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Assessment of household perceptions to climate adaptation for resilient rural development planning in India

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Enhancing resilience of rural communities to climate change requires a clear understanding of micro-level perceptions and adaptation issues and their integration with the rural developmental framework. We collected household level data to understand grass-root perspectives on climate variability, impacts and barriers to adaptation in two different districts; Moga, Punjab and Mahbubnagar, Telangana. Further the study uses meteorological data to validate farmers perceptions. The results show that change in the quantum and distribution of rainfall, rising temperature, ground water depletion, lower farm income, higher unemployment and rural migration are some of the major impacts of climate change. Moreover, farmers perceptions on climate variability were consistent with the observed climate trend. Against climatic variations farmers were making shift to crop varieties of suitable duration, curtailing expenditure, borrowing and participating in employment guarantee schemes. However, farmers responses were constrained by barriers like lack of accessibility to weather information, limited knowledge on the cost-benefit of adaptation, inaccessibility to climate smart technologies, inadequate financial resources and unawareness on welfare schemes. The study concludes there is a need to reorient the developmental programmes at the macro-level considering micro-level needs and constraints for climate resilient agriculture.

Keywords: Adaptation, Climate change, Development, Farmer, Perception

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Changing contours of climatic conditions are posing serious threat to the farm livelihood and adaptation to climate change is imperative to minimize vulnerability in short to medium run[1-3]. Changes in temperature and rainfall not only influence crop yield, but also produces large scale socio-economic impacts which aggravates poverty and inequality in the region[4-6]. Several studies have elaborated that adaptation to climate change is not a one-size fit all approach as it is driven by the potential climate impacts, agro-climatic and socio-economic factors, a wide range of risk coping strategies to limit the losses and vulnerability from climate perturbations, which are largely based on farmers experiential knowledge. In India climatic variability adds an additional burden to 85% of small and marginal land holdings who are already hapless with insufficient financial and technical resources[10-11]. This substantiates the need to integrate climate responses within the broader framework of long-run sustainable development, focusing impacts and constraints to adaptation. The approach aims to create an enabling environment to increase the capacity of an ecosystem to external shocks. However, assessment of grass-root perceptive to climate change and obstacles to adaptation provides useful information to design policies for managing a variety of risks associated with climate change in agriculture[12-15]. The present study attempts to examine farmers perceptions on the impacts of climate variability; risk coping mechanisms and barriers for adopting adaptation strategies in Mahbubnagar district of Telangana and Moga district [illegible]dy verifies farmers perceptions with the meteorological data. Such an understanding of needs and constraints will help in designing region based plans and locally tailored strategies for reinforcing resilience to climate change.

Materials and methods

Study area

This study conducted a household survey to assess farmers perceptions of climate variability, measures adopted to cope up against climate change and barriers that prevents upscaling of adaptation strategies in two different districts; Moga, located in

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north-western state of Punjab and Mahbubnagar situated in southern state of Telangana. Moga covers a geographical area of 2,242 sq. km. with 77% of its population residing in rural areas which are predominately engaged in agricultural activities for their livelihoods. The district experiences tropical and dry sub-humid climate conditions with mean maximum temperature of 40°C and mean minimum of about 5°C. Moga receives a normal annual rainfall of 498 mm of which 78% occurs during the south-west monsoon[16]. As a major rice producing area, Moga is heavily extracting groundwater for irrigation, which is exceeding the sustainable level of groundwater supply and is likely to produce serious consequences for the farming community[17]. On the other hand, Mahbubnagar with an area of 18, 432 sq. km. is the largest district in Telangana. The district has a tropical climate with mean temperature varying from 25°C to 40.9°C and average annual rainfall of 692 mm. The region is characterized by recurrence of droughts and severe groundwater depletion[18]. Moreover, Mahbubnagar is regarded as the most backward region in the state due to large proportion of the population (85%) living in rural areas, higher incidence of poverty and low agriculture productivity.

