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Climate change-oriented risk awareness, knowledge and adaptation strategies in semi-arid region, Agra, India

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ABSTRACT

Knowledge of climate change causes and adaptation practices is crucial for tackling challenges posed by climate change. This study intended to generate information for different stakeholders to understand and facilitate climate change and its related adaptation management in semi-arid region, Agra, India. We collected household-level data from 120 farming households using a well-structured interview schedule, and data were analysed using descriptive statistics. Results showed that the majority of respondents were aware of climate change indicators such as rise in temperature, rainfall, frequency of hot days and cold nights, wind velocity, etc. Less than half of respondents realised that climate change is mainly due to human-beings activities. The majority of respondents reported soil and water conservation (SWC) measures as the most effective adaptation strategy. Similarly, watershed management and change in cropping patterns were reported by 75% of respondents for mitigating effects of climate change. Majority of the respondents had moderate and poor knowledge of climate change causes and adaptation strategies, therefore they have not adopted climate-resilient practices like zero tillage, crop rotation practices and stress-tolerant varieties, etc. For long-term solution to minimise adverse impact of climate change in agriculture, it is essential to have sustainable adaptation strategies in agriculture. This study provides valuable information for different stakeholders in facilitating climate change-related adaptation at the regional level in India.

1. INTRODUCTION

Climate change is likely to adversely affect food security and sustainability of livelihood across the world if appropriate policy measures are not deployed (IPCC, 2007; Ringler *et al.,* 2011). Adverse climate change impacts on livelihood are becoming the main distress, requiring special emphasis on assisting farmers in developing their coping and adaptive capacity (Temidayo, 2011). India is vulnerable to climate change as the country is confronting problems of changing temperature, precipitation patterns and recurrence of extreme natural hazards. Climate change can pose a major threat to agriculture, food and water security, human health and livestock populations (Banerjee, 2015). Rural livelihood to a large extent is dependent on natural resources and any adverse impact on these resources adversely affects the nation's livelihood security and economy. Climate variability can force farmers to alter farming strategies like shifting sowing time, change in cropping pattern, land preparation, duration of cropping seasons, time of harvesting, control and management of insect pests and diseases, and management of natural resources. Agriculture in the semi-arid region is heavily dependent on rainfall, which is dominantly characterized by scanty and uncertain rainfall undulating topography, limiting soil depth, infertile soils, poor infrastructure, extreme poverty and rapid population growth.

Promotion of soil and water conservation (SWC) measures is one of the key climate-proofing strategies to solve problems of water scarcity, land degradation, frequent droughts and desertification and to adapt to adverse impacts of climate change (Lal *et al*., 2011; Kumar *et al*., 2019). SWC measures have significant positive impacts on reducing agriculture production risk. However, the magnitude of effectiveness varies from region to region depending on weather conditions (Kato *et al.*, 2011). Variability in local weather and climate from year to year is a crucial barrier to local people for recognition of human-made climate change

(Hansen *et al*., 2012). Earlier studies reported that the opinion of local people about the existence and impact of climate change depends strongly on their perceptions of recent local climate variations (Manandhar *et al*., 2013). Appropriate policies and actions can be devised by anticipating the type of envisaged changes and understanding how climate change is perceived, experienced and interpreted by local people (Hartter *et al*., 2012). Early public apperception of climate change is critical. Therefore, local people's awareness and knowledge of climate change are essential for developing suitable policies for capacity building of farmers and effective adaptation strategies for sustainable livelihood and food security (Sarkar and Padaria, 2010; Banerjee, 2015). Keeping this in view, a comprehensive study was undertaken to analyse farmers' awareness about climate change, and their knowledge about climate change indicators and adaptation measures to minimise the adverse impact of climate change on agriculture in the semi-arid region, Agra, India.

