

A Study on The Effectiveness of Farmer-Led Adaptation Strategies for Livestock Rearing to Climate Change in Eastern Uttar Pradesh Through a Participatory Approach

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Abstract

Uttar Pradesh is India's largest milk-producing state, with the eastern region highly susceptible to climate change compared to other regions of the state. Therefore, eastern Uttar Pradesh was selected purposely. Total fifteen farmers' -led adaptation strategies to climate change followed in livestock-rearing were documented and quantified by using Climate Change Adaptation Index. Adaptation strategies were evaluated using the Quantification of Indigenous Knowledge method (QuIK). "Use of shed for animals", "providing fresh drinking water to animals", and "providing extra bath/shower to animals", "proper sanitation and healthy practices", "vaccination" and "use of jute cloth to cover animals' body" were the most preferred adaptation strategies. Heavy rainfall has been increased in the region, so "proper sanitation and healthy practices" and "vaccination" were chosen as the most efficient adaptation strategies. The heatwave (loo) and high temperature-induced heat stress on livestock, so "providing extra drinking water and extra bath/shower to livestock" were considered most effective. For protecting animals from cold waves during winter, "jute cloth to cover animals" was preferred effective due to its easy availability and application.

Keywords: Adaptation, Climate change, Effective, Farmer-led, Livestock, Vaccination

Introduction

A large section of the farming community in India depends upon the agriculture-cum-livestock production system. Along with crop production, livestock plays a crucial role in the farmers' production system as they are the extra source of income for farmers and the demand for milk products is growing day by day, offering a strong market for farmers to sell their produce; The dairy sector could provide food security and poverty reduction to small farmers through the marketing of dairy products (FAO, 2018). In the case of the livestock sector, the effect of climate change is very clear. Climate change mostly affects the sustainability of the livestock production system. The cumulative effect of high ambient temperatures and humidity has a detrimental effect on the reproductive efficiency of farm animals (Sinha *et al.*, 2017). The livestock such as cattle and buffaloes are mainly reared for milk production in the Indian livestock production system and high-temperature causes decreased feed consumption by animals and ultimately affects milk production (Nardone *et al.*, 2010). Climate change influences dairy farming in multiple ways (directly, e.g. the performance and well-being of cows, or indirectly, e.g. via impacts on quantity and quality of fodder production). The negative impact of temperature rise on total milk production for India has been estimated at more than 15 million tonnes in 2050 (Upadhyay *et al.*, 2009). Hot climatic conditions cause increased body surface temperature, pulse rate, rectal temperature, and respiration rate leading to decrease feed intake and reduction in production and reproduction efficiency of livestock (IPCC, 2007). Studies are evident that extreme weather condition is affecting milk production such as milk production in Holstein Friesian cross breed cows was affected due to a rise in maximum and minimum temperatures above 22°C. A decrease in milk production in Murrah buffaloes was also observed with an increase in temperature above 2°C. The extreme events like heatwave (> 4°C) and cold wave (<3°C) reduced the milk yield by 10-30 percent in the first lactation and 5-20 percent in second and third lactations in cattle and buffaloes (Upadhyay *et al.*, 2010). The rise in the incidence of different diseases due to higher temperatures, heavy rainfall, and decrease in the availability of components of animal feed, further exacerbated by the decrease in cropping areas, are some of the other challenges faced by farmers due to climate change.

The above scenario demonstrates how climate change affects livestock farmers' livelihoods, necessitating the adoption of adaptation strategies to mitigate the negative effects on their livestock and ensure the farmers' livelihoods' long-term viability. Farmers are the ultimate victims of climate change's negative effects, and their experience and knowledge of how to cope with weather and climate vagaries is the idea behind going for participatory assessment of these strategies. As a result, participatory evaluation of adaptation strategies, in which farmers served as the main agents of change in their production system (here, key informants/opinion leaders of the particular village) rather than trained extension agents or scholars, would be the key to assessing the farmer-led adaptation strategies followed in their villages.