Methods

The study is based on both primary and secondary level database. Multi-stage sampling was used for selecting the sample households. In the first stage, Mahbubnagar district in Telangana and Moga district in Punjab were purposely selected. Next, two blocks from each district and two villages from each block were selected. Finally, simple random sampling technique was used in selecting 20 respondents from each of the villages. Thus a total sample of 160 farmers with different social-economic and demographic attributes was selected for the study (Table 1). The average age and farming experience in the study areas were nearly 47 years and 22 years respectively. More than 40% of the farmers had primary education, 30% with secondary education and 20% of the respondents were qualified up to higher secondary or above. Compositions of the sample signify an educated and experienced group of farmers, who were able to understand the dynamics of changing climatic conditions and can make significant modification in farming practices and decisions. Further, informal interviews with the farmers and focused group discussions (FGDs) with 15-20 stakeholders were organized in the selected villages to extract micro-level information in more detail and depth. During the grass-root enquiry farmers were asked open-ended questions relating to the changes perceived in the weather parameters and the recurrence of extreme weather events (droughts and floods), changes in crop production system, the socio-economic impacts, risk coping strategies/mechanism adopted and various barriers faced in adaptation to climate change. The information collected was later quantified using frequency tables.

Further, farmers perceptions on climate change were compared with climatic data (monthly series on rainfall (from 1981-2014) and temperature (from 1971-2013)) collected from Indian Metrological Department (IMD). For the analyses of annual rainfall variability, Cumulative Departure Index (CDI) was calculated using the following

$$\text{CDI} = \frac{R_{AA} - R_N}{\sigma}$$

where R_{AA} is the actual annual rainfall, aggregated from the monthly series, R_N is the mean annual rainfall and σ is the standard deviation over the entire time interval of the study.

Variation in temperature was analyzed by taking the difference between the actual annual temperature (aggregated from the monthly temperature series) and average annual temperature. Finally trend was analyzed for both the rainfall and temperature series.

Results and discussion

Farmers perceptions of climate change and socio-economic impacts

Understanding farmers perception is a prelude for effective and informed adaptation planning at the farm level[19]. From the FGDs it was ascertained that farmers perceived climate variability than long term

Table 1 — Characteristics of household in the selected districts

Variables	Mahbubnagar, Telangana (N=80)	Moga, Punjab (N=80)
Average family size (persons)	5.20	5.43
Average Age (years)	47.07	47.37
Average agricultural workers	2.03	2.27
Average Farming experience (in years)	22.63	22.40
Average land holdings size (ha)	3.00	4.20
Education (%)		
Primary education	41.25	46.25
Secondary education	36.25	33.75
Higher secondary and above	22.50	20.00

climate change (Table 2). In both the districts, majority of the farmers felt significant variations in the quantum of rainfall and continuous delay in the arrival of monsoon over the years. They believed that rainfall have become more intense over fewer days, leaving rest of the season dry.

Earlier the shower used to begin in the first week of July, but it now starts somewhere in August, affecting kharif sowing. Moreover, there were growing concerns over off-season rains which pose significant damage to the crops. Farmers reported increasing stress on groundwater and increased erraticism in the distribution of rainfall. Increased temperatures and irrigation have resulted in higher level of soil salinity, which is making it difficult to grow/cultivate traditional crops.

Climate related risks are expected to impact livelihoods and socio-economic stability of rural households[20] (Table 3). Farmers expressed lower farm income and profitability with increased climatic variations. Financial hardship due to successive crop failure obligates farm households to sell or mortgage their productive assets for meeting the domestic consumption needs. In addition failure of agriculture results in loss of employment for farming communities in rural and other areas. This along with low level of education and inadequate skill to serve other sectors further adds to their vulnerability. Farmers unanimously agreed that lesser employment opportunities are leading to increased indebtedness and subsequent default in repayment are leading to farmers' suicides. Moreover, farmers opined income stress are forcing villager especially in Mahbubnagar district to migrate to metropolitan cities. There were rising concerns against escalating prices of necessary commodities, education and family health, and erosion of village/ community social support system which were evident from growing water disputes in the region. Farmers also expressed reduction in expenditures on marriage and festivals celebrations due to increased climatic uncertainty and risks.

