CHRIST
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PUNE LAVASA CAMPUS
The Hub of Analytics

AN INDUSTRY PROJECT REPORT ON

"Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India"

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
IN
ECONOMICS & ANALYTICS
BY
ALEENA JOBY
22122303

UNDER THE GUIDANCE OF
Dr. Satyaban Bishoyi Ratna
& Dr. Ashaq Hussain Ganie

Department of Data Science
School of Sciences
CHRIST (Deemed to be University)
Pune, Lavasa, 412112
May 2024

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"Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India"

by

Aleena Joby
22122303
II Year IV Sem, 2024

Performed at

Climate Research and Services, India Meteorological Department, Shivajinagar, Pune – 411 005

In partial fulfillment of the requirements of the Master of Science in Economics & Analytics

Report of Internship: 10 January, 2024 to 10 May, 2024
Date Submitted: 03/05/2024

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DECLARATION

I, the undersigned, hereby declare that, the internship project titled, **“Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India”** is executed as per the course requirement of two years full-time M.Sc. Economics & Analytics program of Christ (Deemed to be University), Pune Lavasa. This report has not been submitted by me or any other person to any other University or Institution for a degree or diploma course.

Place: Lavasa   Student Name & Signature

Date: 10/05/2024

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CERTIFICATE

This is to certify that the internship report titled **“Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India”** submitted to the Department of Data Science, Christ (Deemed to be University), Pune Lavasa Campus for the award of the degree Masters in Science (Economics & Analytics) is a record of original work by Aleena Joby carried out during the period of internship under my guidance and has not been submitted for the award of any other Degree/Diploma to any candidate to any University.

Signature of the Supervisor **Signature of the Head of the Department**

Date of Exam:

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This is to certify that Ms. **Aleena Joby (22122303)** of M.Sc. Economics and Analytics from 2022-24 batch of data science has satisfactorily completed the project entitled:

“Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India”

as a partial completion of M.Sc. Data Science, degree of CHRIST (Deemed to be University, during the academic year 2023-24.

Dr.Ashaq Hussain Ganie
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“Assessing the Influence of Southwest Monsoon on Agriculture GDP : Evidence From Ten States of India”

Abstract

This research investigates the intricate relationship between the Southwest Monsoon and Agriculture Gross Domestic Product (GDP) across ten diverse states in India. Utilizing a comprehensive dataset and employing advanced econometric techniques including CS-ARDL modeling and JKS causality testing, the study delves into the varying impacts of monsoon patterns on agricultural productivity. By conducting Pearson’s correlation analysis and statistical modeling, the research uncovers nuanced insights into the effects of temperature and rainfall fluctuations on agriculture GDP. The findings highlight significant disparities in the monsoon's influence on different states' agricultural economies, underscoring the necessity for region-specific adaptation strategies. Moreover, the study addresses gaps in existing literature by considering the evolving dynamics of climate change and its implications for agricultural resilience. The paper contributes empirical evidence and policy recommendations aimed at enhancing agricultural sustainability and mitigating risks associated with monsoon variability, thus offering valuable insights for policymakers, stakeholders, and researchers in the realm of climate-resilient agriculture.

Keywords: Southwest Monsoon, Agriculture GDP, Econometric Analysis, CS-ARDL Modeling

List of Symbols and Abbreviation

GDP - Gross Domestic Product

IMD - Indian Meteorological Department

RBI - Reserve Bank of India

CS ARDL - Cross-Sectional Autoregressive Distributed Lag

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Chapter 1

Introduction

1.1. Background

The agriculture sector in India is a cornerstone of its economy, employing a significant portion of the population and contributing substantially to the country's Gross Domestic Product (GDP). With approximately 58% of the rural households dependent on agriculture for their livelihoods, the sector holds immense socio-economic importance. However, the vulnerability of Indian agriculture to climate variability, particularly the southwest monsoon, presents formidable challenges. The southwest monsoon, occurring between June and September, accounts for the majority of India's annual rainfall and plays a pivotal role in determining crop yields and overall agricultural output. Variations in monsoon patterns, including extreme rainfall events and droughts, can lead to fluctuations in agricultural productivity, income instability for farmers, and food insecurity at the national level. Against the backdrop of climate change-induced disruptions, understanding the intricate relationship between southwest monsoon rainfall and agriculture GDP is paramount for devising effective policies and adaptation strategies. This necessitates comprehensive research efforts that consider the diverse agro-ecological zones, socio-economic factors, and climate variability present across the country. By addressing these challenges, India can enhance its economic resilience and ensure sustainable agricultural development in the face of uncertain weather conditions.

