OPEN ACCESS JOURNALS
Indiana Journal of Agriculture and Life Sciences
Abbriviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/10.5281/zenodo.15761704

Research Article

Volume-05|Issue-03|2025

The Struggles of Tribal Agriculture: Challenges and the Path to Sustainable Solutions

Prof. B. Sudhakar Reddy[1], Dr. V. Mallikarjuna Naik[2]

[1]Professor & Director, ICSSR – SRC, Osmania University, Hyderabad. India
[2]ICSSR Post Doctor Fellow (PDF), CESS, Hyderabad. India

Article History
Received: 21.05.2025
Accepted: 25.06.2025
Published: 28.06.2025

Citation
Reddy, B. S., Naik, V. M. (2025). The Struggles of Tribal Agriculture: Challenges and the Path to Sustainable Solutions. *Indiana Journal of Agriculture and Life Sciences, 5*(3), 30-48.

Abstract: Tribal agriculture in the Nagarkurnool district of Telangana, particularly within the ITDA Mannanur region, is experiencing significant stress due to a mix of ecological, socio-economic, and infrastructural challenges. Predominantly inhabited by the Chenchus, a Particularly Vulnerable Tribal Group (PVTG), includes over 150 villages across five Mandals: Amrabad, Achampet, Lingala, Padara, and Balmoor. Despite these communities' cultural resilience and adaptive farming knowledge, their agricultural practices are marginalized by systemic constraints that undermine both productivity and sustainability. The agrarian base in the district faces severe limitations from land use patterns and soil composition. Of the district's extensive geographical area, only about 61% of the land is cultivable, with the remainder either under forest cover or classified as non-agricultural land. The dominant red sandy soils, which make up more than 60% of the region, have poor water retention capacity, rendering them unsuitable for water-intensive crops. As a result, tribal farmers have shifted towards cultivating drought-resistant crops such as cotton, red gram, maize, and groundnut. However, even these crops are highly susceptible to erratic rainfall patterns, delayed monsoons, and prolonged dry spells.

The analysis of village-level data reveals significant irrigation deficits, with more than 80% of the cultivated areas relying on rain-fed systems. Villages like Sarlapalli and Appapur report that only 10–13% of agricultural land has access to irrigation. These limitations directly impact crop yield and stability. For instance, cotton yields vary between 420–490 kg/acre, with higher yields observed in areas like Bommanapalli that have better irrigation access. Moreover, the dependency on a single crop, such as cotton, cultivated in over 60% of the area in most villages, reflects both market-driven choices and ecological constraints, raising concerns about crop diversity and long-term soil health. Socio-economic vulnerabilities further aggravate the situation. Household incomes from farming remain low, ranging from ₹68,000 to ₹82,000 annually, while access to formal credit is limited. Debt levels remain significant, with up to 32% of households reporting indebtedness. Although government schemes like FRA, Rythu Bandhu, and PM-KISAN provide some support, their reach is partial and inconsistent across villages.

Climate change has further exacerbated agricultural instability. Average rainfall in the region hovers between 740 and 850 mm, yet dependency on monsoons exceeds 85% in many villages. Frequent droughts and rainfall anomalies have led to significant yield reductions, with 60–72% of farmers across various villages reporting crop losses. This study argues for a multi-pronged approach to achieving sustainable tribal agriculture: enhancing irrigation infrastructure, promoting soil health through crop diversification and organic practices, expanding the reach of institutional credit and insurance, and aligning government schemes more effectively with ground-level realities. Empowering tribal communities through localized agri-extension services, climate-resilient practices, and secure land rights can offer a sustainable pathway forward. In doing so, tribal agriculture can transform from a vulnerable subsistence activity into a resilient livelihood system that honours traditional knowledge while embracing adaptive modernity.

Keyword: Tribal Agriculture, Mannanur Region, Indigenous Farming Practices, Tribal Farmers, Forest Fringe Villages, Amrabad Tiger Reserve, Dryland Agriculture

INTRODUCTION

Agriculture remains the primary source of livelihood for the majority of India's tribal population, particularly in remote and forest-adjacent regions where access to alternative employment opportunities is limited. Within this broader national context, the tribal communities of Nagarkurnool district in southern Telangana exemplify both the strengths and struggles of traditional agrarian systems operating under ecological, social, and economic constraints. Specifically, the Mannanur region, governed by the Integrated Tribal Development Agency (ITDA), encompasses over 150 villages spread across five mandals—Amrabad, Achampet, Lingala, Padara, and Balmoor—and is predominantly inhabited by the Chenchu tribe, one of India's Particularly Vulnerable Tribal Groups (PVTGs). Their livelihoods, deeply intertwined with both forest ecosystems and agriculture, are increasingly at risk due to a convergence of structural challenges, climatic unpredictability, and institutional gaps. A distinct set of geographical and climatic factors shapes Nagarkurnool's agricultural landscape. The district covers a vast area of approximately 14.05 lakh acres, yet only about 8.61 lakh acres are classified as cultivable. The rest of the land is either under dense forest cover or designated as non-

***Corresponding Author:** Prof. B. Sudhakar Reddy

agricultural, limiting the potential for agricultural expansion. This restriction is particularly significant for tribal farmers, many of whom reside in or near forest areas and depend on traditional land rights secured under the Forest Rights Act (FRA). In Mannanur alone, 1,529.80 acres have been allotted to 662 Chenchu families under FRA provisions; however, the scale and quality of this land often fall short of what is needed for sustainable livelihoods.

Soil quality further defines the challenges faced by tribal cultivators in the region. The dominant presence of red sandy soils, which make up over 60% of the agricultural land, creates a hostile environment for water-intensive crops due to their poor water retention capacity. Although patches of more fertile black cotton soil do exist, they are unevenly distributed and comprise only a fraction of the cultivable land. This soil composition has historically pushed farmers towards drought-resistant crops such as cotton, red gram, maize, and groundnut. However, the suitability of these crops is also influenced by irrigation availability, which remains insufficient across the region. On average, more than 80% of agricultural activity relies on rain-fed systems, exposing farmers to high levels of climate-induced risk. The cropping pattern in Nagarkurnool, particularly within tribal areas, shows a heavy reliance on cotton. In most surveyed villages, including Mallapurpenta, Medimalakala, and Bommanapalli, cotton occupies over 60% of the cultivated land during both kharif and rabi seasons. While cotton offers potential for market-based income, its sensitivity to rainfall variation and pest infestation often results in volatile returns. The trend towards monoculture limits crop diversification and depletes soil nutrients, further intensifying long-term agricultural vulnerability. Irrigation coverage remains alarmingly low, with villages such as Sarlapalli and Appapur reporting irrigated land coverage of only 10–13%, leaving the majority of agricultural output at the mercy of erratic monsoon patterns.

Government support has reached tribal areas through targeted welfare schemes like the Forest Rights Act (FRA), Rythu Bandhu, and PM-KISAN. While these schemes have contributed to increased land tenure security and direct cash transfers for agricultural inputs, their implementation remains inconsistent. For example, village-level data shows that only about 35–45% of tribal households benefit from FRA allotments, and even fewer consistently receive aid under Rythu Bandhu or PM-KISAN. This limited outreach constrains the impact of these schemes on transforming agricultural productivity and mitigating financial risks. The socio-economic profile of tribal households in the Mannanur region highlights the precarious nature of their agrarian livelihoods. Farm incomes are modest, typically ranging from ₹68,000 to ₹82,000 annually, and most families have limited access to formal credit. Instead, many rely on informal borrowing, leading to cyclical debt traps. In villages like Inole and Bommanapalli, up to 32% of households report being in debt, and access to institutional loans remains below 40%. Combined with limited landholdings, inadequate irrigation, and unpredictable rainfall, this financial fragility makes it challenging for tribal farmers to invest in improved seeds, farm machinery, or sustainable practices.

Perhaps the most critical stressor affecting tribal agriculture is climate variability. Rainfall patterns in Nagarkurnool are increasingly erratic, with the region receiving an average of 740 to 850 mm annually. Yet, more than 85% of tribal agriculture relies on the monsoon. In years of drought, crop yields drop sharply, with 60–72% of farmers across villages reporting crop losses due to insufficient rainfall. Even in years with normal rainfall, delayed or uneven distribution severely impacts sowing and harvesting cycles. For communities with minimal buffer capital, crop insurance, or alternative income sources, such events lead to long-term livelihood setbacks. Despite these challenges, there is significant potential for resilience and renewal. Traditional ecological knowledge, community-based practices, and the willingness of tribal communities to adopt new technologies offer pathways toward sustainable agricultural development. To achieve this, however, policy interventions must be holistic, participatory, and grounded in the specific realities of tribal regions. Improving irrigation infrastructure, enhancing soil conservation, diversifying cropping patterns, and ensuring better access to credit and insurance are critical components of this transformation. Equally important is the need to strengthen the capacity of local governance institutions and agricultural extension systems to provide tailored support to tribal farmers.

This section aims to provide a comprehensive analysis of the key challenges facing tribal agriculture in the Mannanur region, supported by empirical data from a stratified sample of 400 to 500 households. By integrating village-level evidence with broader developmental insights, it seeks to identify sustainable solutions that are not only economically viable but also socially inclusive and ecologically balanced.

Agriculture in Nagarkurnool: An Analytical Overview

Nagarkurnool district, with its vast land area of 14,05,325 acres, is located in southern Telangana and exemplifies both the challenges and potential of rural agrarian India. Agriculture serves as the backbone of the local economy, employing a significant portion of the population, particularly among tribal and marginal farming communities. However, the district's agricultural sector faces a combination of environmental, infrastructural, and socio-economic constraints. This overview aims to explore the geographic conditions, land use, soil profile, and cropping dynamics of Nagarkurnool to offer a clearer understanding of its agricultural vulnerabilities and opportunities.

***Corresponding Author:** Prof. B. Sudhakar Reddy

Geography and Climate

Nagarkurnool features undulating terrain, especially in the eastern parts, which are part of the Nallamala hill ranges and forested zones. This forested area serves a dual purpose by supporting biodiversity and livelihoods through non-timber forest products while also restricting land available for cultivation due to legal protections and ecological sensitivity. The district falls within a semi-arid to sub-humid climatic zone, with an average annual rainfall of 700 to 900 mm, primarily during the southwest monsoon (June to September). Although the rainfall amount is moderate, its distribution is often uneven, exhibiting significant inter-annual and intra-seasonal variability. This climate pattern has rendered agriculture highly dependent on the monsoon, particularly in the forest-adjacent tribal areas like Amrabad, Achampet, and Lingala, where formal irrigation infrastructure is limited.