Farmers perceptions and climate data

The above perceptions of the farmers were in consonance with the observed pattern in the climatic parameters (rainfall and temperature). Fig. 1, shows the Cumulative Departure Index calculated from the

Table 3 — Socio-economic impact of climate change

Socio-economic Impacts	Mahbubnagar, Telangana	Moga, Punjab
Declining farm income and profitability	57	73
Rising level of farm unemployment	54	41
Increasing price of essential food items	77	51
Reduction in domestic consumption	29	13
Land and livestock mortgage	24	5
Increasing incidence of farm indebtedness	57	37
Increasing rural migration	46	9
Reduction in expenditure on festivals/marriages	69	37
Reduction in expenditure on child education	17	13
Rising inter-society water dispute	21	12
Incidence of farmer's suicide	13	5

Table 2 — Farmers perceptions of climate change

Aspects	Responses	Mabubnagar, Telangana	Moga, Punjab
Amount of rainfall	Quantity of rainfall have changed over the years	83	45
Intensity of rainy day	There is decline in the number of rainy days	69	59
Rainfall onset and cessation	Shift in the arrival /onset of monsoon affecting sowing	59	73
Distribution of rainfall	Rainfall distribution has become erratic, with increased variation during early and late monsoon season	29	32
Temperature	Increase in average temperature especially in Moga during winters affecting wheat crops	45	81
Droughts / flood	Increasing frequency of extreme weather events. Frequency of droughts and long dry spells are rising in both the districts.	33	25
Major climate induced problems identified in selected villages	Decline in crop yield and production	79	21
	Declining level of ground water	77	67
	Scarcity in surface water bodies	65	26
	Decline in soil fertility/change in soil salinity	14	6
	Proliferation of pest and disease infestation	54	18
	Changing flowering period of different crops	42	50

monthly rainfall data from 1981 to 2014 with a 3-year moving average, for Moga and Mahbubnagar district. The results indicate significant oscillations in the hydrologic variable. Rainfall was recorded below-average over much of the time interval in both the districts. Infact, in Mahbubnagar 16 and in Moga 21 out of 34 years indicate lower than normal rainfall, but the magnitude of departure was more intense in case of Mahbubnagar. Annual rainfall was below average in three out of five years from 2010 to 2014 in both Mahbubnagar and Moga. The trend in rainfall verified the farmers perception of increasing erraticism in the distribution of rainfall and rising frequency of dry spells/droughts. Fig. 2 shows variation in average annual maximum and minimum temperatures from 1971 to 2013. For Moga, an increasing trend is observed for both the maximum (0.01°C/year) and minimum temperatures (0.022°C/year) which is in line with the farmers perception of rise in the surface temperatures in the district. While in case of Mahbubnagar a clear upward trend is visible in the maximum temperature (0.02°C/year), not much variation is seen in minimum temperature within the study period. This implies an accelerated warming in Mahbubnagar district.

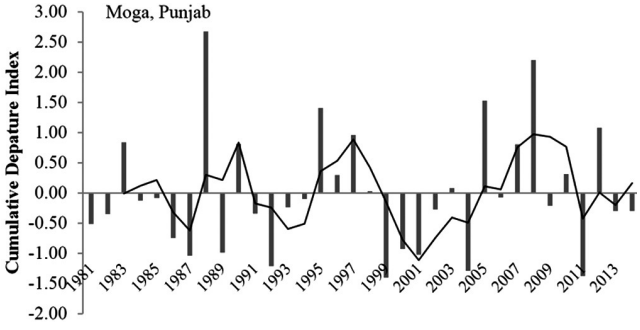

Fig. 1 — Rainfall variations and trend based on Cumulative Departure Index for Moga District, Punjab and Mahbubnagar District, Telangana (1981-2014). Source: Authors own calculation using IMD data, New Delhi

