

Crop diversification as a boom adaptation strategy to climate change: An Empirical evidence

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Introduction

Climate change is not a recent phenomenon, but over the years it has raised a looming threat on the planet. Climate sector has hit the environment and livelihood of human beings but the sector which is hit hardest by the changing climatic scenario is agriculture, particularly in developing countries like India where half the population depends on agriculture and allied sector for their livelihood. The temperature has increased over the years, the erratic and irregular rainfall pattern, and hailstorms etc. which are negatively impacting the crop yields. According to the Economic Survey of India 2017-18, a large percentage of farm revenue and farm income would be decreased by climate change. Therefore, the prevailing situation points out to focus on adaptation strategies, particularly the adaptation practices led by farmers. Adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts. Adaptation strategies were operationalized as the steps taken/adopted by the farming community to cope with the adverse effects of climate change on sustainable agricultural production. Farmer-led adaptation strategies are those strategies where farmers play the key role, not change agents such as extension workers or scientists, and modify their production system based on their past experiences and indigenous knowledge, along with the help of extension contact, from farmer to farmer extension, word of mouth, but the major decision is taken by the farmers. Several studies indicate that the eastern regions of Uttar Pradesh is highly vulnerable to the impact of climate change and therefore was purposefully selected for study and three districts, Azamgarh, Varanasi and Ghazipur were selected randomly. To delineate farmer-led adaptation strategies and exclusive Climate Change Adaptation Index (CCAI) was developed. A total of nine adaptation strategies were documented with the help of

interview schedule prepared by the author on contacting farmers at the doorstep and their farm fields.

Material and Methodology

Sampling Area

For the study, Eastern Uttar Pradesh was selected purposively, and Azamgarh, Varanasi and Ghazipur were selected randomly for the study. Two blocks from each district were randomly selected and two villages were selected from each block, so 12 villages were selected and 15 farmers were selected as respondents from each village. The total sample count for the relevant study was 180 respondents. The farmers who were growing crops were considered as respondent for this study. Households head was considered as the respondent for the study. Fifteen respondents were randomly selected from each village and thus, 180 respondents were randomly selected from 12 villages and were considered a sample of this study. Out of 180 respondents, 143 respondents have adopted at least one adaptation strategy and further analysis was done accordingly.

The respondents who were aware towards climate change were again asked Once again, respondents who were aware of climate change were asked if they had implemented any adaptation strategies in crop farming to cope with the negative effects of climate change on the 'YES' or 'NO' binary response. The snowball technique was used to prepare a set of probable adaptation strategies for crop-farming. Those said yes, then, further asked to place their responses on a continuum viz. continued the adoption, discontinued the adoption and never followed/adopted with the score of 2, 1, and 0, respectively. Finally, '*Climate Change Adaptation Index (CCAI)*' was developed using the following formula:

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

..... (1)

Ranking of these adaptation strategies was done according to their higher index value. Adaptation strategies with higher index value indicated that these adaptation strategies had comparatively more coping capacity than the adaptation strategies with the lower index value.

Table 1 represents the list of and index score of adaptation strategies in crop-farming followed by the farmers.

Table 1: 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)
Vegetable farming	NA	0.42 (VIII)	0.63 (IV)	0.38 (VII)
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)	† (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)
Value addition /Use of by-products of crops	NA	0.55 (VI)	0.50 (VII)	0.38(VII)
In-situ mulching in the rice field by <i>Dhaincha</i>	NA	0.81 (II)	0.58 (VI)	0.51 (V)

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

Results and discussion

The most preferred strategy to impact of climate change on crop-farming was crop diversification in the overall region, even in all three districts. Almost 97 percent of the overall region was going for diversified cropping system to cope up with the negative impact of climate change. Vegetables, short-duration crops, flowers, and other crops apart from normal rice-wheat cropping system were incorporated in the field. Even some farmers adopted complete vegetable farming to compensate the losses caused to major field crops and were considering it helpful in

coping up climate change. Near about 38 percent of farmers went for vegetable farming an option for crop diversification.

A brief of different cropping pattern followed in all three sampled districts is presented below in the tabular form.