Some parts of the district, particularly in the western and central Mandals, benefit slightly from canal irrigation obtained from the Krishna River system. However, this irrigation coverage remains limited and unevenly distributed, leaving over 80% of the cultivated area reliant on rainwater. These conditions have contributed to fluctuating agricultural yields, increased vulnerability to droughts, and greater economic distress for small and marginal farmers.

Land Use and Agricultural Suitability

Despite its vast size, only 8,61,478 acres of Nagarkurnool's land is cultivable, which is just over 61% of its total area. The remaining land includes:

- **Forest land**: 4,02,822 acres (~28.6%)
- **Non-agricultural use**: 1,41,025 acres (~10%)

This land use pattern reveals a structural bottleneck for agricultural expansion. Forest areas are largely concentrated in the eastern parts of the district, such as Amrabad and Lingala, which fall under Project Tiger reserves and ITDA Mannanur jurisdiction. These lands are protected under various legal frameworks, including the Forest Conservation Act and Wildlife Protection Act, which limit the scope of converting forest land into farmland. For tribal communities like the Chenchus, who depend on both forests and agriculture, land tenure under the Forest Rights Act (FRA) has been a crucial tool. However, the scale of FRA implementation remains limited, both in extent and quality. Of the thousands of families eligible, only a fraction have been granted land titles, and many of these holdings are fragmented, degraded, or lack access to irrigation.

Additionally, urbanization and infrastructure projects are gradually encroaching on agricultural land, especially near Mandal headquarters, highways, and irrigation reservoirs. These pressures are progressively reducing the net sown area available, especially for rain-fed subsistence farmers.

Soil Composition and Its Effect on Cultivation

Soil quality significantly determines the cropping potential and productivity in Nagarkurnool. The region's soils can be broadly classified as:

- **Red Sandy Soils** (~62%)
- **Black Cotton Soils** (~30%)
- **Other mixed types** (~8%)

Red sandy soils, predominant in tribal villages like Mallapurpenta, Medimalakala, and Ambagiri, are porous, low in organic matter, and retain little moisture, making them unsuitable for water-intensive crops. However, they are suitable for drought-resistant crops, provided micro-irrigation techniques and organic soil management supplement them. Black cotton soils, found in patches across Achampet and Balmoor, are fertile and moisture-retentive, making them ideal for crops like cotton, red gram, and maize. However, they are less widespread and often located in areas with larger landholdings, creating inequality in productivity potential between villages. The dominance of red soils requires a high dependence on rainfall, which makes the region's agriculture highly sensitive to climate variability. In the absence of effective soil conservation, erosion, nutrient depletion, and water runoff become significant problems, undermining long-term farm sustainability.

Changing Cropping Patterns and Sowing Trends

Over the past decade, there has been a notable shift in cropping patterns in Nagarkurnool, driven by market demand, input subsidies, and changing rainfall patterns. Cotton has become the dominant cash crop, occupying between 63% and 74% of the total cultivated area in villages such as Sarlapalli, Appapur, and Inole.

Farmers are attracted to cotton due to its relatively high market price and support under schemes like the Minimum Support Price (MSP) and input subsidies under the State Scheme Rythu Bandhu. However, this shift has also led to several concerns:

- Monocropping of cotton depletes soil fertility and increases pest infestation, particularly from bollworms.
- Cotton cultivation is capital-intensive, requiring more inputs, making farmers vulnerable to debt.
- Being water-sensitive, cotton performs poorly in erratic rainfall years, exacerbating crop failure rates.

Despite these concerns, data between 2019 and 2020 indicates a significant increase in total cultivated area, from 5,20,258 acres to 6,13,865 acres. This growth can be attributed to:

- Improved monsoon performance during these years.
- Access to crop loans, although still limited to 30–42% of households.
- Adoption of farm mechanization and increased use of fertilizers and HYV seeds.

***Corresponding Author:** Prof. B. Sudhakar Reddy

Nonetheless, the dominance of cotton has come at the cost of neglecting food crops like millets, pulses, and oilseeds, which were historically more climate-resilient and suitable for the region's soils.

Study Area Overview

The Mannanur region in Nagarkurnool district is a significant tribal area, primarily inhabited by the Chenchus, a Particularly Vulnerable Tribal Group (PVTG). Their livelihoods are based on forest activities and traditional subsistence farming. The region consists of 150 villages spread across 23 Mandals. Of the total cultivable land, 7,739 acres are available for Chenchu use. Through the Forest Rights Act (FRA), 1,529.80 acres have been allocated to 662 Chenchu families, promoting agricultural self-sufficiency and legal land ownership. Despite these provisions, challenges such as inadequate irrigation, limited access to markets, and ecological vulnerability continue to impact farm productivity and sustainability.

Soil and Agricultural Practices in the ITDA Mannanur Region

The ITDA Mannanur region, including Mandals such as Padara, Achampet, Lingala, Amrabad, and Balmoor, is primarily characterized by red sandy soils with low fertility and poor moisture retention. These soil conditions significantly limit the cultivation of water-intensive crops, making agriculture highly vulnerable to climate variability. Consequently, tribal farmers in the region depend on drought-resistant and low-water-demand crops like cotton, red gram, maize, and groundnut. These crops are primarily cultivated during the kharif season, coinciding with the southwest monsoon. However, erratic rainfall patterns and extended dry spells often result in reduced crop yields and economic insecurity. Limited access to irrigation facilities further worsens the challenges, leaving most of the agricultural land reliant on rain-fed systems. According to village-level data, many areas have less than 20% of cultivable land irrigated, highlighting a significant infrastructural gap. Despite these challenges, tribal farmers continue to adapt their agricultural practices through traditional knowledge and crop diversification. Nonetheless, to ensure farm sustainability and improved livelihoods, there is an urgent need for soil improvement measures, the expansion of micro-irrigation schemes, and the introduction of climate-resilient farming practices tailored to the region's ecological conditions.

Sample Size and Methodology

To gain a comprehensive understanding of agricultural practices, soil conditions, and socio-economic challenges in the Mannanur region under the ITDA (Integrated Tribal Development Agency), a statistically grounded sampling methodology was adopted. The area is home to a population estimated at between 50,000 and 70,000 individuals, primarily consisting of tribal communities like the Chenchus and Lambadi, and it spans across multiple Mandals with distinct ecological and agricultural profiles.

A sample size of approximately 400 to 500 households was determined using the **finite population correction (FPC) formula**, which adjusts the required sample size based on the size of the total population and desired confidence levels. Specifically, the formula applied considered:

- **Confidence Level**: 95%
- **Margin of Error**: ±5%
- **Population Size**: 50,000 to 70,000

This resulted in a reliable and statistically valid sample size that ensures the findings can be generalized with a high degree of accuracy. The data collected from this sample serve as the empirical basis for analysing land use, cropping patterns, irrigation practices, government scheme coverage, and socio-economic indicators of tribal farming households.

Stratified Sampling by Mandal and Village

To reflect the region's geographic and demographic diversity, a stratified sampling approach was adopted. This method involved dividing the population into subgroups (strata) based on Mandals and allocating samples proportionally. Stratification was critical for capturing the variability in agricultural practices across various terrains, soil types, and levels of access to government support.

Table 1: The sample was distributed Mandal-wise

Mandal	Estimated Sample Size	Percentage of Total Sample
Amrabad	80–100 households	20%
Lingala	60–75 households	15%
Padara	40–50 households	10%
Balmoor	40–50 households	10%
Achampet	100–125 households	25%
Other Villages	60–75 households	15%
Total	400–500 households	100%

Source: *Author*

This sampling structure was informed by:

- **Population Density**: Larger samples in Mandals like Achampet and Amrabad due to higher tribal population concentrations.
- **Agricultural Diversity**: Mandals with varied soil and crop patterns were weighted appropriately.
- **Accessibility and Coverage**: Inclusion of both interior and accessible villages ensured representation of differing levels of development and service delivery.

Data collection tools included structured household surveys, focus group discussions, and key informant interviews. The surveys addressed areas such

***Corresponding Author:** Prof. B. Sudhakar Reddy

as landholding patterns, crop choices, irrigation methods, access to government schemes (like FRA, Rythu Bandhu, and PM-KISAN), yield levels, farm incomes, and vulnerability to climate risks. This methodological framework not only guarantees statistical reliability but also reflects the region's ground realities. It provides a rich dataset for formulating nuanced agricultural and rural development strategies tailored to the unique challenges faced by tribal farmers in the Mannanur region.

RESULTS AND DISCUSSION

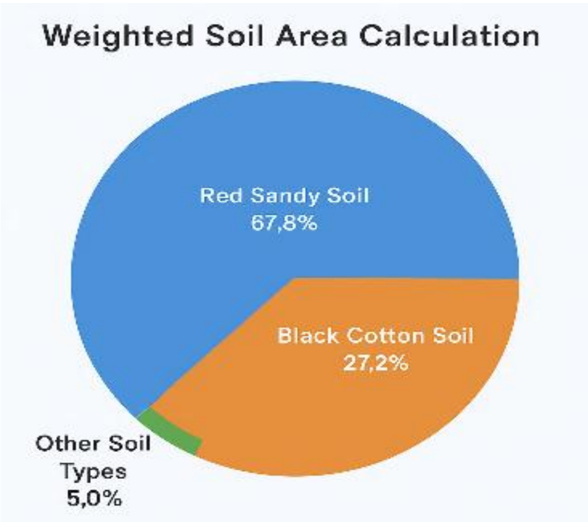
Land Use and Soil Type Distribution

The agricultural land of the Mannanur region spans five key Mandals: Amirabad, Lingala, Padara, Balmoor, and Achampet, encompassing a total of 4,150 acres across ten sampled villages. This analysis concentrates on the distribution of soil types within the cultivable land, specifically the proportions of red sandy soil, black cotton soil, and other soil types.

