P-ISSN 2322 - 0678 & E-ISSN 3048 - 9946
https://doi.org/10.56572/gjoee.2026.41.1.0001

DRIVERS AND CONSTRAINTS FOR ADOPTION OF CLIMATE RESILIENT TECHNOLOGIES ACROSS DIFFERENT AGRO-ECOLOGICAL REGIONS

B. Devojee[1], J. V. Prasad[2] and Shaik N. Meera[3]

1 Senior Research Fellow, TDC-NICRA Project, ICAR-ATARI, Hyderabad-500059
2 Principal Scientist, ICAR-ATARI, Hyderabad-500059
3 Director, ICAR-ATARI, Hyderabad -500 059
Email : devojibhookya@gmail.com

ABSTRACT

The present study assessed the drivers and constraints influencing the adoption of Climate-Resilient Technologies (CRTs) across diverse agro-ecological regions of India using a standardized methodological framework jointly developed by the International Water Management Institute (IWMI) and the Central Research Institute for Dryland Agriculture (CRIDA). The study covered 30 Krishi Vigyan Kendras (KVKs) across 23 states and one Union Territory, representing a wide range of climatic vulnerabilities and agro-ecological zones. Three key stakeholder groups, KVK scientists (n=3), line department officials (n=5), and NICRA-associated farmers (n=10), were purposively selected to capture scientific, administrative, and grassroots perspectives. Data were collected through a structured interview schedule using Likert scales (0–5 and 0–3) to quantify perceptions related to implementation feasibility, adoption barriers, incentive mechanisms, and institutional support systems. Climate-resilient interventions across crop production, livestock and fisheries, water-saving technologies, soil health management, and ex-situ natural resource management were systematically evaluated. Results revealed that crop production technologies were perceived as the most technically feasible (mean score 4.04), followed by water-saving technologies (3.85) and livestock and fisheries interventions (3.76). Ex-situ water harvesting technologies showed the highest alignment with government programmes (3.66). Women's participation was highest in livestock and crop-based interventions, while lower inclusivity was observed in soil and moisture conservation practices. The major barriers to CRT adoption were low technology acceptability (3.26), limited awareness (2.98), and labour constraints (2.95), outweighing purely financial limitations. Access to capacity building (3.23) and market linkages (2.60) emerged as the most influential enabling factors, whereas subsidies and affordable credit played a relatively limited role. Custom Hiring Centers, youth farmer groups, and women self-help groups were identified as the most effective institutional mechanisms for scaling CRTs. The study concludes that strengthening knowledge systems, institutional support, and policy convergence is critical for accelerating the adoption of climate-resilient technologies in India.

Keywords: *Implementation feasibility, synergy with govt plans and inclusivity of women*

INTRODUCTION

Climate variability and extreme weather events are increasingly threatening agricultural productivity, natural resource sustainability, and rural livelihoods in India. Frequent droughts, floods, heat waves, cyclones, and soil degradation have heightened the vulnerability of farming systems, particularly in rainfed and marginal areas. In this context, Climate-Resilient Technologies (CRTs) have emerged as critical interventions for enhancing the adaptive capacity of farmers, improving resource-use efficiency, and ensuring sustainable agricultural production under changing climatic conditions (Tajpara et al., 2018; Tajpara et al., 2020; Thakor and Joshi, 2024; Tiwari et al., 2024).

The Government of India, through initiatives such as the National Innovations in Climate Resilient Agriculture (NICRA) programme, has promoted a range of location-specific technologies and practices to address climate-induced risks (Tajpara et al., 2020; Tiwari et al., 2024). These interventions span crop production, livestock and fisheries, soil and water conservation, water-saving technologies, and natural resource management. Several studies have demonstrated the positive impact of climate-resilient technologies on productivity, resilience, and socio-economic development of farming communities (Tajpara et al., 2018; Thakor and Joshi, 2024). However, despite their proven technical potential, the adoption of CRTs at the field level remains uneven across regions due to a combination of technical, socio-economic, institutional, and behavioral factors (Singh, 2021; Vinaya and Pathak, 2023; Vinaya Kumar and Shivamurthy, 2021).

Understanding the drivers and constraints that influence the adoption of Climate-Resilient Technologies (CRTs) is essential for designing effective policies, extension strategies, and institutional mechanisms. Adoption is not solely determined by technical feasibility but is also shaped by farmers' perceptions, access to knowledge and resources, market opportunities, and institutional support systems (Feder et al., 1985; Shiferaw et al., 2009; Nhemachena et al., 2014). Previous studies have highlighted that awareness, capacity building, and access to extension services play a crucial role in enhancing the adoption of climate-resilient technologies among farmers (Meena et al., 2013; Sulaiman et al., 2005; Tiwari et al., 2024). Multi-stakeholder perspectives are therefore crucial to capture the complex realities that influence technology uptake and to develop effective climate adaptation strategies (Kristjanson et al., 2012; Mills et al., 2017; Ghasura et al., 2024).

In this background, the present study was undertaken using a standardized framework developed by IWMI and CRIDA to systematically assess the implementation feasibility, perceived barriers, incentive mechanisms, and institutional drivers of CRT adoption across diverse agro-ecological regions of India. Previous studies have emphasized the need for systematic assessment of climate-resilient technologies to understand factors influencing their adoption, scaling, and long-term sustainability under changing climatic conditions (FAO, 2017; ICAR-CRIDA, 2019; Prasad et al., 2014). The study aims to generate evidence-based insights to strengthen extension strategies, improve policy convergence, and enhance the scaling of climate-resilient technologies for sustainable and resilient agricultural development (Sulaiman et al., 2005; Kristjanson et al., 2012; Mills et al., 2017; Singh, 2021).

OBJECTIVE

To analyze the drivers and constraints influencing the adoption of promising climate-resilient technologies among farmers.