2. MATERIALS AND METHODS

We selected Agra district purposively because it is one of the highly vulnerable districts to climate change (Fig. 1). Three blocks from Agra district, and one village from each block were selected that were predominantly rainfed and potent to quickly reveal the impact of climate change. Thus, a total of three villages were selected for the present study. Forty respondents were selected randomly from each village that were dependent on agriculture and allied activities for their livelihood. Totally, 120 farmers were selected and interviewed using a well-structured interview schedule. We collected data on farmers' awareness of climate change and their knowledge on causes and expected impacts of climate change, and adaptation strategies. Farmers' responses about awareness of climate change were recorded in terms of yes or no (Yes -1, No -0). Fatalism scale was adapted from Leiserowitz (2006), farmers' responses for each statement of fatalism were recorded using a five-point scale (SA = strongly agree, A = agree, U = undecided, D = disagree, SD = strongly disagree). Farmers were asked if they had noticed any changes in climate change indicators (temperature, rainfall, number of hot days and cold nights), and expected impacts on climate changes. The answers to these questions were classified into three categories: (1) increase; (2) decrease; and (3) remained constant. Answers to the questions regarding the expected future impact on agriculture were also classified into three categories: (1) will increase; (2) will decrease; and (3) remain constant. Data were analyzed using descriptive statistical techniques such as percentage and frequency.

3. RESULTS AND DISCUSSION

Awareness about Climate Change

Adaptation level of farmers to adverse impact of climate change depends upon their awareness level

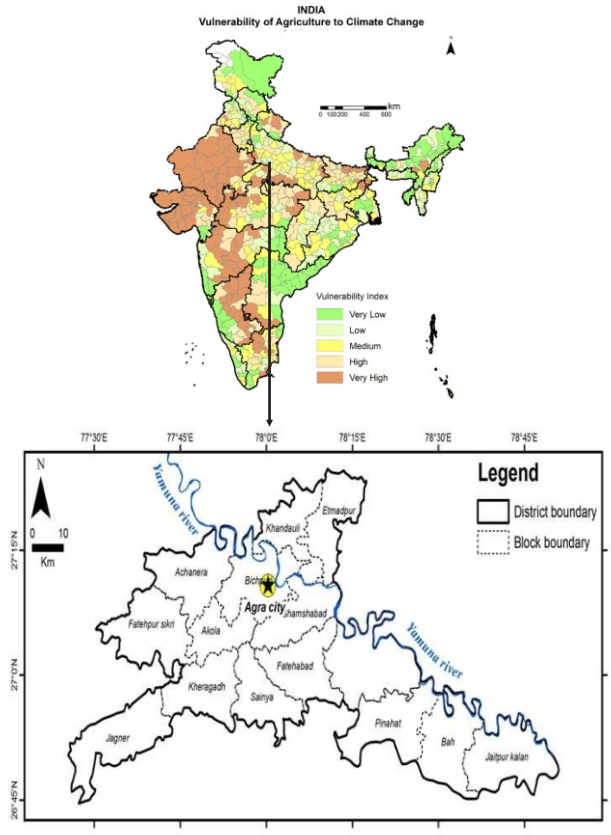

Fig. 1. Agra is one of the highly vulnerable districts to climate change (Rama Rao *et al.*, 2013)

(Banerjee, 2015). The results showed that 86% of farmers had heard about climate change, and 73% said that climate change is a very serious issue (Table 1). Similarly, 42% of respondents were aware of global warming. Results indicated that respondents are less acquainted with global warming terms than climate change. The majority of the respondents (about 85%) were aware of the changes in climate change indicators such as temperature, rainfall, wind velocity, etc.; and about two-thirds of respondents attributed the climate change to deforestation, intensified industrialization and air pollution. These results are also well supported by earlier studies on awareness about climate change in India (Shukla *et al*., 2016; Raghuvanshi *et al*., 2017). Similarly, respondents were aware that climate change causes reduction in crop and livestock yield, ill health to crop and animal, more diseases and pest infestation, and reduction in the amount of rainfall. About 71%, 68%, 40%, and 37% of respondents thought that problem of climate change could be overcome through intensified research work, stopping air pollution, by facing it, and enlightenment campaigns, respectively.

