

Climate-Induced Agrarian Risk and Livelihood Vulnerability: A PLS-SEM Analysis of Small and Medium Farmers in Semi-Arid India

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Abstract

This study analyses the impact of climate-induced agrarian risk on livelihood vulnerability among small and medium farmers in the semi-arid region of West Rayalaseema, India. The study is based on primary data collected from 300 respondents using a structured questionnaire. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to examine the relationships among climate risk, agrarian risk, marketing constraints, financial constraints, and livelihood vulnerability. The findings reveal that climate risk significantly influences agrarian risk ($\beta = 0.65$), which further impacts marketing constraints ($\beta = 0.58$) and financial constraints ($\beta = 0.62$). Among these, financial constraints have the strongest effect on livelihood vulnerability ($\beta = 0.53$), followed by marketing constraints ($\beta = 0.41$). The study also confirms the mediating role of agrarian risk in transmitting climate effects into economic vulnerability. The results highlight the importance of financial inclusion, market reforms, and climate-resilient strategies in reducing farmer vulnerability. The study contributes to the existing literature by integrating environmental and economic risk factors using an advanced SEM approach.

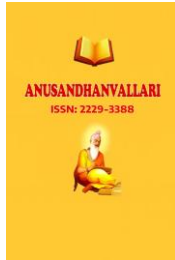
Keywords: Climate Risk, Agrarian Risk, Livelihood Vulnerability, PLS-SEM, Financial Constraints, Semi-Arid India

1. Introduction

Climate change has emerged as a major challenge affecting agricultural sustainability, particularly in semi-arid regions such as West Rayalaseema. Farmers in these regions face significant risks due to unpredictable rainfall patterns, increasing temperatures, and limited institutional support systems. These challenges not only affect agricultural productivity but also increase livelihood vulnerability.

Despite growing research on climate risk and agrarian distress, there is limited integration of environmental, economic, and institutional factors using advanced analytical techniques such as PLS-SEM. Therefore, this study aims to examine the interconnected impact of climate-induced agrarian risks on livelihood vulnerability among farmers.

This study aims to develop an integrated model to examine the direct and indirect effects of climate-induced risks on livelihood vulnerability using PLS-SEM. The study specifically focuses on small and medium farmers in the semi-arid region of West Rayalaseema.



Objectives of the Study

1. To examine the effect of climate risk on agrarian risk among small and medium farmers.
2. To analyse the impact of agrarian risk on marketing constraints.
3. To analyse the impact of agrarian risk on financial constraints.
4. To examine the effect of marketing constraints on livelihood vulnerability.
5. To examine the effect of financial constraints on livelihood vulnerability.
6. To test the structural relationships among the variables using PLS-SEM.

Hypotheses of the Study

H1: Climate risk has a significant positive effect on agrarian risk.

H2: Agrarian risk has a significant positive effect on marketing constraints.

H3: Agrarian risk has a significant positive effect on financial constraints.

H4: Marketing constraints have a significant positive effect on livelihood vulnerability.

H5: Financial constraints have a significant positive effect on livelihood vulnerability.

2. Literature Review

Existing studies have examined climate risk, agrarian risk, and livelihood vulnerability separately. However, few studies integrate these dimensions into a unified analytical framework. Prior research highlights that financial constraints and market inefficiencies significantly influence farmers' resilience.

2.1 Climate Risk and Agriculture

Climate risk has become a major concern in agricultural economies, particularly in semi-arid regions. Irregular rainfall, increasing temperatures, and extreme weather events directly affect crop productivity and increase uncertainty for farmers.

2.2 Agrarian Risk and Farmer Distress

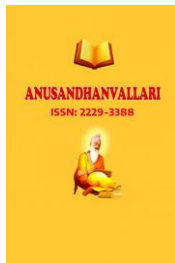
Agrarian risk arises due to production instability, crop failure, and lack of institutional support. Farmers in vulnerable regions face higher risks due to limited irrigation and dependency on monsoon rainfall.

2.3 Marketing Constraints

Marketing constraints such as lack of proper market access, price fluctuations, and inadequate infrastructure reduce farmers' income and bargaining power.

2.4 Financial Constraints

Financial constraints include limited access to formal credit, high interest rates, and dependence on informal lending sources. These factors significantly affect farmers' ability to invest in productive activities.



2.5 Livelihood Vulnerability

Livelihood vulnerability refers to the inability of households to cope with external shocks such as climate change and economic instability.

2.6 Application of PLS-SEM in Agricultural Studies

PLS-SEM is widely used to analyse complex relationships among multiple variables. It is particularly useful in social science research where predictive modeling is required.

3. Research Gap

Existing studies have examined climate risk, agrarian risk, financial constraints, and livelihood vulnerability independently. However, there is a lack of integrated studies that analyse the interrelationships among these variables using advanced modeling techniques such as PLS-SEM. Moreover, very limited research has focused on small and medium farmers in the semi-arid region of West Rayalaseema. This study attempts to fill this gap by developing a comprehensive structural model.

