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Effects of Drought on Farming and Farmer's Income in Betul District of Madhya Pradesh, India

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ABSTRACT This study aims to find out various impacts of drought on farm produce and farmers' income in central India. A range of methods, including scrutinising secondary data to questionnaire surveys of farmers, and focus group discussions were used for gathering information from rainfed and irrigated farmlands. Most of the farmers in the study area blamed poor rainfall and increase in temperature for frequent droughts. In both irrigated and rainfed areas, the majority of farmers (more than 85%) perceived soybean as the most adversely impacted crop in terms of crop yield, during the drought period. The farmer's income from soybean has declined by seventy to eighty percent in irrigated areas during drought period whereas it was more in rainfed areas. There was no significant correlation between the rainfall and crop yield however there was a moderate positive correlation between rainfall and yield of soybean and maize. The study depicts that impacts of drought on rainfed areas were high as compared to the irrigated areas, and therefore, to mitigate the adverse impacts of drought there is a need to provide irrigation facilities to the farmers.

INTRODUCTION

Drought is one of the most destructive disasters, which impacts the environment, economy, and societies across the world (Sönmez et al. 2005; Dumitrascu et al. 2018). The increase in temperature, lack of rainfall and/or the decline in rainfall and shortage of water level with respect to time and space may create conditions for drought to take place (Dai 2013; Kala 2017). The water contents in the atmosphere and lithosphere determine the types of drought. For instance, in a given area, the lack of precipitation over a period of time is classified as a meteorological drought, inadequate surface and subsurface water cause hydrological drought, and reduction in soil moisture is considered as an agricultural drought (Wilhite and Glantz 1985; Udmale et al. 2014). In comparison to other natural hazards, the impacts of drought spread over a larger geographical area (Menghistu et al. 2018). Further, the prediction of increase in mean temperature to 1.5 ^{o}C by 2050, as compared to 2012, may lead to less precipitation, increasing water scarcity and drought conditions across the globe (Sohl and Ginkel 2014).

In India, none of the climatic zones is free from the effects of drought, though the frequency and intensity of drought may vary across the zones. About seventy percent population in India depends on agriculture for their livelihood, either directly or indirectly, by utilising forty-three percent of India's geographical area, which contributes nearly twenty-nine percent to the National Gross Domestic Product (Prasanna 2014). The monsoon rains are very important for Indian agriculture because a large agriculture land here is categorised as rain-fed, which depends on rainfall for crop production (Kala 2010, 2014). The increase in frequency and intensity of drought has dragged the agriculture sector under severe threats. Drought does not only affect crop yield but also affects the quality of food-grains, soil, livestock and pests (Keim and Austin 2013; Agrawal 2003).

The state of Madhya Pradesh, which forms the central part of India, has a population of 7,27,00,000, of which seventy percent is engaged in agriculture for living (Census 2011). Many districts of Madhya Pradesh, including Betul district with 80.38 percent of the rural population, have been threatened by drought in the present century (Kala 2015, 2017). In 2016, four major *tehsils* (administrative subdivisions within a district or sub-districts) of Betul district were declared as drought affected *tehsils* by the state government (Amrute 2017). The prosperity and wellbeing of people in Betul are closely linked with agriculture and allied activities. The pro-

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duction of crops here depends on monsoon rainfall to a large extent. The rise in temperature, erratic rainfall and climatic extremes accelerate adverse impacts of drought (Le Houérou 1996; Kala and Silori 2012; Kala 2017). All these climatic variations affect crop production. However, there is a scarcity of studies on the impacts of drought on agriculture systems in central India. Thoughtful analyses of farmer's perceptions that are based on the range of judgments, beliefs and attitude (Taylor et al. 1988) may help in identifying barriers to behavioural changes that are needed for management of resources and systems (Dessai and Sims 2010; Urquijo and De Stefano 2016). A wide consultation with farmers in view of understanding and analysing their perceptions may further help the policymakers in framing more acceptable and realistic policies for dealing with the impacts of drought, which may vary from one region to another region. With this background, the present study aims to analyse various impacts of drought on farm produce and agriculture related income as perceived by the farmers community.