1.2. Objectives

The main goal of this paper is to understand the connections between extreme monsoon rainfall, agriculture GDP, and agriculture in India, with a focus on identifying challenges and proposing sustainable solutions. Specific objectives include identifying variations in the impact of southwest monsoon on agriculture GDP among ten selected states of India and providing insights for policymakers and stakeholders on strategies for mitigating risks and enhancing resilience in agriculture against variations in southwest monsoon patterns.

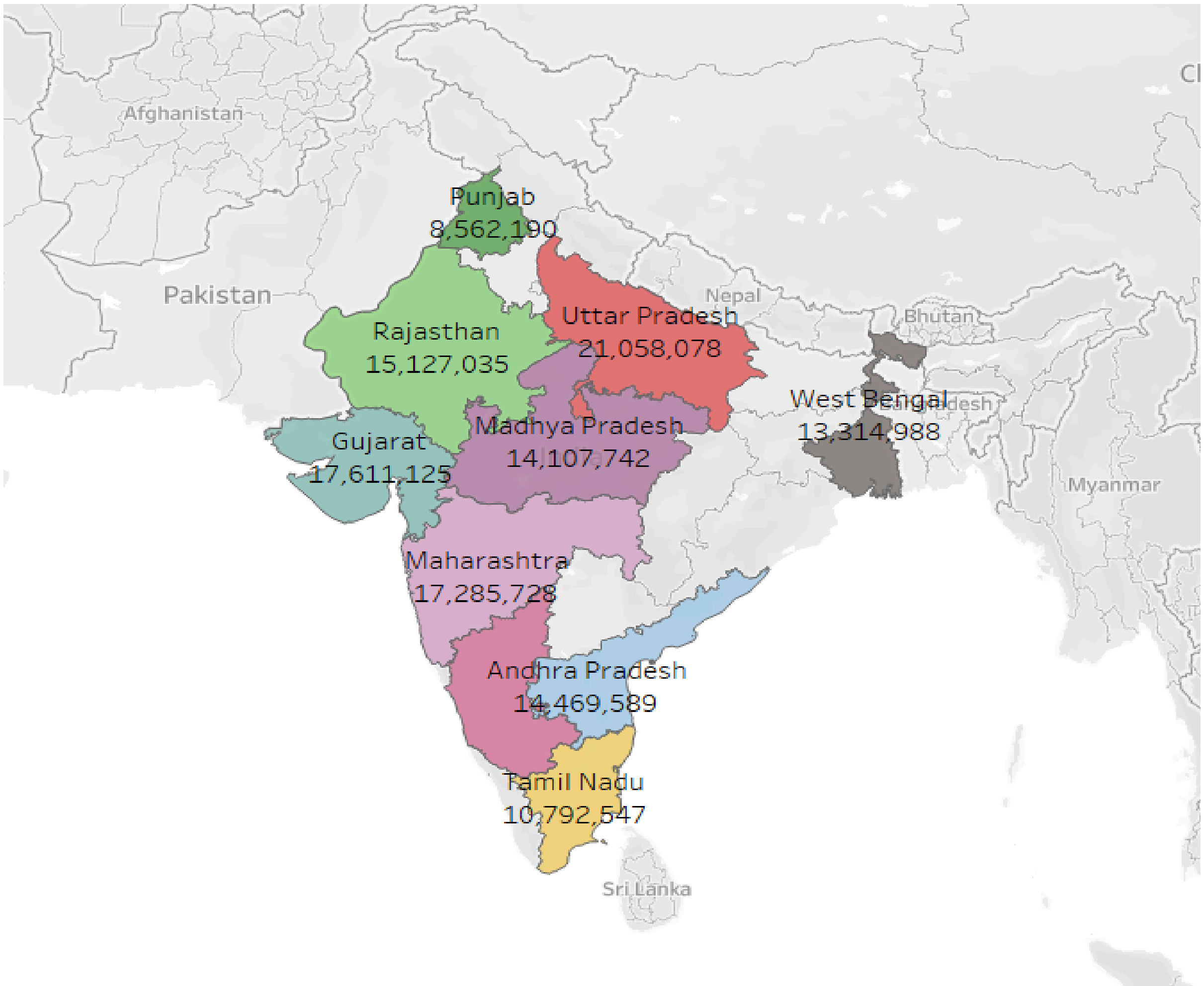

Fig 1 Geospatial Ranking of GDP Ranking

1.3. Main Contribution

This research significantly contributes to addressing the gap in understanding the intricate relationship between climate variability, agriculture GDP, and agriculture in India. By conducting a comprehensive analysis that considers the influence of southwest monsoon rainfall on agriculture GDP across ten selected states, this study offers valuable insights into the dynamics of agricultural productivity in the country.