Table 2: Land Use and Soil Composition across Selected Villages in ITDA Mannanur Region

Mandal	Village	Total Cultivable Land (Acres)	Red Sandy Soil (%)	Black Cotton Soil (%)	Other Soil Types (%)
Amrabad	Mallapurpenta	500	70	25	5
	Sarlapalli	500	75	20	5
Lingala	Medimalakala	400	65	30	5
	Appapur	400	68	27	5
Padara	Petralchenu	350	75	20	5
	Chitlamkunta	350	70	25	5
Balmoor	Chenchugudem	325	68	27	5
	Ambagiri	325	65	30	5
Achampet	Inole	450	60	35	5
	Bommanapalli	450	62	33	5

Source: *Field Survey*



The average red sandy soil proportion is approximately 68%, with low variability (CV ~7.5%), indicating a consistent dominance of this soil type across all villages. Black cotton soil averages 27%, but with higher variability (CV ~19%), reflecting local heterogeneity in patches of more fertile soil. Other soil types are minimal and constant at 5%.

Table 3: Each soil type across villages was calculated

Soil Type	Mean (%)	Standard Deviation (SD)	Coefficient of Variation (CV% %)
Red Sandy Soil	67.8	5.12	7.55
Black Cotton Soil	27.2	5.12	18.82
Other Soil Types	5.0	0.0	0.0

Source: *Statistical tools applied*

Red Sandy Soil vs. Cotton Yield*:* Shows a slight negative correlation, indicating that as the percentage of red sandy soil increases, cotton yields tend to decrease. This reflects the soil's poor water retention capacity, which limits productivity.

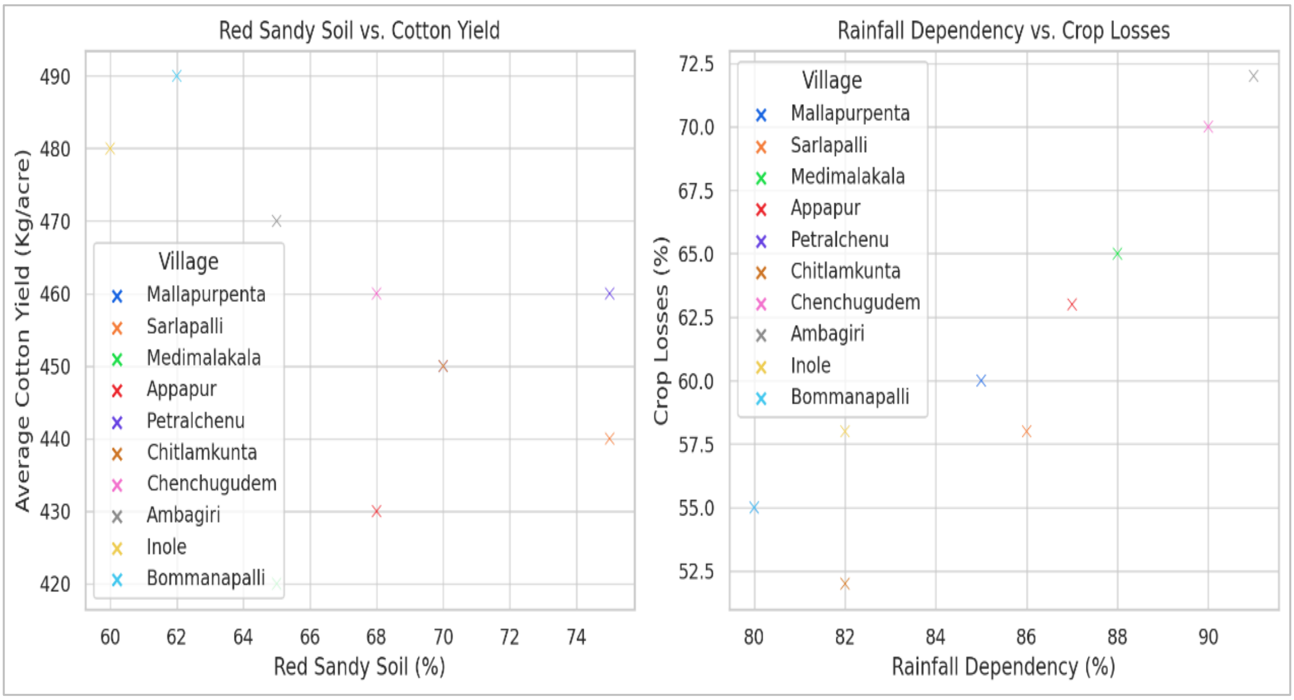
Rainfall Dependency vs. Crop Losses*:* Reveals a strong positive correlation. Villages more reliant on rainfall experience higher crop losses, emphasizing the vulnerability of rain-fed agriculture in the region.

Table 4: Weighted Soil Area Calculation (Descriptive Statistics Summary)

Soil Type	Total Area (Acres)	Percentage of Total Cultivable Land (%)
Red Sandy Soil	2,814	67.8
Black Cotton Soil	1,131	27.2
Other Soil Types	205	5.0

Source: Statistical tools applied

Out of 4,150 acres, approximately 2,814 acres are red sandy soil, dominating the cultivable area, which aligns with the percentage means. Black cotton soil covers about 1,131 acres, mostly found in smaller, more fertile pockets favourable for cotton. The other soil types occupy marginal areas.



Graph 1: Scatter plots comparing soil type vs. crop yield or rainfall dependency vs. crop losses.

Correlation Analysis: Soil Types and Crop Suitability

While this dataset does not include direct crop yield by soil type, literature indicates that red sandy soils are suitable for drought-resistant crops, whereas black cotton soil supports more water-intensive, higher-yielding cotton crops.

A Pearson correlation coefficient can be calculated between soil percentages and crop yield (if available) or irrigation access to understand the impact of soil on productivity. In this context, red sandy soil negatively correlates with irrigation access, as these soils retain less moisture and rely heavily on rainfall.

Interpretation and Discussion

The predominance of red sandy soils (mean ~68%) across the Mannanur region significantly influences agricultural practices. These soils exhibit poor water retention, posing a challenge for water-intensive crops and increasing reliance on the monsoon. The relatively stable percentage of red sandy soils across villages (low CV) indicates limited soil diversity, which restricts crop options and necessitates a focus on drought-tolerant crops such as cotton, red gram, and maize. The presence of black cotton soil (average 27%), though less extensive, is vital for cotton cultivation, offering pockets of greater fertility and improved moisture retention. However, its higher variability (CV ~19%) suggests that access to these soils is uneven across villages, potentially contributing to yield disparities. The consistent 5% of other soil types represents marginal soils or transitional zones that may support minor cropping or non-agricultural uses.

Cropping Patterns and Water Usage

The agricultural landscape of the ITDA Mannanur region, encompassing Mandals such as Amrabad, Lingala, Padara, Balmoor, and Achampet, exhibits a unique cropping pattern significantly shaped by soil type, reliance on rainfall, and limited irrigation infrastructure. Insights and patterns arise from data collected in 10 representative villages.

*Corresponding Author: Prof. B. Sudhakar Reddy

Table 5: Cropping Patterns and Water Usage in Selected Villages

Mandal	Village	Primary Crops	% Area under Cotton	% Area under Maize	% Area under Red Gram	Irrigated Land (%)
Amrabad	Mallapurpenta	Cotton, Red Gram	65	10	25	15
	Sarlapalli	Cotton, Red Gram	63	15	22	10
Lingala	Medimalakala	Cotton, Groundnut	70	5	25	12
	Appapur	Cotton, Groundnut	68	10	22	10
Padara	Petralchenu	Cotton, Maize	60	20	20	20
	Chitlamkunta	Cotton, Maize, Red Gram	63	18	19	18
Balmoor	Chenchugudem	Cotton, Maize	65	15	20	12
	Ambagiri	Cotton, Maize, Groundnut	60	20	20	15
Achampet	Inole	Cotton, Groundnut	74	5	21	18
	Bommanapalli	Cotton, Groundnut	72	7	21	18

Source: *Field Survey*

Dominance of Cotton Cultivation

Cotton is the most widely cultivated crop across all surveyed villages. The percentage of land dedicated to cotton varies from 60% in Petralchenu and Ambagiri to 74% in Inole, averaging 66% across all villages. This high proportion reflects cotton's compatibility with the region's dominant red sandy soils, which favour drought-resistant crops due to their poor water retention. Additionally, cotton's market demand and relative adaptability to low irrigation conditions make it a preferred choice among farmers.

Secondary Crops: Maize and Red Gram

Maize and red gram serve as the secondary crops, grown to varying degrees depending on local soil and water availability:

- Maize is cultivated more extensively in Padara, Balmoor, and parts of Lingala, with its share ranging from 5% (Medimalakala, Inole) to 20% (Petralchenu, Ambagiri). Villages with higher maize acreage tend to have slightly better irrigation coverage.
- Red Gram is prevalent in Amrabad and parts of Lingala, with its coverage peaking at 25% in Mallapurpenta and Medimalakala. Known for its drought tolerance, red gram complements cotton in low-irrigation areas, reinforcing the mixed cropping strategy aimed at ensuring food security and income diversity.

Irrigation Coverage and Its Implications

The availability of irrigation remains modest across the region, averaging around 14.8%. The highest levels are reported in Petralchenu (20%) and Inole/Bommanapalli (18%), while the lowest is in Sarlapalli (10%). Despite this limited coverage, irrigation seems to be strategically used to supplement key periods during the cropping cycle rather than enabling full-season irrigation. This pattern indicates a reliance on rain-fed agriculture, further highlighting the vulnerability of farming systems to monsoon variability.

Village-wise Observations

1. **Amrabad Mandal (Mallapurpenta, Sarlapalli):** Cotton and red gram dominate, with low to moderate irrigation (10–15%). Cropping is heavily rain-dependent.
2. **Lingala Mandal (Medimalakala, Appapur):** Focus on cotton and groundnut, with minimal maize. Red gram maintains a steady presence. Irrigation coverage is among the lowest.
3. **Padara Mandal (Petralchenu, Chitlamkunta):** Shows a more balanced cropping pattern with relatively higher maize cultivation and the highest irrigation (18–20%).
4. **Balmoor Mandal (Chenchugudem, Ambagiri):** Cotton is dominant, but maize and groundnut diversify the cropping structure. Irrigation is low to moderate (12–15%).
5. **Achampet Mandal (Inole, Bommanapalli):** Cotton and groundnut dominate, with better irrigation coverage (18%), likely improving yield stability.

