

Review

Factors Influencing the Adoption of Climate-Resilient Crops: A Comprehensive Review

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Abstract

Global food security is at risk of climate change and therefore need to adopt plant production under climate resiliency. This paper examines the various aspects that influence the adoption of such crops based on economics, society, and environment. These climate resistant crops that can manage various stresses help in securing global food provision, stabilizing yields, as well as reducing the perils arising due to climate fluctuations. These considerations have been categorized into economic, social, and environmental. NICRA in an Indian context entails policy approaches to ensure that people adopt new agricultural practices for the agricultural sector to remain strong. Climate-resistant crops demonstrated beneficial case studies but there are challenges including lack of awareness and limited technology barriers toward implementation in large scale. Technology development, policy landscape, farmers' awareness, market dimension, and community-based techniques are some of the future prospects that offer an overall picture towards improved climate resistant agriculture.

Keywords: Climate change, global food security, climate-resilient crops, NICRA initiative, climate-smart villages, community-based approaches, sustainable agriculture.

Introduction

Given that climate change poses an urgent challenge for global food security, it is high time to grow more adaptive crops in order to meet this challenge. In this section, crops that are resistant to climatic changes and why it is necessary to comprehend the complex features affecting their uptake will be discussed. Climate-associated events have been increasing in frequency, therefore, placing new types of demands on the old ways farmers used in crop and livestock production. There are potential risks of global food production by extreme weather conditions changing precipitation patterns or temperature fluctuations that cause stressor to staple crop. This is an alarming concern hence the promotion of crop resistant to climate change to harden agriculture under climate change.

However, cultivating climate-proof crops goes beyond the farm yield. It stretches to the national and international security systems regarding global food. In the face of rising populations and climate related insecurities; the resilience of agricultural systems is significant. Resilient climate crops ensure stable yield and at the same time provide mitigation of risks associated with unstable climatic weather conditions. The understanding of issues contributing to these crops' rejection is fundamental in developing appropriate measures and recommendations. These include cost competitiveness, reliable yields, and market demands.

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Adoption patterns are shaped by factors such as social dynamics of knowledge dissemination, community involvement, and cultural acceptances. Also, there is a case for including other environmental factors like regional climatic variations and the character of the soils as instruments.

Climate-Resilient Crops: Definition and Types

Climate-resilient crops are crops and crop varieties that have enhanced tolerance to biotic and abiotic stresses such as drought, flooding, heat, chilling, freezing, and salinity, and are intended to maintain or increase crop yields under stress conditions. These crops are designed to withstand and recover from the effects of climate change, ensuring food security for farmers and communities. There are various types of climate-resilient crops, including:

1. **Drought-tolerant crops:** These crops are designed to withstand long periods of drought and require less water than traditional crops, making them particularly useful in regions with limited water resources.
2. **Heat-tolerant crops:** These crops can withstand high temperatures and continue to grow and produce yields even in extreme heat, which is crucial for regions experiencing increasing temperatures.
3. **Pest-resistant crops:** These crops are designed to resist pests and diseases, reducing the need for pesticides and herbicides and promoting sustainable agriculture practices.
4. **Salinity-tolerant crops :** These crops can tolerate high levels of salinity in the soil, making them suitable for areas with high salinity levels or coastal regions.
5. **Flood-tolerant crops:** These crops can withstand periods of flooding and can continue to grow and produce yields even in waterlogged conditions.

The development and identification of climate-resilient varieties with enhanced tolerance to heat, drought, flooding, chilling, and salinity are crucial for building climate resilience among farming communities and ensuring food security. Technological approaches, such as biotechnology, have played a significant role in the development of resilient crops that can withstand climate challenges. In addition to their intrinsic value, climate-resilient crops can also contribute to adaptation strategies for crop production and efficient management of natural resources.

Importance of Adoption

Climate change poses unprecedented challenges to global agriculture, necessitating a paradigm shift towards the cultivation of climate-resilient crops. This section delves into the critical significance of adopting climate-resilient crops as a strategic response to the evolving climatic conditions and their profound impact on agricultural sustainability.

1. **Safeguarding Global Food Security:** The cultivation of climate-resilient crops becomes paramount in ensuring sustained food production amidst erratic weather patterns and extreme climatic events. This subsection explores how these crops act as a safeguard, contributing to global food security in the face of increasing climate uncertainties [1].
2. **Enhancing Yield Stability:** Climate-resilient crops exhibit adaptability to adverse conditions, resulting in increased yield stability. This subsection delves into the importance of stable yields for farmers, reducing the vulnerability of agricultural systems to the impacts of climate variability [2].
3. **Mitigating Risks and Uncertainties:** By mitigating the risks associated with environmental volatility, climate-resilient crops play a crucial role in stabilizing

agricultural livelihoods. This subsection explores how the adoption of these crops can contribute to reducing economic uncertainties for farmers in the context of a changing climate [3].

