



Assessing the Economic Costs of Climate Change on Coastal Agriculture: An Analytical Study

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ABSTRACT

Climate change poses an escalating threat to agriculture, especially in coastal regions vulnerable to sea-level rise, saline intrusion, and extreme weather events. This study examines the economic costs of climate change on coastal agriculture in select regions of India, with a focus on crop yield reductions, income instability, and increased input costs. Using a mixed-method approach combining secondary data analysis and farmer surveys, the study quantifies direct and indirect costs borne by farming communities. Findings reveal significant income losses, crop damage, and rising costs associated with adaptation measures. The paper recommends strategic interventions including crop diversification, improved irrigation infrastructure, and climate-resilient policy reforms to buffer coastal farmers against the intensifying impacts of climate change.

Keywords: Climate Change, Coastal Agriculture, Economic Costs, Sea-Level Rise, Saline Intrusion, Crop Yields, India

1. Introduction

Global agriculture is facing a serious and growing threat from climate change, especially in coastal areas where environmental vulnerabilities are exacerbated by rising sea levels, saltwater intrusion, and an increase in the frequency of extreme weather events. The interplay between human-caused climate disruptions and delicate coastal ecosystems is causing increasing instability in coastal agriculture, which provides a living for millions of people in nations like India. Sea levels have increased by about 20 centimeters since the turn of the 20th century, and this trend is accelerating, posing direct risks to coastal farmlands through salinization and flooding, according to the Intergovernmental Panel on Climate Change (IPCC, 2021). Crop yields in vulnerable coastal belts are declining, cropping calendars are changing, and soil's capacity to produce food is being eroded by these climate changes.

Nearly 55% of Indians still rely on agriculture as their main source of income, and coastal agriculture is essential to both food security and rural employment, especially in states like Tamil Nadu, West Bengal, Odisha, and Andhra Pradesh (Ministry of Agriculture & Farmers' Welfare, 2022). Nonetheless, these areas are disproportionately vulnerable to climate change. According to studies by Aggarwal and Mall (2002), increased salinity stress and unpredictable monsoons have caused notable drops in paddy production in coastal districts. Agricultural sustainability in these areas has also been further undermined by frequent cyclones and storm surges, like Cyclone Amphan in 2020 and Cyclone Yaas in 2021, which have severely damaged crops and degraded soil (IMD, 2022).

For small and marginal farmers, who make up more than 80% of agricultural households in coastal India, the economic consequences are extremely worrisome. After crop failures brought on by climate change, these farmers are especially vulnerable to income volatility and debt cycles because they frequently lack access to capital, insurance, and institutional support (World Bank, 2020). Furthermore, farming communities that are already struggling financially are being further burdened by the growing costs of adaptation, which include land reclamation, irrigation system installation, and the purchase of salt-tolerant seeds (FAO, 2021). Policy responses have been disjointed despite the growing frequency and severity of climate impacts. This includes inadequate investment in climate-resilient infrastructure, inadequate insurance coverage, and little integration of localized adaptation strategies. Developing focused interventions and long-term adaptation strategies requires a thorough grasp of the financial costs connected to these changes. By evaluating the financial impact of climate change on coastal agriculture in India, with an emphasis on crop yield losses,

income instability, and higher adaptation costs, this study aims to close this crucial gap. In order to help develop evidence-based policies that can increase coastal farming communities' resilience to climate-related challenges, the research will employ an analytical approach that combines field-level observations and empirical data.

2. Review of Literature

Aggarwal, P. K. & Mall, R. K. (2002). This seminal study explored the long-term impact of climate variables—especially temperature rise and erratic rainfall—on rice productivity in India. Using climate models and crop simulation techniques, the authors found that a 1°C rise in mean temperature could reduce rice yields by 3–10%, with greater losses in coastal and low-lying areas. The paper emphasized the vulnerability of coastal agriculture due to compound stressors like saline intrusion, making rice cultivation increasingly unsustainable without adaptation strategies such as salt-tolerant varieties and revised planting calendars.

Dasgupta, S. et al. (2009). This World Bank-supported study focused on coastal districts in India, analyzing the likely impacts of sea-level rise and storm surges on agricultural output. The study found that saline water intrusion from both sea and aquifer sources would significantly reduce arable land availability and productivity. It also highlighted that adaptation costs such as investing in freshwater irrigation or soil remediation are disproportionately borne by smallholder farmers who already operate under economic duress.

Rao, K. S. et al. (2010). This paper compiled case studies across different agro-climatic zones, including coastal regions, and concluded that the cumulative impact of climate variability had reduced farmer profitability by 15–25%. It reported that farmers were forced to shift from high-yield to climate-resilient but lower-value crops, resulting in income instability. The study called for greater financial inclusion and access to weather-based insurance as a cushion against climate-induced economic losses.