The cropping data from 10 villages across five mandals in the ITDA Mannanur region reveals the following central tendencies and variation.

Table 6: Cropping Patterns and Water Usage (Descriptive Statistics Summary)

Variable	Mean (%)	Std Dev	Min (%)	Max (%)
Cotton	66.0	4.85	60	74
Maize	12.5	5.87	5	20
Red Gram	21.5	2.07	19	25
Irrigated Land	14.8	3.64	10	20

Source: *Statistical tools applied*

Cotton dominates cropping patterns, covering an average of 66% of cultivable land, confirming its central role in the region's agricultural economy. Maize and Red Gram play secondary roles, with maize displaying greater variability across villages. Irrigated land averages just 14.8%, highlighting the ongoing dependence on monsoon rains and the susceptibility to fluctuations in rainfall.

Table 7: Cropping Patterns and Water Usage (Correlation Analysis)

	Cotton (%)	Maize (%)	Red Gram (%)	Irrigated Land (%)
Cotton (%)	1.00	-0.94	0.33	-0.01
Maize (%)	-0.94	1.00	-0.63	0.16
Red Gram (%)	0.33	-0.63	1.00	-0.43
Irrigated Land (%)	-0.01	0.16	-0.43	1.00

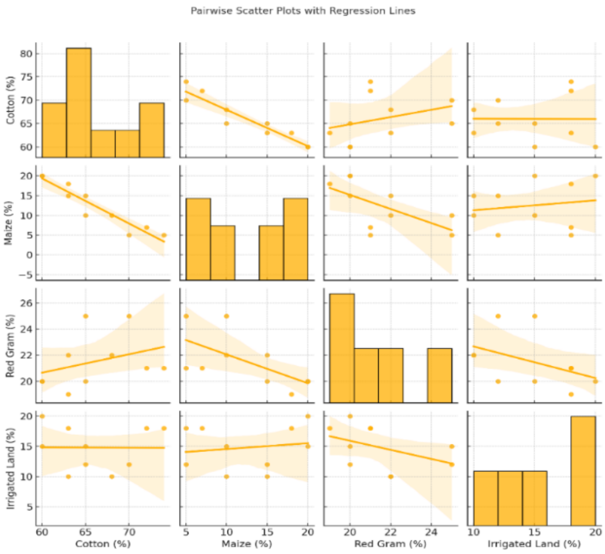
Source: *Statistical tools applied*

Strong Negative Correlation between Cotton and Maize (-0.94): Indicates that in villages where cotton is grown extensively, maize is less cultivated, likely due to competition for limited land and differing water requirements.

Weak Correlation Between Irrigation and Cotton (−0.01): Suggests that cotton cultivation in the region is not significantly dependent on irrigation, highlighting the reliance on rainfall and the drought-tolerance of cotton.

Moderate Negative Correlation between Red Gram and Irrigation (−0.43): Implies that Red Gram is typically cultivated in less irrigated areas, reinforcing its suitability for dryland farming.

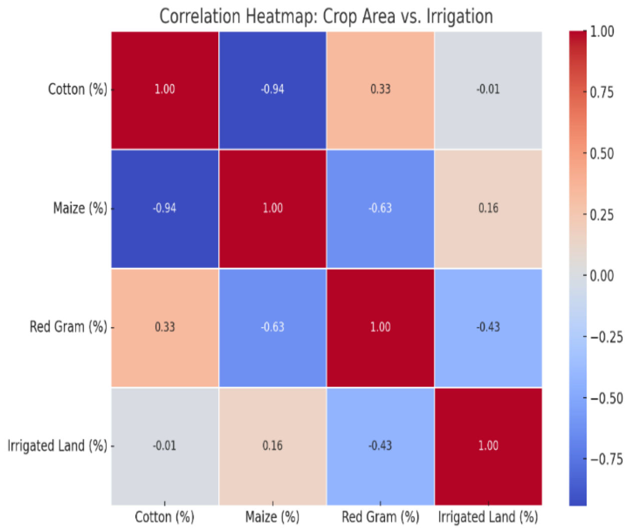
Graph 2: Pairwise Scatter Plots with Regression Lines



The scatter plots with regression lines provide visual confirmation of the above relationships:

- **Cotton vs. Maize:** Strong negative linear relationship.
- **Cotton vs. Irrigated Land:** No significant trend demonstrating that cotton remains the dominant crop regardless of irrigation.
- **Red Gram vs. Irrigation:** A downward trend suggests reduced red gram acreage in better-irrigated villages.

Graph 3: Pairwise Scatter Plots with Regression Lines



*The **correlation heatmap** shows the relationships between the percentage of area under different crops and irrigated land across villages in the Mannanur region.*

The correlation heatmap illustrates the relationships between cropping patterns and irrigation levels across villages in the Mannanur region. A strong **negative correlation** is observed between the percentage of land under cotton and maize, indicating that higher cotton cultivation tends to reduce maize coverage. Similarly, there is a **moderate positive correlation** between maize and irrigated land, suggesting that maize is more likely to be grown where irrigation is available. Red gram shows weak correlations with both cotton and irrigation, reflecting its adaptability to dryland conditions. These insights help identify crop choices based on water availability, guiding sustainable agricultural planning in tribal areas.

Irrigation and Water Access

The irrigation and water access profile of the Mannanur region reveals a predominance of **rain-fed agriculture**, underscoring the region's dependency on monsoon rainfall. The analysis of ten villages across five Mandals, Amrabad, Lingala, Padara, Balmoor, and Achampet, highlights critical disparities in irrigation infrastructure and access, with only 10% to 20% of cultivable land receiving reliable irrigation support.

Table 8: Village-Wise Irrigation Access and Rain-fed Dependency in the Mannanur Region

Mandal	Village	Total Cultivable Area (Acres)	Area with Irrigation (Acres)	Rain-fed Agriculture (%)	Access to Irrigation (%)
Amrabad	Mallapurpenta	500	75	85	15
	Sarlapalli	500	50	90	10
Lingala	Medimalakala	400	60	85	15
	Appapur	400	50	87	13
Padara	Petralchenu	350	70	80	20
	Chitlamkunta	350	60	83	17
Balmoor	Chenchugudem	325	40	88	12
	Ambagiri	325	48	85	15
Achampet	Inole	450	72	84	16
	Bommanapalli	450	81	82	18

Source: *Field Survey*

Overview: Out of a total of **4,050 acres** of cultivable land surveyed:

- **Area under irrigation**: 606 acres (14.96%)
- **Average rain-fed dependency**: 84.9%
- **Average access to irrigation**: 15.1%

This means that nearly **85% of the region's agricultural activity is rain-dependent**, making it highly vulnerable to rainfall variability and droughts.

- Achampet Mandal (especially Bommanapalli and Inole) shows relatively better irrigation access (16–18%), possibly due to proximity to minor irrigation tanks or borewell penetration.
- Padara villages (Petralchenu and Chitlamkunta) also exhibit higher irrigation usage (17–20%), which correlates with more diverse cropping patterns and inclusion of maize.
- Amrabad and Lingala Mandals, despite larger cultivable areas, show weaker irrigation coverage, with some villages like Sarlapalli relying on rain-fed agriculture for up to 90% of cultivation.
- Balmoor villages have the lowest absolute irrigated area, indicating a high need for targeted water resource development interventions.

Table 9: Descriptive Statistics of Irrigation Parameters (Mean, Min, Max)

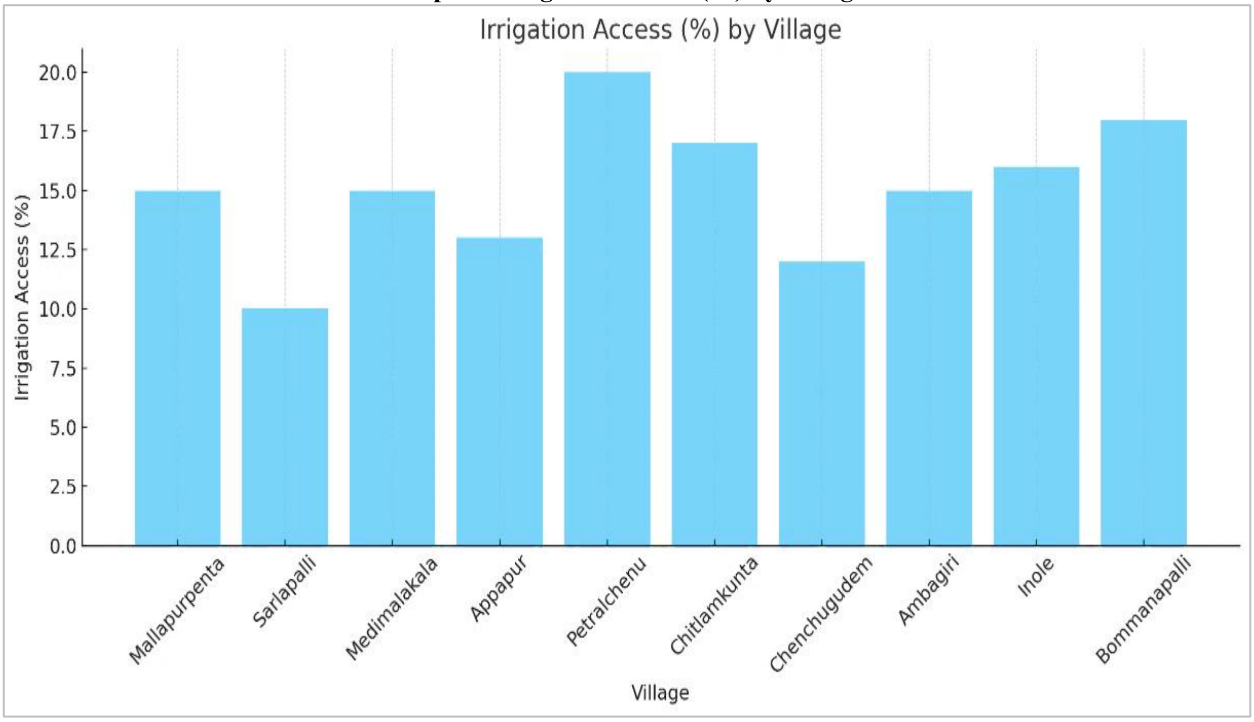
Metric	Mean	Min	Max
Total Cultivable Area	405.0 ac	325 ac	500 ac
Irrigated Area	60.6 ac	40 ac	81 ac
Rain-fed Agriculture %	84.9%	80%	90%
Irrigation Access %	15.1%	10%	20%

Source: *Statistical tools applied*

Using descriptive statistics, we observe a skewed distribution where most villages have irrigation access below 20%, reinforcing the need for water conservation and micro-irrigation schemes (e.g., drip irrigation, farm ponds). A scatter plot comparing irrigated land against rain-fed dependency would show a strong negative correlation, validating the inverse relationship between these two parameters. This analysis indicates that, despite slight variations across Mandals, irrigation remains a bottleneck in enhancing agricultural productivity in the Mannanur region, particularly for tribal farmers cultivating on fragile red sandy soils.

