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Risk and vulnerability due to climate change and adaptation initiatives for agricultural resilience in Panna district of Madhya Pradesh, central India

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Abstract

Present study assessed farmersô perception on risk and vulnerability due to climate change and adaptive initiations to achieve resilience in agriculture by conducting survey of ten selected villages in Panna district of Bundelkhand region in the year 2011. The findings revealed that the farmers had clear cut perception of changing climatic scenarios and realized wide scale impact on agriculture and allied activities. The deviation in weather pattern, monsoon rain, wind and dust storm, and increase in unusual weather extremes has put agricultural production system at risk. Change in phenology of crops manifested by deviation in flowering time and intensity, fruit-bearing pattern, shape, size and quality of grain clearly indicated risk to biodiversity. Similarly, livestock productivity was perceived to be at risk due to change in weather and climate. The farmers of study area have taken some adaptation initiatives for minimizing risk in farming activities, livestock production and coping with extreme weather events. Modification in sowing time of crops and cropping sequence and adoption of agroforestry land use by planting trees on field boundaries and home-yard were main adaptation strategies to achieve resilience in agriculture.

Keywords: Climatic risk, Farmersô perception, Livestock and biodiversity, Local innovation, Traditional knowledge, Weather extreme

Introduction

Climate change has been recognized globally as a most pressing critical issue affecting mankind survival in the 21st century. It is now a proven fact that the global climate is changing and measures for its mitigation and adaptation are essential to face the new challenges (Prasad *et al.,* 2011). Agriculture is likely to be hit most as change in extreme weather events, inter annual variability and mean climate parameters will negatively affect crop and animal yields, and resilience of agro ecosystems. The most obvious manifestation of climate change is global warming. The mean global annual temperature increased between 0.4 to 0.7^{0}C (Singh, 2008).

Arid and semi-arid areas are considered more vulnerable to climate change due to their dependence on climate sensitive sectors such as agriculture, fisheries, forestry and water. Bundelkhand is a semi-arid, socio-economically backward region in central India spreading over the states of Uttar Pradesh and Madhya Pradesh. The people in the region are extremely vulnerable to climate change due to their dependence on subsistence agriculture and livestock. The realization and understanding of climatic change and its likely impact are pre-requisite to take appropriate initiatives for adaptation. Local communities have been coping with environmental change since millennia and most often have considerable knowledge about environmental change and means to cope up with its consequences (Salick and Byg, 2007). Such knowledge can propel scientific inquiry and at the same time help design mitigation and adaptation measures. Thus, documentation of local knowledge about climate change is gaining popularity. In Bundelkhand, there is scarce documentation about traditional knowledge concerning the impact of climate change on agriculture related activities and biodiversity, and local innovative adaptations for climate resilience. Thus, the present study was undertaken to assess farmersô perception about changes in climate, its potential impact on ecosystems, biodiversity, agriculture and livelihoods, and innovative adaptations strategies at local level in Panna district of Bundelkhand region of Madhya Pradesh.

Materials and Methods

Study area and environmental setting

The present study was conducted in Panna district of Bundelkhand region of Madhya Pradesh. Bundelkhand is located between 23^0 20ôand 26^0 20ôN latitude and 78^0 20ô and 81^0 40ô E longitude. Administratively the region

comprises of thirteen districts - seven districts of Uttar Pradesh *viz.,* Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda, Chitrakut and six districts of Madhya Pradesh *viz.,* Datia, Tikamgarh, Chattarpur, Damoh, Sagar and Panna. It is predominantly an agrarian economy; over 80% of population is dependent on agriculture, livestock, usufructs from forest and outsourcing income by seasonal migration after *Rabi* sowing. Lack of investments, assured irrigation and other infrastructures, improved agro-technologies and marketing make it most backward region. The region in Uttar Pradesh and Madhya Pradesh is characterized by hard rocks and undulating terrain of varied slope (Samra, 2008).

The district Panna is located in north-eastern part of Madhya Pradesh with its head quarter at Panna city/town. The total geographical area is 702924 ha out of which 59535 ha is arable land, and 299647 ha is forest. Administratively it is divided into five tehsils *viz.* Ajaygarh, Panna, Gunar, Pawai and Shahgarh. The main crops grown in Panna district include paddy *(Oryza sativa*), wheat *(Triticum astivum),* chick pea *(Cicer arietinum), groundnut* (*Arachis hypogea*), sorghum *(Sorghum bicolor*), pearl millet *(Pennisetum glaucum),* pigeonpea *(Cajanus cajan,* sugarcane *(Saccharum officinarum*), green gram *(Vigna radiata*), barley (*Hordeum vulgare*), lentil (*Lens esculenta*), soybean *(Glycine max),* black gram *(Vigna mumgo)* and mustard *(Brassica species).* The most common fruit plants included ber (*Zizyphus mauritiana*), mango (*Mangifera indica*), guava (*Psidium guajava*), aonla (*Emblica officinalis*) and katahal (*Atrocarpus heterophyllus*). Among tree species neem (*Azadirachta indica*), mahua (*Madhuca indica*), shisham (*Dalbergia sissoo*), koha (*Terminalia arjuna)* and teak *(Tectona grandis)* were more common. Panna received 44 and 54% less rainfall than the normal during 2006-07 & 2007-08, respectively (Samra, 2008).