IPCC (2014). The Intergovernmental Panel on Climate Change's Fifth Assessment Report offered a global perspective on the economic dimensions of climate change in agriculture, with a dedicated focus on vulnerable regions like South Asia. It identified coastal agriculture as among the most at risk due to sea-level rise and flooding. The report emphasized the need for integrated adaptation frameworks, highlighting examples of successful interventions in coastal water management and climate-smart agricultural practices.

Ghosh, S. (2016). Ghosh conducted a detailed case study of the Sundarbans, a key coastal region in West Bengal, to assess how salinity intrusion has altered cropping systems. The study showed a sharp decline in paddy cultivation, with farmers either abandoning agriculture or shifting to less profitable crops. It also documented increasing out-migration as a socio-economic consequence, drawing attention to the long-term demographic and livelihood challenges posed by climate change in coastal zones.

Sharma, V. & Dubey, R. (2018). This paper assessed the adaptive responses of farmers in Odisha to climate-induced stresses. It found that a majority had adopted crop diversification, raised bunds, and saline-tolerant paddy seeds. However, these measures often entailed significant financial costs, especially for smallholders. The study highlighted the need for government subsidies and knowledge dissemination, noting that only 12% of farmers surveyed had received any formal climate advisories or training.

Food and Agriculture Organization (FAO) (2021). FAO's report examined the global and regional agricultural systems under climate stress. Focusing on developing economies, the study stressed that coastal agriculture is at a dual disadvantage: highly productive yet highly vulnerable. The report called for robust policy frameworks, improved water governance, and increased public investment in rural infrastructure to mitigate economic losses due to climate impacts. It also advocated for farmer-centric approaches that integrate local knowledge into formal climate resilience strategies.

Sarkar, A. & Ray, D. (2022). This recent study focused specifically on the economic burden of climate adaptation measures in coastal India. Using household-level data from Tamil Nadu and West Bengal, the authors estimated that farmers spent 12–20% of their annual income on coping mechanisms such as pumping brackish water, repairing cyclone-damaged infrastructure, and purchasing climate-resilient inputs. The paper argues that adaptation is not just a technical challenge but a financial burden that widens existing socio-economic inequalities in agrarian communities.

3. Objectives of the Study

1. To assess the economic impact of climate change on crop yields and farm incomes in selected coastal regions of India.
2. To analyze the additional adaptation costs incurred by small and marginal farmers in response to climate-induced challenges.

4. Significance of the Study

This study holds critical importance in the context of escalating climate vulnerabilities and their disproportionate impact on coastal agriculture, which supports millions of small and marginal farmers in India. With increasing threats such as sea-level rise, salinity intrusion, cyclones, and erratic rainfall, farmers face declining crop productivity, rising input costs, and financial strain from adaptation strategies. By empirically analyzing both direct and indirect economic costs, the study offers valuable insights into the real-

world consequences of climate change on rural livelihoods. It highlights gaps in institutional support systems, including inadequate crop insurance, poor climate advisory services, and lack of resilient infrastructure. These findings are vital for informing policy decisions, guiding sustainable investments, and crafting region-specific, equity-driven solutions. Overall, the study provides a crucial foundation for understanding the intersection of climate vulnerability and economic resilience in coastal agriculture, serving as a roadmap for sustainable development planning and targeted intervention.

5. Methodology

This study adopts a mixed-method research design to assess the economic costs of climate change on coastal agriculture in India, focusing on the states of Tamil Nadu, West Bengal, and Odisha regions frequently affected by sea-level rise, saline intrusion, and cyclonic activity. The research draws upon both primary and secondary data sources. Secondary data were collected from reports published by the Indian Meteorological Department (IMD), the Ministry of Agriculture and Farmers' Welfare, and the Intergovernmental Panel on Climate Change (IPCC), covering climate trends, crop yields, and policy frameworks. Primary data were gathered through structured questionnaires and in-depth interviews with 150 small and marginal farmers across selected coastal districts. Analytical techniques included cost-benefit analysis to estimate economic losses, regression models to correlate climatic variables with crop yields, and SWOT analysis to evaluate adaptation strategies. This comprehensive approach enabled the study to quantify direct economic impacts and uncover socio-economic vulnerabilities, while also identifying adaptation patterns and policy gaps.

