MULTIDISCIPLINARY SCIENCE JOURNAL

RESEARCH ARTICLE
Published Online: July 3, 2025
https://doi.org/10.31893/multiscience.2026058

Indian groundnut production: Growth, irrigation, and the role of sustainable agriculture in the future

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Abstract In this study, productivity, yield, and area covered under irrigation of the groundnut crop are the main emphasis areas, as it investigates the relationship between irrigation and groundnut production outcomes in India from 1950–51 to 2020–21. We estimated the average annual growth rate of groundnut productivity (yield) over the given period via the compound annual growth rate (CAGR). The calculated CAGR of approximately 2.49% indicates a positive and steady growth trajectory in groundnut output over the examined period. Regression analysis was used to examine the impact of irrigation on groundnut production via secondary data from government sources. According to the results, there is a strong positive association between groundnut production and irrigation, with irrigation levels accounting for approximately 50.3% of the production variance. The shade analysis performed in this study revealed patterns such as increasing irrigation coverage over time along with a steady increase in groundnut production over time. A 2020 study by Narayanamoorthy et al. revealed the groundbreaking effects of drip irrigation on groundnut production. The results of their research revealed that the use of flood irrigation techniques resulted in a large increase of 79% in groundnut yield and a remarkable decrease of 36% in water use. Farmers were able to increase their income through the use of drip irrigation since it reduced the costs of manpower, weeding, and intercultivation while simultaneously optimizing water utilization. This is consistent with the research that we have done using secondary data. This research recommends expanding access to modern irrigation methods, including drip and sprinkler systems, for farmers. These improvements can enhance sustainable agricultural practices and increase farmers' income by decreasing the consumption of water and input costs while increasing yields. In addition, future research may focus on examining differences between regions in the use of irrigation and the social and economic impacts of better irrigation systems in areas where groundnuts grow.

Keywords: irrigation, regression analysis, production, groundnut crop, CAGR, sustainable agriculture

1. Introduction

India grows groundnut, an important oilseed crop. China and India are the two countries that produce the most groundnuts, which is noteworthy and highlights the enormous economic and nutritional value of crops in these areas. Owing to their flexibility, people cultivate and trade groundnuts worldwide, allowing them to thrive in a variety of environmental conditions (ICRISAT Report). Groundnut is cultivated year round in a two-crop cycle and harvested in March and October (Agricultural & Processed Food Products Export Development Authority, APEDA 2020). Groundnuts are important crops that support agricultural economies and food security globally. Millions of people rely on it as a major source of food and income since it is grown in a variety of agroclimatic zones, from tropical to temperate. The optimization of agricultural methods, especially irrigation management, is critical for ensuring sustainable production and improving farmer livelihoods in groundnut-growing regions.

Owing to their widespread cultivation in warm temperate, tropical, and subtropical climates, groundnuts have established their position in the world's agricultural economy. Produced over a vast area of over 32.7 million hectares, groundnut production achieved an outstanding yield of 53.9 million tons per year in 2021 (FAOSTAT).

A critical subject in agricultural research and policy development is the relationship between irrigation techniques and groundnut output. To improve total crop output and devise efficient water management strategies, it is imperative to understand how differences in irrigation affect groundnut yield. The purpose of this study was to examine the trends in the area, production, and productivity of groundnuts in India from 1950--51 to 2020--21. We examined the relationship between irrigated areas and groundnut production in India from 1950–51 to 2020–21 via data from several government sources, such as agricultural surveys and administrative records. We used the compound annual growth rate (CAGR) to estimate the total area covered and productivity (yield) of groundnuts in India from 1950–51 to 2020–21. Microirrigation is vital to sustainable agriculture because it increases crop output, soil health, and water usage efficiency. It provides water directly to the root zone, which decreases waste, soil erosion, and energy usage. Fertigation enhances nutrient efficiency and mitigates environmental effects. In the face of water scarcity and climate change, microirrigation requires farmer acceptance and government support to guarantee food security and agricultural sustainability.

