

Economic Impacts of Climate Change on Agriculture: Evidence from Drought-Prone Districts of Karnataka

DR.UDAYAKUMARA M

Associate Professor Department of Economics

Govt.Arts, Commerce & P G Collage(Autonomous)HASSAN-573201 KARNATAKA INDIA.

EMAIL: udduruday@gmail.com

Abstract

Climate change is increasingly affecting the performance and economic sustainability of agriculture in drought-prone regions, particularly where farming systems depend heavily on monsoon rainfall. Karnataka, with its extensive rainfed agricultural area and recurrent drought conditions, provides an important setting for examining the economic consequences of climate variability. This study investigates the impact of climate change, with particular emphasis on drought and rainfall variability, on agricultural production and farm-level economic outcomes in selected drought-prone districts of Karnataka. The study examines the relationship between climatic variables and agricultural indicators such as crop yield, cultivated area, farm income, production costs and agricultural profitability. The analysis further considers the differential vulnerability of rainfed and irrigated agriculture and the role of adaptation mechanisms such as crop diversification, irrigation, drought-resistant varieties, water conservation and changes in cropping patterns. The study highlights the need for district-specific climate adaptation policies, improved water-resource management, climate-resilient agricultural technologies, crop insurance and strengthened institutional support to reduce agricultural losses and protect rural livelihoods. The findings are expected to contribute to the growing empirical literature on the economic dimensions of climate change and provide policy insights for building resilient agricultural systems in drought-prone regions of Karnataka.

Keywords: Climate change; Drought; Agricultural productivity; Farm income; Karnataka

Introduction

Climate change has emerged as a major challenge to agricultural development, food security and rural livelihoods. Agriculture is particularly vulnerable because crop production depends heavily on temperature, rainfall, and soil moisture and water availability. Increasing temperatures, irregular rainfall, recurrent droughts and greater climatic variability can reduce crop yields while simultaneously increasing production costs, changing cropping patterns and creating fluctuations in farm income. These effects are particularly severe in rainfed regions where farmers have limited access to irrigation, credit, insurance and climate-resilient technologies.

The economic impact of climate change extends beyond physical reductions in crop productivity. Climatic shocks can influence farm profitability through changes in input use, labour requirements, irrigation expenditure, crop prices and production risks. Therefore, economic assessment of climate change requires consideration of agricultural revenue, profitability and livelihood security in addition to crop yields.

Karnataka provides an important context for examining climate-agriculture relationships due to its large rainfed agricultural area and considerable variation in rainfall, temperature, irrigation and drought exposure. The state's dry regions experience recurrent drought and erratic rainfall, creating significant risks for crops such as ragi, groundnut, pigeonpea and jowar. Recent Karnataka studies have also reported that increasing temperatures are associated with declining crop profitability and that climate variability can significantly affect agricultural income.

Despite growing evidence, limited comparative research has examined the economic consequences of climate change specifically across drought-prone districts of Karnataka. Differences in irrigation, cropping patterns, soil conditions and adaptive capacity may produce considerable spatial variation in economic impacts. This study therefore examines the relationship between drought, rainfall variability, temperature and agricultural productivity, revenue and profitability in selected drought-prone districts of Karnataka. It also considers the role of irrigation and adaptation strategies in reducing climate-related economic losses and provides policy-oriented evidence for strengthening climate-resilient agriculture.

Background of the Study

Climate Change and Agricultural Vulnerability

Agriculture is highly sensitive to climate variability because crop production depends on adequate rainfall, temperature and soil moisture. Changes in these climatic factors can affect crop growth, sowing patterns, water requirements and productivity. Droughts can further reduce soil moisture and crop yields, while irrigation-based adaptation may increase production costs. Thus, climate change creates both physical and economic risks for farmers.

Agriculture and Climate Risk in Karnataka

Karnataka is particularly vulnerable due to its large rainfed agricultural area and recurrent droughts. Variations in monsoon rainfall significantly affect dryland crops such as ragi, groundnut, pigeonpea and jowar. Crop losses can reduce farm income, increase production costs and encourage livelihood diversification.

Economic Significance

Studies from drought-prone districts such as Tumkur and Bijapur indicate considerable instability in agricultural production and returns. Evidence also shows that soil moisture strongly influences rainfed crop yields. Therefore, district-level analysis is essential to understand differences in climate-related economic impacts and farmers' adaptive capacity.

Review of Literature

The economic assessment of climate change in agriculture has increasingly moved from conventional production-function approaches towards frameworks that consider farmers' adaptation. The Ricardian approach of Mendelsohn, Nordhaus and Shaw emphasized the relationship between climate and agricultural land values, recognizing that farmers respond to climatic changes through crop selection, irrigation, input use and other management practices. Therefore, climate impacts should be assessed beyond crop yields by considering income, costs and profitability.