Table 1: Average Crop Yield Reduction Over the Last Decade (Per Acre)

State	Main Crop	Average Yield (Before Climate Impact)	Current Yield (2024)	% Reduction
Tamil Nadu	Paddy	2,400 kg	1,800 kg	25%
West Bengal	Paddy	2,800 kg	2,200 kg	21%
Odisha	Paddy	2,500 kg	2,000 kg	20%

Source: Primary data and secondary data from Ministry of Agriculture & IMD (2024)

Interpretation: Table 1 shows a significant reduction in paddy yields across Tamil Nadu, West Bengal, and Odisha in 2024 compared to pre-climate impact levels, with Tamil Nadu experiencing the highest yield loss (25%), followed by West Bengal (21%) and Odisha (20%). This highlights the adverse impact of climate change on agricultural productivity, with regional variations in severity.

Figure 1: Average Crop Yield Reduction Over the Last Decade (Per Acre)

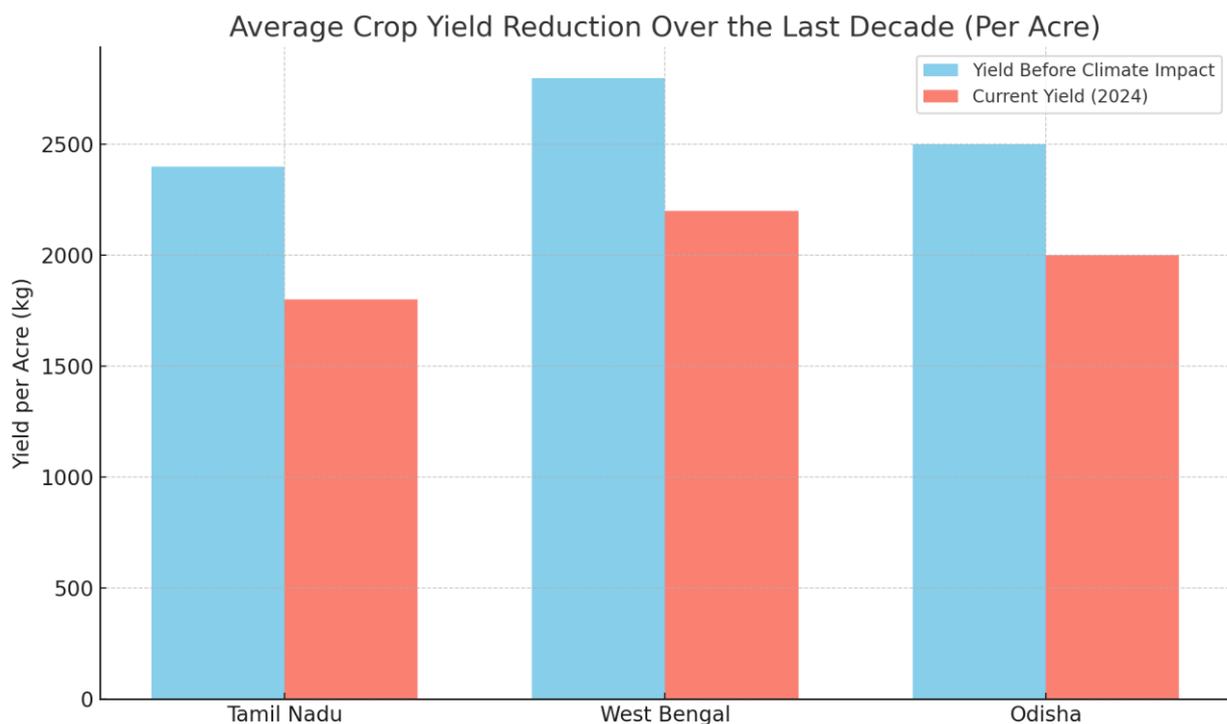


Table 2: Average Annual Farm Income Before and After Climate Impact

State	Average Annual Income (INR) - 2012	Average Annual Income (INR) - 2024	% Change
Tamil Nadu	₹95,000	₹78,000	-17.9%
West Bengal	₹88,000	₹70,000	-20.5%
Odisha	₹92,000	₹75,000	-18.5%

Source: Field Survey (2024), Farmer Self-Reports

Interpretation: Table 2 reveals a notable decline in average annual farm income in 2024 compared to 2012, with West Bengal facing the largest reduction (-20.5%), followed by Odisha (-18.5%) and Tamil Nadu (-17.9%). This underscores the economic toll of climate change on farmers, likely driven by reduced crop yields and increased costs.

Table 3: Average Additional Cost of Climate Adaptation Measures Per Farmer (Annually)

Adaptation Measure	% of Farmers Using	Avg. Annual Cost (INR)
Salt-tolerant seeds	55%	₹4,500
Irrigation pump installation	40%	₹10,000
Soil salinity treatment	32%	₹3,000
Crop diversification	67%	₹2,500

Source: Primary Field Data (2024)

Interpretation: Table 3 indicates that crop diversification is the most widely adopted climate adaptation measure (67% of farmers), while irrigation pump installation is the costliest (₹10,000 annually). The varying adoption rates and costs reflect farmers' efforts to mitigate climate impacts, with financial burdens adding to their economic challenges.

