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Participatory Evaluation of Effectiveness of Farmer-Led Adaptation Strategies to Climate Change in Eastern Uttar Pradesh

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ABSTRACT

India has shown high vulnerability towards the impact of climate change due to the dependency of 58 per cent of India's population on agriculture. The study was carried on 180 respondents in three districts selected randomly of eastern Uttar Pradesh to evaluate farmer-led adaptation strategies to the impact of climate change, activities that are predominantly led by farmers to make them more adaptable to long-term changes in weather patterns. All the respondents had experienced extreme climatic events in the last 5-10 years, making the region climate-prone. Nine farmers'-led adaptation strategies to climate change followed in crop farming were documented and quantified by using Climate Change Adaptation Index. Adaptation strategies were evaluated using the Quantification of Indigenous Knowledge method (QuIK) method; by involving the key informants followed by peer farmers. Crop diversification, use of high yielding varieties of crops and preparations of bunds to control water flow were the most preferred adaptation strategies to climate change. The irregular rainfall increased the incidence of floods in eastern Uttar Pradesh; thus, the preparation of bunds to regulate water flow in crop fields was the most efficient adaptation strategy.

INTRODUCTION

Climate change is affecting the vulnerable section of society i.e. the farming community. It is not only about rising temperatures, shifting precipitation patterns, and extreme weather events. It is much more. It is about changing the way farmers are practicing farming and adapting to change caused by the extreme long-term weather conditions. India is the seventh most climate-affected country in 2019 (Global Climate Risk Index, 2021) with agriculture as the primary source of livelihood of the Indian population with 86.2% of farmers with less than 2 hectares of land, making them more vulnerable to the impact of climate change (Agriculture Census of India, 2019). It was predicted that a 1-2.5 degrees Celsius temperature rise by 2030 is likely to show serious effects on crop yields (Ahluwalia and Malhotra, 2006). An economic survey in 2017-18 cautioned that "climate change might be reducing annual agriculture income from 15 per cent to 18 per cent and up to 20 per cent to 25 per cent for unirrigated areas". Guiteras (2009) indicated that without any adaptation by the farmers the yields for crops decreased by 4.5 per cent to 9 per cent in the short-run (2010-2039) and by 25 per cent in the long run (2070-2099). The challenge of adapting to the impact of climate change is growing and hence research is important in the field of adaptation strategies (Raghuvanshi & Ansari, 2020). Farmers know and understand the environment in which they farm, answers to agronomic questions can be found in the collective experience of the farming community

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(Scoones & Thompson, 1994). QuIK method focuses on farmers' participation in reviewing their practices and, based on their reviews, an intervention that combines farmers' knowledge and scientific rationale could be offered as a solution.

Uttar Pradesh has a strong agriculture base with the most fertile landmasses and a well-connected river network but the climate sensitivity of agriculture is very high with high-level poverty, rapid urbanization coupled with a flood, heat waves and cold waves. The state is divided into four regions: western, central, eastern, and Bundelkhand. Eastern regions have a larger impact on climate change due to low per capita income, low educational status, and high population density, the dominance of the small and marginal resource-poor farmers compared to other regions of Uttar Pradesh. Almost 77 per cent of the area affected by floods in the state is constituted by eastern U P (Uttar Pradesh State Action Plan on Climate Change, 2017). The adaptive capacity was found to be very low in districts located in vindyan, eastern Plain, north-eastern Plain, and Bundelkhand (Tripathi & Mishra, 2017). Rao et al., (2013) study reflected that majority of the districts of eastern Uttar Pradesh were moderate to highly vulnerable to climate change and is expected to show very high and high vulnerability in the mid-century 2021-2050. Sehgal et al., (2013) concluded that 21 out of the 28 districts in eastern Uttar Pradesh are highly vulnerable to climate change. Hence, the livelihoods of farmers in Uttar Pradesh's eastern region are under threat from climate change.