Data collection and compilation

For survey and collection of data, descriptive survey research design was utilized. One district- Panna, representing Bundelkhand region, was purposively selected for the study. From the selected district two tehsils *viz* Panna and Ajaygarh, and from each tehsil, five villages were selected considering potential impact of climate change in the area. Thus, total ten villages were studied. The sample respondents were drawn from older persons (>50 years old). General information on number of households and livestock population of selected villages is given in Table 1. Door-to-door survey was done through personal interview (N = 50) with help of a well structured schedule. Besides, in all villages two or three focused group consisting of at least five elderly farmers were interviewed to refine the perception on climate change and adaptation strategies. Data were collected on farming status and its history, past memory of extreme climate events and their impact, and management responses to those adverse situations, present-day scenario and likely future consequences. In focused group discussion, other farmers were also allowed to participate and involve freely for refinement of information recorded on interview schedule. All the refined information was compiled/ analyzed and results interpreted for conclusion.

Results and Discussion

Perceived risk due to climate change and its impact

Perceived risk and vulnerability indicators of weather pattern: All respondents had perceived change in rainfall pattern (Table 2). In comparison to past, 68% respondents believed that now onset of monsoon is delayed. On withdrawal, majority (84%) agreed for early withdrawal of monsoon rains. Reduction in number of rainy days was perceived by 44% respondents. All the respondents had perceived increase in drought and 64% opined consecutive drought for 3-4 years. Regarding change in pattern of winter rain, the respondents were divided and 60% perceived that rain in winter has reduced. The farmers of the study area have also perceived changes in wind pattern and majority of respondents (44%) felt shift in pattern of winds. Rise in summer temperature was opined by 96% of respondents while all of them felt that events of weather extremes- summer or cold were increasing. Majority of respondents (76%) believed that dust storms in summer have increased.

Delayed onset and early withdrawal of monsoon rains, decrease in number of rainy days, increase in dust storm and droughts, temperature and extreme weather events in summer as well as in winter have multitude of impacts on livelihood and biodiversity of the region. The deficit in rainfall during 2007 and 2008 in Panna district reported by Samra (2008) and consequential drought were clearly reflected in farmersô response. In a similar study conducted in Kanchanjhunga Himalayas, for assessing farmersô perceptions about climate and weather change, Chaudhary *et al.* (2011) reported that overall temperature is increasing with a multitude of impacts on weather and precipitation, snowfall and retreat, and water availability. Similarly, Dhaka *et al.* (2010) reported that most farmers perceived a shift in temperature distribution and its overall increase in Bundi district of Rajasthan.

Table 1. Socio-economic status of households and livestock population in selected villages of Panna district in Bundelkhand

Village	Distribution of households				Distribution of livestock population			
	Total	SC	ST	BPL	Total	Cows	Buffaloes	Sheep/Goat
Sunehara	242	22	103	212	1213	610	302	301
Rajapur	314	74	80	267	1981	1398	342	241
Purushottampur	241	16	36	74	648	382	124	142
Janakpur	437	106	20	88	1071	687	218	166
Hardua	205	18	81	90	719	445	236	38
Ramnai	286	70	-	140	673	374	244	55
Jigni	387	70	-	197	781	480	256	45
Chandaura	231	30	-	156	1027	442	521	64
Kharoni	251	75	5	187	780	361	379	40
Rajpur	326	92	18	290	1044	510	374	160

SC: Scheduled Caste; **ST:** Scheduled Tribe; **BPL:** Below Poverty Line

Table 2. Distribution of respondents according to perceived risk in weather pattern

Indicator of perceived risk/ impact	% of respondents	Explanation on risk-impact
Delay in onset of monsoon rain	68	Sowing of Kharif crops is affected. Choice of crop become limited
Early withdrawal of monsoon rain	84	Yield is reduced as crops suffer with water stress at maturity
Reduction in number of rainy days	44	Crop will not get sufficient growing period, hence reduced yield
Increase in intermittent dry spell	44	Crop growth is affected and dry up before reaching at maturity
More consecutive droughts	64	Consecutive drought for 3-4 years forces locals to migrate in search of livelihood
Reduction in winter rain	60	Severely affect yield in rainfed areas
Changes in seasonal wind speed and its direction	44	Badly affects crop germination and maturity
Increase in temperature	96	Summer become unbearable
Increase in weather extremes (summer/ winter)	100	Extreme weather events increase disease s and affect crop badly
Increase in dust storm in summer	76	Growth and yield of summer vegetable is affected