***Corresponding Author:** Prof. B. Sudhakar Reddy

Graph 4: Irrigation Access (%) by Village



The bar graph shows irrigation access (%) across villages.

Government Schemes and Assistance

The implementation and outreach of government welfare schemes such as the Forest Rights Act (FRA), Rythu Bandhu, and PM-KISAN across the tribal villages of the ITDA Mannanur region reflect varying degrees of effectiveness. The data surveyed from ten villages, each with a consistent sample size of 50 households, provides insight into how well these schemes are reaching the tribal population, particularly in remote and forested Mandals.

Table 10: Government Schemes and Assistance – Household-level Data by Village

Mandal	Village	Total Households Surveyed	Households Receiving FRA Benefits (%)	Households Receiving Rythu Bandhu (%)	Households Receiving PM-KISAN (%)
Amrabad	Mallapurpenta	50	42	58	55
	Sarlapalli	50	40	60	54
Lingala	Medimalakala	50	45	57	52
	Appapur	50	43	55	53
Padara	Petralchenu	50	35	65	60
	Chitlamkunta	50	38	63	58
Balmoor	Chenchugudem	50	40	60	55
	Ambagiri	50	37	59	53
Achampet	Inole	50	45	60	56
	Bommanapalli	50	42	62	57

Source: *Field Survey*

Forest Rights Act (FRA) Coverage

- FRA benefits are received by 35% to 45% of surveyed households.
- The highest coverage is observed in Medimalakala and Inole (45%), indicating better documentation and recognition of forest land rights in these areas.
- Villages like Petralchenu (35%) and Chitlamkunta (38%) reflect relatively lower FRA benefit access, suggesting potential gaps in awareness, documentation, or bureaucratic hurdles in claim approvals.

Rythu Bandhu Scheme

- The Rythu Bandhu scheme, which provides direct income support to farmers, shows higher penetration than the FRA.
- Across villages, 55% to 65% of households report receiving benefits.
- Petralchenu (65%) and Chitlamkunta (63%) top the list, possibly due to better land title records or active local facilitation.
- The lowest uptake is in Appapur (55%), which may point to challenges in accessing updated land records or eligibility criteria barriers.

PM-KISAN Scheme

- The central government's PM-KISAN income support scheme records relatively uniform coverage ranging from 52% to 60%.
- Villages such as Petralchenu (60%), Chitlamkunta (58%), and Bommanapalli (57%) show higher participation.
- Lower access in Medimalakala (52%) and Appapur (53%) might reflect issues with Aadhaar linkage, bank account updates, or verification processes.

Table 11: Government Scheme Coverage (Descriptive Statistics Summary)

Scheme	Mean (%)	Min (%)	Max (%)	Std. Dev. (%)
FRA Benefit Coverage	40.7	35	45	3.5
Rythu Bandhu Coverage	59.9	55	65	3.1
PM-KISAN Coverage	55.3	52	60	2.6

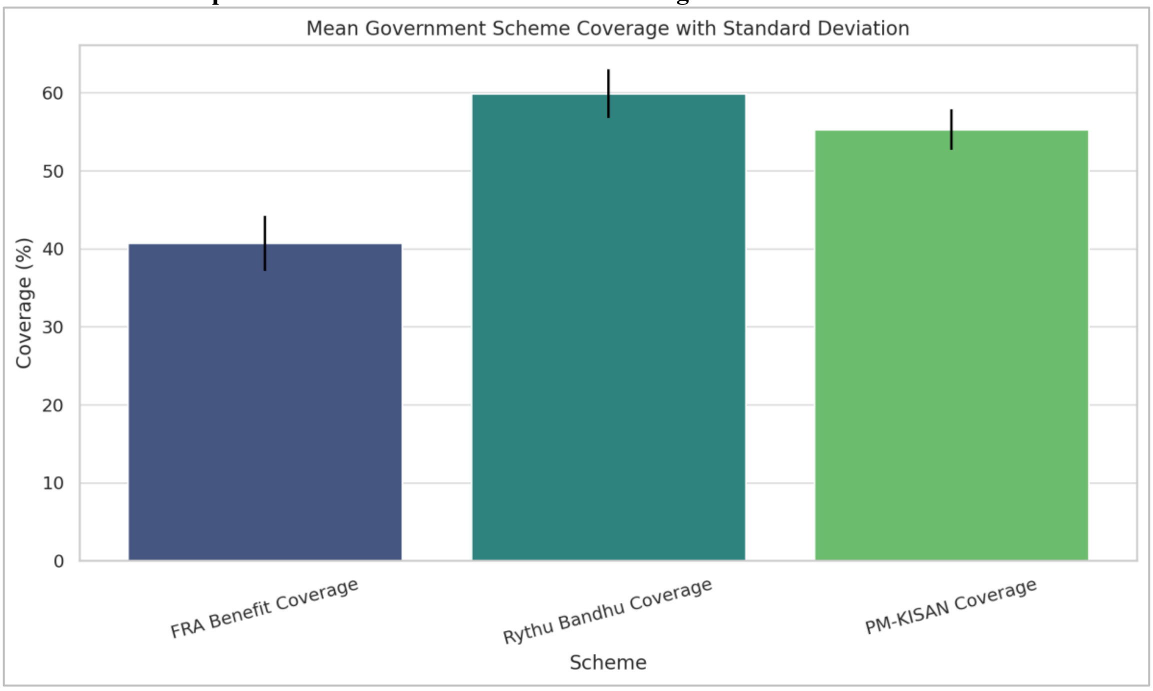
Source: *Statistical tools applied*

Rythu Bandhu has the highest average coverage and relatively stable outreach, reflecting strong penetration in Andhra Pradesh and Telangana, where landholding-based support is prioritized.

PM-KISAN exhibits moderate yet consistent coverage, possibly due to the streamlined Direct Benefit Transfer (DBT) system, but still leaves gaps among landless or marginalized farmers.

FRA Benefit Coverage remains the lowest among the three, with greater variability, pointing to persistent challenges in rights recognition and benefit realization among tribal households.

Graph 5: Mean Government Scheme Coverage with Standard Deviation



The bar chart shows the mean coverage of each government scheme, with the error bars representing the standard deviation.

Crop Yield Data

The village-wise crop yield data collected from five mandals—Amrabad, Lingala, Padara, Balmoor, and Achampet—shows notable variation in the productivity of cotton, maize, and red gram. Cotton yields range from a low of 420 kg per acre in Medimalakala (Lingala mandal) to a high of 490 kg per acre in Bommanapalli (Achampet mandal). Maize yields are relatively consistent, falling between 570 and 620 kg per acre, with the highest yield again recorded in Bommanapalli. Red gram yield exhibits more variability, ranging from 380 kg per acre in Ambagiri (Balmoor) to 440 kg per acre in Bommanapalli. Among all villages, Bommanapalli stands out for achieving the highest yield across all three crops, indicating potentially favorable agro-climatic conditions or effective farming practices. In contrast, villages like Medimalakala and Appapur in Lingala mandal report lower yields, suggesting the need for focused agricultural support or intervention in these areas. Overall, the data provides critical insights for identifying gaps and strengthening village-level planning for crop-specific improvements.

Table 12: Village-wise Average Crop Yields (Kg/Acre) in Selected Mandals

Mandal	Village	Average Cotton Yield (Kg/acre)	Average Maize Yield (Kg/acre)	Average Red Gram Yield (Kg/acre)
Amrabad	Mallapurpenta	450	600	400
	Sarlapalli	440	590	390
Lingala	Medimalakala	420	580	410
	Appapur	430	570	420
Padara	Petralchenu	460	590	410
	Chitlamkunta	450	600	400
Balmoor	Chenchugudem	460	580	390
	Ambagiri	470	590	380
Achampet	Inole	480	610	430
	Bommanapalli	490	620	440

Source: *Field Survey*

Table 13: Analysis of Crop Yields (Kg/acre)

Crop	Mean Yield	Std. Dev.	Min Yield	Max Yield	Range
Cotton	455.0	21.6	420	490	70
Maize	593.0	15.1	570	620	50
Red Gram	407.0	18.0	380	440	60

Source: *Statistical tools applied*

- Bommanapalli (Achampet Mandal) shows the highest yield across all three crops, suggesting better soil, irrigation, or input practices.
- Medimalakala and Appapur (Lingala Mandal) yield lower averages, indicating possible gaps in support or agronomic constraints.
- Red Gram has slightly more yield variability, possibly due to sensitivity to rainfall and pest incidence.

Socio-Economic Data of Households

The socio-economic data collected from ten villages across the mandals of Amrabad, Lingala, Padara, Balmoor, and Achampet reveal important variations in farm income, household composition, and financial access indicators. The average farm income ranges from ₹68,000 in Appapur village of Lingala mandal to ₹82,000 in Bommanapalli village of Achampet mandal, indicating a significant gap in agricultural earnings across regions. Villages in Achampet mandal, particularly Inole and Bommanapalli, stand out with the highest income levels, suggesting relatively better agricultural productivity or market connectivity in this region.