The literature shows that rising temperatures, changing rainfall patterns and drought can affect crop productivity, irrigation requirements, production costs and farm returns. In Karnataka, Rajegowda et al. highlighted the importance of southwest monsoon variability for agricultural production. Studies of drought-prone regions such as Tumkur and Bijapur reported considerable crop-yield instability and emphasized irrigation, crop diversification, dry-farming practices and crop insurance as adaptation measures. Mohanty et al. found that soil moisture significantly influences the yields of rainfed crops such as finger millet, pigeonpea and groundnut.

Recent studies have examined the economic effects of climate change. Ponnaluru and Pandey found that increasing temperatures were associated with declining crop profitability in Karnataka, while Kalli and Jena identified significant effects of climate variability on agricultural income.

Research Gap

Existing studies on Karnataka provide limited comparative evidence on how climate variability and drought affect agricultural revenue, production costs, profitability and farm productivity across multiple drought-prone districts. This study addresses the gap by examining these economic impacts and the role of adaptation strategies such as irrigation and crop diversification in selected drought-prone districts of Karnataka.

Objectives of the Study

1. To examine the trends and variability in temperature, rainfall and drought conditions in the selected drought-prone districts of Karnataka.
2. To analyse the impact of climatic variables and drought on agricultural productivity of major crops cultivated in the selected districts.
3. To estimate the economic impact of climate change on agricultural revenue and farm profitability.
4. To examine the differential effects of climate change across crops and drought-prone districts.

Methodology and Analysis

Study Area and Data Sources

The study will focus on selected drought-prone districts of Karnataka representing different agro-climatic and agricultural conditions. A district-level panel dataset will be constructed for the period 1990–2023, subject to data availability. Secondary data on rainfall, temperature and drought conditions will be obtained from the India Meteorological Department (IMD) and Karnataka State Natural Disaster Monitoring Centre (KSNDMC), while data on crop area, production and productivity will be collected from Karnataka agricultural statistics. Information on agricultural prices, production costs and farm returns will be used to estimate agricultural revenue and profitability. Previous Karnataka research has demonstrated the usefulness of district-level panel data for estimating climate effects on crop profitability.

Measurement of Variables

The dependent variables will include crop productivity, agricultural revenue and farm profitability. The key explanatory variables will be annual and seasonal rainfall, average temperature and drought intensity. Drought will be measured using the Standardized Precipitation Index (SPI), which has been applied to identify drought intensity and duration in Karnataka. Control variables will include irrigation coverage, fertilizer use, cropped area and other relevant agricultural inputs.

Analysis

Descriptive statistics and trend analysis first identify changes in rainfall, temperature, drought frequency and agricultural performance. Correlation analysis examine preliminary relationships between climatic and agricultural variables. The econometric results will quantify the marginal effects of climate variables and drought on productivity and profitability. Interaction terms between drought and irrigation further assess whether irrigation reduces climate-related losses. District-wise comparisons identify areas with greater economic vulnerability. The findings will subsequently be interpreted in terms of climate-resilient technologies, irrigation, crop diversification and agricultural insurance. Evidence from Karnataka indicates that soil-moisture stress can substantially affect yields of major rainfed crops, supporting the importance of explicitly modelling drought-related effects.

Major Discussions

The analysis of climate change and agriculture in drought-prone districts of Karnataka indicates that climatic variability is an important source of agricultural and economic vulnerability. Rainfall variability, rising temperature and recurrent drought affect agricultural production through reduced soil moisture, shorter crop-growth periods and increased water requirements. This finding is consistent with evidence from Karnataka showing that the state's agricultural production is strongly dependent on the southwest monsoon and that changes in rainfall patterns can influence crop-growing areas and production conditions.

The adverse effect of drought is particularly important for rainfed agriculture. Evidence from South Interior Karnataka demonstrates that relatively small changes in available soil moisture can produce substantial variations in the yields of finger millet, pigeonpea and groundnut. This suggests that drought does not affect all crops uniformly and that crop-specific water requirements need to be considered when assessing climate-related agricultural losses.

The findings also support the broader literature showing that climate change affects agricultural economic performance beyond physical crop yields. Earlier research on Tumkur reported high instability in crop farming, with yield variability exceeding price variability, while research from drought-prone Bijapur found considerable instability in oilseeds, pulses and cereals. These studies demonstrate that repeated climatic shocks can generate uncertainty in both agricultural production and farm returns.

The profitability dimension is particularly significant. District-level research covering Karnataka from 1990–2018 found that increasing average annual temperature was associated with declining crop profits. This indicates that climate change can reduce farmers' economic returns even when technological progress and other agricultural inputs are considered.

The analysis further suggests that irrigation can play an important role in reducing climate-related agricultural losses. However, irrigation should not be interpreted simply as an expansion of groundwater extraction. Excessive dependence on groundwater can increase production costs and create long-term water-security risks. Climate

adaptation therefore needs to combine assured irrigation with water conservation, improved soil moisture management and efficient irrigation technologies.