Materials and Methods

Selection of Study Area

Uttar Pradesh is divided into four regions western, central, eastern, and Bundelkhand region. With almost every rural household having one milk animal, Uttar Pradesh is the largest milk-producing state in India (20th Livestock Census, 2020, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India, New Delhi). As per the Times of India report (2017) Uttar Pradesh is also one of the highest emitting states of the country and contributes nearly 14 percent of national greenhouse gases (Fossil fuel consumption, power generation, and agricultural activities are major factors responsible.) According to Tripathi and Mishra (2017) due to low per capita income, low educational status, and high population density, the dominance of small and marginal resource-poor farmers in eastern Uttar Pradesh is greater than in other regions of Uttar Pradesh. Rural infrastructure is well developed in the districts of the western plains, mid-western plains, and central plains, but less so in the districts of the eastern plains (Tripathi and Mishra, 2017). During the 2016 floods, nearly 31 districts were affected, with 18 districts in Eastern Uttar Pradesh. According to Rao *et al.* (2013), the majority of vulnerable districts to climate change are in Eastern Uttar Pradesh, with medium to very high vulnerability. As a result, the study is being conducted in the eastern region of Uttar Pradesh, India, to gain a thorough understanding of the changes farmers are making to their livestock rearing systems to cope with the effects of climate change.

Sampling Plan

The study was conducted in ‘randomly selected’ three districts of eastern Uttar Pradesh viz., Azamgarh, Varanasi and Ghazipur. It was observed in our study that all of the sampled farmers experienced extreme climatic events like drought, flood, heavy rainfall, cold wave, heatwave, and hailstorm over the last 10 years in all three districts making the locale of the study was climate-disaster prone region. From every selected district, two blocks were randomly selected and from each block, two villages were randomly selected. Fifteen respondents were randomly selected from each village and thus, 180 farmers were randomly selected from 12 villages and considered as the sample of the study. Out of 180 farmers, 143 farmers have adopted at least one adaption strategy towards the impact of climate change on livestock-rearing. For the matrix ranking, three key informants were selected from each village i.e., a total of 36 key informants were selected for the study by snowball technique to validate the effectiveness of adaptation strategies followed by the farmers in eastern Uttar Pradesh to cope with the climate change in livestock-rearing.