Table 14: Socio-Economic Data of Households

Mandal	Village	Average Farm Income (₹)	Average Household Size	Households with Access to Loans (%)	Households Facing Debt (%)
Amrabad	Mallapurpenta	75,000	5.0	35	25
	Sarlapalli	72,000	4.8	33	22
Lingala	Medimalakala	70,000	4.5	30	20
	Appapur	68,000	4.7	32	21
Padara	Petralchenu	78,000	5.2	38	28
	Chitlamkunta	77,000	5.1	36	27
Balmoor	Chenchugudem	74,000	5.0	34	24
	Ambagiri	72,000	4.9	33	23
Achampet	Inole	80,000	5.3	40	30
	Bommanapalli	82,000	5.4	42	32

Source: Field Survey

Household sizes across the villages remain moderately consistent, averaging between 4.5 and 5.4 members per household. The smallest average household size is observed in Medimalakala (Lingala mandal), while the largest is found in Bommanapalli. This may reflect demographic or cultural variations in family structure across the mandals. Access to financial credit, as measured by the percentage of households with access to loans, shows considerable variation. While only 30 percent of households in Medimalakala reported having access to loans, this figure rises to 42 percent in Bommanapalli. Generally, villages in Achampet mandal demonstrate stronger financial access, which could be attributed to the presence of banking institutions or active participation in credit-linked government schemes.

At the same time, the data shows that many households with loan access face debt-related burdens. Debt incidence ranges from 20 percent in Medimalakala to 32 percent in Bommanapalli. This suggests a potential correlation between access to formal credit and household indebtedness, raising important questions about the terms of borrowing and the capacity of rural households to manage financial obligations.

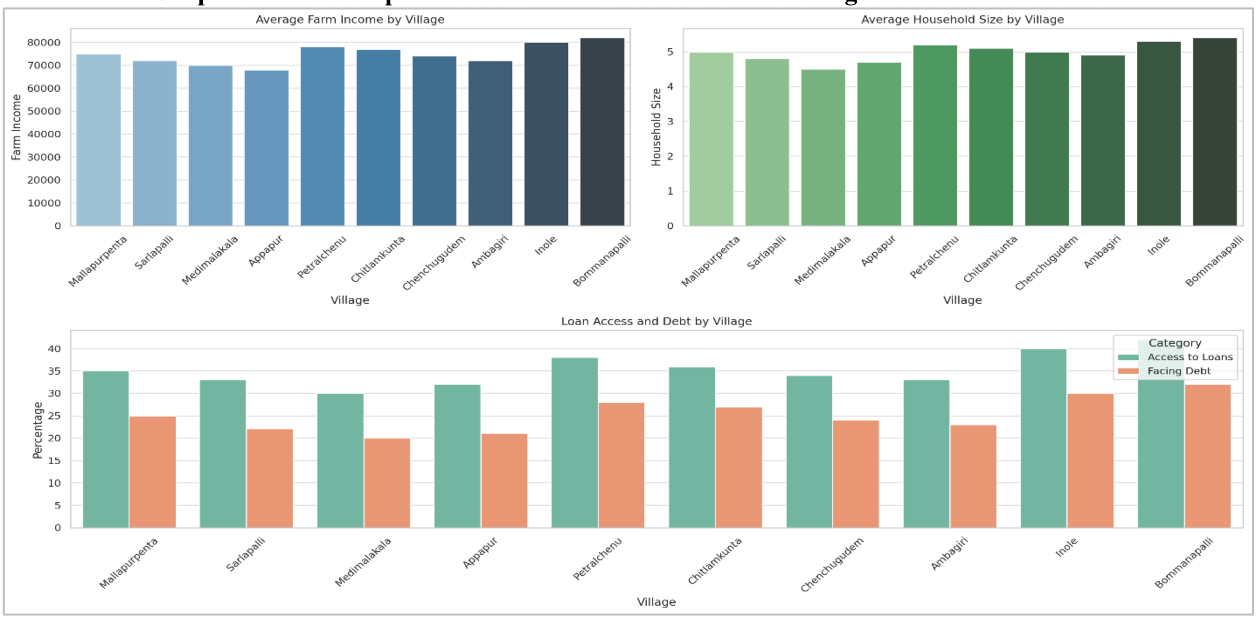
Table 15: Analysis of Socio-Economic Data

Variable	Mean	Std. Dev.	Min	Max	Range
Average Farm Income (₹)	₹74,800	₹4,633	₹68,000	₹82,000	₹14,000
Average Household Size	5.0	0.26	4.5	5.4	0.9
Households with Access to Loans (%)	35.3%	3.68%	30%	42%	12%
Households Facing Debt (%)	25.2%	3.66%	20%	32%	12%

Source: *Statistical tools applied*

Achampet Mandal, particularly Bommanapalli, consistently ranks highest in income, household size, credit access, and debt levels, indicating both active financial participation and potential risks of over-borrowing. In contrast, villages in Lingala Mandal report the lowest farm income, smallest household sizes, and limited access to credit, suggesting a weaker economic position and possible structural isolation. A positive correlation exists between income and credit access, as villages with higher incomes generally enjoy better loan accessibility, although this also aligns with increased debt burdens.

Graph 6: Three comparative visualizations based on the village-wise socio-economic



- Bar Chart - Average Farm Income: Shows income disparities across villages, with Bommanapalli and Inole leading in earnings.
- Bar Chart - Household Size: Most villages report household sizes between 4.5 and 5.4, with Bommanapalli highest.
- Grouped Bar Chart - Loan Access vs. Debt: Reveals that although access to loans is relatively high, a notable proportion of households are also facing debt, especially in Inole and Bommanapalli.

Ten villages across the mandals of Amrabad, Lingala, Padara, Balmoor, and Achampet show clear evidence of climate vulnerability, particularly concerning rainfall dependency and the impact of drought on agricultural productivity. Rainfall levels vary modestly across the villages, with average annual rainfall ranging from 740 mm in Ambagiri to 850 mm in

***Corresponding Author:** Prof. B. Sudhakar Reddy

Bommanapalli. However, rainfall dependency is significantly high throughout the region, exceeding 80% in all villages and peaking at 91% in Ambagiri and 90% in Chenchugudem of Balmoor mandal. This underscores the continued reliance of local agriculture on monsoonal rainfall due to the lack of adequate irrigation infrastructure. The impact of drought on crop yields is especially pronounced in the Lingala and Balmoor mandals. Villages like Medimalakala, Appapur, Chenchugudem, and Ambagiri report yield reductions of 30% or more during drought conditions, indicating their high sensitivity to rainfall variability. In contrast, villages such as Petralchenu and Bommanapalli, which have relatively better rainfall or adaptation mechanisms, show a lower yield impact of 20%.

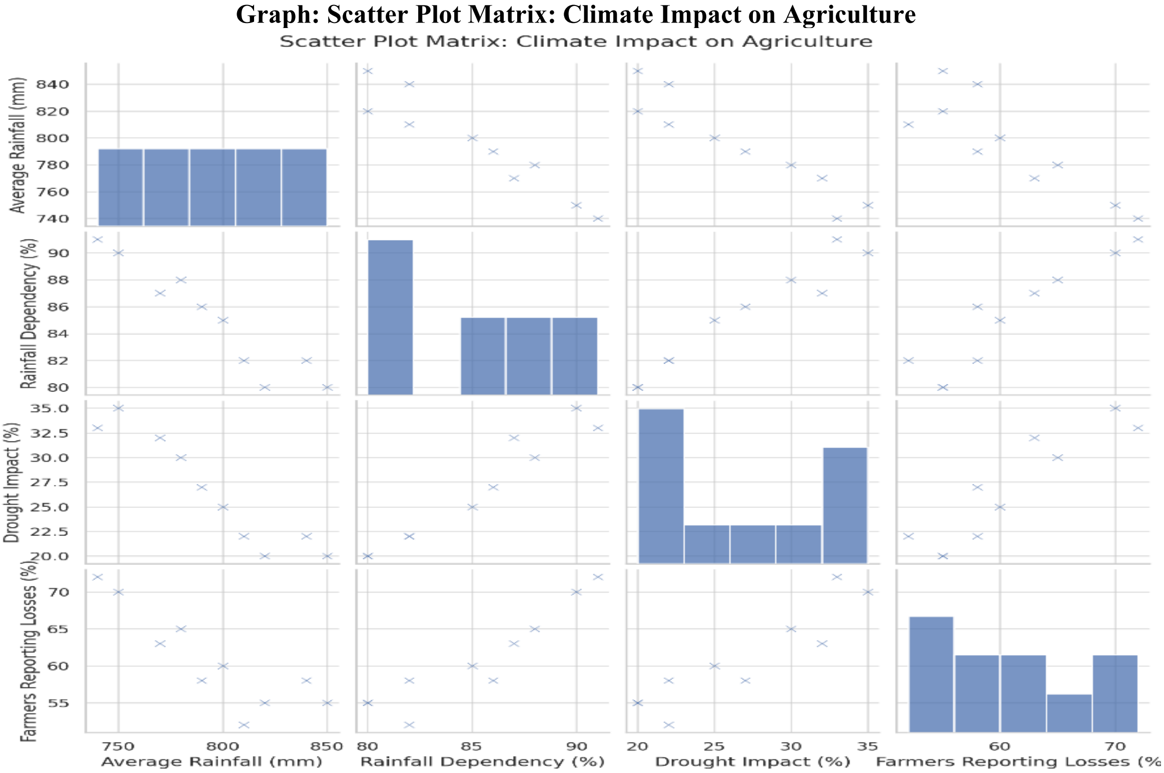
Climate Impact on Agriculture

Mandal	Village	Average Rainfall (mm)	Rainfall Dependency (%)	Impact of Drought on Crop Yield (%)	Farmers Reporting Crop Losses (%)
Amrabad	Mallapurpenta	800	85	25	60
	Sarlapalli	790	86	27	58
Lingala	Medimalakala	780	88	30	65
	Appapur	770	87	32	63
Padara	Petralchenu	820	80	20	55
	Chitlamkunta	810	82	22	52
Balmoor	Chenchugudem	750	90	35	70
	Ambagiri	740	91	33	72
Achampet	Inole	840	82	22	58
	Bommanapalli	850	80	20	55

Source: *Field Survey*

The percentage of farmers reporting crop losses reflects the pattern of drought impact. Chenchugudem and Ambagiri report the highest proportions of affected farmers at 70% and 72%, respectively, suggesting that these villages are among the most vulnerable to climate-induced agricultural shocks. In contrast, Chitlamkunta and Bommanapalli report comparatively fewer farmers experiencing crop losses, at 52% and 55%, respectively. The data highlights that while rainfall amounts may not differ drastically, the degree of dependency on rainfall and resulting crop vulnerability vary significantly across villages. Villages in Balmoor and Lingala mandals emerge as particularly climate-sensitive areas. This underscores the need for targeted interventions in drought resilience, such as micro-irrigation, soil moisture conservation, and climate-resilient cropping systems, to mitigate risk and secure rural livelihoods.