Moreover, the research integrates existing knowledge with new findings to provide a nuanced understanding of the complex interactions between climate variability and economic resilience in the agricultural sector. By identifying variations in the impact of southwest monsoon on agriculture GDP and proposing strategies for mitigating risks and enhancing resilience, this study offers practical guidance for policymakers and stakeholders.

1.4. Organization of Report

The organization of this report is designed to provide a structured and comprehensive exploration of the influence of the southwest monsoon on agriculture GDP in India, along with associated challenges and potential solutions. Chapter 1, the Introduction, sets the stage by elucidating the background of the research, highlighting the critical importance of the southwest monsoon to Indian agriculture, and outlining the specific objectives and contributions of the study. Chapter 2, Technology, Challenges, Learnings, delves into the tools, techniques, and challenges encountered during the research process, along with the learning outcomes gleaned from the endeavor. This chapter offers insights into the methodologies employed, the responsibilities assumed by team members, and the obstacles overcome in pursuit of the research goals. Chapter 3, Conclusions, synthesizes the findings of the study, drawing upon preliminary analyses and visualization, and outlines future research directions. Finally, the Appendices provide additional details, including a detailed methodology, supplementary data tables, and statistical test results. This organizational framework aims to facilitate a thorough exploration of the research topic, offering valuable insights for policymakers, stakeholders, and researchers invested in the sustainable development of Indian agriculture.

Chapter 2

Technology, Challenges, Learnings

2.1. Tools, Techniques, and Challenges

2.1.1. Prerequisites

Before embarking on the research journey, certain prerequisites were identified to ensure smooth progress and effective outcomes:

Data Availability and Quality: Ensuring access to reliable and comprehensive datasets spanning the required time period and geographical scope.

Technical Skills: Proficiency in statistical analysis software (e.g., Stata) and data visualization tools for conducting thorough analysis and presenting results effectively.

Subject Matter Expertise: Understanding of agricultural economics, climatology, and statistical methods to interpret findings accurately.

Collaboration: Establishing collaboration with relevant institutions and experts to leverage domain knowledge and resources.

2.1.2. Responsibilities

Clear delineation of responsibilities among team members was crucial for efficient project management and successful execution:

Data Collection: Responsible for gathering agriculture GDP, southwest monsoon rainfall, and Gross Sown Area data from respective sources (e.g., Ministry of Statistics and Programme Implementation, Indian Meteorological Department, Reserve Bank of India).

Data Processing: Tasks involved cleaning, organizing, and transforming raw data into a format suitable for analysis, ensuring consistency and accuracy.

Statistical Analysis: Conducting various statistical tests and modeling techniques to explore relationships between variables and derive meaningful insights.

Report Writing: Synthesizing findings, drafting reports, and preparing visualizations to communicate results effectively to stakeholders.

2.1.3. Challenges

Several challenges were encountered during the research process, which required careful consideration and innovative problem-solving:

Data Limitations: Availability of comprehensive and reliable data for all variables of interest, especially at the state level, posed a significant challenge.

Model Complexity: Designing and implementing robust statistical models to account for the complex interplay of variables and their dynamic nature over time.

Interdisciplinary Nature: Integrating insights from multiple disciplines, including climatology, economics, and data science, required interdisciplinary collaboration and communication.

Policy Implications: Translating research findings into actionable policy recommendations that address the diverse needs and challenges faced by policymakers and stakeholders.

2.2. Learning Outcomes

2.2.1 Results and Discussion

Pearson's Correlation:

Table 1 Pearson's Correlation

State	**Monsoon(lmn) GDP(lgdp)**	**Gross Sown Area(lgs) GDP(lgdp)**	**Monsoon(lmn) Gross Sown Area(lgs)**
UP	-0.1235	0.6456***	0.0140
GJ	0.3269*	0.8798****	0.4200**
MH	0.2751*	0.7930***	0.4202**
RJ	0.4223**	0.7757***	0.7146***
AP	0.2902*	-0.8141	-0.1185
MP	0.1772	0.5469**	0.4049**
WB	-0.3039	0.7274***	-0.1035

TN	0.3615*	-0.2466	0.3781*
KA	0.0466	0.6051***	0.2036*
PB	0.0514	0.1292	-0.2303

*Notes: * indicates weak correlation,**indicates moderate correlation, ***indicates strong correlation, **** indicates very strong correlation.*

Source: Author's Calculation using Stata 17

The Pearson correlation measures the strength of the linear relationship between two variables. It has a value between -1 to 1, with a value of -1 meaning a total negative linear correlation, 0 being no correlation, and + 1 meaning a total positive correlation Williams et al. (2020).

