# FINANCING SUSTAINABLE AGRICULTURE IN THE CONTEXT OF CLIMATE CHANGE IN INDIA

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**ABSTRACT**

*Agriculture faces significant challenges in achieving global food security and will confront even greater difficulties under the impacts of climate change. This paper aims to explore how financial strategies can help achieve the combined goals of development, climate change mitigation, and adaptation in agriculture, particularly in developing countries. The findings indicate that agriculture is severely underfunded, with foreign aid not increasing at the required pace to support sustainable agricultural practices amidst climate change. Many key areas in climate change mitigation and adaptation need substantial investment. The paper examines successful cases of agricultural mitigation and adaptation that have been implemented in developing nations. It identifies areas that have proven successful, those with potential for scaling up, and those that could be transferred to other regions. The study concludes that integrating agricultural climate mitigation and adaptation into broader agricultural development programs, strengthening local capacities, and addressing the needs of various stakeholders are essential for financing sustainable agriculture in the face of climate change.*

**Keyword**: *Finance, Climate Change, Agriculture, Developing Countries*

## 1. INTRODCTION

Agriculture is a key sector in global food security, but it faces immense challenges under climate change, especially in developing countries. Climate change not only threatens food security but also worsens the conditions of millions already affected by hunger. For instance, a projected 9 to 21% reduction in agricultural productivity by 2050 in developing nations adds to the urgency of addressing these issues (FAO, 2009). Global warming and extreme weather events like droughts, floods, and storms will likely cause fluctuations in crop yields, leading to greater food insecurity, particularly in regions like China and sub-Saharan Africa. These challenges highlight the need for significant investment in agricultural practices that not only aim to increase productivity but also mitigate and adapt to climate change.

Despite the rising demand for agricultural investment, particularly for climate adaptation and mitigation, the financial commitments remain insufficient. Investment in agriculture has historically been underfunded, with a sharp decline in aid to agriculture since the 1980s, when agricultural aid fell from 23% to lower percentages of total foreign aid (Huang & Wang, 2014). The lack of sufficient financial resources undermines the ability of developing countries to implement climate-resilient agricultural strategies. Mitigation measures, such as reducing greenhouse gas emissions from agriculture, are also critically underfunded, despite the sector being responsible for 13.5% of global emissions (IPCC, 2007b). This gap in financing calls for enhanced investment mechanisms and strategies that involve both domestic and international sources of funds.

Addressing these challenges requires integrating climate change adaptation into national agricultural development programs. Successful cases of financing sustainable agriculture show that a combination of public and private sector involvement, along with foreign aid, is necessary to fund long-term agricultural development programs that are

resilient to climate risks. These programs must be tailored to local conditions, with an emphasis on enhancing capacity-building efforts and the inclusion of all relevant stakeholders, including farmers, governments, and private enterprises. In particular, scaling up successful adaptation strategies, sharing knowledge across regions, and improving financial models will be critical to achieving sustainable agriculture under climate change. The paper advocates for broadening the scope of agricultural finance to not only support productivity growth but also to address the intersection of agriculture and climate change mitigation, ensuring that agriculture can meet the future food demands of an increasing global population.

Table 1: Literature Survey

| Author Name | Research Gap | Finding | Suggestion |
|---|---|---|---|
| 1. Arnell N W. (2004) | Limited understanding of global water resources under climate change scenarios. | Climate change significantly affects water availability globally, with SRES emissions and socio-economic scenarios. | Implement adaptive strategies to manage water resources amidst climate change and socio-economic uncertainties. |
| 2. Bouman B, Lampayan R M, Tuong T P. (2007) | Need for water management strategies in irrigated rice under water scarcity. | Efficient water management techniques are critical for sustaining rice production in water-scarce areas. | Promote water-saving technologies and management strategies for sustainable rice cultivation. |
| 3. Chen H, Wang J, Huang J. (2013) | Lack of understanding of policy support and social capital in drought adaptation. | Policy support and social capital are crucial for farmers' adaptation to drought in China. | Enhance policy frameworks and strengthen social capital to improve drought resilience in farming communities. |
| 4. DTMA (2012) | Insufficient research on drought-tolerant crops for smallholder farmers. | Drought-tolerant maize has significantly helped smallholder farmers in Africa by addressing drought challenges. | Scale up the use of drought-tolerant maize and improve access to seeds for smallholder farmers in Africa. |
| 5. Easterling W E, Crosson P R, Rosenberg N J, et al. (1993) | Limited understanding of regional agricultural impacts of climate change. | Climate change will negatively impact agricultural productivity in the MINK region, specifically in crop yields. | Develop region-specific strategies to adapt agriculture to climate change and mitigate its negative effects. |
| 6. Easterling W E. (1996) | Insufficient reviews on North American agriculture's adaptation to climate change. | North American agriculture can adapt to climate change, but it requires significant adjustments to farming practices. | Promote adaptation strategies and research to develop climate-resilient agricultural systems in North America. |
| 7. EU Focus (2010) | Lack of clarity on the EU's role in global food security. | The EU plays a key role in enhancing global food security through international collaborations and policy frameworks. | Strengthen the EU's food security initiatives through continued international partnerships and research. |
| 8. Mushtaq S, Maraseni T N, | Need for assessment of energy and water tradeoffs in food | Balancing energy and water resources is essential to ensure long-term food security, | Explore efficient energy-water-food nexus strategies to enhance global food security |