METHODOLOGY

Study Area

The study was conducted across 30 Krishi Vigyan Kendras (KVKs) located in 23 states and one Union Territory of India, representing diverse agro-ecological regions and climate vulnerabilities such as drought, floods, heat waves, frost, cyclones, salinity, and waterlogging (Table 1). The selected KVKs represented major agro-ecological zones as classified by the NBSS&LUP (2015), ensuring broad geographic and climatic representation. Such diversity in agro-ecological and climatic conditions is essential for evaluating the performance, feasibility, and adoption potential of climate-resilient technologies across varied farming systems and vulnerability contexts (ICAR-CRIDA, 2019; IPCC, 2022; Birthal et al., 2014). Similar approaches have been adopted in studies assessing climate-resilient agriculture interventions across diverse agro-ecological regions to capture location-specific adaptation needs and responses (FAO, 2017; Prasad et al., 2014).

Research Design

A descriptive and analytical research design was adopted to examine the drivers and constraints influencing the adoption of Climate-Resilient Technologies (CRTs). The study employed a standardized methodological framework jointly developed by IWMI and CRIDA, which provided structured tools and indicators for assessing implementation feasibility, adoption barriers, incentive mechanisms, and institutional support systems. Similar analytical approaches have been widely used in studies on agricultural technology adoption and climate change adaptation to systematically assess the socio-economic, institutional, and behavioural factors influencing farmers' decision-making processes (Feder et al., 1985; Shiferaw et al., 2009; Nhemachena et al., 2014). Previous studies have also emphasized the importance of multi-stakeholder assessment frameworks for evaluating the effectiveness and scalability of climate-resilient technologies and adaptation interventions (Kristjanson et al., 2012; Mills et al., 2017; FAO, 2017).

Selection of Respondents

Three categories of stakeholders were purposively selected to ensure balanced scientific, administrative, and farmer perspectives on the adoption of Climate-Resilient Technologies (CRTs), comprising KVK scientists associated with NICRA (n = 3), line department officials from multiple disciplines (n = 5), and NICRA-associated farmers (n = 10). Thus, a total of 18 respondents were selected from each KVK based on their direct involvement, experience, and knowledge of climate-resilient interventions. The inclusion of multiple stakeholder groups enabled a comprehensive assessment of technical feasibility, institutional support, adoption barriers, and scaling opportunities of CRTs, as recommended in studies emphasizing participatory and multi-stakeholder approaches for evaluating climate adaptation technologies and agricultural innovation systems (Kristjanson et al., 2012; Mills et al., 2017; Sulaiman et al., 2005). Similar stakeholder-based assessment approaches have been used in climate-resilient agriculture studies to capture diverse perspectives and improve the relevance of policy and extension recommendations (FAO, 2017; Ghasura et al., 2024; Parikh et al., 2024).

Data Collection Tools and Indicators

Stakeholder perceptions regarding the implementation feasibility of Climate-Resilient Technologies (CRTs), perceived adoption barriers, incentive mechanisms, and institutional support systems. Responses were recorded using Likert-type scales (0–5 and 0–3), where higher scores indicated greater relevance or significance. Similar perception-based assessment tools have been widely employed in studies evaluating agricultural technology adoption, climate change adaptation, and extension interventions (Meena et al., 2013; Jasna et al., 2014; Bhabhor et al., 2024; Tiwari et al., 2024). Implementation feasibility was assessed using five key indicators, namely technical feasibility, inclusivity of women, synergy with government schemes, cost implications, and realized benefits. The major categories of CRTs evaluated included crop production technologies, livestock and fisheries interventions, soil health and fertility management, water-saving technologies, and ex-situ natural resource management practices. These indicators have been recognized as important dimensions for assessing the suitability, acceptability, and scalability of climate-resilient technologies across diverse agro-ecological conditions (Prasad et al., 2014; ICAR-CRIDA, 2019; Thakor and Joshi, 2024).

Data Analysis

All responses were compiled and coded in spreadsheet software for analysis. Descriptive statistical techniques, including calculation of mean scores and weighted averages, were used to interpret stakeholder perceptions. Comparative analysis was carried out across different CRT categories and stakeholder groups to identify variations in feasibility, constraints, incentives, and institutional roles. Similar analytical approaches have been employed in studies examining the adoption of climate-resilient technologies, farmer perceptions, and climate change adaptation strategies to generate evidence-based insights for policy and extension interventions (Meena et al., 2013; Jasna et al., 2014; Ghasura et al., 2024; Parikh et al., 2024). The analytical framework enabled systematic identification of key drivers and constraints and provided an empirical basis for developing recommendations for strengthening the adoption and scaling of climate-resilient technologies across India. Such evidence-based assessments are essential for designing effective extension programmes, institutional support mechanisms, and climate adaptation policies (Sulaiman et al., 2005; FAO, 2017; ICAR-CRIDA, 2019).

Table 1: Study area of project 30 KVKs (23 states and 1 UT)

Sr. No	Zone	State	Name of KVK	Vulnerability	Agro-ecological region represented (NBSSLUP 2015)
1	I	Punjab	Faridkot	High Temperature	Western Plains
2		H. P	Kullu	Drought and cold wave	Western Himalayas
3		Uttarakhand	Uttarkashi	Drought	Western Himalayas
4	II	Rajashthan	Jhunjhunu	Frost and heat stress	Western Plains
5		Haryana	Sirsa	Salinity and heat wave	Western Plains
6	III	UP	Gonda	Floods	Eastern Plains
7			Hamirpur	Drought and heat wave	Northern Plain and Central Highlands
8	IV	Jharkhand	Gumla	Drought and heat wave	Eastern plateau (Chattisgarh)
9			Godda	Drought	Eastern (Chhotanagpnr) Plateau and Eastern Ghats
10		Bihar	Aurangabad	Drought	Northern plain
11	V	West Bengal	Coochbehar	Heavy rainfall	Bengal and Assam Plain
12		Odisha	Kendrapara	Flood and cyclone	Eastern Coastal Plain
13		A & N	Andamans	Cyclone	Islands of A &N
14	VI	Assam	Dhubri	Flash floods and terminal drought	Bengal & Assam plain

