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Farmer's Perception and adaptation of Climate Variability In Rajasthan

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Abstract

Impact of climate on agriculture is a strong phenomena. Implications of Climate variability on farmlands is a major threat to crops grown in arid and semi-arid areas. How the climate is affecting agriculture in dry areas can be seen through the eyes of farmers. Rajasthan is bestowed with an arid and semi-arid climate in India. It is the largest state of India by area covering the total geographical area of 34.2 million hectare or 10.4 percent of the total geographical area of India.The cultivable area is 25.633 million hectare (74.9%of total geographical area) and the net sown area is 17.096 million hectare (66.7% of cultivable area). Rajasthan has two principal cropping seasons : Rabi and Kharif. The kharif crops are sown in the summer season or seeded in the months of June and July with the onset of Monsoon and are harvested in the months of September and October, which includes bajra, pulses, jowar, maize and groundnut. The kharif crops include the total 65%cultivable area of the state (2015-16). While the rabi crops are winter crops and are grown in the months of October and November and harvested in the months of March and April. The paper is based on the primary survey conducted on farmers to enquire about changes in wheat and bajra crops over the seasons due to climate change and its variability. The questionnaire was prepared to know about the changes in crops in three districts of Kota, Alwar and Bharatpur. To justify the results, secondary data was used to corroborate the answers given by farmers on climate variability. It was observed that the farmers were aware about climatological changes occurring in their region and accordingly farmers made certain adjustments in their farming practices.

Keywords Climate Variability, Farmers' Perceptions, Crops, Rainfall, Temperature, Rajasthan

Introduction

The total geographical area of Rajasthan is 34.2 million hectare and the cultivable area is 25.633 million hectare (74.9%of total geographical area) and the net sown area is 17.096 million hectare (66.7% of cultivable area). The gross cropped area of Rajasthan is 21.664 million hectare while the area sown more than once is 5.11 million hectare with the cropping intensity of 124.5percent. The net irrigated area is 5.239 million hectare including canals 25.08 percent, tube wells 72.7 percent and other sources 2.22 percent. The gross irrigated area is 8.09 million hectare and the percentage of net irrigated sown area is 30.6 percent in the state. While the total number of land holdings are 58.19 lakhs out of which 18.49 lakh (31.78%) are marginal farmers, 12.10 lakh (20.79%) small farmers and 27.60 lakh (47.43%) farmers hold land above 2 hectare.

Rajasthan has two principal cropping seasons that are rabi and kharif. The kharif crops are sown in the summer season or seeded in the months of June and July and are harvested in the months of September and October, including bajra, pulses, jowar, maize and groundnut as major crops. The kharif crops include the total 65 percent of area of state (2015-16). While the rabi crops are winter crops and are grown in the months of October and November and are harvested in the months of March and April. The significant rabi crops are barley, wheat, gram, pulses and oil seeds. These crops include 35 percent of the total area of Rajasthan (2015-16). The major oil seeds are rapeseed and mustard. The regions that are highly irrigated or receive abundant water supply are utilized for the cultivation of improved high-yielding varieties of crops like wheat. There are some places in Rajasthan that has black soil that nurture

the growth of major cash crops like cotton and sugarcane. Bajra cultivated area covers 4.04 million hectares(58%) of total cropped area while wheat area covers 3.11 million hectares(10.28%) of total cropped area in Rajasthan as per 2015-16 agricultural statistics report. In case of production, bajra accounts 3.58 million hectares(43.78%) and wheat accounts 9.87 million hectares(10.56%) while productivity of bajra accounts 872kg/ha and productivity of wheat accounts 3172 kg/ha as per 2015-16 agricultural statistics report. Therefore, bajra and wheat crop were selected for the study as both are staple crops in their cropping seasons. Bajra is kharif crop and Rajasthan ranks 1st in production and yield and wheat is rabi crop and ranks 4th in production at national level.

Objective of the Study

To assess the farmer's perception and adaptation due to changing weather phenomena and climate change in their farming methodology on the basis of their actual experience.