4. Sustainable Agriculture Practices: The adoption of climate-resilient crops aligns with the broader goals of sustainable agriculture. This subsection discusses how cultivating resilient crops contributes to environmental sustainability by reducing the need for excessive resource inputs and minimizing the ecological footprint of farming practices (CGIAR Research Program on Climate Change, Agriculture and Food Security) [4].

Factor influencing adoption

The adoption of climate-resilient crops is influenced by various factors, including economic, social, and environmental factors. According to a study by Pathak [5], age and income were the main variables that had a positive and significant effect on the adoption of improved seed varieties, while ownership of livestock had a significant and negative influence on their adoption. A scoping review by Kassie [6] found that the education level of heads of households, including some awareness of climate change and adaptation measures, and farmers' access to inputs, especially seeds and fertilizers, were the most important determinants of adoption of climate-resilient crops. The same study also found that sex, age, education, years of farming experience, and indicators of socio-economic status or wealth (assets) all affected decisions to adopt climate-resilient technologies in context-specific and sometimes opposite ways, depending on interacting environmental, policy, and household factors.

In addition, a study by Kassie [6] found that a range of internal factors, including the size of landholding, asset ownership, savings, and income from secondary occupations, influenced farmers' decision on the adoption of climate-resilient practices. Environmental factors such as soil type, rainfall, and temperature also play a role in the adoption of climate-resilient crops. Overall, the adoption of climate-resilient crops is influenced by a complex interplay of economic, social, and environmental factors. Understanding these factors is crucial for promoting the widespread adoption of climate-resilient crops and ensuring food security in the face of climate change.

Policy Recommendation

In the Indian context, several policy measures and recommendations have been proposed to promote the adoption of climate-resilient crops and ensure the resilience of agriculture. The National Innovations in Climate Resilient Agriculture (NICRA) initiative in India seeks to enhance agricultural resilience through interventions such as fortifying the soil, regenerative agriculture, organic farming, use of cover crops, permaculture, and agroforestry. Additionally, the mitigation of climate risks and the increase in adaptive capacity of farmers and resilience of farming lands have been identified as attainable through a transition towards sustainable agriculture.

Furthermore, the Economic Survey in 2017-18 emphasized the need for suitable policy actions and scientific interventions to ascertain the impacts of agriculture on climate change and to address the stagnation of growth in the agriculture gross domestic product (GDP). The survey also highlighted the importance of suitable policies at all levels-Union, States, and Local self-Governments-for framing and implementing mitigation and adaptation strategies to address the threat of climate change. Moreover, a systematic scoping review and content analysis of

policy recommendations for climate-resilient agriculture emphasized the need for policy measures to enable the transition towards sustainable agriculture in India. This includes the mitigation of climate risks, the increase in adaptive capacity of farmers, and the resilience of farming lands.

The policy recommendations for promoting the adoption of climate-resilient crops in the Indian context encompass a range of measures, including the NICRA initiative, sustainable agriculture transitions, and the mitigation of climate risks. These recommendations are crucial for addressing the challenges posed by climate change and ensuring the resilience of Indian agriculture.

Case Studies

Several case studies and success stories demonstrate the positive impact of climate-resilient crops on farmers and communities. Here are a few examples:

1. **Heat-tolerant rice in India:** A study by Pathak [5] highlighted the successful adoption of heat-tolerant rice varieties in India, which helped farmers cope with rising temperatures and maintain yield levels. These varieties allowed farmers to adapt to changing climatic conditions and secure their livelihoods.

2. **Drought-tolerant crops in semi-arid regions :** A case study in semi-arid regions showed that the adoption of drought-tolerant crops, such as sorghum and millet, significantly improved farmers' resilience to climate change and reduced their dependence on rainfall. These crops allowed farmers to maintain productivity even during periods of water scarcity.

3. **Salinity-tolerant crops in coastal areas :** In coastal regions, the adoption of salinity-tolerant crops has been crucial in addressing the challenges posed by rising sea levels and increased salinity in the soil. These crops, such as mangroves and salt-tolerant crops, help stabilize the soil and support the livelihoods of coastal communities.

