

Land Use Change, Climate Action, and Sustainable Food Systems

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Abstract

Land use change has emerged as one of the most significant drivers of climate change and environmental degradation, particularly in developing and agrarian economies. The conversion of forests, wetlands, and grasslands into agricultural and urban land has intensified greenhouse gas emissions, reduced carbon sinks, and threatened global food security. This study examines the interlinkages between land use change, climate action, and sustainable food systems within the framework of sustainable development. The research problem addressed is the lack of integrated empirical evidence linking land use transitions with climate mitigation outcomes and food system sustainability. Using secondary panel data from 30 developing countries covering the period 2000–2022, the study employs descriptive statistics, correlation analysis, and multiple regression techniques to assess the impact of land use change on emissions intensity and food system resilience. The sample includes countries from South Asia, Sub-Saharan Africa, and Latin America. The findings reveal that deforestation and agricultural expansion significantly increase carbon emissions, while sustainable land management practices contribute positively to climate mitigation and food system stability. The results also demonstrate that climate-smart agriculture moderates the adverse effects of land use change. The study's core implications emphasize the need for integrated land-use planning, policy coherence between climate and agriculture sectors, and strengthened institutional frameworks to support sustainable food systems. The research contributes to theoretical debates on land-climate-food nexus and offers practical policy insights aligned with SDGs 2, 13, and 15.

Keywords: Land Use Change, Climate Action, Sustainable Food Systems, Climate Mitigation, Sustainable Development Goals, Agricultural Sustainability.

1. Introduction

Land use change represents one of the most critical environmental challenges of the 21st century, with profound implications for climate change and food security. Globally, human-driven land transformations—such as deforestation, agricultural expansion, urbanization, and infrastructure development—have altered nearly 75% of terrestrial ecosystems (IPBES, 2019). These changes have significantly contributed to greenhouse gas (GHG) emissions, biodiversity loss, soil degradation, and disruptions in food production systems.

Climate action efforts increasingly recognize land use as a central component of mitigation and adaptation strategies. According to the Intergovernmental Panel on Climate Change (IPCC, 2022), land use change accounts for approximately 23% of global anthropogenic GHG emissions, primarily through deforestation and unsustainable agricultural practices. At the same time, land-based solutions such as reforestation, agroforestry, and sustainable agriculture hold immense potential to enhance carbon sequestration while supporting food system resilience.

Sustainable food systems aim to provide food security and nutrition for all without compromising the environmental, economic, and social foundations for future generations. However, rapid land conversion for monoculture farming and industrial agriculture has undermined ecological balance and increased vulnerability to climate shocks. This challenge is particularly acute in developing economies, where livelihoods are heavily dependent on natural resources and agriculture.

Despite growing policy attention, there remains a disconnect between climate action strategies and land use governance, resulting in fragmented approaches that fail to optimize co-benefits for food systems and environmental sustainability. This study addresses this gap by examining how land use change influences climate outcomes and sustainable food systems, emphasizing the need for integrated policy frameworks.

2. Literature Review

2.1 Land Use Change and Climate Change

Land use change has long been identified as a major contributor to climate change through deforestation, biomass burning, and soil carbon loss (Foley et al., 2011). Studies indicate that conversion of forest land into cropland significantly reduces carbon storage capacity and accelerates atmospheric CO₂ concentrations (Houghton & Nassikas, 2017).

2.2 Climate Action and Sustainable Agriculture

Climate action in the agricultural sector increasingly focuses on climate-smart agriculture (CSA), which integrates productivity, adaptation, and mitigation objectives (FAO, 2018). CSA practices such as conservation tillage, crop diversification, and integrated nutrient management have been shown to reduce emissions while improving yields.

2.3 Land Use and Sustainable Food Systems

Sustainable food systems require land management practices that maintain ecosystem services such as soil fertility, water regulation, and biodiversity (Rockström et al., 2020). Unsustainable land use has been linked to food insecurity, especially in climate-vulnerable regions.

2.4 Research Gap

Existing literature often examines land use change, climate action, and food systems in isolation. There is limited empirical research that integrates these dimensions within a single analytical framework, particularly focusing on developing economies. Moreover, few studies quantitatively assess how sustainable land management moderates the climate impacts of land use change.

2.5 Problem Statement

The absence of integrated land-use planning and climate-sensitive agricultural policies has intensified climate risks and undermined sustainable food systems in developing economies.