Fatalism

Fatalism was operationalized by a belief that human destiny and acts are pre-determined by some supernatural power and can never be influenced by violation or by acts of

Table: 1
Distribution of respondents according to their awareness about phenomena related to climate change (n = 120)

S.No.	Statements	Response - Yes (%)
1.	Have you ever heard the term climate change?	86
2.	Do you feel that climate change is a very serious issue?	73
3.	Are you aware of different impacts of changes in temperature, rainfall, wind velocity, etc.?	85
4.	According to you what are the reasons behind climate change?	
	a. Deforestation	74
	b. Intensified industrialization	64
	c. Air pollution	62
	d. All of the above	70
5.	Are you aware of global warming?	42
6.	Do you think the problem of climate change can be solved at all?	58
7.	Do you think the problem of climate change affects you as a person?	86
8.	How does the problem of climate change affect you?	
	a. Reduces crop yield	83
	b. Causes ill-health	68
	c. Reduces milk yield	79
	d. Increases diseases and pest infestation	59
	e. Reduces the amount of rainfall	83
	f. Causes pollution of the environment	55
9.	How do you think an individual can help to overcome the problem of climate change?	
	a. By prayers	24
	b. By being religiously committed	15
	c. Enlightenment campaigns	38
	d. By facing it	41
	e. Intensified research efforts	71
	f. By stopping air pollution	68
	g. Making sacrifice to Gods	41

Table: 2
Distribution of respondents according to fatalism **(Percentage)**

S.No.	Statement	SA	A	UD	D	SD
1.	The future is too uncertain for a person to make serious plans.	8	52	32	9	0
2.	It doesn't make much difference if people elect one or another political candidate, for nothing will change.	15	42	27	11	5
3.	I feel that life is like a lottery.	6	21	48	18	6
4.	A person is better off if he or she does not trust anyone.	6	36	32	21	5
5.	I have very little control over my life.	8	33	44	14	2
6.	There is no need of worrying about public affairs; I cannot do anything about them anyway.	9	29	32	26	5
7.	I feel women's life will become more difficult / hazardous.	14	48	24	11	3
8.	I feel farmers' lives are going to become tougher.	29	50	20	2	0

Note: SA = Strongly agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly disagree

anyone else. Results revealed that about 59% of respondents believed that the future is too uncertain for a person to make serious plans while 38% of them believed that there is no need of worrying about public affairs because they couldn't do anything about them anyway (Table 2). About 41% of respondents agreed that they had very little control over their life and they are better off if they do not trust anyone. Above 60% of farmers believed that the life of women and marginal farmers are going to become tougher due to climate change. According to Hanjra and Qureshi (2010) life of especially marginal farmers and women will be difficult due to their lower socio-economic status and high cost of adaptation. Fatalistic respondents believe that climatic events are natural and inevitable and that nobody is proficient to avoid their consequences. Thus, fatalistic beliefs about climate change decreased the probability of adoption of any climate change adaptation measure (Mahmood *et al*., 2020).

Knowledge of Climate Change

To have effective adaptation strategies, farmers' knowledge about climate change and its repercussions are

appropriate for eliciting the grass-root imperatives (Singh *et al*., 2018). The farmer's knowledge level of climate change was measured using a mean index ranging from 1 (knowledge on all items) to 0 (no knowledge). We assigned the 1 point for correct answer and no point for wrong or don't know answers. The knowledge level was classified as poor (<0.50), moderate (0.50-.075) and good knowledge (0.75) (Tobler *et al*., 2012; Baig *et al*., 2020).