METHODOLOGY

Eastern Uttar Pradesh was selected purposively and out of 28 districts in eastern Uttar Pradesh, 3 districts were randomly selected viz., Azamgarh, Varanasi and Ghazipur. From each district, 4 villages were randomly selected. A farmer who was growing crops was considered as a respondent for this study. From each village 15 farmers were randomly selected, making the sample size of 180 respondents. Adaptation strategies were operationalized as the measures adopted by the farming community to cope up with the adverse impact of climate change on crop farming for sustainable agricultural production. A set of probable adaptation strategies was prepared using the snowball technique during the pilot study and a total of nine adaptation strategies were documented. 'Climate Change Adaptation Index (CCAI)' was developed at two-level *i.e.* adaptation strategies wise and respondent wise using the following formula:

$$\text{Climate Change Adaptation Index} = \frac{\text{Obtained Score}}{\text{Maximum Obtainable Score}}$$

Ranking of these adaptation strategies was done according to their higher index value. Adaptation strategies with higher index values indicated that these adaptation strategies had comparatively more coping capacity than the adaptation strategies with the lower index value (Table 4). In the study, the effectiveness of the adaptation strategies was operationalized as the ability of farmer-led adaptation strategies to cope up with the adverse effect of the changing climatic scenario. The study adopted the principle De Villiers (1996) where the performance of the farmers' practices was assessed without field trial. The tool of Participatory Rural Appraisal (PRA) like matrix ranking was combined with semi-structured interviews to elicit numerical data from experienced farmers. Key informants were selected based on the snowball technique and by interviewing the farmers from each village. Accordingly, three key informants were selected from each village of the sampled districts. Therefore a total of 36 key informants were used to study the effectiveness of the adaptation strategies. They were asked to weigh practices in comparison among the identified strategies according to the following four criteria of effectiveness: (1) Effect on yield performance (2) Associated cost (3) Reducing climate sensitivity (4) Easy in availability and application. In each block of the matrix, key informants were asked to position the necessary number of pieces of stone out of five to each adaptation strategy for every criterion. Collected data were subjected to one-way analysis of variance followed by Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957) was used to identify the most effective adaptation strategies.

RESULTS AND DISCUSSION

Table 1 clearly shows that all the sampled farmers had experienced extreme climatic events like drought, flood, heavy rainfall, cold wave, heatwave, and hailstorm over the last 10 years. This shows that the locale of the study was a climate-disaster prone region. Ranks were allocated to adaptation strategies followed by the farmers based on CCAI scores. The five most preferred strategies of each three districts were selected for performing QuIK. Climate change has a global effect, but it also has a highly region-specific impact (Chunera & Amardeep, 2018) therefore the adaption measures that people prefer vary from district to district (Table 2).

Effectiveness of adaptation strategies related to crop-farming in Azamgarh district

Table 3 shows that 'search for the alternate sources of income' (mean score = 3.81) was considered the most effective adaptation strategy. Due to the ease in availability of jobs in the farm and non-farm activities in Azamgarh district such as working as agricultural laborers, working in nearby cities as marginal workers (*mistri*). Therefore, farmers preferred this particular strategy as an adaptation to climate change. The farmers have agreed that getting income apart from farm activities could be beneficial in providing sustainability to their livelihood and the additional income earned from alternate

Table 1. Distribution of respondents according to extreme climatic events experienced

Study Area	Azamgarh (n=60) (Percentage)	Varanasi (n=60) (Percentage)	Ghazipur (n=60) (Percentage)	Overall (n=180) (Percentage)
Experienced Climatic Events	100.00	100.00	100.00	100.00
Types of Extreme Events	Cold wave, Heat wave, Flood, Drought and Frost	Drought, flood, Hailstorm, heatwave, cold wave frost and sea-water intrusion	Drought, flood, Hailstorm, heatwave, cold wave and frost	Flood, Drought, Frost, Hailstorm, heatwave, cold wave

Table 2. Index score and ranking of adaptation strategies in crop farming followed by the farmers of eastern Uttar Pradesh

Adaptation strategies	Azamgarh (n=38)	Varanasi (n=53)	Ghazipur (n=52)	Overall (n=143)
Crop diversification	0.87 (I)	1.00 (I)	1.00 (I)	0.97 (I)
Use of tolerant varieties of seeds	0.22 (VI)	0.64 (IV)	0.21 (IX)	0.37 (IX)
Use of high yielding varieties and/or hybrid varieties of seeds	0.55 (III)	0.64 (IV)	0.69 (III)	0.64(II)
Preparation of bunds to control water-flow	0.66 (II)	0.66 (III)	0.62 (V)	0.64 (II)
Search for alternate sources of income	0.39 (IV)	0.40 (IX)	0.44 (VIII)	0.41 (VI)
Use of neem in the field/stored grains	0.37 (V)	0.47 (VII)	0.77 (II)	0.55 (IV)
Vegetable farming	NA	0.42 (VIII)	0.63 (IV)	0.38 (VII)
Value addition /Use of by-products of crops	NA	0.55 (VI)	0.50 (VII)	0.38(VII)
In-situ mulching in a rice field by *Dhaincha*	NA	0.81 (II)	0.58 (VI)	0.51 (V)