Adaptation strategies to climate change

Against the perceived climatic variations farmers were shifting to drought/pest tolerant, short duration crop varieties and making suitable adjustments in the sowing and harvesting dates (Table 4). However, not many reported on changing farming practices towards mixed cropping/intercropping to reduce crop risk exposure. Slow and gradual shift was observed towards water efficient technologies like sprinklers and drip irrigation in both the districts. Only a few farmers expressed availing crop insurance owing to lack of knowledge and lesser incentive especially

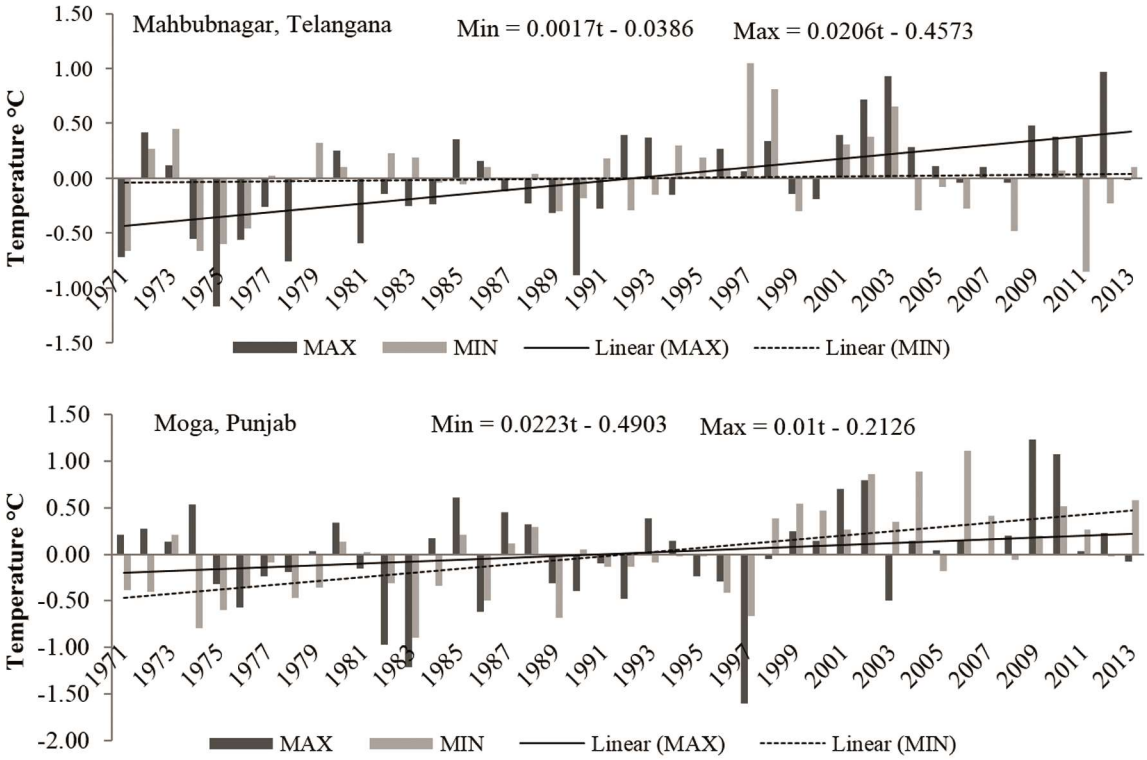

Fig. 2 — Variation and trend in Maximum and Minimum Temperature in Moga and Mabubnagar District (1971-2013) Source: Authors own calculations using IMD data, New Delhi

among small farmers as they have to pay premiums. Large proportion of the respondents in Moga district was rescheduling their loan payment, whereas farmers in Mahbubnagar district resorted to higher borrowing due to lower profitability. To cushion against the increased uncertainty of rainfall and recurrence of extremes, farmers were diversifying to non-farm or off-farm activities such as dairy, small scale manufacturing, transportation, etc. Besides, there was an increasing participation in social protection and employment schemes of the government and transitory migration.