Methodology

Primary survey is conducted in the selective three districts of the state on the basis of highest production of wheat and bajra. To conduct the primary survey questionnaire was prepared on the basis of pilot field survey. Initial field study was performed to observe the farmers responses on changes of rainfall pattern, fluctuating range of temperature, extreme weather events, depleting ground water level, loss of vegetation and biomass cover particularly in village common land, changing nature of crops grown over the time, deviation in agricultural practices due to technological advances over a period of time, identification of new practices adopted in accordance with the climate change and explored the mechanism adopted by farmers to increase the crop production. On the basis of such questions the final questionnaire was prepared and was filled up by stakeholder farmers as respondents. Primary survey of 150 samples was conducted in three districts Alwar, Bharatpur and Kota, 50 respondents from each district identified for data collection.

Study Area

Rajasthan is the largest Indian state in area and the seventh largest by population in India. Geographically it is bestowed with loess plains in western side of Aravalli to lacustrine plains in the east of Aravalli range. Most of the shifting sand dunes and Barchans are stabilized with the provision of transferring the water of Himalayan rivers through canal networks. The climate of Rajasthan as arid to semi-arid where evaporation exceeds the precipitation. Eastern side of Aravalli receives about 50 cm. rainfall in 75 days monsoon season whereas western side of Aravalli receives less than 25 cm. rainfall in less than 50 days rainy season which makes the region as tropical Thar desert. The vegetation structure of the state is dominated by khejri, acacia indicus, porosopisjuliflora and cactus with stunted growth and thorns. Vegetation contains small, leathery and waxy leaves in order to preserve the water in water stressed region. The soil of the state is sandy alluvial to loamy with high porosity, low humus, poor moisture and pH value is more than 7 which is alkali soil.Rajasthan shares 1048 km. long international border with the Pakistan in the west, along the Sutlej-Indus river valley. It is bordered by five Indian states as Punjab in the north; Haryana and Uttar Pradesh in northeast; Madhya Pradesh in the southeast and Gujarat in the southwest. The geographical extent of the state is 23.30-degree North to 30.12-degree North latitude and 69.30 degree east to 78.17 degree East longitude.The Tropic of Cancer passes through southern part of the state and the overhead strike of sun rays during summer force the hot advectional local Loo winds to blow out from the region. Broadly, Rajasthan is divided by Aravali relict mountain range where western part has mainly water stressed arid to semi-arid climate and eastern part has semi-arid climatic conditions.

Review of Literature

A comprehensive literature review has been done for accomplishing the research paper. Assessment of agricultural drought in Rajasthan using remote sensing derived vegetation condition index (VCI) and standardized precipitation index (SPI) published in the Egyptian Journal of Remote Sensing by Dutta D. et. al. (2015) gave regional classification of Rajasthan based on real time data using satellite image remains the breakthrough of the research work. The study of Kakade B. K. et.al. (2003) on combating drought through a participatory watershed development approach: a case study of Gokulpura-Govardhanpur villages in Bundi district, Rajasthan published in Natural Resource Management helped in framing the methodology of empirical research. The research work of Ribot Jesse C. (1996) on climate variability, climate change and social vulnerability in the semi-arid tropics published in Cambridge University Press supported to frame the results and discussions of the paper. The analysis of rainfall and drought in Rajasthan, India paper published in Global Nest Journal by Mundetian N. and Sharma D. (2015) offered scientific approach of statistical analysis of long-term climatic data. Tikadar K. S. and Kamble R. K (2021) published paper on wheat, mustard and barley cultivating marginalized farmers' climate change perceptions, impacts and adaptation strategies in Alwar and Jhunjhunu districts, Rajasthan, India. The study combined the natural adversaries with socio-economic conditions of the habitat. The climate vulnerability assessment in semi-arid and arid region of Rajasthan, India: an enquiry into the disadvantaged districts published in Journal of Agrometeorology (2019) by Naveen P. Singh et. al. compared the crop and climatic data of various districts of Rajasthan.