4. **Climate-resilient crops in small-scale producer contexts :** A scoping review by Maricelis [7] found that small-scale producers in low- and middle-income countries adopted climate-resilient crops and varieties to cope with the impacts of climate change. The review highlighted the importance of education, access to inputs, and awareness of climate change and adaptation measures in driving the adoption of these crops.

5. **Biotechnology-driven resilience :** Studies have found that the use of biotechnology in the development of resilient crops has been instrumental in helping farmers adapt to climate challenges. Genetic engineering techniques, for example, have been used to create crops that can withstand drought, heat, and pests, improving farmers' resilience and food security.

These case studies and success stories demonstrate the potential of climate-resilient crops to transform the agricultural landscape and ensure food security in the face of climate change.

Challenges and Barriers

The widespread adoption of climate-resilient crops faces several challenges and barriers. One of the main challenges is the lack of awareness and knowledge among farmers about the benefits of these crops and their potential to cope with climate change. This lack of awareness can lead to a reluctance to adopt new technologies and practices, hindering the widespread adoption of climate-resilient crops.

Another challenge is the limited availability of suitable crop varieties and technologies that are adapted to local conditions and can withstand the specific stresses faced by farmers. This can be due to technological limitations, lack of research and development, and inadequate funding for the development of climate-resilient crops. In addition, economic factors such as the high cost of inputs, lack of access to credit, and low market demand for climate-resilient crops can also hinder their adoption. These factors can make it difficult for farmers to invest in new technologies and practices, limiting the adoption of climate-resilient crops.

Furthermore, environmental factors such as soil quality, water availability, and land use patterns can also pose challenges to the adoption of climate-resilient crops. For example, in areas with poor soil quality or limited water resources, the adoption of drought-tolerant crops may be limited. Overall, the challenges and barriers to the adoption of climate-resilient crops are complex and multifaceted. Addressing these challenges requires a comprehensive approach that includes education and awareness-raising, research and development, policy support, and investment in sustainable agriculture practices.

Future Perspectives

One of the most compelling aspects of climate-resilient crops is their adaptability. They are designed to thrive in diverse environments, from regions plagued by prolonged droughts to those susceptible to heavy rainfall and flooding. This adaptability not only safeguards crop yields but also mitigates the economic risks faced by farmers who are increasingly vulnerable to weather-related disasters (Pathak [5])

1. **Technological Innovations and Research Initiatives:** This subheading delves into the ongoing and potential technological advancements in climate-resilient crop research within India. It discusses emerging breeding techniques, precision agriculture technologies, and genetic modifications aimed at enhancing crop resilience. Reference to cutting-edge studies and projects in this domain would provide insights into the trajectory of future technological interventions.

2. **Policy Landscape and Government Initiatives:** An exploration of the evolving policy framework in India concerning climate-resilient crops. This section analyzes existing policies, potential reforms, and the impact of government initiatives on the adoption of resilient crops. It also considers international collaborations and agreements shaping the policy landscape.

3. **Farmers Awareness and Education Programs:** Understanding the role of awareness campaigns and educational programs in influencing farmers' perceptions and decisions. This section assesses the effectiveness of existing extension services, farmer training programs, and knowledge-sharing platforms in promoting the adoption of climate-resilient crops among Indian farmers.

4. **Market Dynamics and Agribusiness Integration:** Exploring the evolving market for climate-resilient crops in India, including market demand, supply chains, and the role of agribusiness. This subheading evaluates the economic incentives and market-driven factors influencing farmers' decisions to adopt resilient crop varieties.

5. **Climate Smart Villages and Community-Based Approaches:** Investigating the role of community-based approaches, including Climate Smart Villages and collaborative farming models. This section assesses the impact of community

engagement, shared resources, and cooperative strategies in promoting the widespread adoption of climate-resilient crops.

Conclusion

Finally, climate change poses a severe risk to international food security, making it necessary to transition to climate-resilient crops. The hybrid crops which have been developed to combat different hazards in the environment make it possible for farmers not to fight back but to get ready for any surprises that come along. Besides individual yield, they matter concerning world food insecurity, more consistent harvest, as well as ecological management. Age, income, education, as well as local conditions are closely linked to the decision of farmers on adopting.

An example of this is India's NICRA program that focuses on sustainable transition and mitigation of climate risk. Some case studies have proven that resilient crops can bring about this change, but issues such as low public awareness, technological bottlenecks and economic hurdles still exist. The above discusses the prospects for change in technology, market, community, policy, awareness, and industry. It would entail wholesome approach in India including progressions, legislations, education, marketing rewards, and community efforts. It is only through these extensive measures that agriculture will become a sustainable system and guarantee against food deficiency during climate change.

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