Table 4 — Adaptation strategies at the farm level

Adaptation strategies	Mahbubnagar (Telangana)	Moga (Punjab)
Shift towards improved crop varieties	73	51
Adjustment in sowing and harvesting dates	63	67
Soil and moisture conservation techniques	19	27
Crop diversification and mixed cropping system	26	19
Diversification to non-farm activities	41	27
Use of water harvesting and micro-irrigation	35	30
Liquidation of land and livestock	20	10
Higher financial borrowing	56	29
Delay or Reschedule of loan repayment	23	49
Availing crop insurance products	12	19
Greater participation in social protection schemes	47	21

Constraints to climate adaptation

To minimize risks to climate change, it is pertinent to identify the constraints and interdependence between them. There are large numbers of socio-economic, institutional, technological and financial factors that impede effective implementation of climate adaptation practices (Fig. 3). There was consensus among the farmers that lack of information on shorter-duration crops and drought resilient varieties, inaccessibility to timely weather information, limited access to agricultural extension services and poorly defined property rights were the major deterrents to adaptation across both the regions. Illiteracy, limited knowledge on social costs and benefits of adaptation, high cost of farm inputs and limited access to agricultural markets render adaptation difficult. Farmers voiced that the most urgent need for adaptation to climatic change was to develop and strengthen irrigation facilities. Poor accessibility to formal credit, saving facilities and other financial products has been cited as one of the major constraints to adaptation by the farmers especially from Mahbubnagar district. Inefficient mechanism for continuous evaluation and implementation of policies, leakages and politics of distribution impedes adaptive capacity of rural community. This was evident from the little awareness

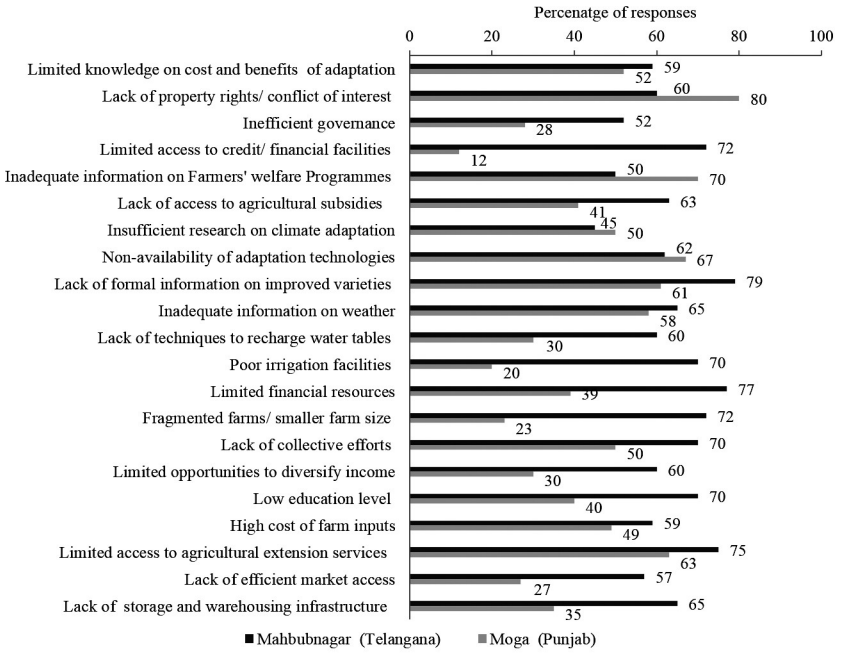

Fig. 3 — Farmers Perceptions on Barriers to Climate Adaptation

and information on various farmer centric welfare initiatives of the government. Further, limited resources, lack of awareness on the need for adapting to the changing climate, uncertainty on the success of climate adaptation strategies/technologies and limited farm size were the other significant constraints as perceived by the farmers especially in Mahbubnagar district.

Strengthening grass-root resilience to climate change: Policy perspective

The ability of the farm households and rural communities to act and survive against the climatic aberrations depends on their existing capacity, which is influenced by the local environment, institutional setup and natural resources management. Climate adaptation planning requires location specificity in interventions which cannot be achieved without understanding grass-root imperatives and engagement of local village communities or their representatives. There is an urgent need to create a repository of micro-level information and blending it with the programmatic interventions relating to agriculture, food security and livelihoods implemented across various departments and ministries of the government. This will not only improve the reliability and acceptability of the top initiatives but more importantly enhance farmers capacity to cope with changing climatic conditions. Policy options or opportunities to incorporate adaptation have been broadly segregated into three categories of *development and promotion of climate adaptation knowledge and technologies, natural resource management and strengthening Institutions*.