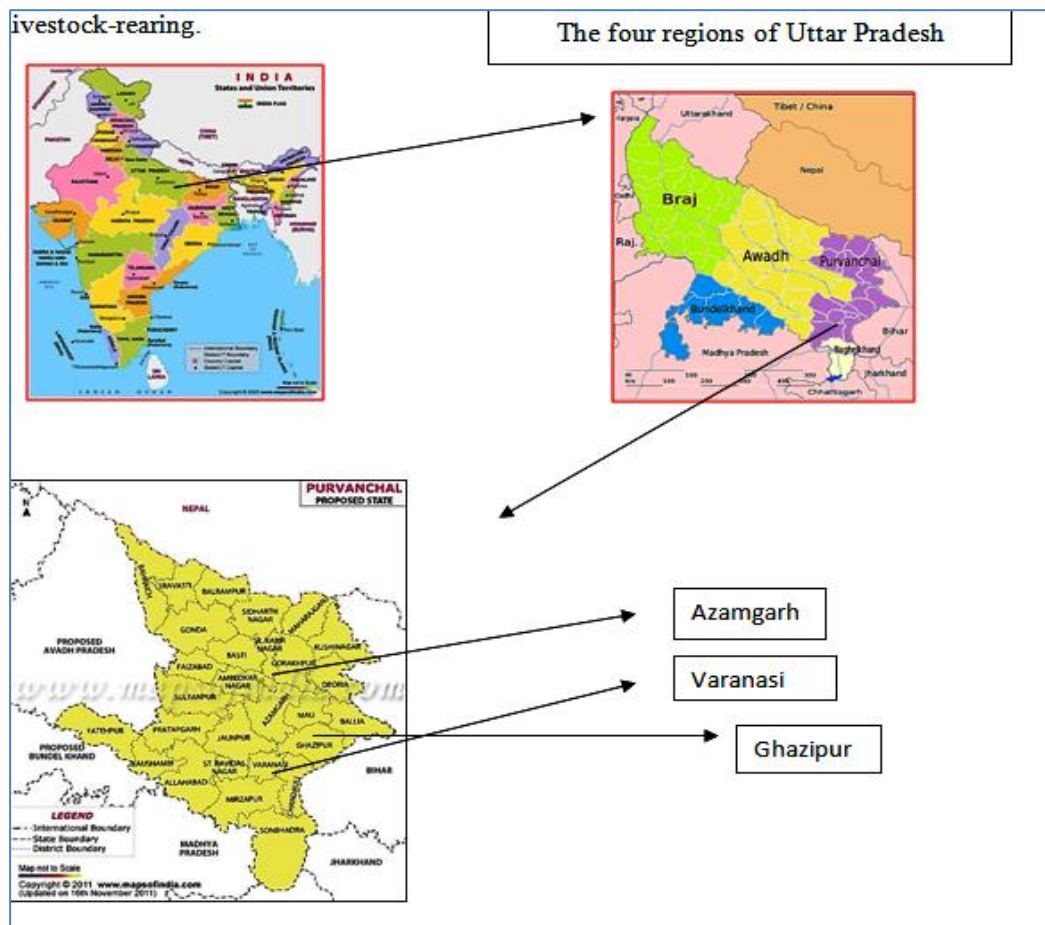


Figure 1: Outline of Map showing the selected regions of the study

Statistical Analysis

The main objective of the study is to identify farmer-led adaptation strategies and to determine their effectiveness by involving farmers in the process of evaluating those strategies. The diagnostic research design was used to evaluate the underlying cause of a specific topic or phenomenon. The diagnostic research design determines the frequency with which something occurs or its association with something. Therefore, in the present study diagnostic research design was used to identify the best adaptation strategies according to the effectiveness and to identify the differential level of perceived impact and adoption of adaptation strategies.

Farmers' Participatory Validation of Adaptation Strategies

The effectiveness of the adaptation strategies was operationalized as the ability of farmer-led adaptation strategies

to cope with the adverse effect of the changing climatic scenario. An exclusive Climate Change Adaptation Index (CCAI) was prepared by creating a list of adaptation strategies in the pilot study and got the respondents responses on a three-point continuum viz., continued the adoption, discontinued the adoption, and never followed. The scores were calculated using equation no 1 to rank the adaptation strategies based on the obtained index score. Ranking of adaptation strategies was done according to the highest index score. CCAI was used as the base for selecting the top five most practiced strategies by the respondents to appraise them further.

$$\text{Climate Change Adaptation Index (CCAI)} = \frac{\text{Obtained Score}}{\text{Maximum Obtainable Score}} \dots\dots\dots (1)$$

The study adopted the principle of De Villiers (1996) where the performance of the farmers' practices as well as indigenous knowledge was assessed without field trial. In this method, a tool of Participatory Rural Appraisal (PRA) i.e., matrix ranking was combined with semi-structured interviews to elicit numerical data from experienced farmers. Key informants 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 climatic 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. Collected data were subjected to one-way analysis of variance followed by Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957) to identify the most effective adaptation strategies.

Results and Discussion

Table 1 depicts the index score of each adaptation strategy in livestock-rearing at the district as well as the overall sampled region. 'Use of cattle shed for cattle and buffaloes' was the most preferred adaptation strategy by the farmers of Azamgarh district, Varanasi district, Ghazipur district, and also for the overall region. Farmers have highly perceived the negative impact of heat stress on their livestock; therefore, almost all of them were adopting this practice to reduce heat stress on the animals.