The potential of this research is to support evidence-based decision-making in agricultural water management and resource allocation, which accounts for its significance. By measuring the link between irrigation and groundnut cultivation characteristics, policymakers, agronomists, and farmers can develop customized interventions that make better use of water, lower production risks, and promote long-term intensification of groundnut farming systems. Through careful empirical analysis and interpretation of data from official sources, this study aims to provide important insights into how groundnut farming and irrigation management work. The purpose of this study is to increase efforts to promote sustainable agriculture, augment rural livelihoods, and achieve global food security by increasing the total irrigated area in agriculture.

1.1. Objectives

1. The goal of this study was to estimate the CAGR in terms of the total area coverage and productivity of groundnuts in India from 1950--51 to 2020--21.
2. The second objective was to analyze the correlation between the irrigated area and the production of groundnuts in India from 1950--51 to 2020--21.
3. The objective of this study was to evaluate the role of microirrigation in enhancing water efficiency and sustainability in agriculture.

2. Materials and Methods

Data collection: We gathered data on the production, yield, area, and coverage of groundnut crops under irrigation across India from 1950–51 to 2020–21 for this study from a number of credible sources. The overall goal of the data collection phase was to create a solid dataset that would allow for comprehensive analysis and understanding of patterns in irrigation and groundnut production over the designated period of time.

Statistical tools:

Statistical tools such as compound growth rate, regression analysis, and decade analysis are used to analyze growth rates and trends in the area, production, and productivity of groundnut crops in India from 1950–51 to 2020–21.

The compound growth rate (CAGR): The compound annual growth rate (CAGR) is a concise measure of the average yearly growth rate of groundnut productivity from 1950--51 to 2020--21. The CAGR formula is *CAGR = {(EV/BV)1/n - 1} * 100.*

where EV = the ending value.

BV = Beginning value

n = Number of years

Regression analysis: The relationship between groundnut production and the proportion of area covered by irrigation was examined via a simple linear regression model. The regression model focused on how variations in irrigated areas affected the yield and production of groundnuts over time.

Equation used: Production = $\beta_0 + \beta_1$ * Area Coverage under Irrigation + ε

Software used for analysis: For data analysis and regression modeling, the statistical software SPSS was used; for decade analysis, Excel was used. After the regression model was fitted to the data, statistical tests were run to evaluate the overall model fit and regression coefficient significance.

Interpretation: Regression analysis findings were evaluated to determine the long-term link between the total irrigated area and groundnut production. We used this analysis's insights to understand how irrigation impacts groundnut production in India.

This study used a decade analysis to investigate the trends and patterns in groundnut cultivation and irrigation coverage over time. On the basis of the results, we organized and analyzed the gathered data on a decade-by-decade basis. To facilitate comparisons and evaluations of variations in output, yield, area coverage, and area under irrigation over the years, each decade was regarded as a separate time period for study.

Definition of variables:

Production: The total amount of groundnuts gathered during the course of a decade is expressed in million tons.
Yield: The average groundnut yield for each decade is determined by dividing total production by total farmed area (e.g., kg per hectare).
Area: The total area coverage is indicated in million hectares that have been cultivated to groundnuts during the course of a decade.
The percentage of cultivated groundnut land that received irrigation over the course of a decade is the average coverage of the irrigated area.

Model assumptions and diagnostics:

2.1. Regression model summary

The regression analysis was conducted to examine the relationship between irrigation (independent variable) and production (dependent variable). The summary is presented in Table 1.

Table 1 Regression model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.709	0.503	0.496	1.2108	2.099

Source: SPSS analysis.

The R2 value of 0.503 suggests that 50.3% of the variance in production is explained by irrigation. The adjusted R2 value of 0.496 confirms the stability of the model.

2.2. Independence of error

The Durbin-Watson statistic was calculated to test for autocorrelation in the residuals. A value of 2.09, as shown in table 1, falls within the acceptable range of 1.5 to 2.5 indicating that there is no significant autocorrelation in the residuals.

2.3. Normality of Residuals

To access whether the residuals are normally distributed, a histogram of standardized residuals (Figure 1) and Q-Q plot (Figure 2) were generated.