Results showed that about one-third of the respondents had poor knowledge of climate change, and half of the respondents had moderate knowledge (Fig. 2). Thus, there was limited scientific knowledge at the local level to address issues of climate change and undergo long-term planning. About 44% of farmers believed that climate change is due to an increase in human activities (Table 3), while about 29% of farmers believed that climate changes in the last 20 or 50 years is mainly due to God's curse. Heavy use of fossil fuel by human beings was also thought to be responsible for climate change were reported by about 62% of respondents. Similarly, about 30% and 36% of farmers thought that heavy use of chemical fertilizers and pesticides were also responsible for the present climate change scenarios, respectively. About half of respondents realized that human activities disturbed the natural balance and led to climate change. Such understanding offers the opportunity to organise discourse for action towards environmental redress and willingness for generous action to minimise and mitigate the adverse consequences of climate change (Sarkar and Padaria, 2010). However, only 4% of farmers were aware that the cultivation of rice also contributes to global warming through the emission of greenhouse gases. Similarly, 8% of respondents were known to have methane gas emitted through livestock farming. Only 8% of farmers heard about climate-resilient technologies. Similar kinds of findings were also reported for Nigeria (Idrisa, 2012).

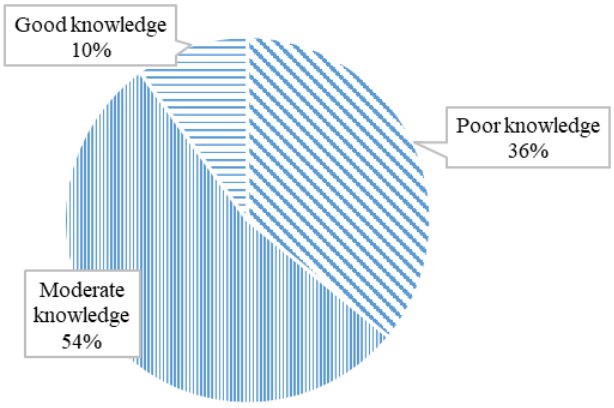

Fig. 2. Distribution of farmers based on knowledge level about climate change

The majority of respondents (about 79%) were aware of the increase in the average temperature of their locality over the last 20 years (Fig. 3). Further, about 90% of respondents felt that number of hot days in their area has increased. About 84% of farmers were aware that the total numbers of rainfall days and yearly total rainfall have declined over the last 20 years. Additionally, about 74% of farmers observed that the frequency of hot nights has increased. Whereas, 77% of respondents mentioned that the frequency of cold

Table: 3
Distribution of respondents according to knowledge about climate change

S.No.	Statements	Percentage of farmers
1.	Do you know any reasons behind climate change?	81
	a) God's curse	29
	b) Increase in human activities	44
	c) Both	27
2.	Do you know about any human activity responsible for climate change?	72
	a) Heavy use water	45
	b) Heavy use of fossil fuels	62
3.	Are certain farming practices also responsible for the present climate change?	44
	a) Heavy use of chemical fertilizers	30
	b) Heavy use of pesticides	36
4.	Do you know that the cultivation of certain crops also contributes to global warming, through the emission of greenhouse gases?	12
	a) Wheat	5
	b) Rice	5
	c) Pigeon pea or any other	5
5.	Are you aware of any gas emitted through livestock farming?	12
	a) Methane	8
	b) Carbon monoxide	2
6.	Have you heard about different climate-resilient technologies?	8
	a) Zero tillage	33
	b) Mulching	2