Result and Discussion

Primary survey of 150 samples was conducted in three districts Alwar, Bharatpur and Kota, 50 respondents were taken from each district. On the basis of a primary survey in three districts namely Alwar, Bharatpur and Kota, following observations were found. Out of the total respondents about 40 per cent were male while about 60 per cent were females. The educational qualifications of female respondents were illiterate or below 5^{th} class and educational qualifications of male respondents were between 5^{th} class to 12^{th} class. The respondents of the older generation were least educated, and the majority of the younger generation is living outside their native villages for alternate employment in secondary and tertiary economic activities. Out of the total respondents about 40 per cent were engaged in agriculture along with government jobs, while other 45 cent were engaged in agriculture only and the rest of the 15 percent were in allied economic activities and other employment. The economic categorization of income is that about 20 percent of the respondents earn in range of Rs. 1 to 2 lakhs per annum per family, while 40 percent earn in the range of Rs. 50 thousand to 1 lakh per annum per family and rest earns below Rs. 50 thousand per annum per family.

In Alwar and Bharatpur districts, most of the respondent farmers grow both the dominant crops i.e. bajra and wheat in kharif and rabi season whereas in Kota district bajra crop is grown in lesser net sown area and wheat is grown widely in association with other crops. About 67 percent respondents grow crops as rainfed and rest of the farmers grow crops with assured sources of alternative irrigation when rainfall is not sufficient and inconsistent.

On the basis of the formal questionnaire method, questions were enumerated, and answers were formed in graphical representation using pie charts and bar charts to understand observations of respondents with precision.

Figure 1.1 explains that the time of growing and harvesting the bajra and wheat crops has altered or not in the recent past. 50 percent of the farmers endorsed that bajra growing and harvesting time schedule has been altered and 40 percent responded with no change while rest of the 10

percent had no idea. Similarly, in the case of wheat crop about 30 percent responded yes, 50 percent responded with no change and the rest of the 20 percent had no idea about the impact of climate change.

In **Figure 1.2** respondents' view on use of methods for cropping was about the application of seeds, fertilizers, pesticide and organic manure. Subsequently, 66 percent farmers endorsed the application of HYV seeds with the argument of higher farm production due to the use of HYV seeds.Whereas 22 percent farmers apply only conventional seeds due to better climatic adaptability and rest rely on weather conditions in choosing the HYV seeds. In case of application of chemical fertilizers, 70 percent of the respondent farmers use fertilizers for increased crop production and yield, 15 percent of the farmers do not use fertilizers due to financial limitations and rainfed climatic conditions while rest of the farmers rely on weather conditions and other factors.

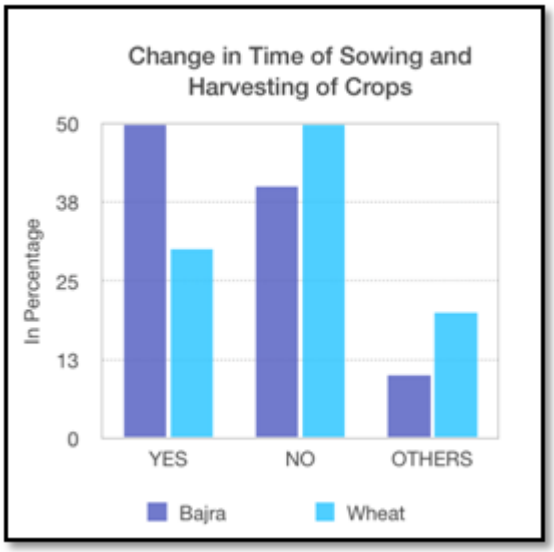

Fig1.1 Change in Time of Sowing and Harvesting of Crops

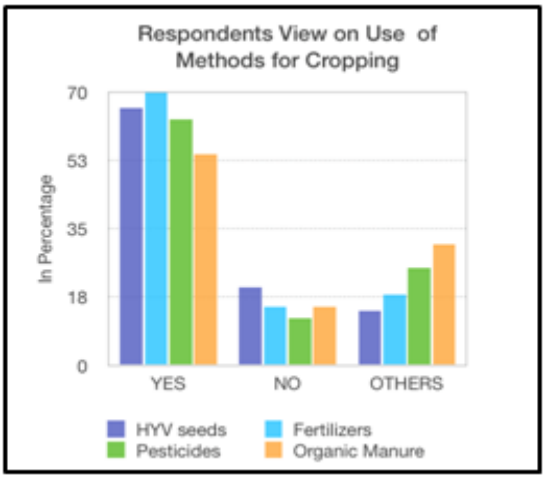

Fig. 1.2 Respondents View on Use of Methods for Cropping

In response to the application of pesticides, 63 percent farmers use the pesticides to prevent the crops from various diseases, while 12 percent respondents do not apply pesticides and rest of the farmers have no idea about the use of pesticides. Similarly, the use of organic or bio-manure is performed by 54 percent of respondents, but it is less or varying in quantity and not sufficient for all fields that leads to farmers' shift for chemical

fertilizers. Most farmers with small landholding use organic or bio-manure initially and in the absence of its sufficient supply due to the decreasing number of livestock population farmers use chemical fertilizers as an alternative.