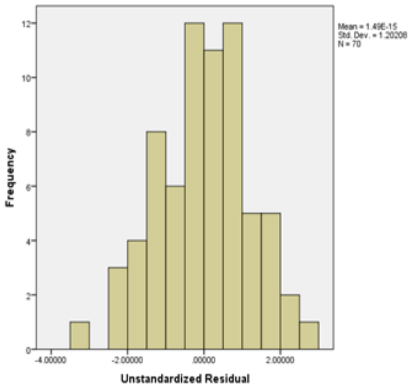

Figure 1 Histogram of standardized residuals.
Source: generated using spss.

The histogram shows a bell-shaped distribution indicating that the resuduals approximate normality.

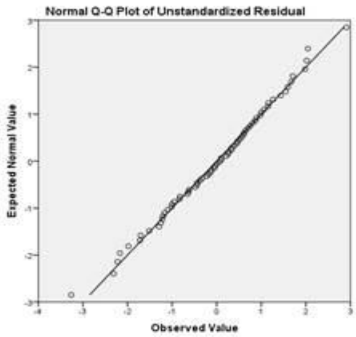

Figure 2 Q-Q plot of standardized rediduals.
Source: Generated using spss.

The Q-Q plot indicates that most data points lie close to the diagonal line which confirms normality.

Additionally, Table 2 represents the Kolmogorov-Smirnov (p=0.200) and Shapiro-Wilk (p=0.991) tests confirm normality as both p-values are greater than 0.05, suggesting that the residual follow a normal distribution. The assumption of normality is satisfied.

Table 2 Test of Normality.

Test	Statistic	df	Sig.
Kolmogorov-Smirnov	0.042	70	0.200
Shapiro-Wilk	0.995	70	0.991

Source: SPSS.

2.3.1. Homoscedasticity check

A scatter plot of standardized residuals vs. predicted values (Figure 3) was analysed to test the homoscedasticity (constant variance of residuals) and the model satisfies the homoscedasticity.

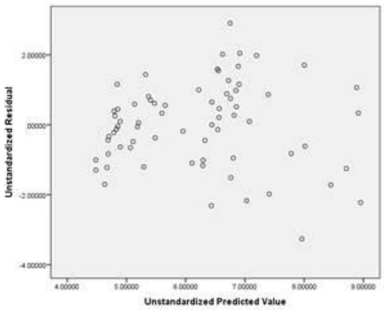

Figure 3 Scatter plot of Residuals vs. Predicted Values.
Source: Generated using spss.

The model mostly meets the homoscedasticity assumption as stated in the residuals vs. fitted values plot, which shows no strong funnel shape and the variance in residuals is relatively stable across all levels of irrigation. However, it is important to acknowledge that the production is influenced by other external factors like soil health, unexpected rainfall and other environmental variables that were not included in this regression model.

Additionally, the Durbin-Watson statistic (2.09) and the lack of clear pattern in residuals support the conclusion that no major heteroscedasticity issue exists, ensuring that the regression results remail valid.

3. Review of Literature

Viswanatha Reddy et al. (2017) analyzed the area, production, yield trends, and pattern of oilseed growth in India. According to this estimate, India is the world's fourth-largest oilseed producer, contributing 2.7% of worldwide production and almost 19% of the world's total area. Over the past 30 years, there has been a notable increase in both the acreage and production of oilseed crops. However, oilseed production and area growth rates are negligible compared with those of other major food grain crops, such as paddy, and yield fluctuations are substantial among the states. This study examined the patterns of variation and growth performance of the main oilseeds in each of the states in India. The regional and temporal production performance of oilseeds revealed an unfavorable outlook.

2. A trend analysis of the area, production, and productivity of groundnut crops in Cuddalore District, Tamil Nadu, was a focus of research performed in 2016 by Shenbagavalli et al. According to a previous report, rainfed conditions cover 80% of the nation's groundnut acreage. Therefore, the amount and distribution of rainfall during the crop season in major groundnut-growing states (Gujarat, Tamil Nadu, Andhra Pradesh, and Karnataka) impact the country's yearly groundnut production as well as average groundnut productivity.