Perceived risk and vulnerability indicators of phenological behavior of plants: A large section of respondents (68%) perceived deviation from normal time in flowering initiation (Table 3). The deviation in flowering initiation whether early or late is bound to impact yield as it is a cumulative effect of flowering intensity and flower drop. Change in flowersô shape and size was perceived by 32% of farmers while 72% favoured changes in smell of the flowers. There was a general perception among respondents (60%) that the fruit bearing patterns has been changing. The deviation in fruit size, shape and taste is perceived by 92% respondents. Farmers feel that taste of fruits has altered and gone bad.

In respect of maturity duration of crops, 72% respondents perceived deviation from the normal time whether delay or early. The keeping quality of fruits and vegetables is undergoing a shift as perceived by majority (64%) of the farmers. Majority of respondents have perceived changes in grain quality of cereals, pulses and oil seeds. Reduction in grain size of wheat and mustard was perceived by 72% of respondents while 12% felt that oil content in mustard was declining. Farmers in study area perceived shift in sowing and harvesting time of crops. The majority of respondents (80%) perceived delayed sowing and early harvesting. Farmers perceived that germination time of crops is getting altered and majority (64%) felt that germination was poor. The general perception of farmers in studied area is that the productivity of crops, fruits and vegetable is decreasing. The decrease in yield of wheat and rice is perceived by 92% while in tomato by 8% of respondents.

Table 3. Perception of farmersôabout impact of climate change on phenological behavior of crops

Indicator of perceived risk/ impact	% of respondents	Explanation on risk-impact
Deviation in flowering time	68	Flowering in guava is heavy but fruit set is minimum due to flower drop
Change in flower shape/size	32	Due to change in flowerôs shape and size insect pollination is affected hence, fruit set is reduced
Change in flower smell	72	Earlier smell (fragrance) of mustard flower was very intense but now-days it became very light
Deviation in fruit bearing	60	In summer early and in winter late bearing.
Deviation in fruit shape/size/taste	92	Mango, guava and ber became less sweet. The taste of jamun is changed and now it causes more dryness in throat
Deviation in maturity duration of crop	72	Wheat and chick pea mature early due to increase in temperature and water stress
Change in keeping quality of fruit/vegetables	64	Easily decay of tomato and pea within 6 to 8 days, less decay of potato and onion
Reduction in grain size	72	Grain size of wheat and mustard reduced. The grain of wheat shrinks
Reduction in oil content	12	Reduction of oil content in mustard
Change in sowing or harvesting time of crop	80	Late sowing & late harvesting of paddy due to rainfall variation
Change in germination time of crop	64	Poor germination
Reduction in food grain productivity	92	Production of wheat, rice is declining
Reduction in vegetable productivity	8	Production of tomato is declining

According to respondents the changes which have already occurred include increase in fruit drop in guava, decrease in size and taste of mango, jamun and other fruits, reduction in oil content and fragrance in mustard flower, early harvesting of wheat and chickpea, shrinkage and reduction in grain size of wheat etc. Decline in productivity of all crops was unanimously felt by villagers. Our findings on phenological behavior of plants corroborates with findings of Moza and Bhatnagar (2005).

Perceived risk and vulnerability indicators of biodiversity: All the farmers perceive a shift in crops/grass composition of the area. Out of total, 48% respondents felt that the grasses like *munja, sewai, hathi and anjan* are disappearing from the studied area. Similarly, 52% farmers perceived that some crops like soybean sunhemp, pearl millet, small millets are disappearing. Appearance of new grass/ crops was perceived by majority (96%) of respondents. Further, majority of respondent perceived that climatic change had no impact on growth behavior of plants; however, 16% perceived that growth has become slow. All the respondents had a general perception that wildlife of the area was getting affected and perceived a clear shift in composition of wild animals /birds etc. Disappearance of birds like cheel, vulture, crow and peacock from the region was perceived by 56% of respondents while 68% believed disappearance of wild animals like jackal, hyena, fox and tiger. Appearance of new unknown bird was perceived by 4% respondents, whereas, another 4% perceived appearance of new animals like blue bull.

The perception of farmers indicated that the grasses like *munja, anjan, sewai*, and *hathi* grass are losing grounds and being replaced by *himani, gajar ghas*, *motha* and others. Similarly, cultivation of crops such as soybean, maize, pearl millet, small millets (kakkun, kodon) and sugarcane are put on back benches and new crops like ground nut, paddy, pigeon pea, green gram *etc* are being preferred. Our findings are in conformity of Joshi and Joshi (2011) who reported appearance of alien grass species and shift in cultivated crops in rain dependent areas of middle Himalaya.