Figure1.3 discussed the opinion of respondents on climate variability; the majority of the farmers had no idea about climate change and climate variability. Subsequently, the observations of farmers were sought on changing nature of rainfall, changing nature of biomass, biodiversity, and livestock population over the decades in the vicinal habitat.The changing parameters of range of temperature and selection of crops during different cropping seasons along with logical reasoning. Changing dependency on sources of water for irrigation,and nature of soil quality change are the major research concerns. Most of the respondents were selected from the elder members of farmers families and village headmen as they had more experience of changing the nature of farmland perspectives over the decades.

In the response to the change in the nature of intensity and amount of rainfall, 65 percent respondents endorsed the significant decrease in rainfall, 50 percent responded the increase in average temperature during cropping season in last few decades, 40 percent responded that soil quality has deteriorated due to lack of moisture and use of chemical fertilizers, 69 percent identified that ground water table has declined by 10 to 30 feet over the decades while rest of the respondents had no idea about ground water table depletion as they rely on rainfed cultivation. In terms of vegetation and biomass diversity, 66 percent farmers responded that there is significant deletion in biomass cover and biodiversity, a few dominant and native tree species disappeared completely and replaced by invader tree species whereas some trees are left with a few numbers.

The changing nature of climate variability is directly affecting cropping conditions. It is represented by figure1.3 where 40 percent respondents endorsed that extreme range of temperature has reduced the crop ripening process along with feeling down of crops resulting in crop production and quality reduced drastically. Farmers get less time to harvest the crop as most of the farm work as cutting, collecting etc.are performed manually. Similarly, 85 percent farmers responded that due to inconsistent endless rainfall, crops fail in absence of soil moisture and need to be reseeded again and again. Similarly, 67 farmers identified that soil quality has degraded due to less rainfall and more use of fertilizers. The application of fertilizers and pesticides become an essential part of crops for assured farm output. 70 percent of respondents acknowledged the decline in ground water table, accordingly conventional wells have dried up, water level has gone 20-30 feet down. Digging the well is very expensive affair for poor farmers and sometimes water does not replenish in wells or it become brackish or non-potable. Hence,farmers are dependent on canals and seasonal rivers of irrigational water for crops.