Sr. No	Zone	State	Name of KVK	Vulnerability	Agro-ecological region represented (NBSSLUP 2015)
15		Sikkim	East Sikkim	Hailstorm, frost and long dry spells	Eastern Himalayas
16	VII	Mizoram	Lunglei	Water stress	North-eastern Hills (Purvachal)
17		Nagaland	Mon	Water scarcity	North-eastern Hills (Purvachal)
18	VIII	Maharashtra	Jalna -I	Drought	Deccan Plateau
19			Nandurbar	Drought and soil erosion	Deccan Plateau
20		Gujarath	Banaskantha-I	Drought	Western Plain. Kachchh and part of Kathia war Peninsula
21	IX	Chattishgarh	Bhatapara	Drought	Eastern Plateau
22		M.P	Datia	Drought	Northern Plain and Central Highlands
23		M.P	Tikamgarh	Drought	Central Highlands (Malwa. Bundelkhand & Eastern Satpura
24		M.P	Jhabua	Drought	Central (Malwa) Highlands. Gujarat Plains & Kathiawar Peninsula
25	X	A. P	Srikakulam	Floods	East Coast Plain
26		A. P	Kurnool	Drought	Deccan plateau and Eastern Ghats
27		Telangana	Khammam-I	Drought	Deccan (Telangana) Plateau and Eastern Ghats
28		Tamilnadu	Namakkal	Drought and heat stress	Eastern Ghats. TN uplands and Deccan (Karnataka) Plateau
29	XI	Karnataka	Tumkur	Drought	Deccan Plateau (hot arid region)
30		Kerala	Alaphuza	Water logging / salinity	Western Ghats & Coastal Plain

RESULTS AND DISCUSSION

Implementation feasibility of Climate Resilient Technologies

The implementation feasibility of Climate-Resilient Technologies (CRTs) was assessed based on stakeholders' perceptions regarding multiple dimensions influencing their adoption and scaling. Feasibility was conceptualized as an interplay of five key indicators, namely technical feasibility, synergy with government schemes, inclusivity of women, cost implications, and realized benefits. These indicators collectively determine the suitability, acceptability, and sustainability of CRT interventions under diverse agro-ecological and socio-economic conditions (Prasad et al., 2014; ICAR-CRIDA, 2019; Thakor and Joshi, 2024). In addition to implementation feasibility, the study examined perceived adoption barriers, incentive mechanisms for promoting CRT interventions, and the role of key institutions in scaling out climate-resilient technologies. Understanding these dimensions is critical for identifying the drivers and constraints influencing technology uptake and for developing effective extension, policy, and institutional support strategies (Feder et al., 1985; Shiferaw et al., 2009; Kristjanson et al., 2012; Mills et al., 2017).

Technical feasibility of climate resilient technologies

`The assessment of the technical feasibility of Climate-Resilient Technologies (CRTs) presented in Fig. 1

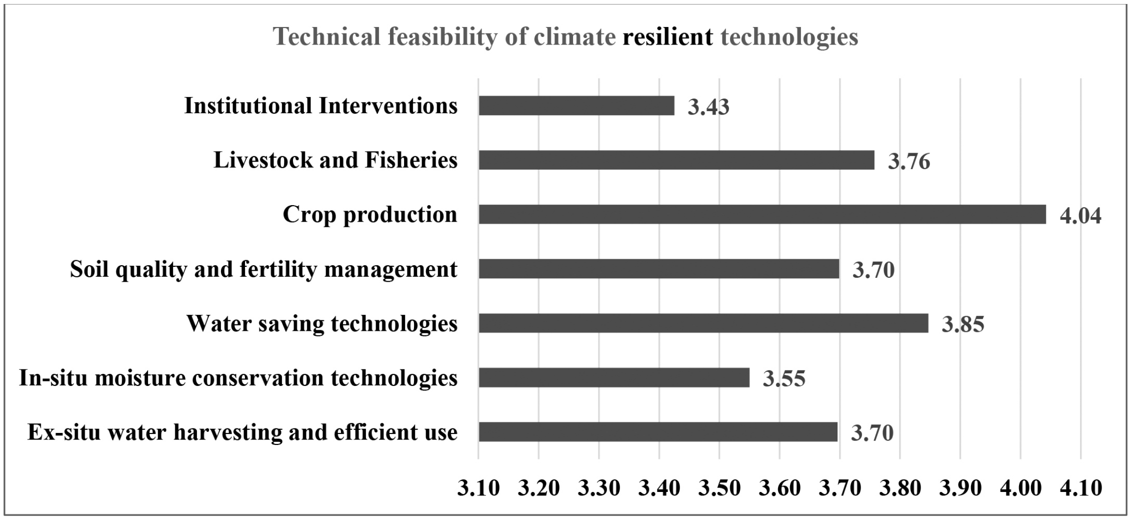

Fig.1 : Technical feasibility of climate resilient technologies

indicates that crop production technologies were perceived as the most feasible (mean score: 4.04), reflecting farmers' confidence in improved agronomic and crop management practices. Similar findings were reported by Meena et al. (2013), Jasna et al. (2014), and Thakor and Joshi (2024), who observed higher acceptance of crop-based climate-resilient technologies due to their visible benefits and ease of adoption. This was followed by water-saving technologies (3.85) and livestock and fisheries interventions (3.76), suggesting strong acceptance of practices that enhance resource-use efficiency and diversify farm livelihoods. Moderately high feasibility was reported for soil quality and fertility management (3.70) and ex-situ water harvesting and efficient use (3.70), indicating positive stakeholder perceptions towards soil and water conservation practices. Similar observations regarding the effectiveness of water conservation and harvesting interventions were reported by Getanah and Tsigae (2013) and Yosef and Kidane (2015). In-situ moisture conservation technologies scored 3.55, indicating certain practical challenges in field-level implementation under diverse agro-ecological conditions. Institutional interventions recorded the lowest feasibility score (3.43), highlighting limitations related to coordination, accessibility, and operational complexity. Previous studies have emphasized that institutional and behavioural factors often influence technology adoption more strongly than technical feasibility alone (Feder et al., 1985; Shiferaw et al., 2009; Vinaya Kumar and Shivamurthy, 2021). Overall, the findings indicate that field-level crop and water management technologies are perceived as more feasible and readily adoptable than institutional-level interventions.