Development and promotion of climate adaptation knowledge and technologies

With a view of simultaneously advancing growth and development of Indian agriculture and the objectives of climate adaptation and mitigation the Government of India has launched several over-arching programmes like National Mission for Sustainable Agriculture, National Innovations on Climate Resilient Agriculture (NICRA) and National Adaptation Fund. These programmes have multi-pronged strategy for facilitating climate adaptation at the farm level in the form of infrastructure development, capacity building of local stakeholders and extensive R&D activities for developing suitable crop varieties and technologies. Adoption of innovative and efficient technologies for adaptation at the farm level demands an active extension system which can be achieved by establishing extension agencies, capacity building and information dissemination via electronic and print media. In this context programmes such as National Mission on Agriculture and Extension, Krishi Vigyan Kendra and Krishi Call Center can play a significant role in ensuring access to suitable adaptation technologies.

Natural resource management

Encouraging adoption of *in situ* water harvesting and management technologies, promotion of micro-irrigation (drip and sprinkler) and groundwater recharge techniques, drought proofing and development of infrastructure in PPP mode can help reduce risk associated with variation in rainfall. It is estimated that India uses 2-4 times more water to produce one unit of major crops than other major agricultural countries like China and Brazil[21]. To this effect schemes like *Pradhan Mantri Krishi Sinchayee Yojana*, National Water Mission, National Mission on Sustainable Agriculture and MGNREGA can help to achieve 'per drop more crop' agenda. Schemes like Soil Health Card, National Project on Management of Soil Health and Fertility and *Paramparagat Krishi Vikas Yojana* of the Ministry of Agriculture and Farmers' Welfare are of great significance in ensuring increased application of integrated nutrient management techniques. Degradation of forest area causes ecological imbalances with profound implications for local communities. Expansion in forest and promotion of agro-forestry through schemes like National afforestation programme, intensification of forest management scheme and *Van Bandhu Kalyan Yojana* could be a potential adaptation cum mitigation measure for climate change.

Strengthening institutions

Easy access to formal credit will promote adoption of progressive farming practices, high value inputs and advanced technologies. e-National Agricultural Market can help farmers to diversify their income sources to high value crops by addressing fragmentation of the markets, price anomalies, multiple functionaries chain and information asymmetry. Existence of local off-farm opportunities will ensure smooth consumption pattern for the farm households while ensuring further investment in farm productivity and lesser migration. Rural population often lacks adequate skills and education to serve other non-farm sectors. Mega programmes of the

government of India such MNREGA, National Rural Livelihood Mission and *Pradhan Mantri Kaushal Vikas Yojana* can help strengthen and empower rural folks to diversify their income.

Conclusion

For making agriculture sustainable and resilient to unpredictable weather perils, assessment of household perceptions is prerequisite to understand local needs and concerns and to streamline them within the rural developmental framework. Field survey reveals impacts of climate change and several constraints to adaptation faced by the farm households. Wide varieties of strategies are adopted by the farmers to reduce vulnerability against climate change. However, limited resources and lower capacity to understand the nexus of agriculture-climate-socio-economic repercussion reduce the effectiveness of such mechanisms. It is crucial to address these challenges by facilitating informed planning among farmers which requires improving extension services and access to insurance and financial products. Besides role of multiple actors such as NGOs, private/commercial sector, farmers groups and associations and cooperatives are important in improve accessibility and promoting the costs and benefits of climate adaptation and technologies for sustaining livelihoods. Policy makers must aim at creating adequate income diversification opportunities and also capacitate rural population through skill and education programmes. For making agriculture sustainable and resilient to unpredictable weather perils, the onus falls on policymakers and government (at various levels) to develop adaptation planning and effectively implement it at the grass-root level.

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