18	5016.59	15.93	1.15	231.47	238.40
IIB	680.71	689.81	2467.51	3106.73	277.36	212.27	2008.53	853.97
IIIA	1460.78	1509.76	2337.88	5019.76	863.06	383.10	517.48	216.19
IIIB	1726.67	1251.15	5073.12	12586.15	229.95	145.20	338.40	333.19
IVA	620.12	740.73	516.63	185.71	4889.45	6148.17	1056.16	327.20
IVB	78.28	33.53	41.50	4.96	3283.45	4529.46	2124.13	16.10
V	9125.69	853.26	122.97	70.74	1032.52	1893.89	493.88	157.97

Source: Calculated by researcher based on data from Department of Agriculture, Jaipur
(IA – Arid Western Region; IB – Irrigated Northwestern Plain ;IC- Hper Arid Partial Irrigated Zone ; IIA – Internal Drainage Dry Zone ; IIB - Transitional Plain of Luni Basin ; IIIA – Semi Arid Eastern Plain ; IIIB – Flood Prone Eastern Zone; IVA – Sub-Humid Southern Plain; IVB – Humid SouthernHilly and Plain Region ; V – Humid South Eastern Plain) (based on formula of Sapre and Deshpande, 1964)

In zone IA and IV B have witnessed marginal decline in productivity of all major rabi crops. A marked change has been experienced in Indian agriculture after early 1990s. A decrease in productivity of Wheat, Gram and Mustard is noticed in zone IIA, IIIA and IVA (Table 2).

TABLE 2

CROP EFFICIENCY OF MAJOR RABI CROPS

	Wheat		Barley		Gram		Mustard	
	1951-60	2001-10	1951-60	2001-10	1951-60	2001-10	1951-60	2001-10
IA	91.15	85.66	113.44	107.91	118.94	90.50	135.17	106.01
IB	103.68	120.81	55.97	99.16	122.40	58.73	53.12	111.88
IC	90.67	94.97	64.29	87.06	104.51	70.53	133.02	83.87
IIA	100.72	108.22	128.48	103.12	58.83	128.64	60.09	99.40
IIB	86.17	66.72	100.27	90.76	65.18	92.38	74.00	88.34
IIIA	107.64	101.24	101.38	102.80	97.10	90.53	97.25	76.99
IIIB	124.20	122.92	102.87	110.10	136.43	125.48	58.33	108.89
IVA	115.37	101.43	107.50	99.75	82.29	100.33	117.27	102.54
IVB	95.19	81.15	109.62	93.75	120.73	114.51	137.31	105.31
V	85.21	116.88	116.17	105.59	93.59	128.38	134.45	116.78

Source: Calculated by researcher based on data from Department of Agriculture, Jaipur
(IA – Arid Western Region; IB – Irrigated Northwestern Plain ;IC- Hper Arid Partial Irrigated Zone ; IIA – Internal Drainage Dry Zone ; IIB - Transitional Plain of Luni Basin ; IIIA – Semi Arid Eastern Plain ; IIIB – Flood Prone Eastern Zone; IVA – Sub-Humid Southern Plain; IVB – Humid Southern Hilly and Plain Region ; V – Humid South Eastern Plain) (based on formula of Sapre and Deshpande, 1964)

4.3 Agriculture Pattern

4.3.1 Crop Combination

It is very uncommon that a crop is cultivated in absolute isolation. Monoculture is rarely being practiced in Rajasthan. Crops are grown in rotation to maintain the fertility of soil, to judiciously use the scarce water resource and to efficiently utilize the farm labour. Crops are also grown in association because they are supplementary to each other. Physical, economic and cultural determinants generally operate in combination in a region and they influence the crop distribution, the production associations are necessarily dependant on them (Singh and Dhillon 1976). The crop combination indices give the understanding about changing crop combinations in the region and also provide knowledge about the existing crop combinations. With crop combination the suitability and consistency of cropping pattern can be evaluated in the context of the role of local environment. With development of better agriculture infrastructure, new varieties of crops can be introduced in place of traditional less economic crop combinations.

The study uses Weaver (1954) crop combination formula, which is based on calculation of standard deviation. The standard deviation is calculated for net sown area under major crops having area more than 5 per cent. While calculating the standard deviations the mean used is equal to ideal per cent of area under each category viz. 100 per cent in case of monoculture, 50 per cent in case of double cropping, etc. The standard deviation calculated for different cases are compared and the case having minimum value is considered as the prevailing crop combination in the region.

The results show that the arid zone were dominated by Pearl Millet in kharif season which was replaced by Moth at the end of 20th century, but with increasing fluctuation in the monsoonal rainfall the trend has again shifted towards cultivation of pearl millet. In recent times, with the farmers are getting good remunerations from cultivation of Guar (Turkish bean) and, therefore, the zone IA and IC have shifted towards cultivation of Guar. The zone IB with good irrigation practices has opted for cotton cultivation (Figure 4).