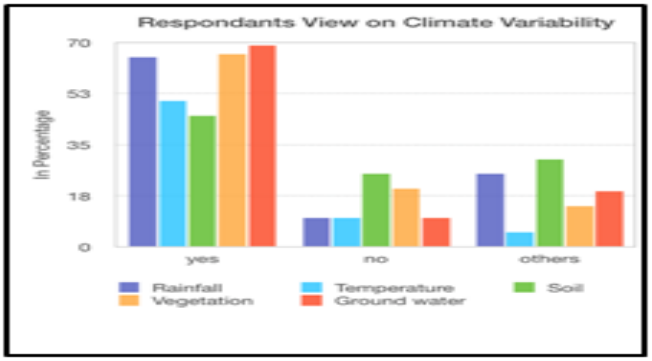

Fig. 1.3Respondents View on Climate Variability

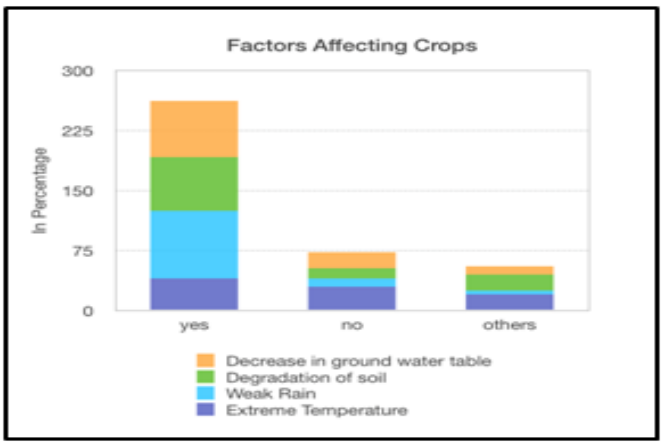

Fig 1.4 Factors Affecting Crops

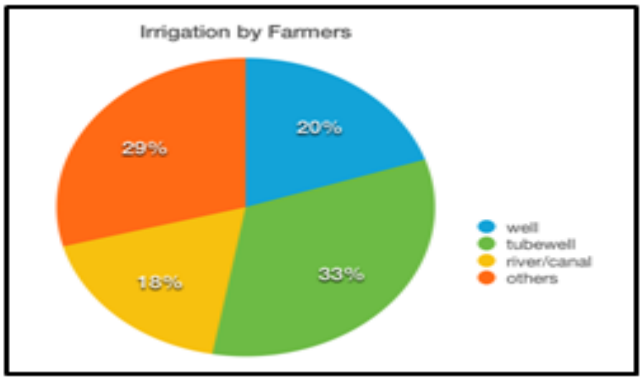

Fig 1.5Irrigation Methods Used by Farmers

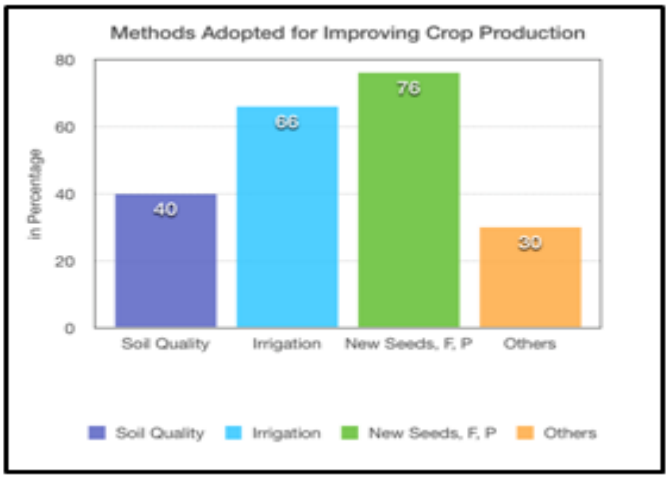

Fig. 1.6 Methods Adopted for Improving Crop Production

As majority of farmers endorsed the sufficient decline in ground water table, erratic and less rainfall, therefore farmers shifted to alternate methods of irrigation for crop sustainability.Figure 1.5 represents that 21 percent farmers still use conventional wells for irrigation, 35 percent farmers use tube wells, 18 percent farmers have accessibility of ephemeral rivers/canals while rest use other methods of irrigation.

Figure1.6 shows different methods adopted by farmers for improving their crop productivity, 40 percent farmers have taken measures to improve soil quality like use of gypsum to add fertility of alkaline soil in semi-arid areas. 66 percent farmers have adopted new irrigation methods like tubewells,

canals, pipeline, diggi (overhead tanks), farm pond, sprinklers, and drip irrigation methods. Similarly, about 76 percent farmers are dependent on HYV certified seeds in market for higher productivity of crops.Traditionally, farmers usenative and less productive conventional seeds and similarly for fertilizers (F) and pesticides (P) farmers are dependent on the market, for which the government gives subsidies also. Government has adopted a certified seed distribution plan of different crops seasonally in the name of the Minikits programme. While the rest of the farmers were reluctant to express with precision on their cropping methods related to application of irrigation and crop productivity.

Adaptation Measures

Adapting to climate change and climate variability entails taking the right measures to reduce the negative effects of climate variability by making appropriate adjustments and changes. The Intergovernmental Panel on Climate Change (2007) defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities. Following crop adaptation strategies have been suggested:

1. Planting and growing the drought resistant and weather adaptable varieties of crops.
2. Use of fertilizers and pesticides: in the case of Rajasthan shown in figure1.7 and figure1.8 that use of chemical fertilizers like nitrogen, phosphorus and potassium has increased in both the kharif and rabi season.