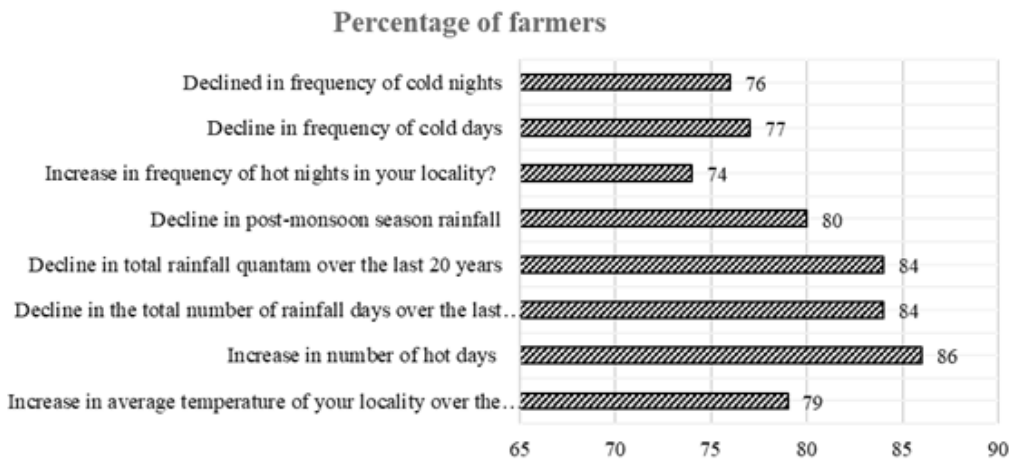

Fig. 3. Farmers' perceptions on climatic variability

days and nights has decreased in their locality. Thus, farmers' in the study area were able to recognize increase in temperature, decrease in intensity of winter, and fluctuation in rainfall pattern. Similar findings were also reported by earlier studies (Baul, 2013; Raghuvanshi *et al*., 2017). Results show that the respondents have correctly perceived change in temperature, pattern and intensity of rainfall and increased incidence of insect pests and diseases, which have largely influenced the experiences and perceptions regarding climate-related events.

Farmers' perceptions on the impacts of climate change on agriculture are presented in Table 4. Results showed that more than half of respondents perceived that crop yield, productivity of livestock, net sown area, total irrigated area, maturity period of major crops, groundwater table, and drinking water quality will decrease due to long-term impact of climate change. Several studies reported that increasing atmospheric temperature adversely impacts crop yield and further induces water stress (Rao *et al*., 2014; Singh *et al*., 2014). Delay in sowing time and early harvesting of crops due to climate change was also felt by more than half the number of respondents. Similar observations were also reported by Shukla *et al*. (2016). Respondents reported that the level of ground water as well as the quality of drinking water will decline due to over-exploitation of fresh water and contaminates in the acquifer.

Results revealed that the majority of respondents reported that SWC measures such as contour bund, farm pond, Nala bund, check dam, and recharge filter implemented in watersheds by the Government are fully helpful in mitigating the effects of climate change (Fig. 4). Similar kinds of findings were also reported by Meena *et al.* (2021). The change in cropping pattern, sowing time and diversified agriculture was identified by about 75%, 60%, and 28% of respondents as one of the major coping technology for climatic variability and climate change, respectively. According to Raghuvanshi *et al*. (2017) seasonal modifications in sowing schedules, fertilizer consumption, and crop varieties are an effective way of dealing with increased climatic variability. The agro-forestry and watershed management is a core strategy to deal with climate change mentioned by about 63% and 72% of the respondents, respectively. The adoption of SWC measures requires high investment and the poor economic condition of respondents impedes their ability to make large-scale investments on the SWC measures (Meena *et al*., 2020). Therefore, economic incentives must be provided by the Government for adoption of these measures (Pande *et al*., 2011). Additionally, a watershed management program must be implemented by the Government because it is considered and adopted as an effective tool to address problems of rainfed areas in the country (Joshi *et al.,* 2008; Raizada *et al*., 2018).

4. CONCLUSIONS

The study showed that most of the farmers have experienced changes in climate indicators such as temperature, rainfall, and drought frequencies over the last few years. The majority of respondents perceived that climate change is real but some of them did not perceive the problem of climate change as a real threat. Awareness of consequences due to climate change was more on the items which affect farmer's livelihood directly like reduction in crop and milk yield as most of the people were engaged in farming for their livelihood. The majority of respondents reported that SWC measures and agro-forestry implemented with watershed approach are the most effective adaptation technology for climatic variability and climate change. The change in cropping pattern and sowing time is one of the most widely adopted adaptation strategies. However, majority of respondents had moderate and poor scientific knowledge of climate change causes and their mitigating strategies at the local level. The majority of respondents either were unaware or still had not adopted adaptation practices like