Table 1: Index score and ranking of adaptation strategies in livestock rearing followed by the farmers of Eastern Uttar Pradesh

| Adaptation strategies | Azamgarh | Varanasi | Ghazipur | Overall |
|---|-------------|------------|-------------|-------------|
| | (n=38) | (n=53) | (n=52) | (n=143) |
| 1. Shower/extra bath to cattle and buffaloes | 0.62 (III) | 0.47 (VII) | 0.77 (III) | 0.62 (III) |
| 2. Proper sanitation and healthy practices for cattle and buffaloes | 0.50 (VII) | 0.40 (XII) | 0.60 (VI) | 0.50 (VII) |
| 3. Vaccination | 0.61 (IV) | 0.58 (V) | 0.54 (VIII) | 0.61 (IV) |
| 4. Reduction in herd size | 0.34 (XII) | 0.47 (VII) | 0.31 (XIII) | 0.34 (XII) |
| 5. Use of shed for cattle and buffaloes | 0.93 (I) | 0.92 (I) | 1.00 (I) | 0.93 (I) |
| 6. Deworming of cattle and buffaloes | 0.41 (X) | 0.72 (II) | 0.32 (XII) | 0.41 (X) |
| 7. Extra concentrate | 0.54 (VI) | 0.59 (IV) | 0.62 (V) | 0.54 (VI) |
| 8. Fumigation of cattle shed with <i>Ajwain</i> and neem | 0.32 (XIII) | 0.28 (XIV) | 0.33 (XI) | 0.32 (XIII) |
| 9. Feeding of minerals supplement | 0.38 (XI) | 0.47 (VII) | 0.44 (X) | 0.38 (XI) |
| 10. Feeding of crop-residue and hay | 0.32 (XIII) | 0.28 (XIV) | 0.27 (IV) | 0.32 (IV) |
| 11. Use of jute cut to cover animals | 0.58 (V) | 0.55 (VI) | 0.81 (II) | 0.58 (V) |
| 12. Massage of the body with mustard oil | 0.45 (IX) | 0.40 (XII) | 0.48 (IX) | 0.45 (IX) |
| 13. Feeding of mustard cake to cattle and buffaloes | 0.46 (VIII) | 0.45 (X) | 0.58 (VII) | 0.46 (VIII) |
| 14. Shifting to indigenous breeds | 0.28 (XV) | 0.43 (XI) | 0.21 (XV) | 0.28 (XV) |
| 15. Providing extra fresh drinking water to animals | 0.63 (II) | 0.62 (III) | 0.69 (IV) | 0.63 (II) |
| (Values in parenthesis indicate column-wise rank) | | | | |

The top five most preferred adaptation strategies were chosen from 15 farmer-led adaptations strategies for analyzing the effectiveness of farmer-led adaptation strategies adopted by farmers to cope with the impact of climate change on livestock-rearing. For the evaluation of farmer-led adaptation strategies, key informants from each village were used as appraisers. Even though the districts are adjacent, farmers in all three districts perceive the impact of climate change differently in some variables, which influences their preferences for adaptation strategies to climate change. Climate change has a broader impact, but it also has a location-specific impact. The differences of socioeconomic variables of farmers provided insight into why differences in preference and effectiveness of adaptation strategies appeared.

Effectiveness of Adaptation Strategies Related to Livestock-Rearing in Eastern Uttar Pradesh

Vaccination was chosen the most effective by key informants with a score of 4.13 (Table 2). Though Vaccination is not truly an adaptation strategy per se these were coping strategies and tolerate stress during adverse climatic conditions, it was included in the study as an appreciable number of farmers was seeking vaccination as an adaptation strategy to climate change. The finding was in-line with Koirala and Bhandari (2018) study where; regular vaccination and deworming were considered important adaptation strategies to climate change by farmers of Nepal. Similarly, Moenga *et al.* (2016) found that “vaccination and deworming” were considered effective to control diseases caused by changes in climate in Africa. The unhygienic conditions created by the erratic rainfall pattern of all three districts is the rationale behind farmers choosing regular vaccination and maintaining sanitation around cattle sheds and for animals as the most effective adaptation strategies. In Azamgarh, rainfall in 2019 broke a 14-year record, causing the Tamsa River to overflow, causing flood-like conditions in the sampled villages. Flooding encourages farmers to practice proper sanitation and vaccinate their livestock to protect them from pest and disease attacks, as heavy rain creates an ideal environment for pests and diseases to thrive. In the summer season, farmers have agreed upon the heat stress caused to animals in the summer season.