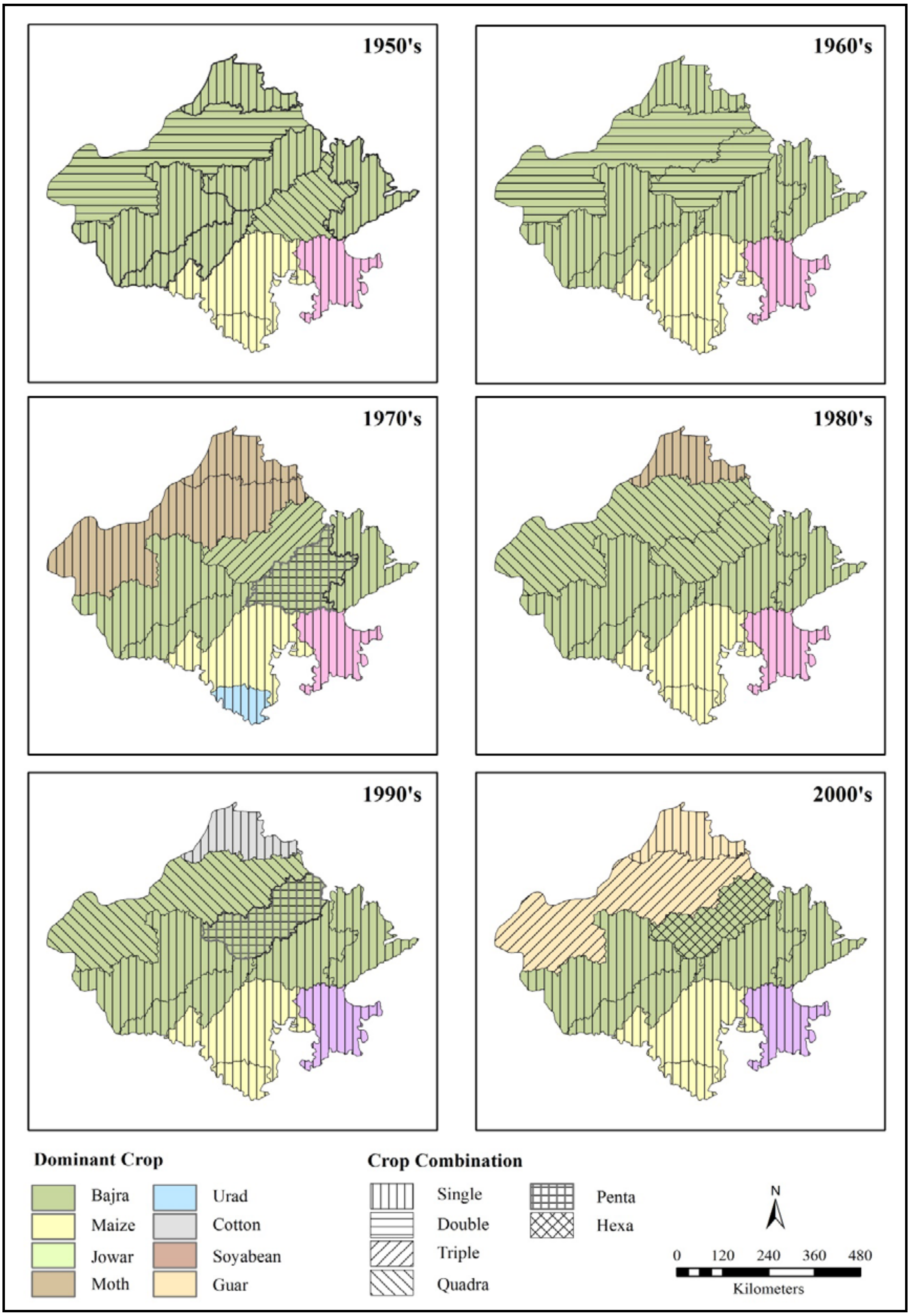


Figure 4: Decade-wise Changes in Crop Combination in Kharif Season, 1950-2010

In the southern zone, IVA maize has always been preferred for the dominant crop. The edaphic factors support the cultivation of maize in the region. The region has less variability in rainfall; therefore, it gives it advantage for cultivation of maize. The zone V is dominated by Soyabean cultivation. The region being a plateau region and is adjacent to the state of Madhya Pradesh which is largest producer of Soyabean. The crop combination in central tract viz. zone IIA has shifted from monoculture to cultivation of six crops. The crop combination in rabi season has shifted from gram dominated cropping pattern to mustard dominated. The reason behind such a shift is increasing variability of monsoonal rainfall, as the gram crop is dependent on the monsoonal rainfall. The cultivation of mustard has also increased due to increased irrigation facilities (Figure 5). The cultivation of spices has also increased in the zone IC and zone V. Zone IC is dominated by the cultivation of Cumin, whereas the zone V dominates in cultivation of coriander. The better remunerative prices of mustard and spices have also attracted farmers to opt for cultivation of these crops.