Table: 4
Impact on agriculture

S.No.	Statements	Percentage of farmers
1.	The future effects of climatic changes on the yield of crops	83
	a) Will increase	20
	b) Will decrease	62
	c) Remain constant	2
2.	The future effects of climatic changes on the net sown area	76
	a) Will increase	15
	b) Will decrease	55
	c) Remain constant	18
3.	The future effects of climatic changes on total irrigated area	82
	a) Will increase	33
	b) Will decrease	47
	c) Remain constant	8
4.	The future effects of climatic changes on the productivity of livestock	85
	a) Will increase	2
	b) Will decrease	83
	c) Remain constant	3
5.	The future effects of climatic changes on maturity period of major crops	76
	a) Will increase	11
	b) Will decrease	58
	c) Remain constant	20
6.	Changes in sowing time due to climate change	67
	a) Getting early	14
	b) Getting delayed	53
	c) No change	21
7.	Changes in harvesting time due to climate change	68
	a) Getting early	59
	b) Getting delayed	9
	c) No change	20
8.	Change in cropping pattern	70
9.	Change in groundwater level	82
	a) Increased	2
	b) Decreased	82
	c) Constant	3
10.	Change in drinking water quality	79
	a) Improved	2
	b) Deteriorated	74
	c) No change	11

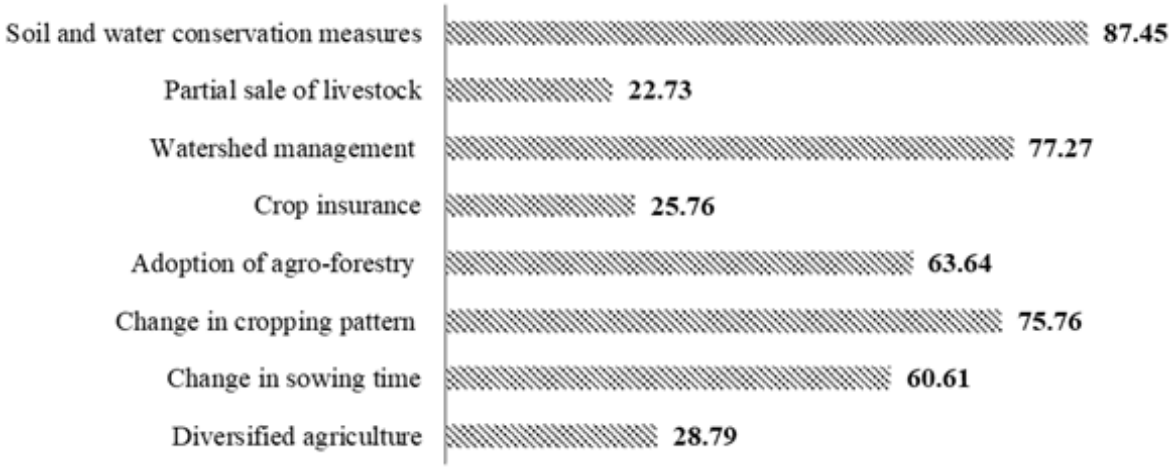

Fig. 4. Distribution of farmers based on the adaptation strategies

zero tillage, crop rotation practices and stress-tolerant varieties. Effective mass media programmes and efficient extension services are needed to improve their knowledge level about climate change. For long-term solution to the adverse impact of climate change in agriculture, it is essential to have sustainable adaptation strategies for achieving climate resilience. Integrating local-level perceptions about climate change and adaptation strategies in development planning is crucial for enriching the adaptive capacity of the farmers. This study generated valuable information for researchers, policymakers and development department officials involved in natural resource management for understanding climate change and achieving climate resilience at a local level in the semi-arid region as well as in other regions of the country. Identification and quantifying the effectiveness of the best region-specific suitable climate-resilient technologies are suggested for future research.

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