3. Pusadekar et al. (2020) examined Gujarat's groundnut output, productivity, and growth trends, as well as a breakdown of the crop area. The 20-year secondary dataset, which was divided into two subperiods—period I, from 1996–1997 to 2005–06, and period II, from 2006–07 to 2015–16—formed the basis of the analysis. An exponential function was used to calculate the growth rates, and the coefficient of variation and Cuddy Della Valle instability index were used to calculate the instability. Using the Minhas decomposition model, the relative contributions of area and yield to the output change were calculated. The decomposition study revealed that area had the most significant impact on groundnut output over the whole period. The study also revealed that the cubic function worked best for area, productivity, and production. During the first period, area, production, and productivity all increased at positive compound rates.

4. Groundnut production and processing in India are highly inefficient, as noted by Ma Cynthia Bantilan (2012). She recommended replacing outdated seed varieties with improved varieties through creative seed systems, implementing low-cost technology to increase production efficiency, and promoting oil seed clusters to increase processing industry productivity. These steps can increase and stabilize groundnut production in India.

5. Suthar et al. (2024) conducted a study based on secondary data from 2002–03 to 2019–20. The top five states that produced the most groundnuts were chosen on the basis of the average production throughout the previous three years. We calculated the growth rate and volatility via the Compound Annual Growth Rate and Cuddy-Della Valle Index. With the exception of Rajasthan State (7.667%), the growth pattern of groundnuts tended to be negative. The growth pattern of groundnuts tended to decrease in the states of Andhra Pradesh, Karnataka, and Tamil Nadu with respect to output. Gujarat had the highest growth rate in terms of groundnut output (4.442%). According to the instability index, Gujarat (41.660%) and

Andhra Pradesh (44.453%) have greater variations in their groundnut production. The region beneath the groundnuts presented a low rate of instability.

6. The findings of the article by Ramteke et al. (2019) demonstrate that the proper implementation of water-saving technologies in agriculture may substantially enhance the overall sustainable growth of agriculture in China.

4. Results and Discussion

Table 3 shows data on groundnut agriculture in India for the years 2020--21 and 2021--22, indicating the area, productivity, yield, and irrigation coverage throughout principal producing states. In the fiscal year of 2021--22, Gujarat accounted for over 44% of India's groundnut production. The total cultivated area in Gujarat decreased slightly from 2.16 million hectares in 2020-21 to 1.99 million hectares in 2021-22, whereas the yield increased markedly from 1911 kg/ha to 2262 kg/ha, indicating enhanced agricultural practices, seed varieties, or climatic conditions.

Table 3 Presents the groundnut area, production, yield, and irrigation coverage for the years 2020--21 and 2021--22 in major producing states in India.

2021-2022						2020-2021					(%) Area under irrigation 2019-20
State/ UT	2021-22 Area (Mha)	% of All India	2021-22 Production (MT)	% of All India	Yield (kg/ha) 2021-22	2020-21 % of Area (Mha)	% of All India	2020-21 Production (MT)	% of All India	Yield (ka/he) 2020-21	
Gujarat	1.99	34.59	4.49	44.48	2262	2.16	35.96	4.13	40.35	1911	21.93
Rajasthan	0.80	13.89	1.70	16.83	2131	0.86	14.23	1.93	18.85	2256	87.86
Tamil Nadu	0.37	6.45	0.95	9.36	2553	0.41	6.80	1.02	9.99	2502	38.17
Madhya Pradesh	0.39	6.81	0.67	6.66	1722	0.29	4.87	0.52	5.11	1786	6.78
Karnataka	0.63	11.02	0.55	5.41	863	0.72	11.99	0.72	7.03	999	26.22
Andhra Pradesh	0.82	14.32	0.52	5.13	630	0.87	14.46	0.78	7.75	891	18.28
Maharastra	0.30	5.14	0.38	3.72	1273	0.31	5.14	0.41	3.98	1318	20.80
Others	0.45	7.78	0.85	8.41	1902	0.39	6.56	0.73	7.13	1852	-
All India	5.75	100.00	10.11	100.00	1759	6.01	100.00	1.24	100.00	1703	36.09

Source: Fourth Advanced Estimates (2021--22) *Provisional Estimates for 2020—21. *Note:* Area–Million Hectares; Production–Million Tonnes; Yield–kg/Hectare.