(Values in parenthesis indicate column-wise rank); *NA:* Not Adopted

Table 3. Effectiveness of adaptation strategies related to crop-farming in Azamgarh (n=12)

Adaptation strategies	Effect on yield performance	Associated cost	Reducing climate sensitivity	Easy in availability and application	Overall effect
Crop Diversification	$1.33^{b}\pm0.14$	$1.83^{c}\pm0.21$	$1.25^{d}\pm0.13$	$1.75^{d}\pm0.22$	$1.54^{d}\pm0.10$
Use high yielding varieties and hybrid varieties of seeds	$1.75^{b}\pm0.18$	$3.50^{ab}\pm0.19$	$2.67^{c}\pm0.22$	$3.83^{b}\pm0.27$	$2.94^{c\pm}0.09$
Preparation of bunds to control water flow	$3.92^{a}\pm0.29$	$2.91^{b}\pm0.36$	$3.67^{b}\pm0.19$	$2.92^{c}\pm0.19$	$3.35^{b}\pm0.11$
Search for alternate source of income	$3.92^{a\pm}0.19$	$4.00^{a}\pm0.39$	$2.67^{c}\pm0.36$	$4.67^{a}\pm0.14$	$3.81^{a}\pm 0.18$
Use of neem in the field and stored grains	$4.25^{a}\pm0.28$	$2.00^{c}\pm0.35$	$4.75^{a}\pm0.25$	$1.58^{d}\pm0.23$	$3.14^{bc}\pm0.15$

Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.

occupations enabled farmers to practice more innovation in their agricultural practices. Hence, it was also considered as the most cost-effective (mean score = 4.00) adaptation strategy.

Off-farm work involvement is one of the key climate change adaptation approaches used by small-scale rice farmers (Kyeremeh & Bannor, 2018). In case of reducing the climate sensitivity, the use of neem (leaves, fruits etc.) in the crop-field and stored grains was most effective by preventing attack of pests and insects, though the availability and application pose a problem to farmers as the standard formulation of neem solution was not clear to them and the seasonality of neem fruit production has also been cited as constraints to the usage of neem as pesticides.

Effectiveness of adaptation strategies related to crop-farming in Varanasi district

Table 4 depicts that the preparation of bunds to control water flow (mean score = 4.08) was considered the most effective adaptation strategy in Varanasi district. The incidence of floods has shown an increasing trend in Varanasi district leading to huge damage to standing crops therefore, making soil bunds to control the water and channelize the water for other uses in the future irrigation purposes was proved to be beneficial and reducing climatic sensitivity. Chouksey et al., (2021) study indicated that water-saving irrigation methods and water harvesting and recycling for supplement irrigation had good adaptation scores. Due to the increased frequency of localized and short-term rainfall events, flooding events have increased in Eastern Uttar Pradesh in recent years and are expected to increase in the future (Guhathakurta et al., 2008) which impose the need for water management practices. The adverse effect of climate sensitivity on rice, wheat, sorghum, *Arhar*, *Bajra* productivity can be alleviated by irrigation (Kar & Kar, 2008; Ranuzzi & Srivastava, 2012; Singh, 2012; Zou et al., 2012). The practice was considered even effective in stabilizing the crop yield (mean score = 4.33), easy in availability and preparation (mean score = 4.50) and cost-effective (mean score = 4.00) too. As already some incentives and support were provided by local government to assist farmers in preparation of bunds; hence leading this particular practice scored more value in terms of easy availability and application and associated cost. The use of high yielding varieties was also considered effective in reducing climate sensitivity (mean score = 3.92) in Varanasi district.

Farmers were introducing improved varieties such as early maturing; flood-tolerant and short-duration varieties to maintain profitability and protect crops during flood-like conditions.