Cowpea has also emerged as a good option in the central tract of Rajasthan. The crop combination in Rajasthan in general is dominated by Wheat-Mustard. The highest changes in crop-combination have been noticed in the central tract of Rajasthan.

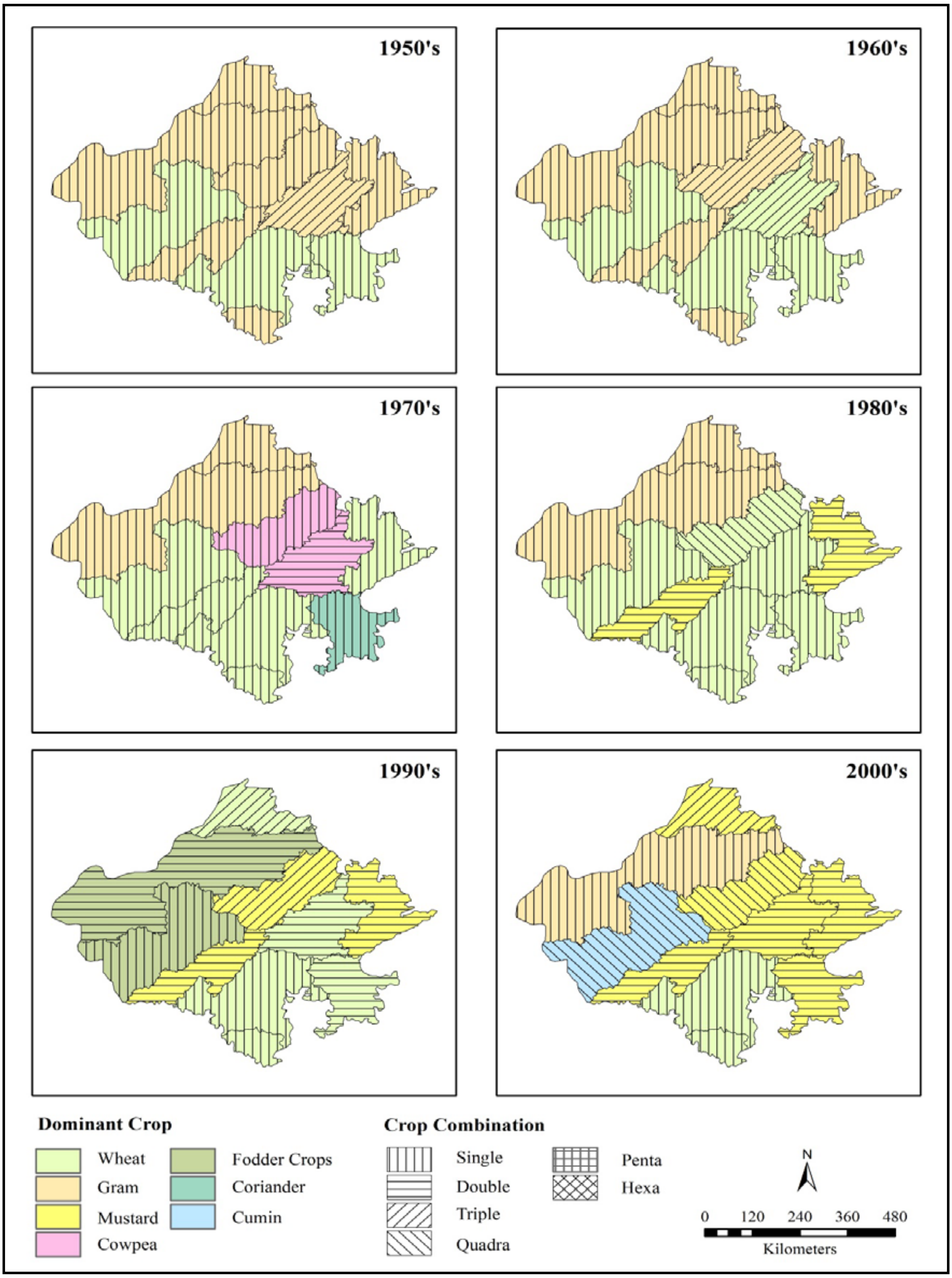


Figure 5: Decade-wise Changes in Crop Combination in Rabi Season, 1950-2010

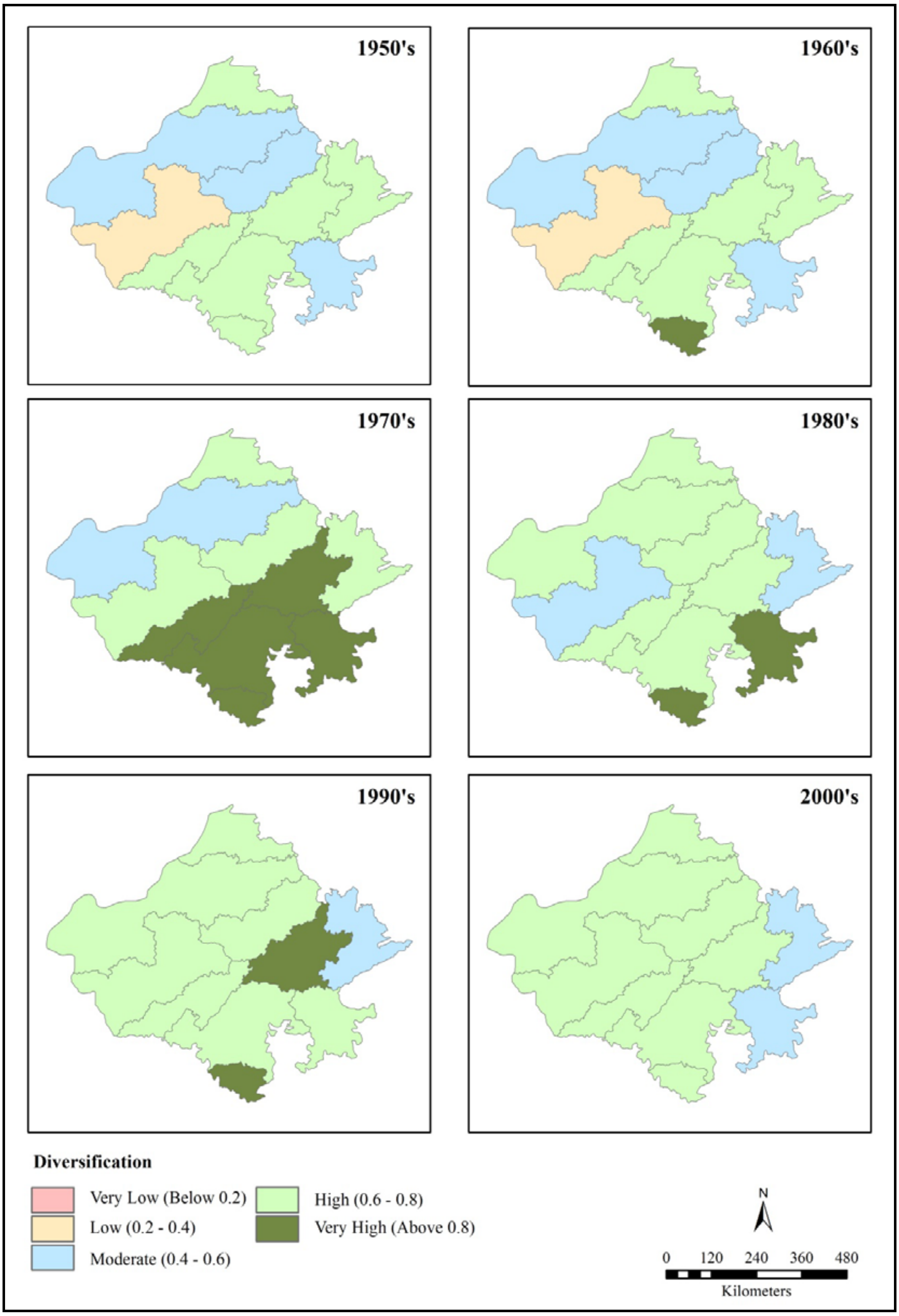
4.3.2 Crop Diversification

The crop diversification reduces the risk from vagaries of climate. The cultivators grow a number of crops to get some returns under adverse conditions of climate. Diversification also helps farmers to get most of their domestic requirements from their farm. The magnitude of crop diversification shows the impact of physical, socio-economic, technological and institutional influents. The spatial pattern of agriculture diversification is significant in understanding the competition among different agriculture activities for space. When local prevailing conditions are conducive for growth of variety of crops, the farmers opt for diversification. The Gibbs and Martin (1962) Index of Diversification is useful for measuring the extent of diversification. The formula is:

$$\text{Diversification} = 1 - \frac{\varepsilon x^2}{(\varepsilon x)^2}$$

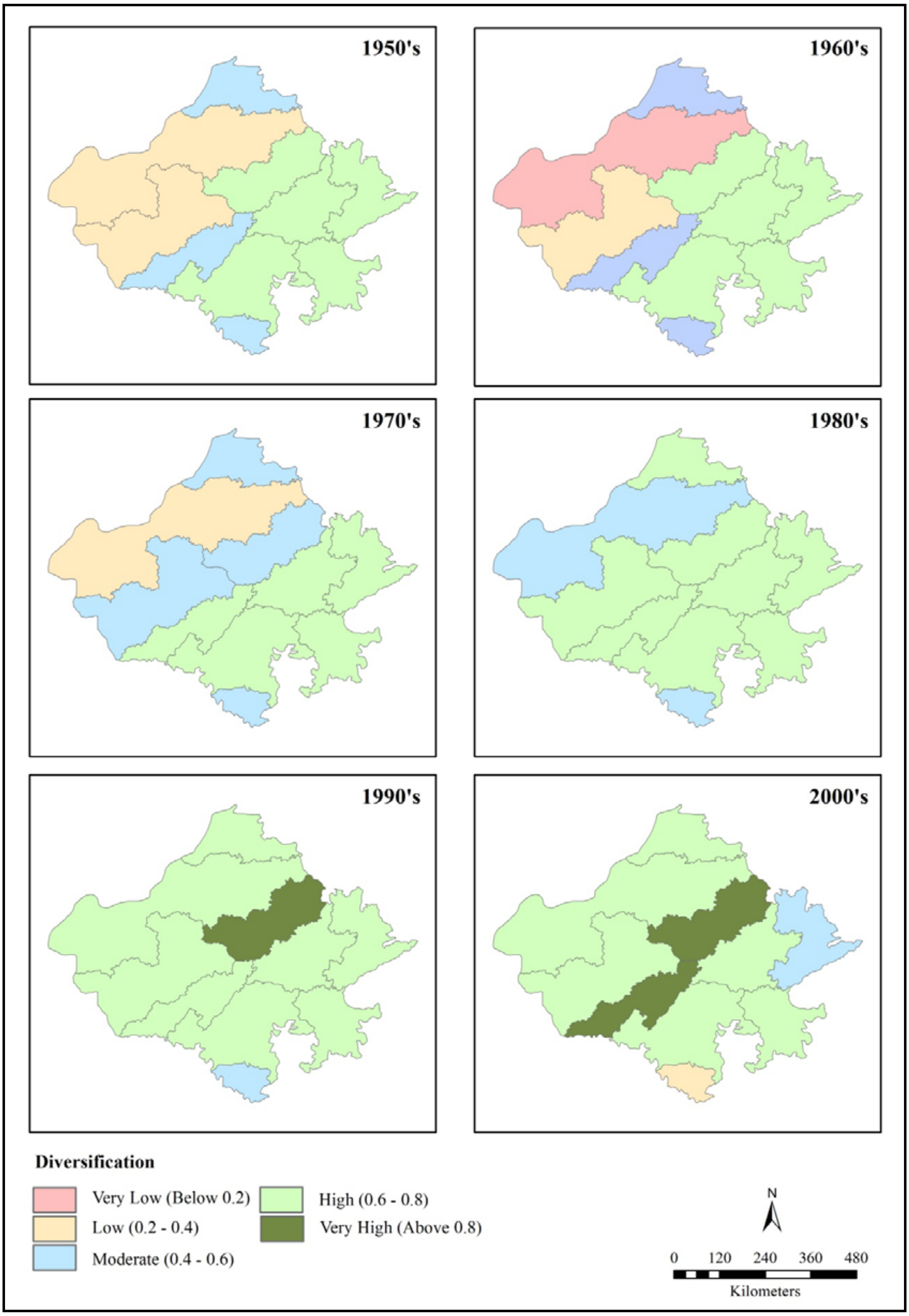
where x is the per cent of total cropped area occupied by each crop

In the kharif season, the diversification increased at the end of 20th century and has now again declined. Whereas, for the rabi season the crop diversification has continuously increased since 1950's (Figure 6 and 7).



Source: Prepared by authors based on Crop Diversification formula of Gibbs and Martin (1962)

Figure 6: Changes in Crop Diversification in Kharif Season, 1950-2010



Source: Prepared by authors based on Crop Diversification formula of Gibbs and Martin (1962)

Figure 7: Changes in Crop Diversification in Rabi Season, 1950-2010

The changes in diversification for kharif season have noticed highest in the southern part of the Rajasthan. The zone IIIB and V have shown a severe decline in diversification during the kharif season. The reason is linked with increasing fallow land for the cultivation of more remunerative rabi crops. Farmers in kharif season prefer to grow kharif crops for subsistence.The central tract of zone IIA and IIB has shown maximum increase in crop diversification during the rabi season as farmers use crop diversification as a tool to adapt to climatic variability. Improvements have also been seen in the zone IC where the crop diversification has increased from very low to high. The zone IVB has a consistency and the crop diversification has always been moderate in the region.

4.3.3 Agriculture Efficiency

The agriculture efficiency is the aggregate performance of various crops in in regard to their output per hectare. For measurement of agriculture efficiency Sapre and Despande (1964) have used the following formula:

$$E_i = \frac{I_{ya} \times C_a + I_{yb} \times C_b + ... + I_{yn} \times C_n}{C_a + C_b + ... + C_n}$$

where, E_i = Agriculture Efficiency Index

I_{ya} = Yield Index of Crop a, calculated by following formula:

$$I_{ya} = \frac{Y_C}{Y_r} \times 100$$

C_a = Percentage of Cropland under crop 'a'

They have used the weighted average ranks instead of the simple average ranks. The weighted ranks are proportionate to percentage of cropland under each crop.