Synergy with government plans

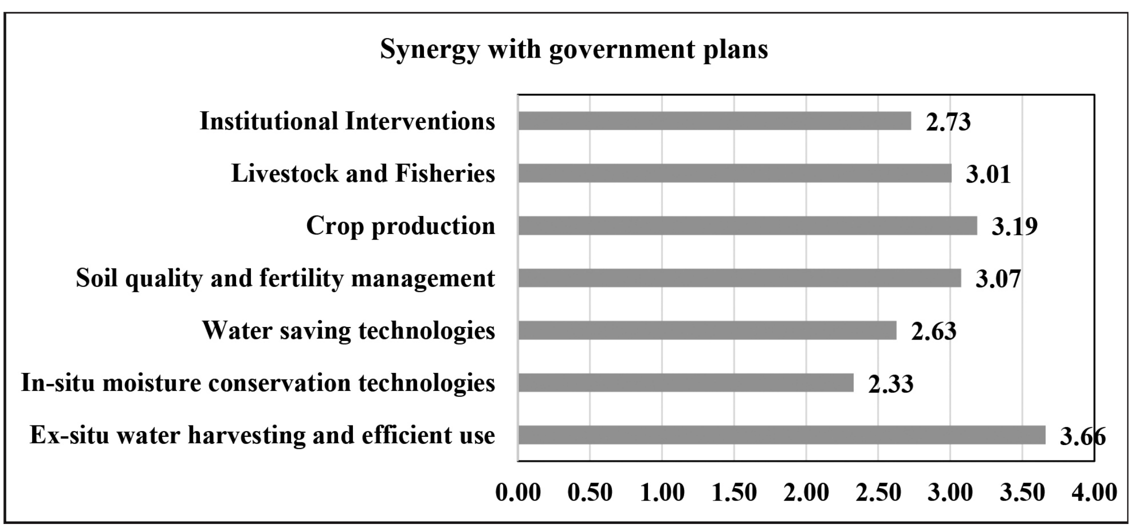

Fig.2 : Synergy with government plans

The assessment of synergy with government plans presented in Fig. 2 revealed that ex-situ water harvesting and efficient use technologies exhibited the highest alignment (mean score: 3.66), indicating strong integration with ongoing government schemes and development programmes. This finding is consistent with earlier studies highlighting the importance of government-supported water resource management interventions in enhancing climate resilience and resource-use efficiency (Prasad et al., 2014; ICAR-CRIDA, 2019; Yosef and Kidane, 2015). Crop production technologies (3.19) and soil quality and fertility management practices (3.07) also demonstrated relatively high levels of convergence with government programmes, reflecting sustained policy support and institutional backing for these interventions. Similar observations were reported by Tajpara et al. (2020) and Thakor and Joshi (2024), who documented the positive role of government-supported climate-resilient technologies in improving farm productivity and resilience. Moderate synergy was observed for livestock and fisheries interventions (3.01) and institutional interventions (2.73), suggesting partial integration within existing development frameworks. Water-saving technologies (2.63) and particularly in-situ moisture conservation technologies (2.33) showed comparatively lower levels of convergence with government plans, indicating gaps in policy prioritization, funding support, and implementation mechanisms. Previous studies have emphasized that stronger institutional coordination, extension support, and policy convergence are critical for enhancing the adoption and scaling of climate-resilient technologies (Sulaiman et al., 2005; Kristjanson et al., 2012; Mills et al., 2017). Overall, the findings underscore the need for improved integration of water and moisture conservation technologies into government programmes to facilitate wider adoption and long-term sustainability.