Table 2: Crops grown /cropping pattern followed by the farmers of Eastern Uttar Pradesh

S. No	Azamgarh	Varanasi	Ghazipur
1.	Paddy –Wheat -fallow	Pigeon pea, Paddy, <i>Bajra</i> -Sugarcane- Wheat, Chickpea, Pea, Potato	Paddy, Maize, Brinjal, Sugarcane-Wheat, Onion, Garlic, Cauliflower, Potato, Berseem +Vegetable Pea
2.	Paddy, Pigeon Pea – Wheat, Mustard, Berseem	Paddy, Marigold(Floriculture), Wheat, Onion, Coriander	Paddy, Chari, Cucumber, Pumpkin, Watermelon, Muskmelon, Potato, Wheat, Mustard +Berseem, Onion, Garlic, Vegetable Pea
3.	Paddy, Pigeon Pea, Bajra- Wheat, Mustard, Potato, Spinach	Paddy-Toria-Wheat- <i>Sesbania aculeate</i> (Green manure)	a. Paddy-Wheat-Green manure b. Paddy-Maize-Green Manure
4.	Paddy, Pigeon Pea, Sorghum -Gram, Berseem	Paddy, Chari, Cucumber, Pumpkin, Watermelon, Muskmelon, Yam - Potato, Wheat, Mustard +Berseem, Onion, Garlic, Vegetable Pea	a. Paddy-potato +garlic-maize- cowpea (fodder) b. Paddy-potato +garlic-maize- Sorghum (fodder)

Why crop-diversification is the most preferred adaptation strategies to impact of climate change on crop-farming?

- The adaptive capacity of farmers towards climate change depends upon the vulnerability of the farmers and climate sensitivity. The vulnerability could be decreased by increasing the sustainability of the farmers and crop-diversification is one such measure in reducing

climatic sensitivity and increasing the adaptive capacity of the farmers. Yegbemey *et al.* (2017), Tripathi and Mishra (2016), Belay *et al.* (2017) and Gedefaw (2018) reported crop diversification as an important adaptation strategy followed by farmers to cope up with climate vagaries. Crop diversification is perceived as one of the most ecologically feasible, cost-effective and rational ways of reducing climatic uncertainties in agriculture especially among the small-holder farmers (Joshi, 2005).

- Crop diversification has strengthened the climate resilience of farmers by increasing household income and family nutrition. The complete crop loss due to extreme climate vagaries could be avoided and the risk is reduced. More diversification has been seen in the Rabi season, including seasonal vegetables such as peas, chickpeas, radishes, cauliflower, carrots, onions and potatoes, etc. During water-stress condition, the cultivation of vegetable crops is quite feasible as they require less water for irrigation and even water is saved for other purposes or crops.
- Crop diversification could be seen in many forms such as mixed farming, intercropping multiple cropping and crop rotation. Farmers were growing pearl-millet, sorghum, maize, lentil, mustard, pigeon pea apart from growing major field crops paddy and wheat.
- The farmers are opting for short duration crops along with leguminous crops leading to more crops per year and also improving the fertility of the soil as climate change has caused land degradation due to run-off losses during heavy and erratic rainfall.
- Some of the farmers also incorporated flower-production (e.g. Marigold) and marketed it to neighboring town which fetched an additional source of income. Farmers informed that the input cost of flower-production is much lower than the field crops and they were able to get year-round yield which fetched good market values. Flowers were less affected by harsh climate vagaries than the other field crops like paddy and wheat. They are not as weather-dependent as the major field crops are.
- Small farmers were also seen opting for diversification with livestock such as rearing goats for sale along with cattle-rearing.
- Intercropping cereal crops such as cowpea maize (legumes) did not need additional input other than seeds, but the net return was more than just mono-cropping, which made the

practice more profitable. Intercropping with legumes and multiple crops mixed with livestock found to be effective adaptation strategies to climate change (Apata *et al.* 2013).

- According to Lin (2011), crop diversification with legumes increases soil fertility, controls pests and diseases and provides about yield stability that improves the farmers' adaptive capacity to the impact of climate change.
- Some of the farmers were also cultivating fruit crops like guava which can withstand the harsh climate of high temperature during the growing season and fetching additional income to farmers. Even some went for growing fruit crops on bunds around their field crops to protect the crops from strong wind-flow.

Conclusion

The above discussion points out that one of the most favored adaptation strategies led by farmers was crop diversification. The conventional rice-wheat crop system could not cope with the challenge of climate change, opting for drought-tolerant, frost-tolerant and hardy crops are a good choice along with field crops. Cultivating more crops each year and practicing crop rotation will not only contribute to the yield but will also restore soil fertility and enrich it with beneficial nutrients. Many types of research are in favor of the result obtained in the study. Farmers could also be trained to follow polyhouse vegetable production techniques and to practice organic farming, which would improve their adaptive ability to a greater degree.