The overall agriculture efficiency has increased in the state for the kharif season. But, the agriculture efficiency for the rabi season has increased for the first half of investigation period and then has decreased in the later half (Figure 8 and 9). The agriculture efficiency for the rabi season is moderate or low for all the zones. The reason lies in the fact that increase in crop diversification has reduced the area under each crop and the good performance of different crops is limited to some specific zones thereby reducing the crop efficiency and thereby reducing the overall agriculture efficiency.

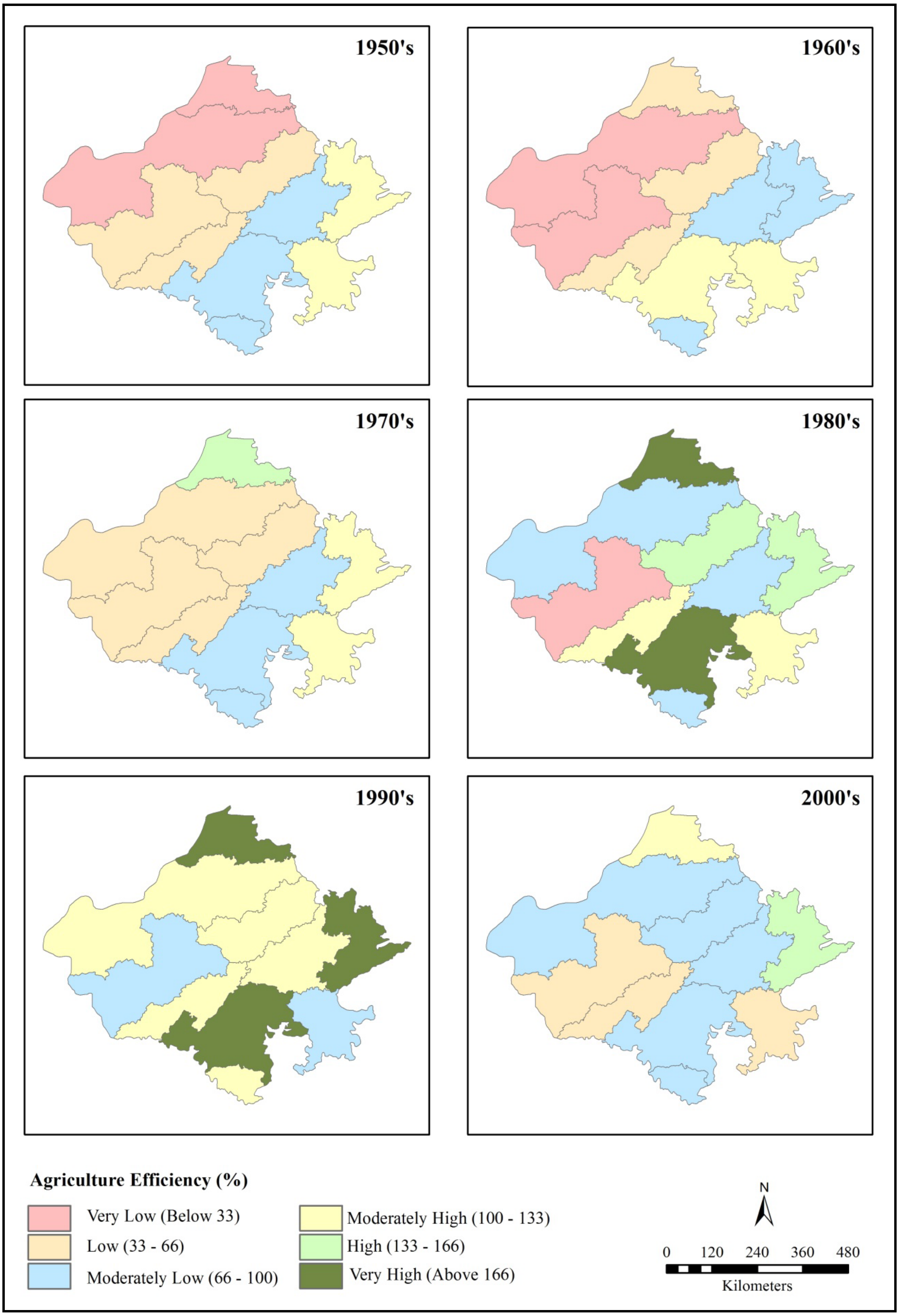


Figure 8: Decade-wise Changes in Agriculture Efficiency in Kharif Season, 1950-2010