METHODOLOGY

Study Area

The present study was conducted in Betul district of Madhya Pradesh state in India during 2016-2017. Betul district spans over 10,059.48 square kilometres between latitude 21° 22' - 22° 24' N and longitude 77° 04' - 78° 33'00'' E. It is bounded by Hoshangabad district on the north, on the west by the district of Khandwa, on the south by Amravati (in Maharashtra) and on the east by Chhindwara district. Betul district falls in the Satpura plateau agro-climatic zone, which is surrounded by high peaks of Satpura hills and dense forests. Some important rivers, which flow through the district, are Tapti, Tawa, Machna, Sapna, and Purna (Anonymous 2016). The human population of this district is 15,75,247, which is 157 individuals per km^2 with 971 females per 1000 males. The district is rich in tribal population, which is 6,67,018 in numbers (Census 2011). Gond and Korku are the most dominant tribes in the district (Amrute 2017). Betul district supports rich biodiversity with forty percent of its geographical area under forest cover. The majority of population here depends on agriculture for livelihood. They grow both *kharif* and *rabi* crops. Major *kharif* crops are soybean, paddy, maize, groundnut and sugarcane, whereas major *rabi* crops are wheat, gram, green pea, lentil and mustard.

The climate of Betul is characterised by a hot summer, cold winter and monsoon. The month of May generally remains the hottest month of the year with an average temperature of 39 ^{o}C, whereas the minimum temperature (10 ^{o}C) is recorded during December. The normal annual mean maximum and minimum temperature is 31 ^{o}C and 18 ^{o}C, respectively (Lokhande 2016). The normal annual rainfall goes up to 1024.9 mm, of which eighty-seven percent rainfall is received during the monsoon season (Anonymous 2016). Only thirteen percent rainfall takes place between October and May. The humidity comes down lowest in April, which varies from thirty-one to ninety-one percent in different seasons. The wind velocity is higher in June (around 8.5 km/hour) and lowest in November (3.8 km/hour).

Survey Methods

Stratified sampling technique was applied by dividing study area into two stratums, that is, irrigated (having irrigation facilities) and rainfed (depend on rainfall). The information on availability of irrigation facility provided to the villages was collected from the District Agriculture Department of Farmer Welfare and Agriculture Department, Madhya Pradesh. The villages considered under irrigation category were based on the criteria where ninety to one hundred percent land areas were under irrigation. The rainfed category was considered where only twenty percent of land was under irrigation and rest was dependent on rainfall for cultivation. Two villages each from irrigated and rainfed categories were surveyed intensively for data collection. A total of 240 farmers' families were interviewed, of which 60 farmers' families (15% of the population) in each village were approached randomly for gathering information. The farmers were classified into three categories based on their land holdings such as big farmers (having more than 2 ha of land), small farmers (having 1 to 2 ha of land) and marginal farmers (having less than 1 ha of land) as per the Census (2011). In each category of farmers, a minimum of 10 farmers' families were approached for interview. Semi-structured and open-ended questionnaires were used, which include demography, land holding, detailed account of the perception of farmers about drought, and its possible impacts on agriculture, the availability of water and means for irrigation. Field observations were also made by visiting farmers' fields and water bodies such as wells, ponds, and rivers.

Besides literature review, the data on crop productivity and crop-sown area were collected from the Betul District Agriculture Department of Farmer Welfare and Agriculture Department, Madhya Pradesh. Meteorological data was collected from District Administrative Division, Betul, and Indian Meteorological Department. Ground water level data were collected from the Public Health Engineering Division, Betul. Besides analysing perceptions of farmers, the collected data were analysed for estimation of crops productivity and income generation. The correlation was established between crops productivity and rainfall and temperature by using Spearman's rho. The result of this correlation is projected with correlation coefficient or r-value, which ranges from -1.0 to +1.0. The r-value close to 0 indicates that there is no relationship between the variables. With the r-value close to +1 or -1, it the more closely the two variables are related. The p (or probability) value ranges between 0 (0%) and 1 (100%). A p-value close to 1 suggests no correlation. A p-value of 0.05 (5%) or less is considered statistically significant.

RESULTS

Perception of Farmers on Environmental Change

The amount of rainfall and temperature is considered to be the most important environmental indicators of drought in the given area. During present investigations, the majority of farmers in irrigated (62%) and rainfed (71%) villages experienced that their areas have been receiving poor rainfall in the present decade, which was considered one of the possible causes of drought (Table 1). The other possible cause of drought is increasing temperature. The farmers perceived a number of factors to be responsible for increase in temperature, of which the majority of farmers (more than 65%) in both rainfed and irrigated villages considered the decrease in rainfall to be the reason behind the increasing temperature, followed by reduction in tree cover (Table 2).