Inclusivity of women

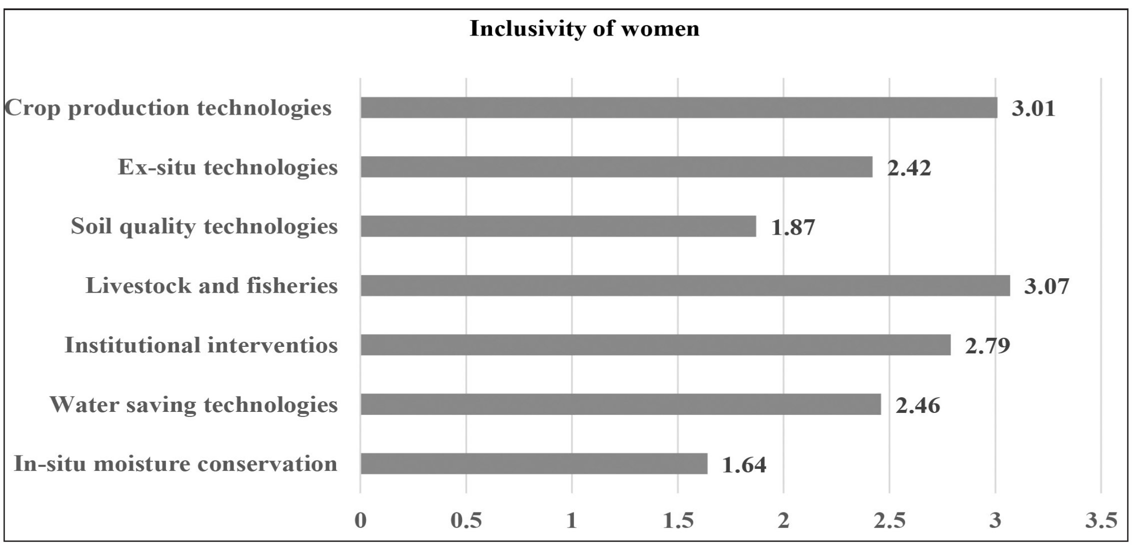

Fig.3 : Inclusivity of Women

The analysis of women's inclusivity in Climate-Resilient Technologies (CRTs) presented in Fig. 3 revealed that livestock and fisheries interventions recorded the highest level of women's participation (mean score: 3.07), followed closely by crop production technologies (3.01). This indicates that women are more actively engaged in activities related to animal husbandry, fisheries, and crop production, which are traditionally associated with their roles in farm households. Similar findings were reported by Parikh et al. (2024), who observed that women play a significant role in climate adaptation and agricultural decision-making processes. Institutional interventions exhibited moderate inclusivity (mean score: 2.79), reflecting women's participation through self-help groups, farmer organizations, and development programmes. Lower participation was observed in water-saving technologies (2.46) and ex-situ water harvesting technologies (2.42), suggesting limited access to infrastructure-intensive interventions and decision-making processes. The lowest inclusivity was reported for soil quality technologies (1.87) and in-situ moisture conservation technologies (1.64), indicating persistent gender gaps in natural resource management activities. Similar constraints related to women's access to climate-resilient technologies, information, and resources have been documented in climate adaptation studies (FAO, 2017; Kristjanson et al., 2012; Vinaya and Pathak, 2023). Overall, the findings underscore the need for gender-responsive extension approaches, targeted capacity-building programmes, and institutional support mechanisms to enhance women's participation in soil and water management interventions and ensure inclusive scaling of climate-resilient technologies.

Implementation Feasibility scores of CRTs

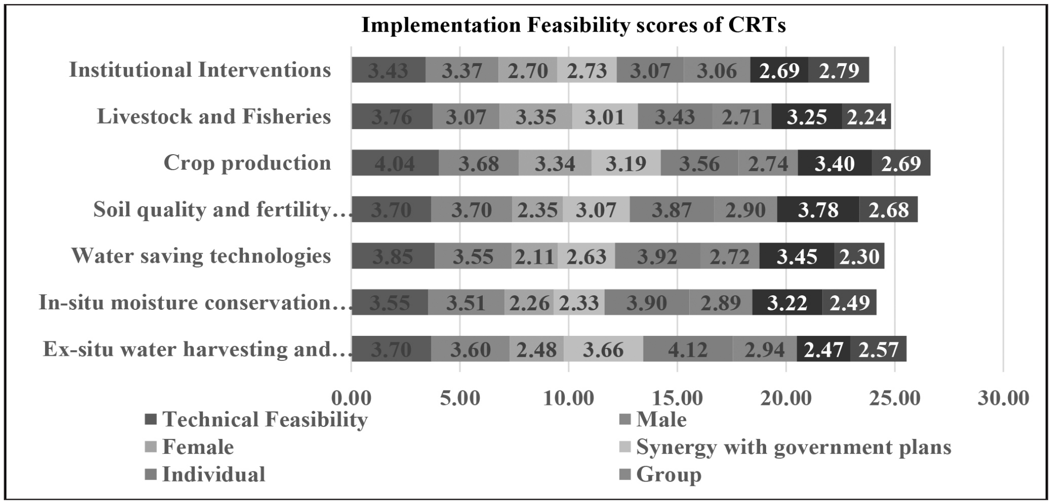

Fig.4 : Implementation Feasibility scores of CRTs

The implementation feasibility scores of Climate-Resilient Technologies (CRTs) presented in Fig. 4 varied across intervention categories and adoption dimensions. Crop production technologies recorded consistently high scores for technical feasibility and perceived ease of implementation, indicating strong field-level applicability and farmer confidence in these interventions. Similar findings were reported by Meena et al. (2013), Jasna et al. (2014), and Thakor and Joshi (2024), who observed greater acceptance of crop-based climate-resilient technologies due to their visible benefits and compatibility with existing farming practices. Ex-situ water harvesting and efficient water-use technologies also demonstrated high overall feasibility, particularly in terms of synergy with government programmes and implementation through both individual and group approaches, reflecting strong institutional and policy support. Comparable observations were reported by Yosef and Kidane (2015) and Tajpara et al. (2020), who highlighted the effectiveness of water resource management interventions in enhancing climate resilience.

Livestock and fisheries interventions, along with soil quality and fertility management technologies, exhibited moderate to high feasibility, suggesting that these technologies are technically sound but may require additional capacity building, extension support, and awareness creation for wider adoption. Similar findings were reported by Vinaya Kumar and Shivamurthy (2021) and Vinaya and Pathak (2023), who emphasized the role of farmer perceptions, knowledge, and institutional support in influencing adoption behaviour. Water-saving technologies and in-situ moisture conservation practices recorded relatively lower scores in terms of policy convergence and implementation ease, particularly for individual adoption, indicating operational, financial, and resource-related challenges at the farm level. Similar constraints were identified by Bhabhor et al. (2024), Ghasura et al. (2024), and Tiwari et al. (2024), who reported inadequate awareness, technical guidance, and institutional support as major barriers to climate adaptation.