Rajasthan, the second-largest producer, boasts the highest irrigation coverage at 87.86%. Rajasthan yielded 2256 kg/ha in 2020–21 and 2131 kg/ha in 2021–22, although there was a minor reduction in area. This illustrates the impact of irrigation infrastructure on sustained production. Tamil Nadu produced 2553 kg/ha in 2021--22, the highest among all states, although it accounted for only 6.45% of India's total. Tamil Nadu has increased groundnut yields to 38.17% with advanced farming techniques, irrigation assistance, and superior seed varieties.

Madhya Pradesh raised its agricultural area from 0.29 Mha in 2020-21 to 0.39 Mha in 2021-22, notwithstanding its small contribution. Nonetheless, its productivity decreased from 1786 kg/ha to 1722 kg/ha, perhaps due to insufficient irrigation coverage (6.78%), rendering it vulnerable to climate change. On the other hand, the productivity of Andhra Pradesh increased from 630 kg/ha from 2020--21 to 891 kg/ha from 2021--22, even though only 18.28% of its agricultural land received irrigation. This demonstrates improved input management and agronomic techniques throughout the state. Karnataka reported the lowest groundnut yield, which decreased from 999 kg/ha in 2020-21 to 863 kg/ha in 2021-22. Climate variability, soil degradation, and inadequate technical interventions may have diminished production despite irrigating 26.22% of its agricultural area. Maharashtra maintained a balance between rainfed and irrigated agriculture, achieving 20.80% irrigation coverage alongside consistent output and yield.

The national groundnut area decreased from 6.01 million hectares in 2020-21 to 5.75 million hectares in 2021-22, whereas production remained consistent at 10.24 million tons to 10.11 million tons. Despite a reduction in cultivated land, the national average yield increased from 1703 kg/ha to 1759 kg/ha, increasing production. Indian groundnut production has an irrigation coverage of 36.09%, indicating a substantial reliance on rainfed and monsoon-dependent practices.

The regression analysis for this study revealed a strong positive relationship (R = .709) between the predictor variable, which was irrigation, and the dependent variable. This suggests that there is a substantial linear correlation between the two variables. Variations in irrigation levels can account for approximately 50.3% of the variance in the dependent variable, according to the coefficient of determination (R square) of .503. A small constraint related to the predictor variables is shown by the adjusted R square value (.496), which is somewhat adjusted for the number of predictors in the model. The average difference between the observed values and regression model predictions was 1.21089, the estimate's standard error. The inclusion of the constant term and the irrigation variable as predictors clarified the relationship between irrigation and the outcome variable. The significance of irrigation in claiming changes in the dependent variable, which is production, is emphasized by the results above Table 4.

Table 4 Regression analysis.

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
						.000b
1	Regression	100.977	1	68.867		
	Residual	99.705	68	1.466		
	Total	200.682	69			
a. Dependent Variable: production						
b. Predictors: (Constant), irrigation						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.709a	.503	.496	1.21089
		a. Predictors: (Constant), irrigation		

To improve the comprehensiveness of the study's findings, we need to investigate other factors impacting the correlation; more analysis could be needed.

The ANOVA table represents the findings of a regression analysis that looked at the connection between agricultural output and irrigation levels. The highly significant F statistic ($F = 68.867$, $p < 0.001$) shows that the regression model explains much of the variation in production. It does this by using the predictor "irrigation" and a constant term. These findings indicate that productivity and irrigation levels have a strong overall relationship. With a regression sum of squares (SS) of 100.977, the model specifically explains a significant amount of the variability in production. On the other hand, the residual sum of squares (SS), which represents a very large variability of 99.705, means that a large portion of the variance in production is captured by the model. Overall, these results show how important it is to use effective irrigation methods to obtain the most crops and how much irrigation has a large effect on agricultural output.

Table 5 clearly shows that the amount of land used for cultivation has changed over the years, with a small increase observed recently. On the other hand, a steady increase in the output per hectare suggests that groundnut farming techniques are becoming more productive and efficient. The groundnut yield has been steadily increasing despite changes in the distribution of land, which emphasizes the need for innovation in maintaining and enhancing crop productivity. Figure 4 illustrates these trends, showing the all-India area coverage along with yield across decades.