Table 1: Perceptions of farmers on the causes of drought in irrigated and rainfed areas

Causes of drought	*Irrigated (%)*	*Rainfed (%)*
Poor rainfall	62	72
Increase in temperature	18	19
Unpredictable weather	9	5
Erratic rainfall	11	4

Table 2: Perception of farmers on the causes of increasing temperature in irrigated and rainfed areas

Causes of increasing temperature	*Irrigated areas*	*Rainfed areas*
Decrease in rainfall	85 (71%)	78 (65%)
Reducing tree cover	18 (15%)	0
Global warming	0	3 (3%)
Don't know	17 (14%)	39 (32%)
Total	120	120

Perceptions of Farmers on Impacts of Drought

Farmers' perceptions on drought were not uniform across the villages in the study area. The majority of farmers in rainfed villages (83%) reported facing drought in their area, whereas forty-three percent farmers in irrigated villages denied severe impacts of drought in their area (Table 3).

Table 3: Perception of farmers on the occurrence of drought in irrigated and rainfed areas

Occurrence of drought	*Irrigated areas (%)*	*Rainfed areas (%)*
Yes	23	83
No	43	13
Don't know	34	4

Impacts on Crops and Crops Yield

Changes in temperature and rainfall affected crop productivity as well as the availability of fodder for livestock in the pasturelands. Irrespective of irrigated and rainfed, all studied villages suffered from crop losses during the drought period. Almost all farmers had responded affirmatively on the decrease in crop yield due to drought, followed by decrease in fodder availability. Due to deficiency in rainfall and long dry spells, the fodder availability in pasturelands decreased, which has affected the livestock. Soybean and wheat were the major cash crops in the study villages. The majority of farmers (more than 85%) in both irrigated and rainfed areas perceived that soybean was among the most influenced crops by drought or shortage of water in the study area. Farmers also perceived that pathogens and pests increased during drought. Diseases, such as bean yellow mosaic virus in soybean, increased during drought in the study area. It is a very dangerous disease because it spreads very fast and costs huge damages to the farmers. The farmers perceived that new diseases such as wheat streak mosaic on wheat crop and attack of white fly on crops and vegetables have increased in their farms damaging crop, which were not experienced earlier.

The decline in crop yield, as mentioned by the farmers, was reflected in crop yield. In comparison to normal periods, there was decline in yield of various crops and vegetables during drought period (Table 4). Some crops showed high fluctuation whereas, others showed minimum decline in yield. In irrigated areas, the yield of soybean declined from 2,446 kg per hectare in the normal period to 544 kg/ha in the drought period, and in rainfed areas from 2,076 kg/ha to just 247 kg/ha. The overall productivity of soybean was impacted badly in both rainfed and irrigated areas, which showed seventy-eight to eighty-eighty percent of decline during drought period. Besides soybean, there was decline in productivity in other crops as well during the drought period (Table 4).

Impacts on Income

The crop composition and/or the diversity of crops also determined the impacts of drought on farmers' income. The prices of soybean had decreased from 2011 to 2017 whereas prices of wheat had increased. In irrigated villages, the farmers' income from soybean had declined to seventy to eighty percent during drought period irrespective of their status as big or marginal farmers. However, in rainfed villages, the decline in income from soybean was relatively higher than the irrigated villages (Table 5). The income from wheat was also declined during drought years in both irrigated and rainfed areas (Table 6) but the decline in income from wheat was relatively low in comparison to soybean.

Table 4: Yield (in kg per hectare) of major crops and vegetables in normal and drought periods in the study area

Season	*Local name*	*English name*	*Irrigated areas*		*Rainfed areas*	
			Normal period	*Drought period*	*Normal period*	*Drought period*
Kharif - Cereals and Pulses	Soybean	Soybean	2446	544	2076	247
	Makka	Maize	2510	2125	1850	1352
	Dhan	Paddy	2298	1409	1483	964
	Barbati	Beans	-	-	1236	247
	Moongfali	Groundnut	914	741	1606	742
	Tuar	Pigeon pea	1730	865	1359	494
	Urad	Black gram	-	-	865	247
	Moong	Green gram	-	-	1483	494
Kharif - Vegetables	*Gobhi*	Cabbage	6178	5682	-	-
Rabi - Cereals and Pulses	*Gehun*	Wheat	4324	3583	2718	1977
	Chana	Chickpea	3583	2842	2595	1730
Rabi - Vegetables	*Gobhi*	Cabbage	6795	6300	-	-
Summer - Pulse	*Moong*	Green gram	3700	3212	-	-
Summer - Vegetable	*Gobhi*	Cabbage	6050	5560	-	-