Institutional interventions showed mixed feasibility outcomes, with lower scores for individual-level implementation but better performance under group-based approaches, highlighting the importance of collective action and stakeholder participation. Previous studies have emphasized that farmer organizations, community institutions, and multi-stakeholder platforms play a crucial role in facilitating technology dissemination and scaling (Kristjanson et al., 2012; Mills et al., 2017; Sulaiman et al., 2005). Overall, the findings indicate that technologies related to direct crop and water resource management are more feasible and scalable, particularly when supported by strong policy convergence, institutional backing, and group-based implementation mechanisms.

Perceived adoption barriers for adapting CRTs

The study presented in Fig. 5 revealed that acceptability of technology was the major barrier to the adoption of Climate-Resilient Technologies (CRTs) (mean score: 3.26). This was followed by lack of awareness (2.98) and labour availability (2.95), indicating that knowledge gaps and labour shortages significantly influence adoption decisions. Similar findings were reported by Bhabhor et al. (2024) and Tiwari et al. (2024), who observed that inadequate awareness and limited knowledge of climate-resilient practices were among the major constraints affecting technology adoption. Moderate barriers included access to extension services (2.87) and availability of water (2.73),

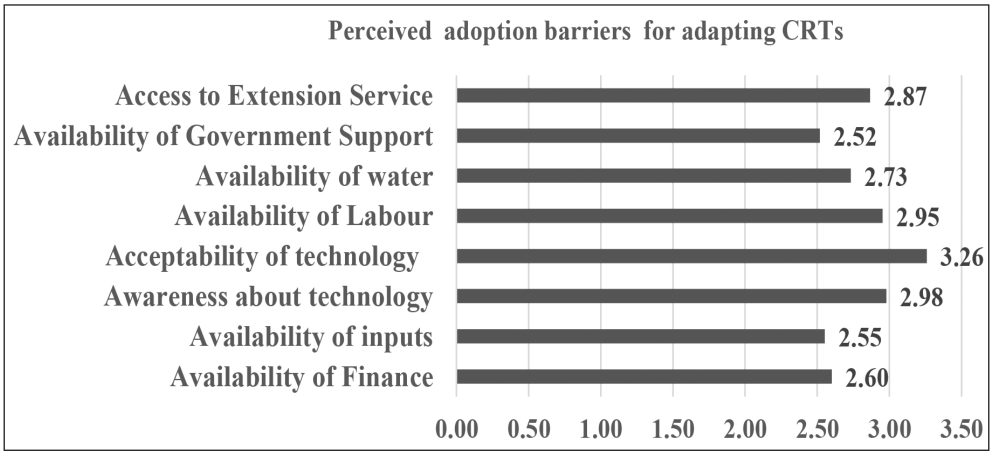

Fig. 5 : Perceived adoption barriers for adapting CRTs

highlighting the importance of effective advisory support and natural resource availability in promoting climate adaptation. Previous studies have emphasized the critical role of extension systems and institutional support in facilitating technology uptake among farmers (Sulaiman et al., 2005; Mills et al., 2017). Lower but still important constraints were availability of finance (2.60), inputs (2.55), and government support (2.52). Similar constraints related to resource availability, institutional support, and technology acceptance were reported by Ghasura et al. (2024), Pokiya et al. (2024), and Vinaya Kumar and Shivamurthy (2021). Overall, the findings suggest that perception- and knowledge-related barriers are more significant than financial constraints in limiting the adoption of CRTs, which is consistent with earlier studies on climate change adaptation and agricultural technology adoption (Feder et al., 1985; Shiferaw et al., 2009; Vinaya and Pathak, 2023).

Incentive mechanisms to promote CRT interventions

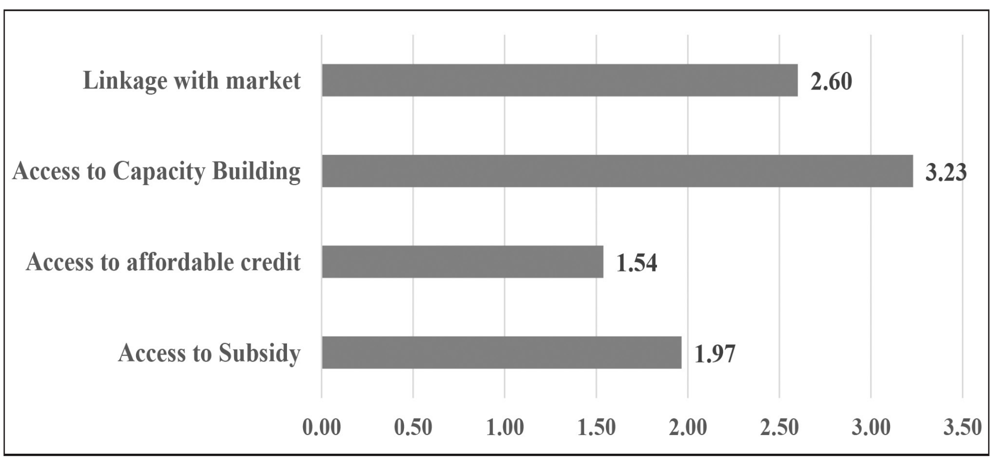

Fig.6 : Incentive mechanisms to promote CRT interventions

The results presented in Fig. 6 indicate that access to capacity building was the strongest driver for the adoption of Climate-Resilient Technologies (CRTs) (mean score: 3.23), highlighting the critical role of training, skill development, and technical support in enhancing farmers' adaptive capacity. Similar findings were reported by Sulaiman et al. (2005), Tiwari et al. (2024), and Thakor and Joshi (2024), who emphasized the importance of extension services and capacity-building programmes in promoting the adoption of climate-resilient agricultural practices. Market linkages also positively influenced adoption (2.60), indicating the significance of market access and economic opportunities in encouraging farmers to invest in climate-resilient technologies. In contrast, access to subsidies (1.97) and affordable credit (1.54) were perceived as relatively weak enablers, suggesting limited effectiveness of financial incentives in driving technology adoption. Similar observations were reported by Pokiya et al. (2024), Ghasura et al. (2024), and Vinaya K. Hebsale Mallappa and Pathak (2023), who found that awareness, knowledge, and institutional support often play a more decisive role than financial assistance alone. Overall, the findings highlight that knowledge-based support mechanisms are more critical than financial incentives in promoting the adoption and scaling of climate-resilient technologies.

