

Climate change : Perceived risk in agriculture and innovative adaptations at local level in Bundelkhand region of Madhya Pradesh

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ABSTRACT: Survey of 10 selected villages in Panna district of Bundelkhand region was conducted to assess perceived impact of climate change and farmers' adaptive initiations. The findings revealed that the farmers at local level had realized wide scale impact of climate change on agriculture and related activities. Deviation in weather pattern, occurrence of monsoon rain, wind and dust storm, and increase in unusual weather extremes put agricultural production system at risk. Change in phenology of crops manifested by deviation in flowering time & intensity, fruit-bearing pattern, and shape, size and quality of grain clearly indicated risk to biodiversity. Drawing from their traditional wisdom, farmers at local level had taken adaptation initiatives for minimizing risk in farming activities. 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 were the main adaptation strategies.

Key words: Biodiversity, Impact assessment, Local innovation, Risk perception, Weather extremes.

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1. INTRODUCTION

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 and other natural resources as well as limited capacities to anticipate and effectively respond to climate change. 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). Bundelkhand is a typical example of a semi-arid region. It is a 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 climate and its change is pre-requisite to take appropriate initiatives to counter climate change. 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). The documentation of local knowledge about climate change is essential as it can propel scientific inquiry and help in designing the mitigation and adaptation measures. Thus, the present study was undertaken to assess farmers' perception about changes in climate, its potential impact on agriculture and innovative adaptations strategies at local level in Panna district of Bundelkhand region of Madhya Pradesh.

2. MATERIALS AND METHODS

The present study was conducted in Panna district of Bundelkhand region of Madhya Pradesh. Administratively, bundelkhand comprises of thirteen districts - seven districts of Uttar Pradesh viz., Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and 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, undulating terrain of varied slope (Samra, 2008). About 21.4 % of geographical area of Bundelkhand is under forest and scrubs. About 50% of geographical area is cultivated and rest is under various other land uses. Agriculture is mostly rainfed. As compared to Uttar Pradesh (51%) relatively lesser percentage (43%) of the geographical area of Madhya Pradesh is under cultivation. Bovine and small ruminants rearing are an integral part of agricultural production system in Bundelkhand and contribute significantly to the livelihood of the farmers especially women headed, landless and small farmers. Livestock sector in this area is characterized by high population of unproductive cattle. The traditional practice of *annapratha* in Bundelkhand region, wherein cattle are let loose for free grazing particularly during kharif season has been causing considerable problem in production of kharif crop.

Among the domestic animals cattle, buffalo, goat and sheep are the dominant. The district Panna is located in north-eastern part of Madhya Pradesh with its head quarter at Panna city/town. Panna is known as diamond city of India. 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.

For survey and collection of data, Panna district representing bundelkhand region was purposively selected and descriptive survey research design was used. From the selected district two tehsils viz Panna and Ajaygarh, and from each tehsil five villages thus making total ten villages, were selected for survey. The sample respondents were drawn from selected ten villages randomly. Door-to-door survey was done through personal interview with individual households (N = 50) covering various age groups and gender mixes, with emphasis on older persons. The respondents were interviewed with help of a well structured interview schedule. Besides, in all these villages 2 or 3 focused group consisting of at least five elderly farmers were interviewed to analyze and refine the perception of climate change and the adaptation strategies adopted by the farmers to cope up with

these changes. All the refined information was compiled/ analyzed and results interpreted for conclusion.

3. RESULTS AND DISCUSSION

3.1 Perceived risk and challenges

The results on perceived risk due to change in rainfall, temperature, winds etc. are presented in Table 1. All respondents have perceived change in rainfall pattern. Majority (68%) of respondent believed that now onset of monsoon is delayed. On withdrawal, majority (84%) of respondents agreed for early withdrawal. Reduction in number of rainy days was perceived by 44% respondents. All the respondents 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 are increasing. Majority of respondents (76%) believed that dust storms in summer have increased.

Table 1. Distribution of respondents according to perceived risk and challenges of climate change

Perceived risk / Challenge	% of total respondents	Explanation on risk and impact
Delay in onset of monsoon rain	68	Sowing of <i>kharif</i> crops is affected. Limited choice of crop
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

Delayed onset and early withdrawal of monsoonal 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 bio diversity of the region. In a similar study conducted in Kangchenjunga Himalayas, for

assessing farmers' 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. Ecological knowledge in relation to climate held by the indigenous people has also been documented from other parts of the world, mainly North America and Europe. These studies have looked at "native oral tradition" or indigenous knowledge to assess changes in local climate.