Table 5: Changes in income (annual in Rs.) of farmers from soybean in normal and drought periods in rainfed and irrigated areas

Land areas	Big farmers		Small farmers		Marginal farmers	
	Normal	*Drought*	*Normal*	*Drought*	*Normal*	*Drought*
Irrigated	123200	30000	46900	11250	27720	6600
Rainfed	117600	15000	59220	7500	23520	3000

Table 6: Changes in farmers' income (annual in Rs.) from wheat in normal and drought period in rainfed and irrigated areas

Land areas	Big farmers		Small farmers		Marginal farmers	
	Normal	*Drought*	*Normal*	*Drought*	*Normal*	*Drought*
Irrigated	174000	162000	105600	85050	48720	45000
Rainfed	123200	100800	52800	43200	26400	21600

Relationship between Environmental Factors and Crop Yield

In the study area, there was no significant correlation between the rainfall and crop yield, however there was a moderate positive correlation between the maize yield and rainfall (r= 0.480; *p*=0.097) (Table 7). Further, there was a moderate positive correlation between temperature and yield of soybean (r= 0.575; *p*=0.064) and moderate negative correlation between temperature and wheat yield (r= -0.646; *p*=0.032). However, there was no significant correlation between temperature and crop yield (Table 8).

Table 7: Correlation between rainfall and productivity of crops in the study area

Crops	*Correlation (r value)*	*Level of significance (p value)*
Soybean	0.244	0.421
Maize	0.480	0.097
Wheat	-0.009	0.976
Gram	-0.042	0.891

Table 8: Correlation between temperature and productivity of crops in the study area

Crops	*Correlation (r value)*	*Level of significance (p value)*
Soybean	0.575	0.064
Maize	-0.405	0.217
Wheat	-0.646	0.032
Gram	-0.383	0.245

Farmer's Perceptions versus Scientific Observations

The farmers' perceptions were corroborated with scientific observations on changes in temperature, rainfall, ground water level and crops yield. Majority of farmers perceived that there is decline in rainfall during the drought year, which was confirmed by forty-six percent decline in rainfall data for the drought year. The farmers' perceptions on decline in crop yield, especially soybean, wheat and maize during drought years were corroborated with actual decline in both rainfed and irrigated areas (Table 9).

Table 9: Scientific observations and farmers' perception for drought period

Parameters	*Farmers perception*	*Actual*
	Drought period	*Drought period (2015-16)*
Rainfall (mm)	Decline in rainfall (60% farmer respondents)	46% decline in rainfall
Temperature (^{0}C)	High rise in temperature (30% of farmers respondents)	Upto~3% rise
Ground water level (Feet)	Water sources dried in March	3.2% decline
Soybean (kg/ha)	Decrease	78-88% decrease
Maize (kg/ha)	Decrease	15-23% decrease
Wheat (kg/ha)	Decrease	17-27% decrease

DISCUSSION

The findings of the present study indicate that impacts of drought on rainfed areas were high as compared to the impacts on irrigated areas. The present finding corroborates with the studies conducted elsewhere (Rockström et al. 2010; Massarutto et al. 2013). There were variations in the perceptions of farmers of rainfed and irrigated areas. In rainfed areas, eighty-three percent farmers agreed on the prevalence of drought and its impacts, whereas in irrigated areas only forty-three percent farmers admitted that they were facing negative impacts of drought. In rainfed areas, the severity of drought was higher than irrigated areas due to total dependency on rainfall and lesser number of water sources for agriculture. The farmers admitted that decrease in rainfall was the major reason for drought and the study area has been consistently receiving poor rainfall in the present decade. Besides, majority of farmers believed that unpredictable weather and increasing temperature were other important environmental factors for drought in the present study area. The similar findings are reported by Bhuiyan et al. (2006). The farmers' perceptions when corroborated with scientific observations, it shows similarity. Studies conducted elsewhere (for example, Rahman and Lateh 2016; Marchildon et al. 2016; Hasan and Kumar 2019) report consistency in farmers' perceptions and observed climatic data, especially temperature, rainfall and drought conditions.