Table 5 Decade analysis of groundnut crops: All-India area coverage and yield.

Decade	Average Area (million hectares)	Average Yield (
1950-1959	5.5	715.8
1960-1969	7.1	728
1970-1979	7.13	798.1
1980-1989	7.7	864.9
1990-1999	7.31	971.2
2000-2009	5.92	1054.6
2010-2019	5.13	1490.2
2020-2021	5.88	1731

Source: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.
Note: The yield rates given above have been determined on the basis of production & area figures taken in '000 units.

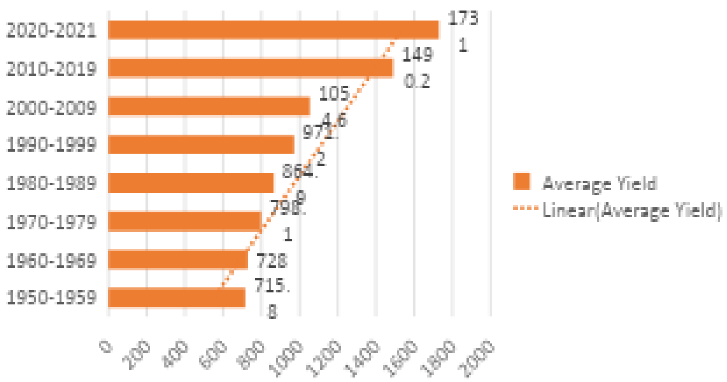

Figure 4 All-India area coverage along with yield.

4.1. Compound growth rate analysis (CGRA)

Understanding the average annual growth rate of groundnut productivity over a given period, from 1950–51 to 2021–22, is conducted with the help of the compound annual growth rate (CAGR). For groundnut output over the course of 72 years, the computed CAGR is approximately 2.49%. This suggests that groundnut productivity is increasing in a steady and positive way. This growth pattern shows how resilient groundnut farming is and how crucial it is to increasing agricultural production and food security. It is very important to consider how outside factors, such as unpredictable weather, new technologies, improvements in irrigation, and changes in policies, affect trends in groundnut production. For stakeholders in agricultural development, researchers, and policymakers, the CAGR study offers insightful information. It helps with resource allocation, policy formulation, and strategic planning to guarantee an increase in yield.

Table 6 Decade analysis of groundnut crops: All-India area coverage under irrigation and productivity.

Decade	Average Area under Irrigation (%)	Average Production (million tonnes)
1950-1959	2.23	4.01
1960-1969	4.1	4.86
1970-1979	7.68	5.64
1980-1989	15.59	6.24
1990-1999	18.58	7.45
2000-2009	21.29	6.49
2010-2019	33.12	7.99
2020-2021	N/A (Data not available)	10.175

Source: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.
Note: Area - million hectares, Production - million tonnes.

According to the data, India's average area under irrigation and groundnut output have significantly increased over the years, as shown in Table 4 Between the 1950s and the 2010s, the amount of area under irrigation increased steadily, from 2.23% to 33.12%. Similarly, groundnut production increased gradually and peaked from 2020–2021 at 10.175 million tonnes, indicating both effective agricultural development and possibly advantageous policy implementation. This trend is further illustrated in figure 5, which shows the all-India area coverage under irrigation and productivity.

