**An Analytical Study on the Challenges and Strategies for Enhancing the Adoption of Climate-Smart Agricultural Technologies (CSATs)**

**ABSTRACT**

Climate change has led to rising temperatures and unpredictable rainfall, threatening millions globally, especially in developing countries with limited resources. The rural poor, relying on agriculture, forestry, and fishing, are among the hardest hit. Climate-Smart Agriculture (CSA) was introduced by the FAO in 2010 to enhance productivity while ensuring sustainability. CSA includes practices like crop residue management, soil and water conservation, nutrition management, and pest control. CSA integrates adaptation and mitigation, addressing climate change while improving food security. This study in Chhattisgarh state assessed to reveal constraints of adaptation of Climate-Smart Agricultural Technologies (CSATs) among 360 farmers, selected through random sampling. Data was collected through an interview schedule and analysed using the Garrett ranking technique. Key challenges hindering CSATs adoption include limited information, inadequate weather-based advisory services, lack of technical training, difficulties in accessing quality inputs, and poor equipment maintenance. Farmers recommended reliable weather forecasting, modern training, and easy access to agricultural inputs for combating climate changes. Enhancing information dissemination, technical support, and resource availability is vital to overcoming these barriers, promoting CSAT adoption, and ensuring long-term agricultural sustainability.

**Key words:** Climate smart, Conservation, Challenges, CSAT, Sustainability.

**INTRODUCTION**

In recent decades, climate change has brought about rapid and lasting impacts, including rising temperatures and unpredictable shifts in rainfall patterns, posing a serious threat to millions of people worldwide. It is primarily driven by greenhouse gas emissions from both natural systems and human activities, leading to significant disruptions in weather patterns. Unfortunately, developing countries are the most affected, as their populations often have limited resources to cope with disasters or adapt to these environmental challenges. One of the hardest-hit groups is the rural poor, with nearly 70% depending on agriculture, forestry, and fishing for their livelihoods(Hertel and Lobell, 2014). To address these growing challenges, Climate-Smart Agriculture (CSA) was introduced as a way to manage agricultural systems more sustainably while responding effectively to climate change. The FAO first introduced the concept in 2010 at "The World Conference on Agriculture, Food Security, and Climate Change," presenting it as a strategy to enhance agricultural productivity while ensuring long-term sustainability.

To implement CSA effectively, various approaches have been outlined. FAO emphasizes practices such as crop residue management, soil and water conservation, nutrition management, knowledge sharing, and integrated pest control. Similarly, Chandra *et al.* (2017) categorized CSA strategies into five major areas: crop management, soil and water management, reclamation of degraded land and waste, and market and technology management. Since CSA encompasses a broad range of techniques, different strategies must be developed and prioritized based on specific conditions and communities while addressing its three core dimensions. Rather than being separate efforts, adapting to climate change and mitigating its negative impacts go hand in hand, making it possible to achieve all three CSA goals in practice. Although climate-smart agriculture can simultaneously decline greenhouse gas emissions, increase the adaptive capacity of farmers and improve food security under climate change, constraints are not entirely addressed. CSA practices and technologies, such as conservation agriculture and agroforestry continue to be under adopted by Indian smallholder farmers due to lack of financial resources for initial investments and existing insecure land tenure system (Negera, et al., 2022). Therefore, a better knowledge of factors that influence farmer's adoption behaviour is critical for developing policies that will sustainably increase the uptake of CSA practices. Empirical evidences indicate that smallholder farmers' adoption of CSA practices is greatly influenced by socio-economic, farm characteristics, institutional, access to basic infrastructure services, informational and technology awareness, social capital and climate-related factors (Nandini et al. 2023). This study was conducted in Chhattisgarh state to explore the problems in adopting of Climate smart agricultural technologies and suggestions recommended by farmers.

**OBJECTIVE**

To document the problems and suggestions for better adoption of Climate Smart Agriculture Technologies (CSATs) among the farmers.

**MATERIALS AND METHODS**

The study was conducted in 2022-24 in Chhattisgarh State, which include 33 districts. To represent the whole state, districts were selected from all three agro-climatic zones using proportional random sampling, with 20% of districts chosen from each region, resulting in six districts for the study. At the second stage, two blocks were randomly selected from each district, totalling 12 blocks. From each block, two villages were chosen randomly (24 villages in total). To assess constraints of Climate-Smart Agricultural Technologies (CSATs), 15 farmers were randomly selected from each village, leading to a total of 360 respondents. The selection was done using a simple random sampling method, and primary data was collected through individual interviews. The gathered data was entered and tabulated in Microsoft Excel and analysed as per the study’s objectives. The Garrett ranking technique was applied for further analysis, leading to meaningful findings and interpretations.

A list of constraints faced by farmers was compiled, and data on the rank order of these major problems were collected using a pretested structured schedule. To analyse the data, the Garrett ranking technique was employed. In this method, respondents were asked to rank the constraints they encountered across four different categories. These rankings were then converted into score values using the formula proposed by Garrett (1979). Garrett’s table was used to estimate the percent position, which was then converted into corresponding scores. Subsequently, the scores assigned by each individual for each constraint were summed up, and the total and mean scores were calculated. The constraint with the highest mean score was identified as the most significant and was assigned the top rank.

|  |  |
| --- | --- |
| Percent position = | 100 (Rij - 0.5) |
| **Nj** |

Where, Rij = Rank given for the ith attribute by jth respondent.