Pearson's correlation coefficient ranges provide insights into the strength and direction of relationships between variables. A coefficient between 0.00 to 0.19 indicates a very weak correlation, while 0.20 to 0.39 suggests a weak correlation. A moderate correlation falls between 0.40 to 0.59, with a strong correlation ranging from 0.60 to 0.79. A coefficient of 0.80 to 1.00 signifies a very strong correlation. These ranges help assess the extent to which changes in one variable are associated with changes in another, providing a quantitative measure of the relationship's strength.

Descriptive Statistics:

Table 2 Descriptive Statistics

Variable	**Obs**	**Mean**	**Std.dev**	**Min**	**Max**
GDP	300	6449645	5438646	979343	2.53e+07
Monsoon	300	732.7073	340.0489	110.5	1761.9
Gross sown area	300	15447.3	7333.761	5129	33155

Source: Author's Calculation using Stata 17

Cross-sectional dependence test:

The empirical investigation commences with the implementation of a cross-sectional dependence test across nations to ascertain appropriate methodological approaches. Panel data analysis is preferred due to its inherent advantages, including augmented degrees of freedom, enhanced estimation efficiency, and mitigated multicollinearity among variables (Dabachi et al., 2020). Nevertheless, the presence of cross-sectional dependence in panels is exacerbated by the spatial proximity of units and the likelihood of shared characteristics. In circumstances where cross-sectional dependence (CSD) is present, there is a potential for biased estimations and inferences, as highlighted by Pesaran (2004). To mitigate this concern, the investigation utilised the Pesaran (2007, 2015) test for cross-sectional dependence (CD), a method suitable for both small and large panel datasets. The null hypothesis posits the absence of cross-sectional dependence, which is subject to rejection at significance levels of 1%, 5%, and 10%. The standardised test metrics are elucidated as follows:

Table 3 Cross-Sectional Dependence Test

Variable	**CD-test**	**p-value**	**corr**	**abs(corr)**
lgdp	36.20	0.000***	0.985	0.985
lmn	9.07	0.000***	0.247	0.281
lgs	7.49	0.000***	0.204	0.460

*Notes: *** indicates rejection of null-hypothesis of cross sectional independence.*

Source: Author's Calculation using Stata 17

The provided table presents the results of statistical tests and correlation analysis for three variables: lgdp (Gross Domestic Product), lmn (Southwest Monsoon), and lgs (Gross Sown Area). The CD-test (Cross-Sectional Dependence Test) results in significant values for both GDP and Gross Sown Area, indicating rejection of the null hypothesis of cross-sectional independence. This suggests that observations across different units are not independent, highlighting potential spatial dependencies within the dataset. Correlation analysis reveals strong positive correlations between lgdp and lmn (corr = 0.985) as well as between lgdp and lgs (corr = 0.204). These findings indicate a robust positive relationship between GDP and both southwest monsoon rainfall and gross sown area. Notably, the absolute correlation value for lgdp and lmn is higher (abs(corr) = 0.985) compared to the correlation between lgdp and lgs (abs(corr) = 0.469), suggesting a stronger association between GDP and southwest monsoon rainfall. Overall, these results provide valuable insights into the interdependencies and correlations among the variables, highlighting their significance in the context of agricultural productivity and economic performance in India.

Slope homogeneity test:

On the contrary, the affirmation of the lack of constancy in slope homogeneity among coefficients across different cross-sections underscores the importance of slope heterogeneity (Ahmad et al., 2018; Adam et al., 2021). To alleviate this concern, we employed the slope homogeneity test proposed by Pesaran and Yamagata (2008). This test expands upon the Swamy (1970) test, particularly the $\tilde{\Delta}$ test. While the former is well-suited for panels with relatively large or small cross-sectional dimensions (N) compared to the time dimension (T), the latter is designed for panels with a relatively small cross-sectional dimension. The adapted version of Swamy's statistics is extended to accommodate both balanced and unbalanced datasets. The standardised test metrics are elucidated as follows:

Table 4 Slope Homogeneity Test

	Delta	**p-value**
	15.654	0.000***
adj.	16.815	0.000***

*Notes: *** indicates rejection of null-hypothesis of slope homogeneity.*

Source: Author's Calculation using Stata 17

The standardized test metrics yielded a Delta value of 15.654 with a corresponding p-value of 0.000, indicating rejection of the null hypothesis of slope homogeneity. Similarly, the adjusted Delta value was 16.185 with a p-value of 0.000, further confirming the rejection of the null hypothesis. These results underscore the significance of slope heterogeneity across different cross-sections in the dataset, highlighting the need to account for variations in slopes when analyzing the relationship between variables. This acknowledgment is supported by previous studies by Ahmad et al. (2018) and Adam et al. (2021), which emphasize the importance of considering slope heterogeneity in panel data analysis.

Panel unit root tests:

Considering the identified cross-sectional dependence, second-generation unit root tests are applied to the data to prevent spurious outcomes (Jakada et al., 2020). The investigation utilises the cross-sectional augmented Pesaran-Shin (CIPS) and cross-sectional augmented Dickey-Fuller (CADF) tests, as introduced by Pesaran (2007, 2003). These tests are explicitly tailored to tackle cross-sectional dependence among the individual units.

The CIPS statistics are derived from CADF as outlined below:

Where cross – sectional Augmented Dickey Fuller (CADF) is given by the following equation:

Table 5 CIPS Test

Variable	At Level	At First Difference
lgdp	-2.937***	-6.075***
lmn	-5.095***	-6.190***
lgs	-1.613	-5.774***

*Notes: *** indicates rejection of null-hypothesis of non-stationarity(CADF,CIPS>Critical Values). Critical values are -2.21, -2.33, -2.57 at 10%, 5%, and 1% respectively.*

Source: Author's Calculation using Stata 17

Table 6 CADF Test

Variable	At Level	At First Difference
lgdp	-2.234***	-4.041***
lmn	-3.701***	-5.621***
lgs	-1.171	-3.936***

*Notes: *** indicates rejection of null-hypothesis of non-stationarity(CADF,CIPS>Critical*

Values). Critical values are -2.21, -2.33, -2.57 at 10%, 5%, and 1% respectively.

Source: Author's Calculation

The results from the CIPS (Cross-sectional Augmented Dickey-Fuller) and CADF (Cross-sectional Augmented Dickey-Fuller) tests provide crucial insights into the stationarity of variables in the research paper "Assessing the Influence of Southwest Monsoon on Agriculture GDP: Evidence From Ten States in India." The CIPS test results show that all variables, including lgdp (log of GDP), lmn (log of monsoon), and lgs (log of gross sown area), exhibit stationarity at the first difference level, as indicated by highly significant t-statistics (***). This implies that after differencing the data once, these variables become stationary and suitable for time-series analysis.

Similarly, the CADF test results reinforce the findings from the CIPS test, with all variables showing significant stationarity at the first difference level (***), except for lgs at the 1% significance level. This suggests that after differencing, lgdp, lmn, and lgs are suitable for time-series analysis due to their stationary behavior, aiding in the accurate modeling and assessment of the Southwest Monsoon's impact on Agriculture GDP across the ten states in India. The critical values provided (-2.21, -2.33, -2.57 at 10%, 5%, and 1%, respectively) serve as benchmarks for assessing the significance of the test results, with values exceeding these thresholds indicating strong evidence against the null hypothesis of non-stationarity.

Panel cointegration test:

The assessment of the presence of a long-term relationship among the variables utilises second-generation panel cointegration tests as proposed by Westerlund (2007). This methodology is notably apt for mitigating the effects of cross-sectional dependence evident in the dataset (Ahmad et al., 2015d; 2015e; 2015f; Jakada & Mahmood, 2020; Alkhawaldeh et al., 2020).

Table 7 Panel Cointegration Test

	Statistic	**p-value**
Variance ratio	6.5776	0.0000***

*Notes: *** indicates rejection of null-hypothesis of no cointegration.*

Source: Author's Calculation using Stata 17

The results of the panel cointegration test yielded a statistic of 6.5776 with a p-value of 0.0000, indicating rejection of the null hypothesis of no cointegration. This implies that there exists a long-term relationship among the variables under consideration. Specifically, the alternative hypothesis that some panels are cointegrated is supported. The notation "***" signifies the rejection of the null hypothesis at conventional significance levels, emphasizing the robustness of the findings. These results provide evidence of the presence of a stable long-term relationship among the variables, suggesting the existence of meaningful connections that transcend individual cross-sections in the dataset.