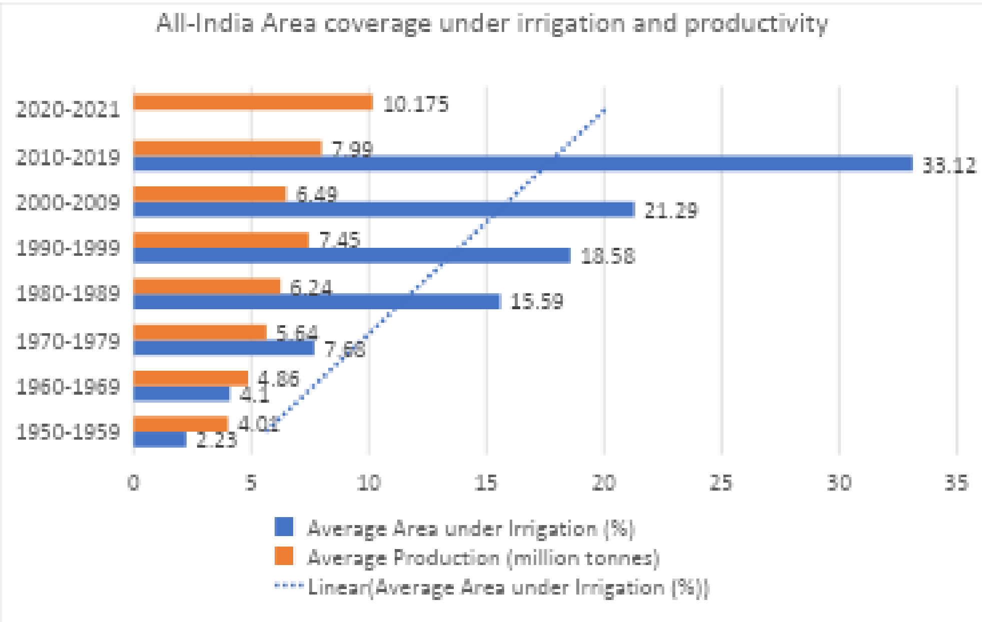

Figure 5 All-India area coverage under irrigation and productivity.

4.2. Regional Disparities in Groundnut Production

Groundnut production in India is region-specific, with Gujarat accounting for 27.34% of the total output, followed by Andhra Pradesh 24.19%, Tamil Nadu 14.84% then Karnataka, and Maharashtra as the primary cultivators (Thulasiram et al., 2018). However, despite favorable agroclimatic conditions, areas such as Odisha, Madhya Pradesh, and Uttar Pradesh have low yields because of insufficient seed quality, inadequate irrigation, and traditional farming practices. The prevalence of soybean and wheat agriculture in Madhya Pradesh restricts the growth of groundnut farming. In contrast, in Uttar Pradesh, fragmented land ownership and insufficient understanding of contemporary agricultural techniques further impede output.

Data from the Directorate of Economics and Statistics reveal that northeastern states, such as Nagaland, Manipur, Mizoram, Arunachal Pradesh, and the Andaman and Nicobar Islands, have the lowest groundnut production levels, typically limited to a few tons (ICAR-Indian Institute of Oilseeds Research, 2021). For example, the Anjaw district in Arunachal Pradesh recorded just 0.04 tons in 2019-2020, primarily because of excessive rainfall, humid climate, and mountainous terrain, which diminishes the availability of arable land. Moreover, aluminum toxicity in the soil adversely affects groundnut development, which requires integrated nutrient management and liming procedures (ICAR-Krishi, 2018).

Research in Gujarat's Saurashtra area indicates that farmers may improve technical efficiency by 15% only by utilizing current resources without the need for new inputs (Varasani et al., 2016). Research in Tamil Nadu has underscored the essential need for excellent seeds, fertilizers, and insecticides to enhance crop efficiency (Jagadesh et al., 2021). These results highlight the need for region-specific initiatives including enhanced irrigation availability, soil management measures, and agricultural education programs. A focused legislative strategy emphasizing infrastructure enhancement and technical education may markedly increase production in lagging states.

Role of microirrigation for sustainable agriculture:

Compared with traditional irrigation technologies, microirrigation delivers a consistent water supply to the roots of crops and results in higher crop yields and enhanced water usage efficiency. Microirrigation systems prove minimal surface runoff.

Microirrigation is the most efficient approach for enhancing crop yield and conserving water. According to Paar et al. (2023), the agricultural water productivity index has increased from 0.20–0.51 to 0.56–0.96. This indicates that the efficiency of water use in agricultural production has improved to ensure sustainable farming, enabling farmers to obtain greater yields per unit of water consumed. (Ramteke et al., 2019). A well-rounded agricultural strategy incorporates both sustainable agriculture and efficient irrigation, two interconnected but different concepts. Sustainable agriculture, which prioritizes resource efficiency, environmental preservation, economic viability, social equity, and climatic resilience, may contribute to ensuring that food is accessible to people both today and in the future. Narayanamoorthy's (2004) research in Maharashtra revealed that drip irrigation significantly conserves water compared with traditional surface irrigation.