The farmers of the study area also perceived impact of changing climate on phenological behavior of crops /grasses and trees (Table 2). A large section of respondents (68%) perceived deviation from normal time in flowering initiation. The deviation in flowering initiation whether early or late bound to impact yields as it is a cumulative effect of flowering intensity and flower drop. There was a general perception about the change in flower's shape , size and smell in study area. Change in flowers' shape and size was perceived by 32% of farmers while 72% favored 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 was perceived by 92%

respondents. Farmers feel that taste of fruits have altered from good to bad. In respect to maturity duration of crops, 72% of respondents perceived deviation from the normal time. The keeping quality of fruits and vegetables was 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. General perception of farmers in studied area was 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 2. Distribution of respondents according to perceived impact of climate change on phenological behavior of crops

Perceived risk in Phenology	% of total respondents	Explanation on risk and impact
Deviation in flowering time	68	Flowering in guava was heavy but minimum fruit set
Change in flower shape/size	32	Due to change in flower's shape and size insect pollination gets affected hence, fruit set was 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 pattern	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 has changed and now it gives 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 decaying of tomato and pea (within 6 to 8 days)
Reduction in grain size	72	Grain size of wheat and mustard reduced .The grain of wheat shrink
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 and prolonged time
Reduction in food grain productivity	92	Production of wheat and rice is declining
Reduction in vegetable productivity	8	Production of tomato is declining

Deviation in flowering time, flower intensity, shape, size and smell of flower, fruit bearing pattern, shape, size, and taste of fruits, change in maturity time, quality of grain, sowing and harvesting time, and

yield are the key indicators reflecting impact of unusual weather and climate. Our findings on phenological behavior of plants corroborates with findings of Moza and Bhatnagar (2005) who

suggested changes in plant phenology (like advancement of flowering in *Rhododendron arboreum*) and movement of species (like *Tagetis minuta*, *Lantana camara* and *Eupatorium* spp.) to higher ridges may be the earliest responses to modest climate change in Himalayan region. Another study by Joshi and Joshi, (2011) reported that flowering in *Rhododendron* (*R. arboreum*) occurred 1–2 months earlier (January–February instead of March–April) and the size of the flower reduced from about 7–8 inches to 4–5 inches. Early ripening of berries in the Kaphal tree (*Myrica sapinda*, *Myrica nagi*), from May–June to March–April also reflected the phenological changes in tree species of Himalayan region.

Impact of climate change on livestock of the study area was also perceived by the farmers. It was revealed that a steady shift in feeding habit of domestic animals, 1st calving age of heifers, veterinary complications and death of new born calves were taking place. 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 was perceived by 24% of respondents. The general perception of farmers was reduction in milk production. In general, farmers perceived that livestock production system was at risk due to changing weather and climate. In comparison to earlier time now the cattle were to be more stall fed, which indicate that both grazing lands and the quality of fodder/ browse have decreased. The poor quality fodder is manifested in poor health of animals which, consequently increased age of heifers to reach at 1st calving. Further, poor health also invites more complications in calving process resulting in more deaths of newly borne calves. The ultimate result was decrease in milk production. 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). They reported decrease in livestock number, outbreak of new disease and decrease in grazing land in Nepal. 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

3.2. Local innovative adaptation strategies

For different climatic challenges, farmers have evolved their own adaptation mechanism based on their generation's experience (Table 3). 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 had 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. For lighting fire, fuelwood of babool and shisham was obtained from trees planted on farmland. For protecting animals from cold, 32% respondents used jute blanket made-up of old gunny bags (bardana).

To minimize risk in crop production, majority (80%) of respondents favored change in sowing time of different crops. Most of summer crops were sown on arrival of monsoon. A sizeable section (20%) of respondents had changed the cropping sequence to cope up with the climate change. All the farmers believed that adoption of agroforestry land use was the best remedy for minimizing farming risk in changing climatic scenario. Planting trees on field boundary has been adopted by 76% of respondents while, 24% had planted trees as block plantation. In agroforestry plantations, fruit bearing trees such as mango, guava, aonla and ber were given preference. Besides, many farmers have planted fruit bearing plants in their home-yard/ back-yard where, protection from stray animals and irrigation were ensured. These agroforestry systems based on trees and fruit plants provided fuel, fodder, timber and nutritional security and thus, the resilience against climate change to rural people. The nutritional security provided by fruit plant based agroforestry gains paramount importance as most often villagers do not purchase and consume fruits from market due to economic constraints.

The farming communities of the study area appears to be custodian for evolving innovative climate resilient management practices and use of natural resources with their traditional skills and local knowledge. Farmers adapted some initiations, which can be seen in different sectors like minimizing risk in farming activities, livestock production and cope up extreme weather events. 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 were 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 Bundelkand 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, Prasad *et al.*, 2010).

Table 3. Innovative local adaptations to minimize risk of climate change

Vulnerability / risk factor	Adaptation strategies	% of total respondents	Remark
Hot weather	Indigenous methods	68	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 was 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	

4. CONCLUSION

Based on the findings of present study it can conclusively be said that the local communities in the Panna district of Bundelkhand region appears to have extensive knowledge and clear cut perception about climate change and its impact 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. Deviation in flowering time, flower intensity, shape, size and smell of flower, fruit bearing pattern, and shape, size, and taste of fruits have been observed. In crops, change in maturity time, quality of grain, sowing and harvesting time, and yield are indicated. The livestock production system appears to be at risk due to changing weather and climate. Based on their own knowledge and skills, farmers in study site have taken some adaptation initiatives for minimizing risk in farming activities, live stock production and coping up extreme weather events.

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