Table 2: Effectiveness (Overall Score) of identified adaptation strategies in all three sampled districts of eastern Uttar Pradesh

| Adaptation Strategies/Districts | Azamgarh (Overall Effect) |
|--|----------------------------------|
| 1. Extra bath/Shower to animals (EB) | 3.48 ^a ± 0.14 |
| 2. Proper sanitation practices (SP) | 3.81 ^a ± 0.18 |
| 3. Regular Vaccination (V) | 3.65 ^a ± 0.23 |
| 4. Use of Cattle shed for cattle and buffaloes (CS) | 1.75 ^b ± 0.15 |
| 5. Providing extra fresh drinking water to animals (FW) | 2.23 ^b ± 0.15 |
| Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT. | |
| Adaptation Strategies/Districts | Varanasi (Overall effect) |
| 1. Vaccination (V) | 4.13 ^a ± 0.15 |
| 2. Use of cattle shed for cattle and buffaloes (CS) | 2.44 ^c ± 0.23 |
| 3. Deworming (DW) | 3.29 ^b ± 0.15 |
| 4. Extra Concentrate (EC) | 2.58 ^c ± 0.16 |
| 5. Providing extra fresh drinking water to animals (FW) | 2.50 ^c ± 0.11 |
| Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT. | |
| Adaptation Strategies/Districts | Ghazipur (Overall effect) |
| 1. Extra bath/ Shower to animals (EB) | 3.42 ^a ± 0.09 |
| 2. Use of cattle shed for cattle and buffaloes (SP) | 2.42 ^b ± 0.20 |
| 3. Extra Concentrate (EC) | 2.88 ^{ab} ± 0.17 |
| 4. Use of jute clothing to cover animals (JC) | 3.44 ^a ± 0.12 |
| 5. Providing extra fresh drinking water (FW) | 2.98 ^a ± 0.28 |
| Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT. | |

Farmers have reported that the temperature during the summer season has increased with more incidence of the heat

wave (locally known as *loo*) in May-June. They have experienced a severe summer from April to July, with the temperature soaring to about 45 degrees Celsius. Heat stress has considerable effects on cattle welfare and production. In hot and humid climate conditions, dairy cows produce less milk with lower milk quality characteristics (Summer *et al.*, 2019). Farmers have pointed out that livestock had shown symptoms like increased body temperature, increased open-mouth panting with a reduction in feed intake. Therefore, adaptation strategies like extra bath/shower to animals were proved to be effective in dissipating heat and making animals comfortable. Some of the farmers who could afford heavy equipment have fitted hosing systems in the cattle shed to sprinkler animals for 1-2 hours to cool them. As indicated by Legrand *et al.* (2011), water is commonly used to cool cattle during the summer season. The findings are supported by Singh (2021) study reported that heat stress can be managed by spraying/ sprinkling water directly on the body of animals for a period of 1 to 5 minutes at an interval of 10- 30 minutes.