5. Conclusions

In this study, which covered the period from 1950–1951 to 2020–21 in India, the relationships between groundnut areas under irrigation and production and yield were analyzed. Regression analysis was used to analyze data from different government sources. This provides important new information about how groundnut crops and irrigation management have changed over time.

The results of regression analysis revealed a substantial positive relationship between irrigation and groundnut production, with irrigation levels accounting for approximately 50.3% of the variation (R2 = 0.503). The model satisfies important regression assumptions: normality of residuals, confirmed by histogram and Q-Q graphs, and no significant heteroscedasticity, as shown in the residuals vs. fitted values plot. The Durbin-Watson value (2.09) implies no substantial autocorrelation. As irrigation is the only independent variable, multicollinearity is not an issue. Moreover, other factors like soil health, unexpected rainfall and other environmental conditions may cause variations in production. In general, the model offers a reliable estimate; however, adding various variables could improve its analytical strength.

We estimated the average annual growth rate of groundnut productivity over the given period via the compound annual growth rate (CAGR). The calculated CAGR of approximately 2.49% indicates a positive and steady growth trajectory in groundnut output over the examined period.

A decade of analysis revealed significant historical trends and patterns in irrigation and groundnut farming. From the 1980s onward, there was a consistent increase in the average area under groundnut cultivation along with a rise in the proportion of land covered by irrigation. Additionally, groundnut production and yield have steadily increased over the decades, highlighting developments in agricultural technology and practices.

In summary, this research provides insightful information about the complex relationship between irrigation and groundnut cultivation, creating the opportunity for well-informed agricultural policies and practices aimed at increasing the resilience, productivity, and sustainability of groundnut farming.

6. Recommendation

Research into drought-tolerant varieties and water-efficient farming methods is suggested to improve groundnut production. Other things that should be done include investing in the development of irrigation infrastructure, promoting effective irrigation methods such as drip irrigation, strengthening extension services to help farmers build their skills, making it easier for farmers to access markets and add value to crops, incorporating climate-resilient practices, and setting up reliable monitoring and evaluation systems. Working together is essential if these suggestions are to be implemented successfully and groundnut farming in India is to remain resilient and sustainable over the long run.

Given the importance of irrigation in groundnut production, states with inadequate irrigation access, such as Odisha and Uttar Pradesh, must be prioritized for enhancing their infrastructure. Enhancing micro-irrigation methods, including drip and sprinkler irrigation, may improve water consumption efficiency (Thulasiram et al., 2018).

The northeastern states face challenges such as aluminum toxicity, hilly terrain, and excessive rainfall. Research institutions like ICAR should focus on developing region-specific solutions, including acid-tolerant groundnut varieties and integrated nutrient management practices to address soil constraints (ICAR, 2021).

7. Limitation

The analysis depends on secondary data that were gathered from government sources and could contain mistakes or flaws that are a natural part of data collection procedures. This study focused only on data from India, which could reveal differences in how people water their crops and grow groundnuts in different parts of the country. This would mean that the results would only be useful in certain places. Additionally, although regression analysis sheds light on the connection between irrigation and the results of groundnut cultivation, the production is impacted by other external factors such as the health of the soil, unexpected rainfall, high-yield variety seeds, the control of pests and diseases, and socioeconomic factors and other environmental variables that were not included in our regression model. It is important to note that these factors have an impact on the outcomes of the production. Further longitudinal studies and experimental research are needed to validate the results, as the retrospective design of the study makes it more difficult to determine causal correlations between irrigation and groundnut yield. Finally, because the study concentrates solely on groundnut farming, it ignores any connections with other crops and agricultural systems that can impact irrigation strategies and results. By addressing these issues, the conclusions of this study would be more reliable and applicable, and they would offer a more complete understanding of the variables affecting irrigation and groundnut cultivation.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

Funding

This research did not receive any financial support.

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