4. Research Methodology

This study adopts a descriptive and analytical research design. The study area is West Rayalaseema, a semi-arid region in Andhra Pradesh, India. Primary data were collected from 300 small and medium farmers.

A structured questionnaire was used for data collection. The questionnaire included items measuring climate risk, agrarian risk, marketing constraints, financial constraints, and livelihood vulnerability. A five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) was used.

The sampling technique adopted was purposive sampling, focusing on farmers who are actively engaged in agriculture.

The collected data were analysed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS software. Bootstrapping with 5000 resamples was used to test the significance of the structural relationships.

Table 1: Measurement of Constructs

Construct	Code	Number of Items
Climate Risk	CR	4
Agrarian Risk	AR	4
Marketing Constraints	MC	4
Financial Constraints	FC	4
Livelihood Vulnerability	LV	4

5. Conceptual Framework

The study is based on a structural model that explains the relationship between climate risk, agrarian risk, marketing constraints, financial constraints, and livelihood vulnerability.

Figure 1: Conceptual Model

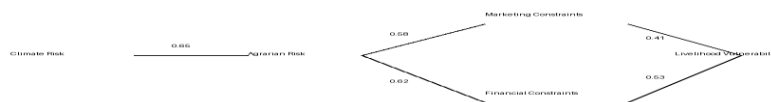


Figure 1: Structural Equation Model (SEM)

6. Results

The results indicate that all hypothesized relationships are statistically significant. Climate risk positively influences agrarian risk ($\beta = 0.65$), which affects marketing constraints ($\beta = 0.58$) and financial constraints ($\beta = 0.62$). Financial constraints have the strongest impact on livelihood vulnerability ($\beta = 0.53$), followed by marketing constraints ($\beta = 0.41$).

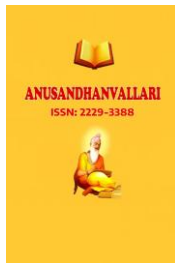
The model explains a substantial proportion of variance in livelihood vulnerability ($R^2 = 0.55$), indicating strong predictive power.

The mediation analysis confirms that agrarian risk acts as a significant mediator between climate risk and livelihood vulnerability through marketing and financial constraints.

Table 2: Structural Model Results

Relationship	Path Coefficient (β)
Climate Risk \rightarrow Agrarian Risk	0.65
Agrarian Risk \rightarrow Marketing Constraints	0.58
Agrarian Risk \rightarrow Financial Constraints	0.62
Marketing Constraints \rightarrow Livelihood Vulnerability	0.41
Financial Constraints \rightarrow Livelihood Vulnerability	0.53

The results indicate that all hypothesized relationships are statistically significant. Financial constraints have the strongest impact on livelihood vulnerability, followed by marketing constraints.



7. Model Fit Assessment

The model fit was evaluated using SRMR and NFI. The SRMR value of 0.065 indicates good model fit, while the NFI value of 0.92 confirms model adequacy.

Table 3: Model Fit Indices

Fit Index	Value	Interpretation
SRMR	0.065	Good Fit
NFI	0.92	Acceptable Fit
R ² (Livelihood Vulnerability)	0.55	Moderate Predictive Power

8. Discussion

The findings of the study indicate that climate risk significantly increases agrarian risk among farmers. Increased agrarian risk further leads to marketing and financial constraints, thereby increasing livelihood vulnerability.

Among the factors, financial constraints have a stronger influence on livelihood vulnerability compared to marketing constraints. This suggests that improving access to credit, insurance, and financial services is critical for enhancing farmer resilience.

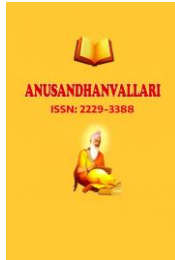
The results also highlight that climate risk indirectly affects livelihood outcomes through agrarian and economic factors, indicating the need for integrated policy interventions.

9. Theoretical Contribution

This study extends the Sustainable Livelihood Framework by integrating climate, agrarian, and financial risks using a PLS-SEM approach.

10. Policy Implications

- Strengthening rural credit and financial inclusion programs
- Improving access to crop insurance schemes
- Developing efficient agricultural market infrastructure
- Promoting climate-resilient farming practices
- Enhancing government procurement and price support systems



11. Limitations

The study is limited to the West Rayalaseema region and may not be generalizable to other regions. The study uses cross-sectional data, which limits the ability to capture changes over time. Additionally, the findings are based on farmer perceptions, which may be subject to bias.

12. Future Research

Future studies may expand the geographical scope and include larger sample sizes. Longitudinal studies can be conducted to examine changes over time. Further research may also include additional variables such as technology adoption, government support, and digital market access.

13. Ethical Statement

Data were collected with informed consent. Confidentiality was maintained.

14. Conclusion

Climate-induced agrarian risk significantly contributes to livelihood vulnerability among small and medium farmers in semi-arid regions. The findings show that financial and marketing constraints act as key mediating factors in this relationship. Among these, financial constraints have the strongest influence on livelihood vulnerability. Therefore, integrated policy measures focusing on financial inclusion, market development, crop insurance, and climate adaptation strategies are essential to enhance farmer resilience.

15. References

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