Key Institutions to Scale out CRT interventions

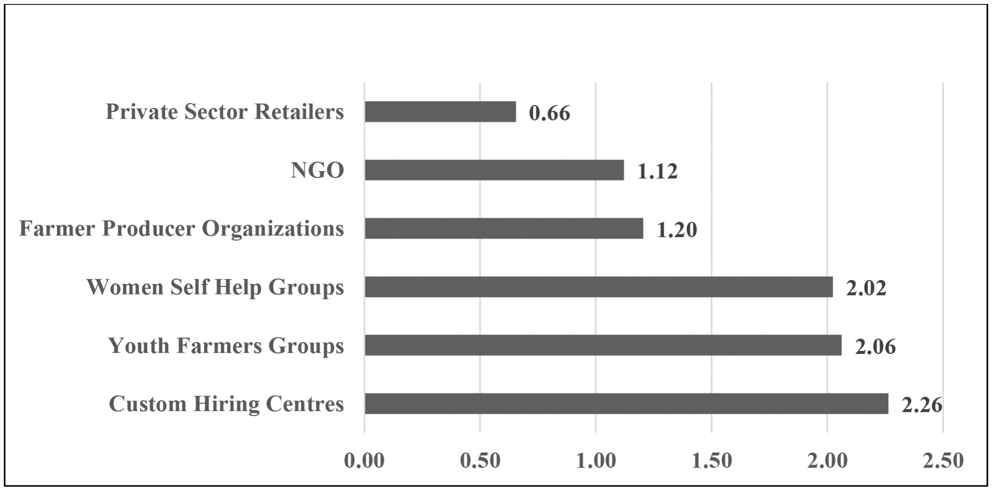

Fig.7 : Key Institutions to Scale out CRT interventions

The findings presented in Fig. 7 indicate that Custom Hiring Centres (CHCs) provided the strongest institutional support for the adoption of Climate-Resilient Technologies (CRTs) (mean score: 2.26). This highlights the importance of shared access to farm machinery and equipment in reducing investment costs and facilitating technology adoption among small and marginal farmers. Similar observations were reported by Thakor and Joshi (2024), who found that institutional support mechanisms significantly enhanced the adoption of climate-resilient interventions. Youth Farmers' Groups (2.06) and Women Self-Help Groups (2.02) also emerged as important institutional drivers, emphasizing the role of collective action, social networks, and community participation in promoting climate adaptation. Similar findings were reported by Parikh et al. (2024), Kristjanson et al. (2012), and Mills et al. (2017), who highlighted the contribution of community-based organizations in strengthening resilience and technology dissemination. Moderate support was observed from Farmer Producer Organizations (FPOs) (1.20) and Non-Governmental Organizations (NGOs) (1.12), indicating their supportive but relatively limited role in facilitating CRT adoption. Private sector retailers recorded the lowest support score (0.66), suggesting weaker engagement in climate adaptation initiatives. These findings are consistent with Sulaiman et al. (2005), who emphasized that public extension systems and farmer-based institutions continue to play a dominant role in agricultural technology dissemination. Overall, the results indicate that public and community-based institutions are more effective than private actors in promoting the adoption and scaling of Climate-Resilient Technologies.

CONCLUSION

The study provides a comprehensive understanding of the drivers and constraints influencing the adoption of Climate-Resilient Technologies (CRTs) across diverse agro-ecological regions of India. The findings clearly indicate that the adoption of CRTs is strongly influenced by a combination of technical feasibility, institutional support, and knowledge-based factors, rather than financial incentives alone. Crop production and water-related technologies were perceived as highly feasible and well aligned with existing government programmes, while institutional interventions and in-situ moisture conservation practices faced comparatively greater challenges in field-level implementation. The major constraints identified were low acceptability of technologies, limited awareness, and labour scarcity, highlighting the critical role of perception, capacity, and human resources in determining adoption outcomes. The relatively lower influence of financial barriers suggests that improving access to quality training, demonstrations, and extension services may yield greater impact than subsidy-based approaches alone.

Capacity building and strong market linkages emerged as the most influential drivers for promoting

CRT adoption, emphasizing the importance of knowledge dissemination and economic incentives through better value chain integration. Institutional mechanisms such as Custom Hiring Centres, youth farmer groups, and women self-help groups were found to be key enablers for scaling out CRTs, demonstrating the effectiveness of community-based and collective action models. Overall, the study concludes that strengthening extension systems, policy convergence, gender-inclusive approaches, and institutional networks is essential for accelerating the large-scale adoption of climate-resilient technologies in India. These insights provide valuable guidance for policymakers, researchers, and development agencies to design more targeted, participatory, and sustainable strategies for building climate-resilient agricultural systems.

RECOMMENDATIONS

- Policies should prioritize capacity building, strong extension services, and better market linkages to improve awareness and acceptability of climate-resilient technologies.
- Greater policy convergence, simplified credit and subsidy access, and support for community institutions like CHCs and SHGs are essential for scaling adoption.
- Special focus is needed on women's inclusion, labour-saving mechanization, and location-specific innovations to strengthen climate-resilient agriculture.

ACKNOWLEDGEMENT

This research was funded by ICAR and the project was lead by ICAR-ATARI, Hyderabad and implemented by 30 KVKs under 11 ATARIs. The contribution of 30 KVKs and 11 ATARIs is duly acknowledged by the authors.