Graph: Scatter Plot Matrix: Climate Impact on Agriculture

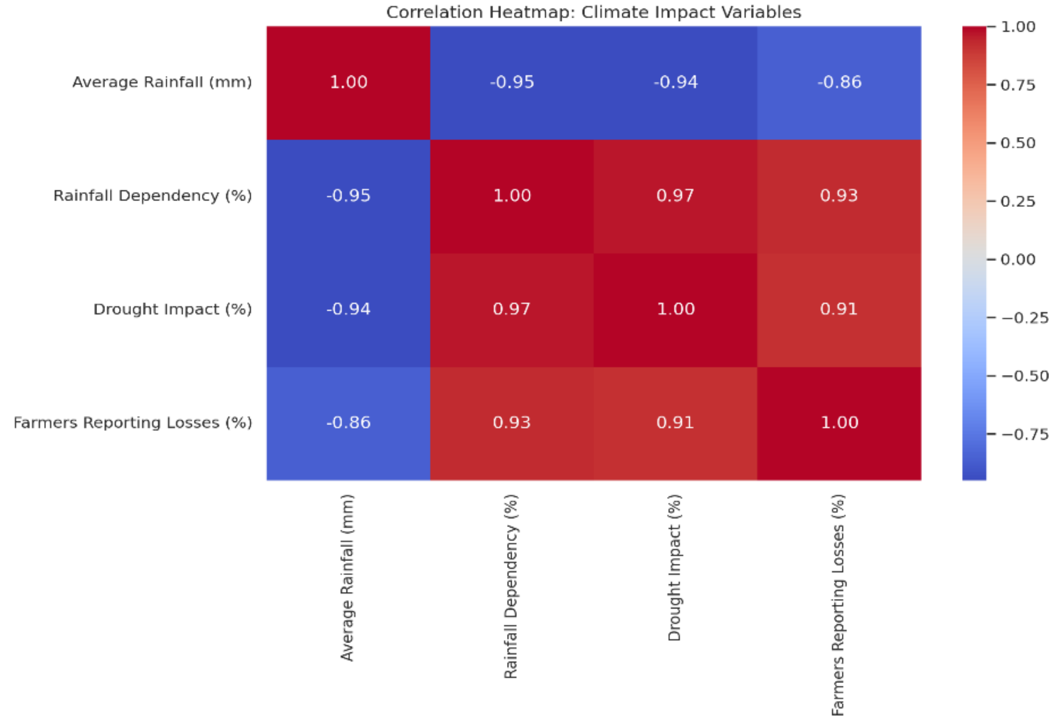


***Corresponding Author:** Prof. B. Sudhakar Reddy

The scatter plot matrix shows the relationships among all four climate-related variables. Notably:

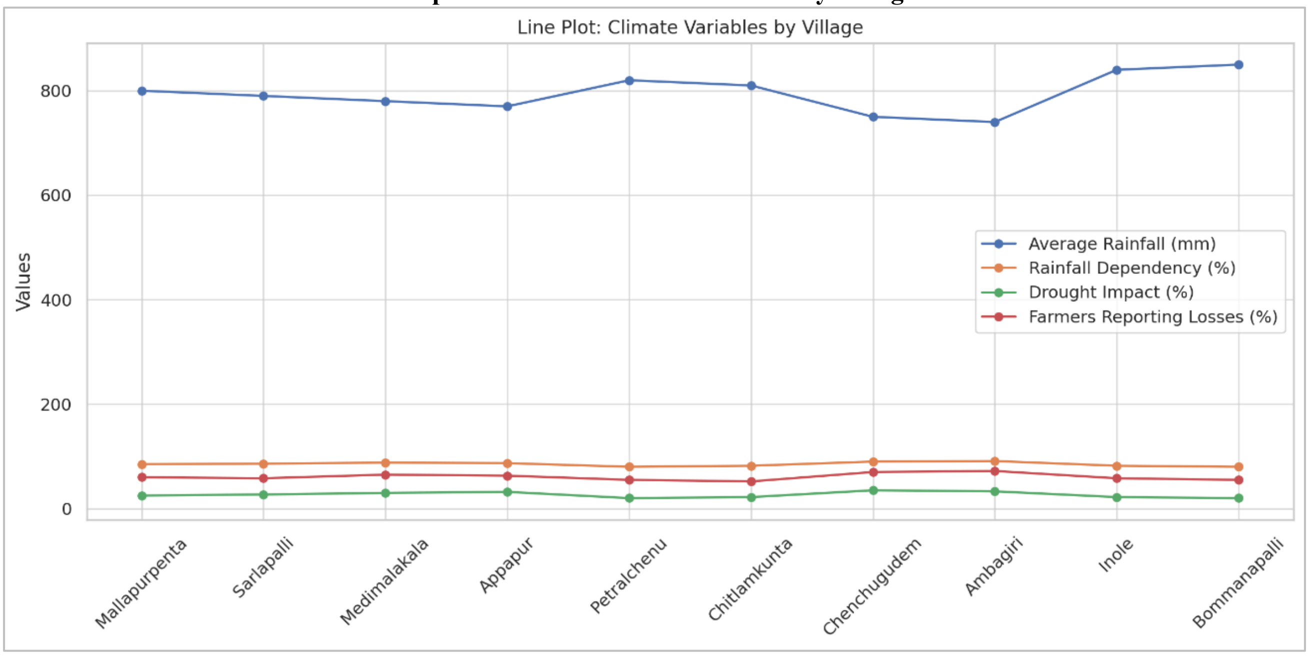
- There is a strong positive correlation between rainfall dependency and crop loss.
- As drought impact increases, farmers reporting losses also tend to increase.
- Villages with lower rainfall appear to suffer more severe impacts from drought.

Graph: Correlation Heatmap: Climate Impact on Variables



- Rainfall Dependency and Drought Impact show a strong positive correlation.
- Farmers Reporting Losses is highly correlated with Drought Impact, indicating vulnerability in areas with higher dependency on rainfall and frequent droughts.

Graph: Line Plot Climate Variables by Village



- This plot compares all villages across four indicators.
- Villages like Ambagiri and Chenchugudem stand out with high rainfall dependency, high drought impact, and a large share of farmers reporting losses.
- In contrast, Bommanapalli and Petralchenu perform better across most indicators.

Challenges Faced by Tribal Farmers in Mannanur Region

Tribal agriculture in the Mannanur region, part of the Nallamala forest area spanning the Nagarkurnool district in Telangana, faces a complex set of challenges rooted in ecological vulnerability, economic marginalization, and policy neglect. The predominantly tribal communities, including the Chenchus and Lambadas, rely on subsistence farming practices shaped by tradition and limited resources. This essay examines the core challenges that tribal farmers encounter, using evidence from field studies and ground realities.

Water Scarcity and Irrigation Constraints

One of the most critical challenges tribal farmers in the Mannanur region face is the scarcity of water. The area primarily relies on rain-fed agriculture. With annual rainfall patterns becoming increasingly erratic due to climate change, the reliability of monsoons has significantly declined. Most farmers lack access to irrigation infrastructure such as borewells, check dams, or minor lift irrigation schemes. The undulating terrain, red sandy soils with poor moisture retention, and the absence of watershed development worsen the water crisis.

For example, in Mallapurpenta village, farmers report cultivating cotton and red gram during the kharif season. However, any delay or early withdrawal of the monsoon leads to stunted growth or complete crop failure. The absence of a secondary water source forces them to abandon their fields or rely on forest produce for survival. In 2022, more than 40% of small tribal farmers in Lingala Mandal left their lands fallow due to the lack of irrigation, according to reports from local agricultural extension officers.

While the government has initiated programs like Mission Kakatiya and the revival of minor irrigation tanks, their impact remains limited in remote forest-adjacent areas due to logistical and administrative challenges.

Low Agricultural Productivity

Agricultural productivity in tribal areas like Mannanur remains significantly below the state average. The reasons are multifaceted: poor soil fertility, lack of mechanization, insufficient access to quality seeds and fertilizers, and traditional farming methods that are low-input and low-output. Tribal farmers often rely on saved seeds and traditional crop varieties that, while resilient, do not produce enough for market surplus.

For example, in villages like Appapur and Medimalakala, the average cotton yield is approximately 420–430 kg per acre, significantly lower than the state average of 700–800 kg per acre. A similar trend is observed in maize and red gram yields. The causes are not limited to natural factors but also include institutional issues: tribal farmers encounter challenges in accessing agricultural extension services, soil testing facilities, and timely guidance on crop planning.

The existing subsidy programs under the Department of Agriculture, such as input kits and soil health cards, do not adequately reach these remote farmers. Many tribal farmers are not registered under formal land titles, which disqualifies them from receiving key benefits, including input subsidies or crop insurance under PMFBY (Pradhan Mantri Fasal Bima Yojana).

Limited Market Access and Poor Price Realization

Another significant challenge is market access. Mannanur and the surrounding tribal areas are geographically isolated, with poor road connectivity, particularly during the monsoon season. Most tribal farmers sell their produce at local weekly markets (shandies) or to intermediaries who visit the villages, often at prices much lower than the Minimum Support Price (MSP). This informal market system takes advantage of the farmers' lack of bargaining power and awareness.

For example, in Petralchenu and Chitlamkunta, maize and red gram farmers report selling their produce at rates 15–20% lower than MSP because the nearest Agricultural Market Committee (AMC) yard is 40–50 km away. Transporting goods is both expensive and time-consuming, and in some cases, farmers are compelled to accept advance payments from traders, locking them into unfavourable terms.