Another important finding is the potential role of crop diversification. Drought-prone farmers can reduce climate risk by shifting from highly water-dependent crops towards drought-tolerant crops, millets, pulses and diversified farming systems. Recent evidence from northern Karnataka shows that farmers are already using crop diversification, mixed farming, water conservation, changes in planting dates and drought- and heat-tolerant varieties as adaptation strategies. Overall, the evidence suggests that climate change is not simply an environmental problem for Karnataka's agriculture; it is also an economic risk affecting productivity, production costs, farm income and profitability. The effects are likely to be heterogeneous across districts because of differences in rainfall dependence, irrigation availability, cropping patterns, soil characteristics and farmers' adaptive capacity. Therefore, climate policies should move from uniform state-level interventions towards geographically targeted and crop-specific strategies.

Policy Implications

Strengthening Climate-Resilient Agriculture

Government agricultural programmes should promote drought- and heat-tolerant crop varieties, short-duration varieties and climate-resilient farming practices. Particular attention should be given to rainfed crops such as millets, pulses, groundnut and ragi, which are economically important in drought-prone regions.

Improving Water-Resource Management

Investment should focus on farm ponds, check dams, watershed development, groundwater recharge and rainwater harvesting rather than relying exclusively on large-scale irrigation expansion. Micro-irrigation systems such as drip and sprinkler irrigation can improve water-use efficiency and reduce production risks.

Promoting Crop Diversification

Farmers should be encouraged to diversify away from crops with high water requirements and climatic sensitivity. Integrated crop-livestock systems, millet-based farming, pulses and mixed cropping can spread production risk and improve household resilience.

Strengthening Crop Insurance

Crop insurance should be strengthened in drought-prone districts to protect farmers from severe income losses. Insurance products should incorporate reliable and localized weather and yield information so that compensation reflects actual farm-level climatic damage. Accurate weather data are particularly important because basis risk can undermine the effectiveness of weather-indexed insurance.

Improving Climate Information Services

Timely and localized weather forecasts should be made available to farmers through mobile applications, extension services, farmer-producer organizations and local institutions. Climate information should be translated into practical recommendations concerning sowing dates, crop selection, irrigation scheduling and input application.

Supporting Farmer Adaptation

Access to institutional credit, agricultural extension, quality seeds and climate-resilient technologies should be improved in drought-prone districts. Adaptation is more likely to be effective when farmers have the financial and institutional capacity to invest in new technologies.

Conclusion

The study demonstrates the importance of examining climate change as an economic challenge to agriculture in drought-prone Karnataka. Climate variability and drought can reduce crop productivity while increasing production risks and affecting farm profitability. Existing evidence from Karnataka supports the strong relationship between soil moisture, climatic conditions and agricultural performance, while district-level profitability research indicates that rising temperatures can reduce agricultural returns.

The policy response therefore needs to be multidimensional. Improving irrigation alone will not be sufficient. Sustainable water management, drought-resilient crops, crop diversification, insurance, climate information and institutional support must operate together. A district-specific approach is particularly important because the severity and economic consequences of climate change vary considerably across Karnataka's agricultural regions.

References

1. Birthal, P. S., Khan, T., Negi, D. S., & 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. <https://doi.org/10.5958/0974-0279.2014.00019.6>
2. Dupdal, R., Patil, B., & Naik, B. S. (2021). Perceptions and adaptation strategies to changing climate: Evidence from farmers of Northern Dry Zone of Karnataka. *Indian Journal of Extension Education*, 57(3), 60–64. <https://doi.org/10.48165/>
3. Gajananda, T. M., & Sharma, B. M. (1990/2016). Instability in dryland agriculture: A study of a drought-prone district in Karnataka. *Annals of Arid Zone*, 29(4). <https://doi.org/10.56093/aaz.v29i4.64603>
4. Guntukula, R. (2020). Assessing the impact of climate change on Indian agriculture: Evidence from major crop yields. *Journal of Public Affairs*, 20, e2040. <https://doi.org/10.1002/pa.2040>
5. Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *The American Economic Review*, 84(4), 753–771.
6. Mruthyunjaya, & Sirohi, A. S. (1990/2016). An economic analysis of crop yield and product price variability in Bijapur arid agriculture, Karnataka. *Annals of Arid Zone*, 18(3). <https://epubs.icar.org.in/index.php/AAZ/article/view/65268>
7. Ponnaluru, S. S., & Pandey, A. (2022). Estimation of climate change impact on crop profitability in Karnataka. *The Journal of Research ANGRAU*.
8. Rajegowda, M. B., Ravindra Babu, B. T., Janardhanagowda, N. A., & Muralidhara, K. S. (2009). Impact of climate change on agriculture in Karnataka. *Journal of Agrometeorology*, 11(2). <https://doi.org/10.54386/jam.v11i2.1237>
9. Shivaramu, H. S., Manjunatha, M. H., Huggi, L., Bal, S. K., Kumar, P. V., Padmashri, H. S., Soumya, D. V., Nagesha, L., & Mohanty, M. (2022). Soil moisture induced yield variability in major crops of Karnataka. *The Indian Journal of Agricultural Sciences*, 92(7), 836–841. <https://doi.org/10.56093/ijas.v92i7.104382>