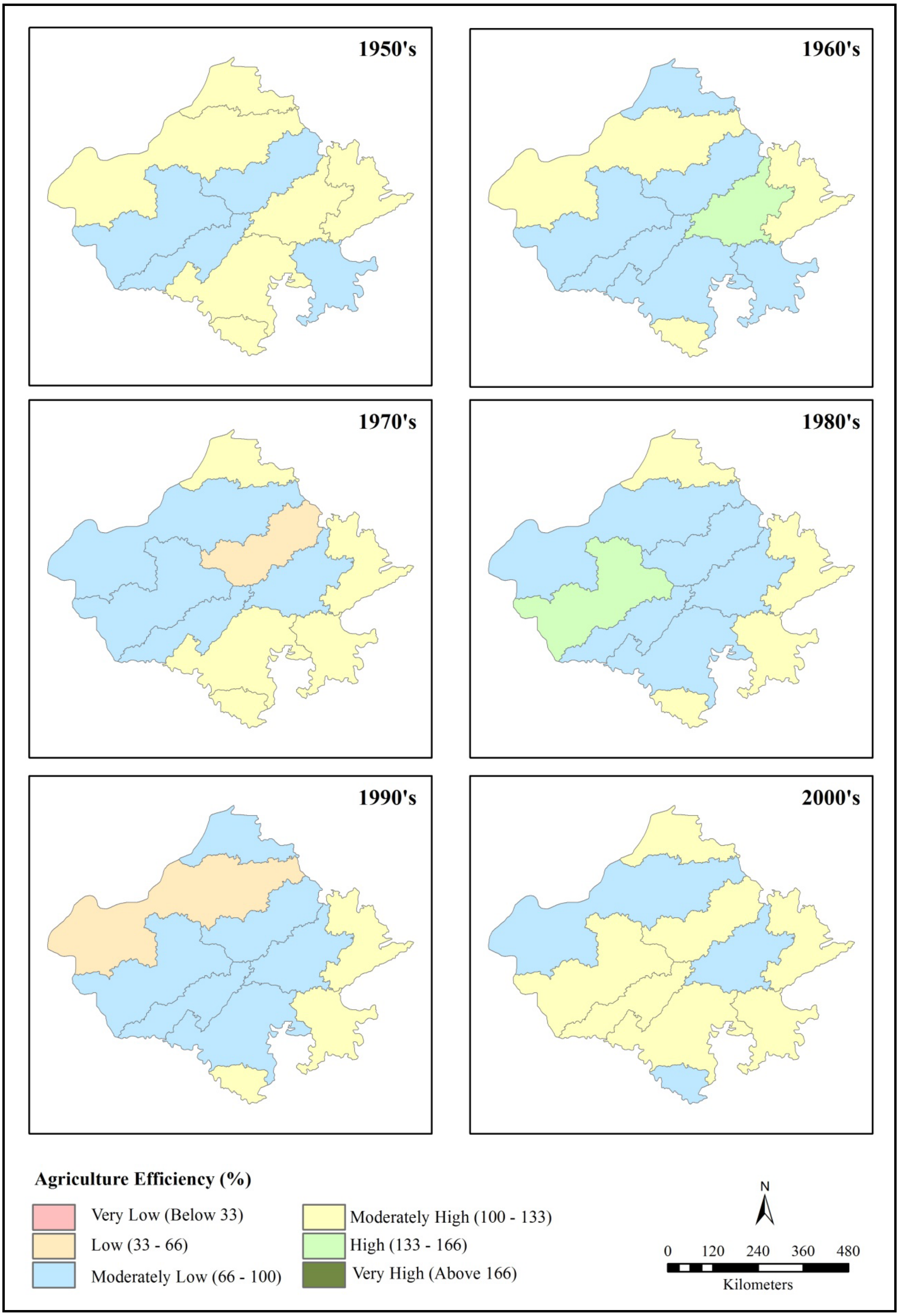


Figure 9: Decade-wise Changes in Agriculture Efficiency in Rabi Season, 1950-2010

4.4 Management Strategy

The vulnerability of these regions can be reduced through technology intervention along with revival of traditional resource conservation techniques. Following suggestions can be valuable to mitigate the impact of climate variability in the state:

4.4.1 Land Resources

Widespread land degradation is a persistent challenge in Rajasthan. The climatic variability of Rajasthan which has increased aridity has foremost impact on the soil moisture. According to the primary survey ~50 per cent of farmers believe that the climate variability is causing decline in soil moisture which has resulted into increased frequency of irrigation. The landholdings are scattered along with being small in size. The farmers are unable to provide appropriate inputs in such farms. With increase in population size and increasing trend of nuclear families, the farm size has reduced considerably. Therefore, there is urgent need of land consolidation. The scattered farms need to be consolidated in one farm so that the economic efficiency of the farms increases and farmers can adopt single strategy to improve the productivity and cope with extreme events. The soil testing facilities need to be further strengthened and soil health cards to the farmers should be provided through PPP wherein private fertilizer companies and NGOs should be involved in running mobile soil testing labs. The organic farming is also identified as good option to maintain the soil fertility and decrease the harmful effect of fertilizers in the state. The nature and extent of degradation of land varies considerably in the state requiring attention of the planners and project implementing agencies not only in arresting the degradation, but also regenerating the degrading lands. As conservation and land rehabilitation measures are highly expensive, the area for reclamation should be prioritized based on the severity of the land degradation, the nature of the extent of the problem and the proposed land use. Common lands in Rajasthan are crucial sources of livelihood for rural households. In the context of villages, the common lands provide wide-ranging contributions to village economy from food and fodder to farming systems, animal husbandry, resource conservation, and recharge of ground water. Over the years there has been a steady decline both in the extent as well as the health of common lands. The common lands need to be regenerated through involvement of local communities/user groups in planning.