CONFLICT OF INTEREST

All authors declare that they have no conflict of interest

REFERENCES

Birthal, P. S., Khan, M. T., Negi, D. S. and Agarwal, S. (2014). Impact of climate change on yields of major food crops in India: Implications for food security. *Agricultural Economics Research Review*, 27(2): 145–155. DOI: https://doi.org/10.5958/0974-0279.2014.00019.6

Bhabhor, G. K., Shaikh, A. A. and Machhar, R. G. (2024). Awareness about climate change among the farmer friends. *Gujarat Journal of Extension Education*, 37(1): 34-38. https://doi.org/10.56572/gjoee.2024.37.1.0005

FAO (2017). *Climate-smart agriculture sourcebook*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Feder, G., Just, R. E. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2): 255-298.

Getanah, M. and Tsigae, A. (2013). Comparative analysis of lining materials for reduction of seepage in water harvesting structures, Adet, Ethiopia. *International Journal of Sustainable Development*, 2(2): 1623-1635.

Ghasura, R. S., Rani, D. V. and Singh, R. R. (2024). Dairy farmers' views on overcoming barriers to adopting climate change adaptation strategies. *Gujarat Journal of Extension Education*, 37(2): 195-200. https://doi.org/10.56572/gjoee.2024.37.2.0033

ICAR-CRIDA (2019). *Vision 2050: Climate Resilient Agriculture*. Central Research Institute for Dryland Agriculture, Hyderabad, India.

IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem and B. Rama. Cambridge University Press, Cambridge, UK and New York, NY, USA. https://doi.org/10.1017/9781009325844

Jasna, V. K., Sukanya, S. and Roy, R. (2014). Socio-economic impact of climate resilient technology. *International Journal of Agricultural, Food and Science Technology*, 5(3): 185-190.

Kristjanson, P., Neufeldt, H., Gassner, A., Mango, J., Kyazze, F. B., Desta, S., Sayula, G., Thiede, B., Forch, W., Thornton, P. K. and Coe, R. (2012). Are food insecure farmers more likely to adopt climate-smart agriculture practices? *Food Security*, 4(3): 407-421.

Meena, M. S., Singh, K. M. and Sharma, P. (2013). Farmers' knowledge and adoption of climate resilient technologies. *Indian Research Journal of Extension Education*, 13(3): 53-59.

Mills, J., Gaskell, P., Ingram, J., Dwyer, J., Reed, M. and Short, C. (2017). Engaging farmers in environmental management through a better understanding of behaviour. *Agriculture and Human Values*, 34: 283-299.

Nhemachena, C., Hassan, R. and Chakwizira, J. (2014). Analysis of determinants of farm-level adaptation measures to climate change in Southern Africa. *Journal of Development and Agricultural Economics*, 6(5): 232-241.

Parikh, N. L., Patel, J. B. and Usadadiya, N. H. (2024). Correlation and regression analysis of women farmers' characteristics and their sensitivity towards effects of climate change on cereal crops. *Gujarat Journal of Extension Education*, 38(2): 102-105. https://doi.org/10.56572/gjoee.2024.38.2.0016

Pokiya, N. J., Swaminathan, B. and Vekariya, D. J. (2024). Constraints faced by farmers in adapting to climate change. *Gujarat Journal of Extension Education*, 37(1): 120-124.

Prasad, Y. G., Maheswari, M., Dixit, S., Srinivasarao, Ch., Sikka, A. K., Venkateswarlu, B., Sudhakar, N., Prabhu Kumar, S., Singh, A. K., Gogoi, A. K., Singh, A. K., Singh, Y. V. and Mishra, A. (2014). *Smart Practices and Technologies for Climate Resilient Agriculture*. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India.

Shiferaw, B., Okello, J. and Reddy, R. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture. *Environment, Development and Sustainability*, 11: 601-623.

Singh, A. K. (2021). Climate resilient agriculture: Opportunities and challenges. *Indian Journal of Extension Education*, 57(2): 1-8.

Sulaiman, R. V., Hall, A. and Suresh, N. (2005). Effectiveness of agricultural extension in India. *Current Science*, 88(9): 1391-1398.

Tajpara, M.M., Vakaliya, M, A. and Kalsariya, B.N. (2018) Impact of climate resilient technology in NICRA Village of Rajkot district of Gujarat. Guj. J. Ext. Edu. Special Issue on National Seminar, 77-80.

Tajpara, M. M., Kalsariya, B. N. and Dadhania, V. P. (2020). Application of climate resilient technologies in NICRA village of Rafala. *Gujarat Journal of Extension Education*, 31(1): 136-140.

Thakor, R. F. and Joshi, P. J. (2024). Impact of climate resilient technologies on socio-economic development of tribal farmers. *Gujarat Journal of Extension Education*, 37(2): 43-46. https://doi.org/10.56572/gjoee.2024.37.2.0008

Tiwari, M. V., Poshia, V. K. and Chauhan, N. M. (2024). Knowledge level of farmers on climate resilient agro-technologies in NICRA village. *Gujarat Journal of Extension Education*, 37(1): 134-137. https://doi.org/10.56572/gjoee.2024.37.1.0022

Vinaya K. Hebsale Mallappa and Pathak, T. B. (2023). Climate smart agriculture technologies adoption among small-scale farmers: A case study from Gujarat, India. *Frontiers in Sustainable Food Systems*, 7:1202485. https://doi.org/10.3389/fsufs.2023.1202485

Vinaya Kumar, H. M. and Shivamurthy, M. (2021). Factors influencing fishery-based farmers' perception and their response to climate-induced crisis management. *Environment, Development and Sustainability*, 23: 11766-11791. https://doi.org/10.1007/s10668-020-01141

Yosef Binyam Alemu and Asmamaw Desale Kidane (2015). Rainwater harvesting: An option for dryland agriculture in arid and semi-arid Ethiopia. *International Journal of Water Resources and Environmental Engineering*, 7(2): 17-28.

Received : January 2026 : Accepted : March 2026