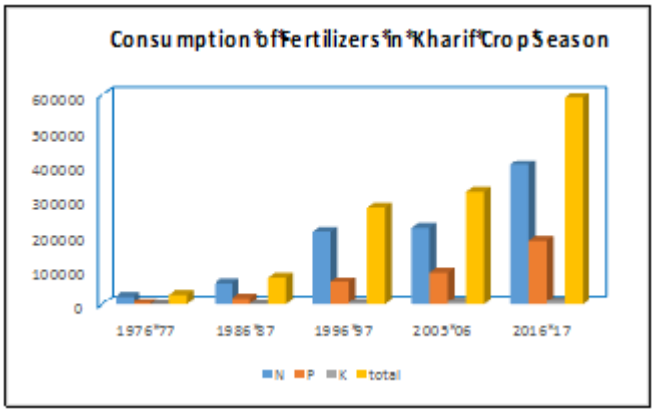

Fig. 1.7 Decadal Consumption of Fertilizers in Kharif Crop Season of Rajasthan (figure in Kg.)

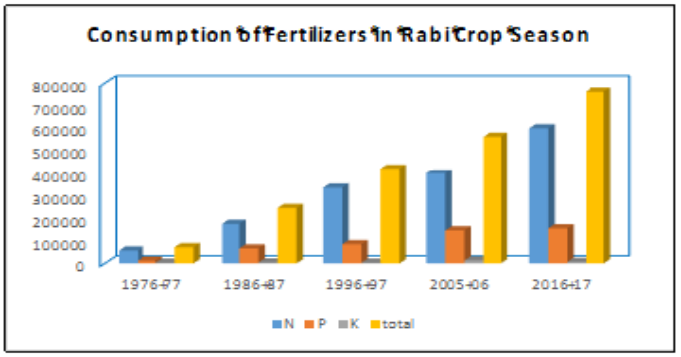

Fig. 1.8. Decadal Consumption of Fertilizers in Rabi Crop Season of Rajasthan

1. Crop Diversification: diversification towards high value crops is feasible in the medium to long term. Crop Diversity is a high priority adaptation measure in both irrigated and non-irrigated rainfed dryland farming areas. Case studies like in Southern Africa for example, land use is manipulated leading to land use conversion, such as the shift from livestock farming to game farming. (Ziervogel et al., 2008). In Kordofan andDarfur states of Western Sudan, food crops have replaced cash crops, and more resilient crop varieties have been introduced (DFID, 2004). In Tanzania,farmers diversify crop types as a way of spreading risks on the farm (Orindiand Eriksen 2005; Adger et al., 2003).
2. Change in Cropping Pattern and Calendar of Planting: Climate variability affects crop production through long term alterations in rainfall resulting in cropping pattern and calendar of operations.
3. Mixed Cropping: Mixed Cropping involves two or more crops in proximity in the same field. The system is commonly practiced in Tanzania where cereals, legumes, nuts are grown together.
4. Improved Irrigation Efficiency: As water becomes a limiting factor, improved irrigation efficiency will become an important adaptation tool, especially in dry season, because irrigation practices for the dry areas are water intensive.

In figure 1.9 it can be observed that different methods have been used for irrigation in Rajasthan and use of some methods have increased over a period of time while use of some old and conventional methods have decreased.

Figure 1.10 represents new methods like sprinkler and drip irrigation methods that have been adopted over a period of time. Use of drip irrigation has increased more because it saves water and uses water efficiently without any enhanced maintenance cost of farm infrastructure.

Local farmers have improved their adaptive capacity by using traditional pruning and fertilizing techniques to double tree densities in semi-arid areas. This helps in holding soils together and reversing desertification. Other methods like use of zero tillage practices in cultivation, mulching and other soil moisture management techniques. Natural Mulching moderate soil temperatures and extremes suppress diseases and harmful pests and conserve soil moisture. Use of organic farming has increased as a new method of agricultural practices.