Nj = Number of attributes ranked by jth respondent.

Garrett’s table was used to estimate the percent position, which was then converted into corresponding scores. Subsequently, the scores assigned by each individual for each constraint were summed up, and the total and mean scores were calculated. The constraint with the highest mean score was identified as the most significant and was assigned the top rank.

**RESULTS AND DUSCUSSION**

**Problems in the adoption of climate smart agricultural technologies (CSATs)**

Observation of Table 1 highlights the problems / constraints faced by respondents in adopting Climate-Smart Agricultural Technologies (CSATs). The challenges reported by farmers were ranked based on the highest number of responses and presented in the table. Data express those major problems faced by the respondents in the study area for the adoption of climate smart agricultural technologies, that was poor information accessibility and utilization of weather based agro advisory services ranked 1st with garret score 60.67 % followed by lack of technical knowledge and guidance about the Climate Smart Agricultural Technologies and scarcity of quality seeds, fertilizers, and pesticides, coupled with inadequate equipment maintenance at Custom Hiring Centres during seasonal demand ranked 2nd and 3rd with garret score 58.57 % and 57.39 % respectively. Moreover, findings of the study indicate that other major problems reported by respondents were lack of effective extension support for adoption of CSATs, Inability to wait for longer duration to get positive returns from adopted interventions (time incompatibility), uncertain returns due to market fluctuations ranked 4th,5th and 6th with garret score 55.19 %, 52.50 % and 50.08 % respectively. Whereas, Agronomic practices are more expensive when dealing with Climate change, Lack of awareness about climate change issues, lack of promoting activities and subsidies for adoption of CSATs and lack of skilled labours for adoption of climate smart agricultural practices ranked 7th, 8th, 9th and 10th with garret score 47.16 %, 46.80%, 44.71 % and 37.78 % respectively.

**Table 1: Constraints faced by the farmers in the adaptation of Climate Smart Agricultural Technologies (CSATs).**

|  |  |  |  |
| --- | --- | --- | --- |
| SL. No. | Constraints in adoption | Garret score % | Rank |
| 1 | Lack of effective extension support for adoption of CSATs | 55.19 | IV |
| 2 | Lack of technical knowledge and guidance about the Climate Smart Agricultural Technologies | 58.67 | II |
| 3 | Unavailability of quality seeds, fertilizers, and pesticides, coupled with inadequate equipment maintenance at Custom Hiring Centres during peak demand | 57.39 | III |
| 4 | Inability to wait for longer duration to get positive returns from adopted interventions (time incompatibility) | 52.50 | V |
| 5 | Agronomic practices are more expensive when dealing with Climate change | 47.16 | VII |
| 6 | Lack of promoting activities and subsidies for adoption of CSATs | 44.71 | IX |
| 7 | Lack of trained labour for adoption of climate smart agricultural practices | 37.78 | X |
| 8 | Poor information accessibility and utilization of weather based agro advisory services | 60.67 | I |
| 9 | Uncertain returns due to market fluctuations | 50.08 | VI |
| 10 | Lack of awareness about climate change issues | 46.80 | VIII |

**Suggestions given by the farmers to overcome from barriers in adoption of CSATs**

The respondents of the study area were also asked about their suggestions for better adoption of CSA technologies. Table 2 reveals that the majority of the respondents suggested that Mechanism for timely information about weather forecasting should be available to farmers which ranked 1st with mean score 2.50 followed by technical knowledge and guidance should be provided towards climate smart agriculture technologies and availability of agricultural inputs at village level on time at lower price ranked 2nd and 3rd with mean score 2.42 and 2.41 respectively.

**Table 2: Suggestion for greater adaptation of Climate Smart Agricultural   
Technologies (CSATs)**

|  |  |  |  |
| --- | --- | --- | --- |
| SL. No | Farmers' suggestion | Mean scores | Rank |
| 1. | Mechanism for timely information about weather forecasting should be available to farmers. | 2.50 | I |
| 2. | Technical knowledge and guidance should be provided towards CSATs. | 2.42 | II |
| 3. | Facilitate the various training programmes for acquiring knowledge about climate change to farmers. | 2.37 | IV |
| 4. | Availability of agricultural inputs at village level on time at lower price. | 2.41 | III |
| 5. | Need based water supply in canal should be ensure. | 2.33 | VI |
| 6. | Effective extension service should be available to the farmers. | 2.35 | V |
| 7. | Demonstration of climate smart agricultural technologies in villages. | 2.32 | VII |
| 8. | Providing financial support for soil nutrient enrichment. | 2.02 | IX |
| 9. | Distribution of literature on Climate Smart Agricultural Technologies. | 1.91 | X |
| 10. | Arranging field visits to CSATs adopted successful farm. | 2.30 | VIII |

Further facilitation of various training programmes should be organised for acquiring knowledge about climate change to farmers, effective extension service should be available to the farmers and need based water supply in canal should be ensure ranked 4th, 5th and 6th with mean score 2.2.37, 2.35 and 2.33, respectively.