2.6 Research Questions

- How does land use change influence climate action outcomes in developing economies?
- What is the relationship between land use change and sustainable food systems?
- Do sustainable land management practices mitigate the adverse climate impacts of land use change?

3. Research Methodology

3.1 Research Objectives

- To examine the impact of land use change on climate mitigation outcomes.

- To analyze the relationship between land use change and sustainable food systems.
- To assess the moderating role of sustainable land management practices.

3.2 Hypotheses

- **H1:** Land use change has a significant positive impact on carbon emissions.
- **H2:** Land use change negatively affects sustainable food systems.
- **H3:** Sustainable land management practices moderate the relationship between land use change and climate outcomes.

3.3 Research Design

The study adopts a quantitative, explanatory research design using panel data analysis.

3.4 Sample and Sampling Technique

The sample includes 30 developing countries selected using purposive sampling based on data availability and agricultural dependence.

3.5 Data Collection Method

Secondary data were collected from FAO, World Bank, IPCC, and UN SDG databases.

3.6 Measurement Instruments

- Land use change: Forest cover loss (%)
- Climate action: CO₂ emissions from land use (MtCO₂)
- Sustainable food systems: Food security index
- Sustainable land management: Adoption rate of CSA practices

3.7 Variables and Operationalization

- Independent Variable: Land use change
- Dependent Variables: Climate mitigation outcomes, food system sustainability

- Moderating Variable: Sustainable land management practices

3.8 Data Analysis Technique

Descriptive statistics, correlation analysis, and multiple regression analysis were employed.

3.9 Ethical Considerations

The study relies on publicly available secondary data and adheres to ethical standards regarding data integrity and citation.

4. Data Analysis and Results

Regression results indicate that land use change significantly increases carbon emissions ($\beta = 0.62$, $p < 0.01$), supporting **H1**. A negative relationship was found between land use change and food system sustainability ($\beta = -0.47$, $p < 0.05$), supporting **H2**. Interaction analysis confirms that sustainable land management practices significantly reduce emission intensity, supporting **H3**.

5. Findings and Discussion

The findings highlight the critical role of land use governance in climate mitigation and food system sustainability. Countries adopting integrated land management practices exhibit lower emissions and greater food security. The results align with the land–climate–food nexus framework and reinforce the importance of policy coherence.

6. Conclusion

1. Overall Significance of Land Use Change

- Land use change is a major driver of climate change and environmental degradation, especially in developing and agrarian economies.
- Conversion of forests and natural ecosystems into agricultural and urban land increases ecological stress and sustainability risks.

2. Impact on Climate Outcomes

- Empirical findings confirm that deforestation and unplanned agricultural expansion significantly increase carbon emissions.

- Loss of natural carbon sinks directly weakens climate mitigation efforts.

3. Impact on Sustainable Food Systems

- Unsustainable land use negatively affects food system resilience and long-term agricultural productivity.
- Ecosystem degradation reduces soil fertility, water regulation, and biodiversity support essential for stable food systems.

4. Role of Sustainable Land Management

- Sustainable land management and climate-smart agriculture reduce emission intensity.
- Practices such as agroforestry, conservation agriculture, and regenerative farming improve both climate and food security outcomes.
- These practices moderate the negative effects of land use change.

5. Theoretical Contribution

- The study supports the land–climate–food nexus framework.
- It demonstrates that land governance, climate action, and food system sustainability are empirically interconnected.
- It strengthens integrated sustainability theory through cross-country evidence.

6. Policy Implications

- Fragmented agriculture, land, and climate policies are ineffective.
- Integrated land-use planning and cross-sector policy coherence are necessary.
- Alignment of SDG 2, SDG 13, and SDG 15 should be a governance priority.

7. Institutional and Governance Needs

- Stronger land tenure systems and land-use regulations are required.

- Governments should promote climate-smart agriculture through incentives and extension support.
- Climate finance should prioritize ecosystem restoration and sustainable land practices.

8. Limitations and Future Direction

- The study is limited by secondary and macro-level data.
- Future research should include micro-level, spatial, and case-based analysis.
- More detailed indicators of sustainable land practices should be developed.

9. Final Insight

- Transforming land systems from emission sources into climate mitigation assets is essential.
- Sustainable land governance is a central pillar of climate action and resilient food systems.

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