Criteria-Wise Effectiveness of Farmer-Led Adaptation Strategies in The Study Area

When we look at the criteria (Table 3) “Effect on yield performance” of a particular adaptation strategy, we find that ‘Extra bath/shower to animals (EB)’ (mean score = 4.42) was most effective in improving milk yield performance in the overall sampled region. Almost all of the respondents (91 percent) believed that rising temperature and humidity reduce bovine milk production, prompting farmers to employ heat stress management techniques for their animals. The findings were backed by findings of Verma *et al.* (2017) that provides two times bathing and grooming in cross-bred cows under hot conditions may be used by dairy farmers as effective routine management practices to increase milk yield and its compositional quality while also reducing heat stress during the summer season. These practices are simple to implement, easy to manage, profitable, and do not require any complex technological intervention in dairy buffalo management (Savaliya *et al.*, 2016). Savaliya *et al.* (2017) also reported that the efficiency of milk production in Jaffrabadi buffaloes can be enhanced through photoperiod manipulation and showering twice a day. Surprisingly, providing regular vaccination to livestock was regarded as more cost-effective by farmers in terms of the most cost-effective adaptation strategies. It is due to assistance from extension agencies and local government incentives to provide services at a low cost, as well as a good result on milk production due to the prevention of pest and disease attacks on animals. Thus, the use of veterinary vaccines emerges as one of the most promising alternatives to control parasites in livestock, particularly in cattle, sheep, and pigs. This strategy not only would reduce transmission to humans (McManus and Dalton, 2006), but also the economic losses caused by the prevalence of these infections in livestock. It is generally accepted that the administration of vaccines for infections is the best-available public health intervention and, also represents the best cost-benefit ratio, and helps to reduce mortality, to improve health; and to promote socio-economic development (Hewitson and Maizels, 2014; McAllister, 2014).

Even Vaccination was considered most effective in reducing climatic sensitivity. Climate change, as we know, influences the occurrence and transmission of a wide range of livestock diseases through multiple pathways, and is expected to increase the risk of many vector-borne diseases (Bett *et al.*, 2018). As a result, control measures such as livestock vaccination against pests and disease attacks are required to reduce the climatic sensitivity of farmers' production systems. Practicing proper sanitation practices in and around the animals was considered easy in availability and application by the farmers. Farmers believed that infections in animals have increased due to unhygienic conditions around the livestock; therefore, apart from only cleaning the nearby areas or cattle sheds, they were also opting for disinfection to kill most of the contaminants in the given area. The major adaptation strategies by the livestock farmers in Ethiopia included proper health care and clean shade of livestock (Ruo *et al.*, 2018). As following simple sanitation and hygiene protocols were easy to follow and do not fetch some out of market product farmers have chosen the particular under these criteria. However, if talk about the winter season, the most effective adaptation strategy farmers have preferred is covering the animals with jute cloth and straw for their bedding materials. These materials are easily available in villages and can be locally prepared at home making it an effective adaptation strategy.

Table 3: Criteria—Wise effectiveness of adaptation strategies related to livestock-rearing in the sampled region (n=36)

| Effectiveness of adaptation strategies related to livestock-rearing in Azamgarh (n=12) | | | | | |
|---|-----------------------------|-----------------|------------------------------|--------------------------------------|----------------|
| Adaptation strategies | Effect on Yield performance | Associated cost | Reducing climate sensitivity | Easy in availability and application | Overall effect |