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| Maroulis J, Hafeez M. (2009) | security. | especially under global challenges. | and sustainable practices. |
| 9. MWR (2010) | Lack of detailed data on flood and drought disasters in China. | China faces severe water-related disasters, which exacerbate the vulnerability of its agricultural sector. | Enhance disaster preparedness and implement water management systems to reduce the impacts of floods and droughts. |
| 10. Nelson G C, Rosegrant M W, Koo J, et al. (2010) | Insufficient understanding of the costs of agricultural adaptation to climate change. | Agricultural adaptation to climate change involves significant costs, but it is essential for future food security. | Prioritize investment in agricultural adaptation strategies to mitigate future climate impacts on food security. |

**1.1 Reducing Methane from Ruminants**

Methane emissions from ruminant animals are a significant source of greenhouse gases, primarily due to the digestive processes of cattle, sheep, and other livestock. Reducing these emissions presents challenges, as it is primarily linked to the number of animals raised. In developing countries, where income growth leads to increased demand for beef, mutton, and dairy products, methane emissions are expected to rise. A reduction in the number of ruminants would be required to significantly decrease emissions, but this could conflict with rising food demands and economic growth.

**1.2. Methane Emission from Rice Paddy Fields**

Rice fields are another major source of methane emissions, due to the waterlogged conditions that promote methane production by microorganisms. Rice is a staple food for about half of the global population, and with around 144 million hectares cultivated each year, it is a key sector in agriculture. Effective management of irrigation in rice farming, such as practices like alternate-wetting and drying (AWD), has shown potential in significantly reducing methane emissions. Studies from the Philippines' Bohol Island demonstrate that AWD can reduce methane emissions by up to 40%, while also improving water usage and productivity.

**1.3. Soil Carbon Sequestration and CO2 Emission Reduction**

Soils play a critical role in mitigating climate change through carbon sequestration. Agricultural soils, being large carbon reservoirs, can help reduce atmospheric greenhouse gases. The Kyoto Protocol emphasizes enhancing carbon sequestration to mitigate climate change. By improving soil management practices, agricultural lands can sequester substantial amounts of carbon, potentially mitigating up to 10% of anthropogenic emissions. This presents a valuable opportunity for carbon offset programs and further agricultural development aligned with climate change mitigation goals.

## 2. AGRICULTURAL SCIENCE AND TECHNOLOGY

As the global population continues to rise, the demand for food will surge, requiring agricultural systems to produce more with fewer resources. Technological advancements are seen as the key to achieving this objective, especially in the context of climate change and limited natural resources. In developing countries, a significant portion of agricultural growth—estimated at 80%—will come from yield increases and more efficient cropping systems, as per an FAO (2009) report. This reliance on improved yields is especially critical in land-scarce countries.

However, climate change poses a serious challenge to agricultural productivity. Shifting weather patterns, water scarcity, and increased frequency of extreme events like droughts or floods complicate the task of improving yields. To overcome these challenges, significant investments in agricultural technology are necessary. Key areas for investment include developing crop varieties that are resilient to climate change, understanding the impacts of climate change on crops, and facilitating the transfer of modern agricultural technologies to developing countries.

The Rockefeller Foundation's initiative to promote drought-tolerant rice varieties in Asia exemplifies such efforts. This multi-country program aimed to improve crop resilience by funding research and facilitating technology transfer to farmers. By 2011, drought-tolerant rice varieties were already being cultivated in India, China, and Thailand, offering farmers a tool to combat the unpredictable effects of climate change, especially droughts.

To address the challenges posed by climate change, technology must focus on enhancing productivity while reducing the environmental footprint. This includes adopting modern biotechnology, water conservation techniques, and ecological farming practices. Such innovations not only help improve food security but also provide long-term sustainability in agriculture. The future of agriculture thus lies in strategic investments in technology that foster both productivity and resilience against climate change.