The other suggestions provided by respondents were, demonstration of climate smart agricultural practices in villages, arranging visits to successful field, providing financial support for soil nutrient enrichment and distribution of literature related to Climate Smart Agricultural Technologies should be distributed to the farmers ranked 7th, 8th, 9th and 10th with mean score 2.32, 2.30, 2.02 and 1.91, respectively.

**CONCLUSION**

Successful adoption of Climate-Smart Agricultural Technologies (CSATs) is hindered by several key challenges, including limited access to information, inadequate utilization of weather-based agro-advisory services, and a lack of technical knowledge and training. Additionally, difficulties in obtaining quality agricultural inputs and poor equipment maintenance further restrict implementation. To overcome these barriers, farmers emphasized the need for a reliable weather forecasting system, improved technical training, and better accessibility to essential agricultural inputs at the village level. Addressing these issues through enhanced information dissemination, technical support, and resource availability will be crucial for promoting CSATs adoption. By implementing these recommendations, farmers could adopt better to climate change, improve productivity, and ensure long-term sustainability in agriculture.

**References**

Aryal, J. P., Rahut, D. B., Maharjan, S. and Erenstein, O. 2018. Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo Gangetic Plains of *India. Nat. Res. Forum*, 42: 141-158. <https://doi.org/10.1111/1477-8947.12152>

Baidhya, K. 2022. Study on awareness and adaptation of Climate Smart Agricultural Practices by the farmers of Chhattisgarh Plains. Ph.D. Thesis. IGKV, Raipur (C.G)

Chandra, A.; Dargusch, P.; Mcnamara, K.E.; Caspe, A.M.; Dalabajan, D. 2017. A study of climate-smart farming practices and climate-resiliency field schools in Mindanao, the Philippines. World Dev. 98, 214-230.

FAO. Climate Change and Food Security: Risks and Responses.

FAO. Climate Smart Agriculture Source Book; FAO: Rome, Italy, 2013

Fawzy, S.; Osman, A.I.; Doran, J.; Rooney, D.W. 2020. Strategies for mitigation of climate change: A review. *Environ. Chem. Lett*. 18, 2069-2094.

Füssel, H.M. 2007. Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. Sustain. Sci. 2, 265–275.

Garrett, H.E. 1979. Statistics in Psychology and Education. Vakils Feffer and Simons Ltd., Bombay, India.

IPCC. Food Security and Food Production Systems in Climate Change 2014: Impacts, Adaptation, and Vulnerability. IPCC Working Group II Contribution to AR5, IPCC/World Meteorological Organization, Geneva.

Mallappa, H. V. K. and Pathak, T. B. 2023. Climate smart agriculture technologies adoption among small-scale farmers: a case study from Gujarat, India. *Front. Sustain. Food Syst*, 7: 20-24. <https://doi.org/10.3389/fsufs.2023.1202485>

Musemwa, L.; Muchenje, V.; Mushunje, A.; Zhou, L. 2012. The impact of climate change on livestock production amongst the resource-poor farmers of Third World Countries: A review. Asian J. Agric. Rural Dev. 2, 621–631.

Mwongera, C.; Shikuku, K.M.; Twyman, J.; Läderach, P.; Ampaire, E.; Van Asten, P.; Twomlow, S.; Winowiecki, L.A. 2017. Climate smart agriculture rapid appraisal: A tool for prioritizing context-specific climate smart agriculture technologies. Agric. Syst. 151, 192–203.

Nassiri, M.; Koocheki, A.; Kamali, G.A.; Shahandeh, H. 2006. Potential impact of climate change on rainfed wheat production in Iran. Arch. Agron. Soil Sci. 52, 113-124.

Panda and Shivamurthy, 2017. Information Needs for climate change adaptation and climate smart agricultural technologies among rice-pulse growing farmers in puri district of Odisha, *India. Int. J. Adv. Res*, **5**(8): 172-181.

United Nations Association of Iran. Climate Change and Iran. UNA-IRAN Report. 2008.

Wekesa, B.M. 2013. Effect of Climate Smart Agricultural Practices on Food Security of Small-Scale Farmers in Teso North Sub-County, Kenya. Master’s Thesis, Egerton University, Njoro, Kenya.

Hertel, T. W., & Lobell, D. B. (2014). Agricultural adaptation to climate change in rich and poor countries: Current modeling practice and potential for empirical contributions. *Energy Economics*, *46*, 562-575.

Nandini H. M., Venkataramana, M. N., Anil K., & Thimmegowda, M. N. (2023). Determinants of Adoption of Climate Smart Agricultural Technologies among Farm Households in Southern Karnataka, India. International Journal of Environment and Climate Change, 13(11), 4354–4366. <https://doi.org/10.9734/ijecc/2023/v13i113616>

Negera, M., Alemu, T., Hagos, F., & Haileslassie, A. (2022). Determinants of adoption of climate smart agricultural practices among farmers in Bale-Eco region, Ethiopia. *Heliyon*, *8*(7).