| | | | | | |
|---|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| EB | 4.08 ^a ± 0.26 | 2.92 ^{bc} ± 0.34 | 3.42 ^a ± 0.36 | 3.50 ^a ± 0.31 | 3.48 ^a ± 0.14 |
| SP | 3.75 ^a ± 0.40 | 3.75 ^{ab} ± 0.33 | 3.50 ^b ± 0.34 | 4.25 ^a ± 0.18 | 3.81 ^a ± 0.18 |
| V | 2.58 ^b ± 0.47 | 4.42 ^a ± 0.26 | 4.17 ^a ± 0.27 | 3.42 ^a ± 0.36 | 3.65 ^a ± 0.23 |
| CS | 2.16 ^b ± 0.32 | 1.83 ^d ± 0.24 | 1.33 ^c ± 0.19 | 1.67 ^b ± 0.35 | 1.75 ^b ± 0.15 |
| FW | 2.42 ^b ± 0.31 | 2.08 ^{cd} ± 0.36 | 2.50 ^b ± 0.31 | 1.92 ^b ± 0.19 | 2.23 ^b ± 0.15 |
| <i>Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.</i> | | | | | |
| Effectiveness of adaptation strategies related to livestock-rearing in Varanasi (n=12) | | | | | |
| V | 4.25 ^a ± 0.22 | 4.33 ^a ± 0.19 | 3.92 ^a ± 0.29 | 4.00 ^a ± 0.35 | 4.13 ^a ± 0.15 |
| CS | 2.75 ^{bc} ± 0.43 | 2.67 ^{bc} ± 0.38 | 1.92 ^b ± 0.29 | 2.42 ^b ± 0.36 | 2.44 ^c ± 0.23 |
| DW | 3.17 ^b ± 0.39 | 3.33 ^b ± 0.43 | 3.42 ^a ± 0.45 | 3.25 ^{ab} ± 0.43 | 3.29 ^b ± 0.15 |
| EC | 1.92 ^c ± 0.38 | 2.50 ^{bc} ± 0.38 | 2.83 ^{ab} ± 0.34 | 3.08 ^{ab} ± 0.36 | 2.58 ^c ± 0.16 |
| FW | 2.67 ^{bc} ± 0.26 | 2.00 ^c ± 0.43 | 3.08 ^a ± 0.47 | 2.25 ^b ± 0.41 | 2.50 ^c ± 0.11 |
| <i>Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.</i> | | | | | |
| Effectiveness of adaptation strategies related to livestock-rearing in Ghazipur (n=12) | | | | | |
| EB | 4.42 ^a ± 0.15 | 2.17 ^a ± 0.32 | 3.75 ^a ± 0.37 | 3.33 ^a ± 0.33 | 3.42 ^a ± 0.09 |
| CS | 2.00 ^c ± 0.28 | 3.08 ^a ± 0.31 | 1.50 ^b ± 0.26 | 3.08 ^a ± 0.51 | 2.42 ^b ± 0.20 |
| EC | 1.58 ^c ± 0.19 | 3.42 ^a ± 0.47 | 3.67 ^a ± 0.31 | 2.83 ^a ± 0.39 | 2.88 ^{ab} ± 0.17 |
| JC | 4.08 ^a ± 0.26 | 3.08 ^a ± 0.43 | 3.17 ^a ± 0.34 | 3.42 ^a ± 0.36 | 3.44 ^a ± 0.12 |
| FW | 3.08 ^b ± 0.38 | 3.25 ^a ± 0.46 | 3.00 ^a ± 0.41 | 2.58 ^a ± 0.43 | 2.98 ^a ± 0.28 |
| <i>Mean with different superscripts in a column differ significantly at a 5 percent level of significance. Multiple comparisons were based on DMRT.</i> | | | | | |

Conclusion

Regarding adaptation strategies followed for livestock, it was observed that the locally available and cheap remedies, most of which could be prepared homes and are easily available at farm fields formed an integral part of the adaptation strategies by the farmers; many of which lacked a scientific temper. Therefore, providing training that incorporates scientific knowledge along with indigenous techniques will be of immense help to the farmers. Awareness campaigns and training programmes regarding the vaccination protocols and sanitation practices to avoid diseases incidence on livestock should be organized by public authorities. Apart from standard improved livestock farming practices, there should be more induction of farmers related to advanced practices of adaptation to climate change. The study illustrated the value of documenting farmers' local livestock-rearing practices, as well as producing a package of local practices and disseminating them to other parts of the country to popularize them. In addition to the experimental research procedures, a participatory approach was introduced, thereby offering a valuable platform for both farmers and extension service providers to gain insight into different groundbreaking practices in climate-smart agriculture. The ultimate ideology of extension is "helping people help themselves" and the QUIK approach is one of the strategies that induce the involvement of major stakeholders in the decision-making process, so a successful strategy for promoting climate-smart agriculture could be developed with higher acceptance rates.

Conflict of Interests

There is no conflict of interest.

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