Table 4. Adaptation strategies of farmers against climate change

Vulnerability / risk factor	Adaptation strategies	% of respondents	Remark
Hot weather	Indigenous methods	64	Using thatched /kachha houses, bamboo-made hand fan, tree shade, *etc*
	Use of modern fan and coolers	32	Some farmers have access to such facilities
Cold weather	Woolen cloth and lighting fire	68	The fuel wood from Babool and Shisham is used
	Jute blanket made of old bags	32	For protection of animals
Minimizing risk in crop production	Changing sowing time	80	Sowing of paddy depends on rain
	Changing cropping sequence	20	If rain is delayed then crop like sesame is grown
Minimizing farming risk	Planting trees on field boundary	76	Preference is given to fruit trees like mango and guava
	Planting trees as block plantation	24	

***Perceived risk and vulnerability indicators of livestock*:** Majority of respondents (44%) perceived increase in stall feedings, age at 1st calving (88%) and demand of veterinary doctor due to complications at the time of calving (32%). In absence of veterinary help, calves die hence increasing calf death rate is perceived by 24% respondents. Earlier *desi breed* heifers used to come at 1st calving in 3 years, but now it is taking more than 3 years. The general perception of farmers was reduction in milk production. In comparison to earlier time now the cattle are to be more stall fed. The changing trends in livestock rearing in the form of more stall feeding due to lack of grazing lands has also been reported by Maharjan *et al.* (2011). The reduction in milk production as an impact of climatic alteration has also been observed by Joshi and Joshi (2011) in middle Himalaya and Sarkar and Padaria (2010) in coastal ecosystem of West Bengal.

Adaptation strategies for resilience in agriculture

For different climatic adversities, farmers have evolved their own adaptation mechanism based on generations experience (Table 4). For protection from hot weather, 64% farmers used indigenous methods such as thatched or Kachha houses, bamboo made hand fan, tree shelter and keeping themselves confined inside house during extreme hot summer. A sizable section of respondents have access to modern facilities such as electric fans and coolers for coping with hot summer. Most of the respondent (68%) used woolen clothes and fire to keep their bodies warm during winter and extreme cold weather. Fuel wood of babul and shisham was obtained from trees planted on farmland. For protecting animals from cold, 32% respondents used jute blanket made-up of old /used gunny bags (bardana).

To minimize risk in crop production, majority (80%) of respondents favoured change in sowing time of different crops. Most of the summer crops were sown on arrival of monsoon and a sizeable section (20%) of respondents has changed cropping sequence to cope up with the climate change. All the farmers believed that adoption of agroforestry land use is best remedy for minimizing farming risk in changing climatic scenario. Planting trees on field boundary has been adopted by 76% of respondents while 24% have planted trees as block plantation. In agroforestry plantations, fruit bearing trees such as mango guava, aonla and ber are given preference. In addition, many farmers have planted fruit bearing plants in their home-yard/ back-yard where protection from stray animals and irrigation are ensured. These agroforestry systems based on trees and fruit plants provide fuel, fodder, timber and nutritional security and thus, the resilience against climate change to rural people.

The adaptation initiatives in different sectors like minimizing risk in farming activities, livestock production and coping with extreme weather events shows that farmers at local levels are well aware of risk of climate change. Modification in sowing time of crops and cropping sequence according to monsoon rain, and adoption of agroforestry land use by planting trees on field boundaries and home-yard are the main adaptation initiatives. These adaptation strategies have also reportedly been adopted by local people in middle Himalaya and coastal region of West Bengal (Joshi and Joshi, 2011; Sarkar and Padaria, 2010). Adoption of agroforestry land use is well defined for arid and semi arid regions such as Bundelkhand as trees not only provide shelter to human and livestock but, also minimize wind borne hazards (Prasad *et al.,* 2009;

Prasad and Mertia, 2009). Further, agroforestry helps in providing livelihood and environmental security due to various tangible and intangible benefits (Prasad and Dhyani, 2010).

Conclusion

Conclusively, it can be said that the local communities in Bundelkhand seems to have extensive knowledge and clear cut perception about climate change and its impacts on agriculture, animal husbandry and biodiversity. Delayed onset and early withdrawal of monsoon rains, decrease in number of rainy days, increase in dust storm and droughts, temperature and extreme weather events in summer as well as in winter have multitude of impact on livelihood and biodiversity of the region. Modification in sowing time of crops and cropping sequence according to monsoon rain, and adoption of agroforestry land use by planting trees on field boundaries and home yard are the main adaptation strategies in study area.

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