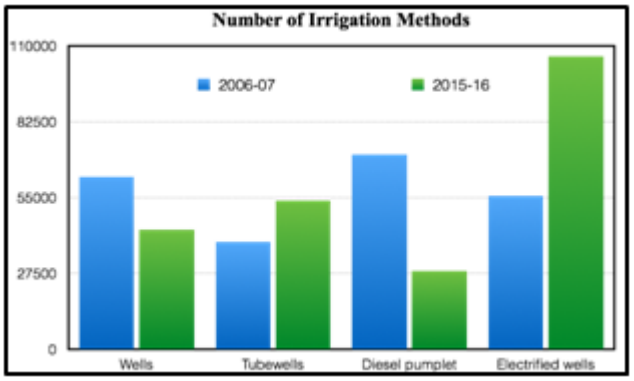

Fig.1.9:Number of Irrigation Methods used in Rajasthan

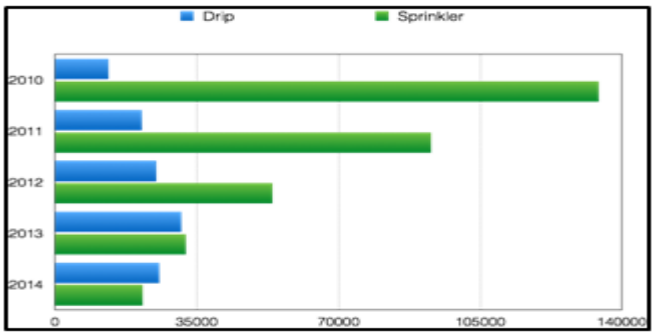

Fig. 1.10: Use of Drip and Sprinkler Irrigation Methods in Rajasthan

SWOT Analysis

The analysis of strengths, weaknesses,opportunities and threats is of the agriculture sector of Rajasthan done on the basis of primary survey and readings of secondary data sources, as given in table below.

Table: 1.1: SWOT Analysis

Strengths	Weaknesses
Vast land area Diversity of region Traditional farming knowledge To know about local demands Societal acceptance and trust Resources, solar energy	Lack of water Lack of education Fear of crop failure Lack of infrastructure Lack of expertise in climate change modelling
Opportunities	**Threats**
Possibilities for adaptation and mitigation Sustainable agriculture Environment Impact Assessment Advancement of technology	Scanty rainfall High temperature Drought events Wild livestock More use of Fertilizers, pesticides Salinity

Preparation of the Climate Change Agenda for Rajasthan (CCAR) was an important beginning given towards addressing climate risks that Rajasthan is the largest state in the country.Subsequently, there are unique vulnerabilities associated with the state in terms of exposure to climatic extremes and varying capabilities to be able to respond to the likely risks, and opportunities that can be tapped on like harnessing solar energy.

Rajasthan Released a State Environment Policy (SEP) in 2010 identifying the key environmental challenges that the state must address to ensure continued sustainable development and economic growth that is equitable.The Rajasthan Environment Mission was constituted to bring into focus the high priority issues emerging from the SEP and CCAR, and mobilize government and non-government stakeholders to address these issues. Within the StateEnvironment Mission, some sectors have been

identified as being critical in terms of the climate change impacts on them. These include sectors such as human health, agriculture and animal husbandry, enhanced energy efficiency including solar energy, and strategic knowledge for climate change..

Conclusion

Rajasthan has been identified as one of the four states most vulnerable to climate change. Accordingly, a detailed action plan for climate change adaptation and mitigation for rural areas is under preparation.The state government plans to take up multiple actions to address unique vulnerabilities to create newer opportunities with respect to the changing climate.

The state has developed a specialized Climate Change Agenda for Rajasthan(2010-2016), under the Rajasthan State Environment Policy, 2010. In case of agriculture, Agriculture practices can be strengthened by improvements in agro-extension services related to seed development, on-ground demonstrations of new techniques, promotion of better irrigation infrastructure and improvement in reclamation of saline alkaline soils. By enhancing crop productivity by producing climate resistant crops and promotion of rainfed agricultural techniques including soil moisture conservation, watershed management, efficient water harvesting can help dealing with many issues.

Crop insurance based on weather-based derivatives; role of sharing and dissemination of agro-climatic information;assessment of livestock health as affected due to climate change; and controlling green-house gas emissions from livestock sector through promotion of integrated crop-livestock management, efficient fodder development,improved animal feeding technologies and organic animal farming practices will help in achieving Sustainable Agriculture in the state.

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