## 3. INVESTMENT IN CAPACITY-BUILDING PROGRAMS

There is a growing call for increased investment to enhance the adaptive capacity of developing countries in response to climate change. Despite the rising need, meaningful investments have been minimal. Adaptive capacity refers to a range of issues, including adaptability, planning, management skills, flexibility, and resilience (Smit and Wandel, 2006). According to recent studies and expert interviews, three key areas warrant more attention for future financial support. First, investment is needed to improve the capacity of national and local governments to develop and implement long- and short-term adaptive strategies. Second, financing should focus on enhancing local communities' ability to adapt to climate change, especially in the face of extreme weather events. Third, targeted investment in improving farmers' capacity to cope with weather shocks or disasters, through training or self-managed organizations like farmers' and water users associations, is crucial to building resilience in rural areas.

Several successful capacity-building programs highlight the potential of such investments. For instance, the "Mainstreaming Climate Change Adaptation in Irrigated Agriculture" project in China's 3H Basin has built the capacity of decision-makers and irrigation staff to integrate climate adaptation strategies into their programs. The project also included participatory training to improve agricultural water management. Similarly, the European Commission has initiated food security programs in developing countries like Burma, Ethiopia, Mongolia, and the Philippines. These programs have helped improve the capacity of local populations to fight natural disasters and address food insecurity linked to climate change. Such initiatives demonstrate the impact of investing in adaptive capacity and highlight the need for expanded funding in the future.

## 4. INVESTMENT IN RISK MANAGEMENT

Climate change has significantly intensified the risks associated with agricultural production, which is highly dependent on weather patterns. While these risks are not new to agriculture, the increasing frequency and severity of climate-related events, such as extreme weather, have made adaptation crucial. According to the IPCC (2007), these events include droughts, floods, and storms that disrupt crop production, leading to economic losses and food insecurity. Adaptation to climate change involves better risk management strategies to address these challenges. This management should include structural and non-structural measures, designed to prevent or mitigate the adverse effects of climate-related hazards. Key areas of investment in climate-related risk management include agricultural insurance programs, market-based insurance, disaster relief, restoring natural buffers against climate impacts, and developing early warning and information systems. These strategies, when effectively implemented, can help farmers better manage the risks they face in the face of unpredictable climate events.

One significant strategy to address these risks is agricultural insurance, which can help protect farmers from losses due to extreme weather. However, many developing countries struggle with limited access to subsidized agricultural insurance due to financial constraints. While such programs are well-established in developed countries, they are less accessible in the global South, where small-scale farmers are more vulnerable to climate-related disasters. In these regions, governments often cannot afford to provide sufficient subsidies for crop and livestock insurance. Market-based private insurance programs are also rare in developing countries, as the small-scale nature of farming and the high costs involved make them unattractive to private insurers. To overcome these barriers, it is crucial for governments to adopt financial mechanisms and public policies that leverage private investment and create enabling conditions for sustainable agricultural insurance schemes. Such efforts could help increase farmers' resilience to climate risks and improve overall food security.

Another essential aspect of climate adaptation is the use of early warning systems and information services. The Food and Agriculture Organization (FAO) has been instrumental in providing early weather forecasts and crop condition updates to inform agricultural decision-making in developing countries. These systems enable farmers to plan and adapt their production strategies in anticipation of climate hazards. A recent study in China examined the role of early warning systems in mitigating the impacts of drought on agriculture. It found that farmers who had access to government disaster information services were more likely to adopt adaptation measures, thereby reducing yield losses. Such systems not only help farmers make informed decisions but also contribute to long-term agricultural sustainability by improving crop forecasting and providing timely updates on weather conditions. Expanding these early warning systems to more regions, particularly in developing countries, could significantly enhance climate adaptation efforts and support national food security goals.

## 5. CONCLUSION

This paper examines how to finance mitigation and adaptation in agriculture in developing countries. The results show that agriculture is under-invested, and both domestic and foreign aid have not increased appropriately to maintain sustainable agriculture. While recent climate change funds are emerging, little funding has been raised. Raising climate change funds is important, and effectively using these funds is equally essential. Recently, funding agencies and donors have been exploring innovative approaches to agricultural mitigation and adaptation in developing countries.

The review of literature and case studies shows that there are a wide range of areas in mitigation and adaptation that need substantial financing. Major cases on agricultural mitigation and adaptation are examined, with a focus on scalable areas. Four categories of mitigation measures are identified, including reducing nitrous oxide emissions, methane reduction, soil carbon sequestration, and energy-saving technologies. Proposed finances for agricultural adaptation also cover investments in water conservation infrastructure, agricultural science and technology, capacity building, and risk management. Successful financing requires integrating agricultural mitigation into global and national climate plans and adapting agricultural programs to changing climates.

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