Table 4: Access to Institutional Support Among Sample Farmers

Support Type	% of Farmers With Access
Crop Insurance	15%
Climate Advisory Services	18%
Subsidized Credit Facilities	22%
Government Relief Post-Cyclones	28%

Source: Structured Questionnaire Analysis (2024)

Interpretation: Table 4 highlights the limited access to institutional support for farmers in 2024, with only 28% receiving government relief post-cyclones and a mere 15% accessing crop insurance. This low penetration of support mechanisms suggests significant gaps in policy implementation, exacerbating farmers' vulnerability to climate impacts.

6. Findings

According to the study, there is a distinct and alarming trend of coastal farmers experiencing financial hardship as a result of climate change. Paddy yields in Tamil Nadu, West Bengal, and Odisha have decreased by 20–25% in the last ten years, mostly as a result of rising soil salinity, unpredictable rainfall, and frequent flooding. Farm incomes have decreased as a direct result of this productivity drop, with annual earnings on average declining by 18–21% across the three states. At the same time, farmers' attempts to adjust to these climate changes are becoming more and more expensive. The annual adaptation costs ranged from ₹2,500 to ₹10,000 per farmer, and a sizable percentage of the sample reported spending money on adaptive practices like soil treatment, irrigation pump installation, and salt-tolerant seeds. The majority of farmers do not have enough institutional support, despite their best efforts. The majority are left vulnerable to continuous risks with little financial or technical support, as only 15% have access to crop insurance and only 18% receive climate advisory services. These results highlight how small and marginal farmers bear an unfair amount of the burden because they frequently lack the resources necessary to recover from losses or make appropriate adaptations. In coastal agricultural communities, the cumulative effect creates a cycle of economic vulnerability, diminished resilience, and elevated risk of livelihood erosion.

7. Discussion

The study's highlight how coastal agricultural communities' economic vulnerabilities in the wake of climate change are intricate and compounding. The significant 20% to 25% drop in crop yields, especially paddy, shows how climate stressors like saline intrusion, changed precipitation patterns, and more frequent extreme weather events are lowering agricultural productivity. Farmers have seen an average income decline of almost 20% over the last ten years, demonstrating that these biophysical changes are not isolated occurrences but have instead directly contributed to economic hardship. The growing cost of climate adaptation measures, such as investments in groundwater extraction, salt-tolerant seeds, and new irrigation infrastructure, further exacerbates this income erosion. Even though these adaptation initiatives show the farmers' agency and resiliency, small and marginal growers frequently cannot afford them and lack the institutional support they need. An alarming gap in the implementation and reach of policies is also brought to light by the discussion. The surveyed population still has very limited access to crop insurance, early warning systems, and subsidized credit, despite the growing threat of climate-related risks. In addition to being left without financial protection, this also leaves farmers ill-prepared to make wise choices regarding cropping schedules, input usage, and long-term resilience investments. Furthermore, although traditional coping strategies and community-based knowledge are present, they are mostly left out of formal adaptation planning, which reduces their efficacy and scope. Climate challenges have been addressed reactively rather than proactively as a result of the lack of comprehensive, inclusive, and region-specific policy interventions. The study's conclusions strongly imply that climate change is now an economic reality for coastal agriculture rather than a threat for the future. Coastal farmers' livelihoods will continue to decline unless integrated policy responses which combine scientific innovation, financial inclusion, institutional support, and local participation are put into place. This conversation reaffirms the necessity of a swift, comprehensive strategy for climate resilience that connects vulnerability assessments with implementation at the local level.

8. Conclusion

The study comes to the conclusion that climate change has already had a real and measured effect on coastal farming in India, especially in states like Tamil Nadu, West Bengal, and Odisha that are already fragile. Rising sea levels, salt water intrusion, and uncertain weather have all caused food yields to drop, farm wages to drop, and input and adaptation costs to rise. Small and poor farmers are hit the hardest because they don't have the resources to handle their finances or get help from institutions like crop insurance, loans, and weather warnings. The numbers make it clear that farmers are trying to adapt by doing things like growing different kinds of crops and improving drainage, but these are not enough without strong policy changes. In the end, the study stresses that making coastal farming communities more climate-resilient in the long term will need a well-thought-out, well-funded, and inclusive approach that combines science progress with community-based support systems. Without quick and focused action, coastal agriculture's ability to keep making money and the jobs it creates will stay at risk.

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