4.4.2 Water Resources

Water availability is fundamental to food security. Thus, adaptations in water sector are vital for the future in order to prevent the rural exodus and guarantee food security for the population. Thus, as a policy response, Rajasthan is required to be treated as a special area from climate change perspective and comprehensive water management plans for agriculture, domestic and industrial sectors should be supported by a special economic package and investments that help in: (i) large-scale construction and renovation of rainwater harvesting systems in rural landscape and urban public buildings; (ii) augmenting water infrastructure in urban and rural systems, including water supply, water desalination, and water treatment and recycling for industrial and domestic uses; (iii) large scale infrastructure development for enhancing the groundwater replenishment; (iv) enhancing the preparedness through various inputs for drought mitigation, drought monitoring and development of early warning systems; (v) long-term insurance system to minimize the crop failure losses.

4.4.3 Cropping Strategy

The diversified cropping pattern and the presence of livestock as a major livelihood source has helped the state in managing the wide range of risks associated with dryland agriculture. The foremost strategy adopted by the farmers during climatic variability is through changing cropping pattern followed by changing occupational pattern. The varied agro-climatic conditions and soils in the state make it suitable for growing a wide range of fruits like ber, pomegranate, citrus, aonla, mango, papaya, custard-apple, etc. Besides, cultivation of seasonal vegetables; medicinal and aromatic plants like Isabgol, mehandi, senna, etc., spices like cumin, methi, coriander, chillies, ajwain, ginger, garlic, etc., betel vine; flowers like rose and jasmine and oil yielding plants like jajoba, castor, jatropha, etc., offer opportunities for much desired diversification in agriculture through a balanced use of land, water and other resources for promoting sustainable agriculture besides increasing the income of the farmers by raising high value crops.

4.4.4 Farm Input Management

The limited access to inputs and unstable climatic conditions have resulted in a predominance of low productivity, risk-minimizing and subsistence-oriented farming systems (often integrating crop and livestock production) capable of resilience (within limits) against droughts as well as able to produce a marketable surplus in years of good monsoon rainfall. Thus, there is need to strengthen the input delivery system in the state. For increasing the agricultural productivity and production, proper management and availability of agricultural inputs including seeds are important. Distributions of improved seeds need to be improved mainly through Rajasthan Seeds Development Corporation, National Seeds Corporation in addition to other private dealers.

4.4.5 Agriculture Marketing

Adequate return on farmers produce is one of the driving forces for better agricultural growth. Better marketing channels and warehouse facilities are essential for ensuring adequate returns on agricultural output of farmers. The farmers in lack of proper marketing facilities and low market prices of products are forced to sell their products, especially, spices in the local weekly markets by themselves. Thus, there is a need of further expansion of network of warehouses in the state.

5. CONCLUSION

In India most of the states in the country are largely dependent on rainfall for irrigation this is more so in the case of Rajasthan. Any change in rainfall patterns poses a serious threat to agriculture, and therefore to the state's economy and food security. Agriculture is adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of the rainfall. In Rajasthan, rise in temperature has been estimated to reduce production of Pearl Millet, which is staple crop during kharif season. Changes in the soil, pests and weeds brought by climate change will also affect agriculture in Rajasthan. Large shifts in the geographical distribution of agriculture and its services along with crop combination are observed. Farming of marginal land in drier regions has become unsustainable due to water shortages, environmental degradation and social disruption. Besides ecological, technological and socio-economic drivers, climate change / variability associated frequent extreme weather events has become an important determinant of agricultural productivity in arid region of Rajasthan. With use of modern farm technology and inputs the area and productivity has continuously rose in the state. In rabi season also, change is visible in cropping patterns. Farmers are shifting their focus from cereal crops to oilseeds. Cereal crops require more water and care as compared to oilseeds, and also they earn more profit on oilseed crops. Cropping pattern is changing in both *rabi* and *kharif* season. Farmers are shifting to HYV crops which need less water and are also less dependent on rainfall and increased the area under irrigated crops. The impact is critical especially for arid and semi-arid regions of Rajasthan where more than 70 per cent of the population depends directly or indirectly on agriculture.

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