Table 4. Effectiveness of adaptation strategies related to crop-farming in Varanasi (n=12)

Adaptation strategies	Effect on yield performance	Associated cost	Reducing climate sensitivity	Easy in availability and application	Overall effect
Crop Diversification	$1.33^{d}\pm0.14$	$2.42^{a}\pm0.36$	$1.33^{c}\pm0.19$	$1.83^{c}\pm0.34$	$1.73^{c\pm}0.13$
Tolerant Varieties	$3.58^{ab}\pm0.31$	$3.33^{a\pm}0.38$	$2.33^{b}\pm0.28$	$2.67^{cb}\pm0.40$	$2.98^{b}\pm0.13$
Use of high yielding varieties/hybrid varieties	$2.42^{c}\pm0.31$	$2.58^{a}\pm0.38$	$3.92^{a}\pm0.26$	$2.75^{cb}\pm0.25$	$2.92^{b}\pm0.15$
Preparation of bunds to control water flow'	$4.33^{a}\pm0.22$	$3.58^{a}\pm0.34$	$3.92^{a}\pm0.29$	$4.50^{a}\pm0.19$	$4.08^{a}\pm0.14$
In-situ mulching of paddy field with *Dhaincha*	$3.33^{b\pm}0.40$	$3.17^{a}\pm0.47$	$3.42^{a}\pm0.42$	$3.08^{b}\pm0.40$	$3.25^{b}\pm0.20$

Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.

Table 5. Effectiveness of adaptation strategies related to crop-farming in Ghazipur (n=12)

Adaptation strategies	Effect on yield performance	Associated cost	Reducing climate sensitivity	Easy in availability and application	Overall effect
Crop diversification	$1.67^{c}\pm0.19$	$3.33^{ab}\pm0.37$	$1.75^{c}\pm0.22$	$2.08^{c}\pm0.29$	$1.77^{c}\pm0.92$
Use of high yielding varieties/hybrid varieties	$2.67\ ^{b}\pm0.14$	$3.67^{a\pm}0.41$	$3.25^{bc}\pm0.30$	$2.83^{bc}\pm0.27$	$2.48^{b}\pm0.14$
Preparation of bunds to control water flow	$4.17^{a}\pm0.21$	$3.25^{ab}\pm0.33$	$4.00^{a}\pm0.28$	$4.33^{a}\pm0.14$	$3.15^{a}\pm0.74$
Use of neem in the crop field and stored grains	$4.58^{a}\pm0.15$	$2.50^{ab\pm}0.41$	$3.92^{ab}\pm0.34$	$3.50^{ab}\pm0.48$	$2.90^{a}\pm0.21$
Vegetable farming (Olericulture)	$1.50^{c}\pm0.19$	$2.00^{c}\pm0.35$	$2.08^{c}\pm0.44$	$2.2^{c}\pm0.43$	$1.57^{c}\pm0.16$

Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.

Effectiveness of adaptation strategies related to crop-farming in Ghazipur district

Table 5 shows that preparation of bunds to control water flow (mean score = 3.15) was considered most effective in improving yield performance (mean score = 4.17), helped reduce climatic sensitivity (mean score = 4.00) and was easy to avail and prepare (mean score = 4.33). Therefore, the preparation of bunds was considered the most effective adaptation strategy. However, the use of high yielding varieties was considered by the farmers in Ghazipur district to be the most cost-effective adaptation strategy. Farmers observed improved yields due to the use of high yielding varieties which were short-duration varieties of paddy and wheat, allowing them to go for more vegetables in the cropping system and enabling crop diversification which ultimately helps in improving overall crops yield. The study by Harikrishna et al., (2019) mentioned that adoption of climate-resilient practice increased the availability of irrigation water, usage of improved varieties and input use efficiency which will increase the quantity of produce.

CONCLUSION

Farmers by integrating their expertise, local and extension contact opted for practices like the use of high yielding varieties and better water conservation techniques. The public authorities can provide more information on adaptation strategies to climate change along with routine improved practices of crop farming. The preference for adaptation strategies for each district was different. Hence, region-specific contingency plans and documentation of farmer-led practices should be planned by bringing farmers, key informants of a particular region, extension agents, scientists and policymakers on the same platform. Scientists can learn most from farmers about factors in the farmers' lives that are important and easy to observe and accordingly can develop technologies that will increase the extent of adoption of practices suggested by extension functionaries. QuIK facilitates rapid transfer knowledge and can unpack the practice of successful farmers/enterprises so that it reaches a wider group of a farmer.

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