Farmers in the rainfed areas cultivated less number of crops due to scarcity of water in all seasons except rainy season. The farmers in the irrigated areas were also affected by droughts due to drying up of their irrigation sources, particularly tube-wells and open wells. Besides drying of water sources, farmers admitted that drought brought several problems, including decrease in crop production, increase in diseases in crop plants, decrease in fodder and water availability, and reduction in size of food grains. Majority of farmers perceived the decrease in crop yield as the major impact of drought in comparison to other impacts. Some farmers believed that changes in cropping pattern have aggravated the losses from drought. Earlier, some of the farmers used to grow sugarcane due to availability of sufficient water but now they switched over to maize due to water scarcity.

The farmers' perceptions on decline in soybean yield during drought years were corroborated by the actual decline in soybean yield from 2,446 kg/ha to 544 kg/ha in irrigated and 2,076 kg/ha to 247 kg/ha in rainfed areas. Similar observations are made by Lal et al. (1999), and the National Food Security Mission (2018), which report that soybean yield varies under rainfed (1600-2000 kg/ha) and irrigated conditions (2000-2500 kg/ha). In 1986-1987, the average soybean yield in Madhya Pradesh was 560 kg/ha that increased to 784 kg/ha within a period of 10 years during 1995-1996 (SOPA 1996). Moreover, the soybean yield varies across the districts in central India. The mean soybean crop yield was observed 1,234 kg/ha for Indore, 1,097 kg/ha for Gwalior, 1,407 kg/ha for Jabalpur and 1,586 kg/ha for Raipur during 1991-1997 (Lal et al. 1999). The average yield of soybean in Madhya Pradesh was about 790-890 kg/ha before 2007 (ICAR 2007) that exceeded to 1,231 kg/ha in 2016-2017 (National Food Security Mission 2018). In India, per hectare soybean production, which was 1,200 kg/ha in 2016-2017 (Sharma and Patel 2017), is quite below the world average of around 2,760 kg/ha in 2016 (Terzic et al. 2018). The average yield of soybean in the study area was better than the Madhya Pradesh state and also the country's average. The increase in soybean yield during the past decade is due to introduction of improved varieties, which has also reduced the cultivation period from 110-130 days to 80-90 days. However, the improved hybrid varieties of soybean require more water.

The impacts of drought varied across the seasons. Ninety percent farmers informed that they faced drought related problems mainly during the summer season. This may be due to the fact that increasing temperature during summer dried up the water sources. The present study reveals that though there was no significant correlation between rainfall and crop yields, there was a moderate positive correlation between maize yield and rainfall, and temperature and soybean yield. These results are in close agreement with the findings of Kumar et al. (2008). *Rabi* crops were negatively correlated with rainfall and temperature. Revadekar and Preethi (2012) found significant positive correlations between rainy days and *kharif* food grain yield over large parts of India.

The availability of an irrigation facility and the amount of land holdings of farmers also determine the drought impacts (Pangapangaa et al. 2012). The variability in rainfall affects different water sources in different ways, and therefore the diversification of water sources may help to mitigate the vulnerability to drought (Knutson et al. 2011). Big farmers can reduce the vulnerability from drought by cultivating diverse crops and vegetables and also by introducing hybrid seeds and efficient irrigation facility (Gandure et al. 2013). In the present study area, the small and marginal farmers were impacted more than the big farmers, as the big farmers had resources and economic support to deal with adversity of drought. Similar observations are reported by Asha Latha (2012). However, irrespective of big or small, the farmers in rainfed areas were affected more from drought than the farmers of irrigated areas. Since the drought impacted the fodder and water for livestock, it subsequently impacts the milk production, which is more prominent in the rainfed areas than the irrigated areas. Overall, the drought adversely impacts the crop production and also the farmers' income from agricultural produce and livestock.

CONCLUSION

Frequent and prolonged droughts affect the environment, economy, and society across the climatic zones in India. In a given area, the patterns in rainfall and temperature do indicate the severity of drought, which subsequently affect the farmer communities. In the present study area, the majority of farmers, irrespective of irrigated and rainfed villages, have experienced poor rainfall and increase in temperature in the recent decade. Such changes in temperature and rainfall have affected crop yield as well as the availability of fodder for livestock in the pasturelands. Irrespective of whether they are irrigated or rainfed, the villages suffered from crop losses during the drought period. Some crops like soybean showed high fluctuations in yield and decline of more than seventy-eight percent during drought period, which subsequently leads to decline in a farmer's income. Overall, the adverse impacts of drought on farming in rainfed areas were high as compared to the irrigated areas. In the rainfed areas, farmers cultivated less number of crops due to scarcity of water in all seasons except rainy season. In order to mitigate the adverse impacts of drought, there is a need to provide irrigation facilities to the farmers and managing the available water resources judiciously.

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