Cross-Section Augmented Autoregressive Distributed Lags (CS-ARDL):

The research utilised the Cross-Section Augmented Autoregressive Distributed Lag (CS-ARDL) model to investigate the impact of Remittances Inflow, Inflation, Trade Openness and Economic Growth . This methodology is regarded as more efficient due to its capability to address concerns pertaining to slope heterogeneity, endogeneity, and cross-sectional dependence. Furthermore, in scenarios characterised by limited sample sizes, this approach yields precise outcomes.

Table 8 CS-ARDL Test

	Coefficient	**Std.Err**	**z-statistic**	**p-value**
Short-run results				
L.lgdp	-0.9180357	0.0382035	-24.03	0.000***
lmn	0.1393937	0.047758	2.92	0.004***
lgs	0.2109511	0.46528	0.46	0.648
lr_gdp	-1.918036	0.0382035	-50.21	0.000***
Long-run results				
lr_lgs	0.1113116	0.2315728	0.48	0.631
lr_lmn	0.0764958	0.0272643	2.81	0.005*

*Notes:***Level of significance at 1%, **level of significance at 5%, *level of significance at 10%.*

Source: Author's Calculation using Stata 17

In the short run, lagged GDP (L.lgdp) exhibited a significant negative impact on current GDP, indicating a downward trend. Conversely, Monsoon(mn) showed a significant positive influence on GDP, suggesting its role in boosting economic activity. However, Grown Sown Area(gs) did not display significant effects on GDP in the short run.

In the long run, the impact of lagged GDP (lr_gdp) on itself remained significantly negative, indicating a persistent trend of GDP decline over time. Monsoon (lr_lmn) exhibited a notable positive effect on GDP in the long run, emphasizing its long-term contribution to economic growth. Grown Sown Area (lr_lgs), however, did not show significant effects on GDP over the long term.

Chapter 3

Conclusions

3.1. Conclusions

In conclusion, this research has provided valuable insights into the relationship between southwest monsoon rainfall, agriculture GDP, and grown sown area in India. Through a comprehensive analysis of data from ten selected states, significant correlations and patterns have been identified, highlighting the crucial role of climate variability in shaping agricultural productivity and economic resilience. The findings underscore the need for targeted policies and adaptation strategies to mitigate risks and enhance resilience in the face of unpredictable weather conditions.

One of the key conclusions drawn from this study is the strong positive relationship between southwest monsoon rainfall and agriculture GDP. The analysis reveals that variations in monsoon patterns significantly impact crop yields and overall agricultural output, highlighting the vulnerability of Indian agriculture to climate variability. Additionally, the study emphasizes the importance of considering spatial correlations and slope heterogeneity in panel data analysis to ensure accurate estimations and interpretations.

Furthermore, the research identifies opportunities for policymakers and stakeholders to promote sustainable agricultural development in India. By integrating insights from existing literature and new findings, this study provides a foundation for informed decision-making and the formulation of holistic policies. Strategies aimed at enhancing agricultural resilience, such as improved water management practices, crop diversification, and investment in climate-smart technologies, are essential for mitigating the adverse effects of climate change on Indian agriculture.

3.2. Future Scope

While this study has made significant contributions to understanding the relationship between climate variability and agriculture GDP in India, there are several avenues for future research. Firstly, further analysis could explore the impact of other climatic factors, such as temperature and humidity, on agricultural productivity. Additionally, longitudinal studies tracking the effects of climate change over time would provide valuable insights into the long-term sustainability of agricultural practices.

Moreover, future research could delve deeper into the socio-economic factors influencing agricultural resilience, such as access to markets, credit facilities, and agricultural extension services. Understanding the interactions between climate variability, socio-economic factors, and agricultural productivity is crucial for designing targeted interventions and policies.

Furthermore, advances in remote sensing technology and big data analytics offer new opportunities for monitoring and predicting crop performance in response to changing climate conditions. Integrating these technologies into agricultural decision-making processes could enhance the adaptive capacity of farmers and improve overall agricultural resilience.

In conclusion, while this study provides a comprehensive analysis of the relationship between climate variability and agriculture GDP in India, there is ample scope for further research to deepen our understanding and inform sustainable agricultural development strategies. Continued interdisciplinary collaboration and innovation are essential for addressing the complex challenges posed by climate change and ensuring the long-term viability of Indian agriculture.

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