While digital marketing initiatives and Farmer Producer Organizations (FPOs) are being promoted, tribal regions are often left out due to a lack of digital literacy, poor internet connectivity, and a lack of trained institutional support.

Land Tenure and Title Issues

Although the Forest Rights Act (FRA), 2006, has enabled some tribal households to receive titles for individual forest lands, the implementation remains uneven in regions like Mannanur. Many tribal families continue to cultivate land without formal recognition, affecting their ability to secure credit, crop insurance, or participate in government welfare schemes.

In a recent survey in the Padara Mandal, it was found that over 30% of tribal cultivators did not possess

***Corresponding Author:** Prof. B. Sudhakar Reddy

any legal land title, though they had been cultivating the same plots for generations. This legal ambiguity also increases the risk of eviction, especially when forest authorities undertake afforestation projects or wildlife conservation efforts.

The lack of secure land rights remains a fundamental bottleneck in improving agricultural investment, access to formal credit, and long-term sustainability of tribal agriculture.

Inadequate Financial Inclusion and Debt Dependency

Financial exclusion continues to affect tribal farmers, despite government claims of expanded banking services. Many tribal households do not have access to institutional credit and rely heavily on informal sources such as local moneylenders, often at exploitative interest rates. Banks and cooperative societies are hesitant to lend to farmers with unregistered land or poor credit history.

In Chenchugudem and Ambagiri, over 40% of farmers reported being in a debt cycle due to borrowing for agricultural expenses. Without insurance or guaranteed support, a failed crop season pushes them further into debt. This also leads to seasonal migration, with youth leaving villages to work as laborers in cities like Hyderabad or Guntur.

Self-help groups (SHGs) under the National Rural Livelihoods Mission (NRLM) have made some inroads, especially among tribal women, but the scale is insufficient to meet the needs of an entire agricultural economy.

Climate Change and Environmental Risks

The Mannanur region is increasingly facing the brunt of climate variability, delayed monsoons, unseasonal rains, and prolonged dry spells. These climatic shifts are compounding the already fragile agricultural systems. With little capacity to adapt, tribal farmers are caught in a cycle of poor harvests and economic insecurity.

Farmers in villages like Inole and Bommanapalli have observed shorter cropping seasons, increased pest attacks, and a reduction in groundwater recharge. The lack of climate-resilient agriculture programs tailored to forest-adjacent tribal regions means that adaptation strategies are virtually non-existent.

While Zero Budget Natural Farming (ZBNF) and agroforestry are being promoted in some parts of Andhra Pradesh and Telangana, these have not yet reached tribal belts like Mannanur due to a lack of extension personnel and the need for culturally sensitive training.

Government Schemes and Support

Government schemes play a critical role in supporting tribal farmers and addressing the multiple vulnerabilities they face, especially in remote regions like Mannanur and the surrounding mandals. Over the past decade, both the central and state governments have introduced a variety of welfare and development schemes aimed at improving agricultural productivity, securing livelihoods, and enhancing financial inclusion. However, while these schemes hold significant promise, their reach and impact among tribal communities remain uneven. One of the most notable interventions is the Forest Rights Act (FRA), 2006, which aims to recognize the land and livelihood rights of forest-dwelling Scheduled Tribes. In the Mannanur region, many individual forest rights (IFRs) have been distributed, allowing tribal families to claim ownership of forest land they have cultivated for generations. While this has offered legal security, gaps in implementation persist, with several eligible households awaiting claim approvals or facing disputes over mapped boundaries.

Another major support initiative is Rythu Bandhu, a state-funded input support scheme in Telangana, which provides ₹5,000 per acre per season to farmers. While it has helped many in securing seeds and fertilizers, tribal cultivators without formal land titles are often excluded from the benefits. Similarly, PM-KISAN, a central government scheme offering ₹6,000 per year in direct benefit transfer, also requires proper land records, which many tribal farmers lack. To address credit challenges, the government has launched the Kisan Credit Card (KCC) scheme, enabling farmers to access low-interest, short-term credit for agricultural needs. However, tribal farmers in interior villages often face difficulties in completing paperwork, visiting banks, and understanding loan terms. As a result, many continue to depend on informal lenders at high interest rates.

Integrated Tribal Development Agency (ITDA) programs, specific to tribal regions, have made efforts to promote horticulture, livestock development, and skill training. In Mannanur and surrounding areas, the ITDA has supported minor irrigation works, distributed mini-tractors, and organized agricultural training camps. Despite this, the outreach remains limited due to staffing shortages and logistical hurdles in forested terrain. MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) has provided employment and income security in the agricultural off-season. Tribal families use these wages to support farming activities or repay debts. However, delays in wage payments and limited convergence with agriculture-specific activities reduce the scheme's potential to boost farm resilience.

Several livelihood support schemes under the National Rural Livelihoods Mission (NRLM), particularly for tribal women through self-help groups, are helping to diversify income sources through poultry, goat rearing, and small enterprises. These initiatives are vital in reducing dependence on seasonal farming and mitigating distress migration. While government schemes have the potential to uplift tribal farmers, their effectiveness depends on improved targeting, awareness, local institutional capacity, and ensuring that tribal-specific realities such as land tenure issues, geographical isolation, and cultural distinctiveness are fully addressed. Greater community involvement, localized planning, and last-mile delivery reforms are essential to translate these schemes from paper to tangible change in tribal agricultural landscapes.

RECOMMENDATIONS

To ensure the inclusive and sustainable development of tribal agriculture in regions like Mannanur and the surrounding forested mandals, a series of policy, institutional, and community-level interventions is necessary. These recommendations focus on improving agricultural productivity, securing livelihoods, and enhancing the resilience of tribal farming households in the face of climate and market uncertainties.

Strengthen Land and Tenure Security

Many tribal farmers continue to cultivate forest land without formal recognition. Expediting the implementation of the Forest Rights Act (FRA) and addressing pending claims can provide legal assurance, which is vital for accessing credit, government schemes, and long-term planning. Efforts should also be made to digitize and map land records in collaboration with tribal communities, ensuring transparency and accuracy.

Expand Irrigation and Water Harvesting Infrastructure

Given the high dependency on rainfall, the promotion of minor irrigation projects, check dams, and traditional water harvesting structures like farm ponds and percolation tanks is essential. These initiatives should be locally planned, using watershed approaches that combine technical inputs with indigenous knowledge. Government convergence with MGNREGA can ensure labour-intensive implementation with community participation.

Promote Climate-Resilient Agriculture

Adoption of sustainable farming practices like Zero Budget Natural Farming (ZBNF), mixed cropping, agroforestry, and drought-tolerant crop varieties should be scaled up. Demonstration plots, farmer field schools, and mobile-based advisory services can help spread awareness and increase adoption. Special emphasis should be placed on women farmers, who often manage household food security.

Improve Access to Institutional Credit and Inputs

Financial inclusion remains a challenge. Expanding the reach of Kisan Credit Cards (KCC), linking Self-Help Groups (SHGs) with bank credit, and setting up mobile banking units in remote areas can help bridge the gap. Subsidized inputs, timely seed and fertilizer supply through village-level cooperatives or Farmer Producer Organizations (FPOs) should be institutionalized.

Strengthen Market Linkages and Value Addition

Tribal farmers suffer from weak bargaining power due to a lack of direct access to markets. Establishing rural haats (markets), aggregation centres, and cold storage units under the PMFME and e-NAM schemes can reduce post-harvest losses and improve price realization. Encouraging tribal cooperatives and FPOs to engage in the processing and branding of millets, NTFPs (non-timber forest produce), and organic produce can also add value.

Invest in Capacity Building and Extension Services

Agricultural extension workers, preferably from tribal communities, should be trained and deployed to bridge the knowledge and practice gap. Periodic workshops, exposure visits, and digital literacy programs can empower farmers with relevant knowledge. ITDA, Krishi Vigyan Kendras (KVKs), and NGOs must collaborate for integrated capacity-building models.

Ensure Holistic and Inclusive Governance

Planning must adopt a bottom-up approach, involving Grama Sabhas under the PESA (Panchayats Extension to Scheduled Areas) Act in all developmental decisions. Feedback mechanisms and social audits can ensure transparency and accountability in scheme delivery. State Tribal Sub-Plan (TSP) funds should be more strategically allocated with measurable outcome indicators. Revitalizing tribal agriculture requires a multi-sectoral and culturally sensitive approach. Strengthening institutional mechanisms, building local capacities, and ensuring that tribal voices are central to planning and implementation will help transition these vulnerable communities from subsistence to resilience and prosperity.

REFERENCES

Journal Articles

1. Reddy, K. S., Maruthi, V., Pankaj, P. K., Pushpanjali, P., & Krishna, T. S. (2020). Transforming tribal farming from subsistence to sustainable. *Indian Farming*, *69*(11).
2. Naik, B. M., Singh, A. K., Roy, H., & Maji, S. (2023). Assessing the adoption of climate resilient agricultural technologies by the farmers of Telangana State. *Indian Journal of Extension Education*, *59*(1).
3. Sri, C. R., Suhasini, K., Ashok, K., & Raj, B. M. U. (2024). Climate resilient technologies, adaptation, mitigation and their influence on farm income in Telangana State of India. *International Journal of Environment and Climate Change*, *14*(2), 894–901.
4. Naik, B. M., Singh, A. K., Maji, S., & Venkatesan, P. (2024). Exploring farmers' attitudes towards climate resilient agricultural technologies in Telangana State, India. *International Journal of Environment and Climate Change*, *14*(7), 171–180.
5. Acharitha, G., Savitha, B., Rekha, B., & Babu, K. M. (2022). Problems in the adoption of climate-resilient technologies by the farmers of Telangana

State, India. *International Journal of Environment and Climate Change*, *12*(11), 3385–3389.

6. Samuel, J., Rao, C. A. R., Pushpanjali, P., Beevi, C. N. A., Raju, B. M. K., Reddy, A. A., Kumar, R. N., Reddy, A. G. K., Singh, V. K., Prabhakar, M., Siva, G. S., & Teggelli, R. G. (2024). Enhancing farm income resilience through climate-smart agriculture in drought-prone regions of India. *Frontiers in Water*, *6*. https://doi.org/10.3389/frwa.2024.XXXXX
7. Reddy, A. A., Ricart, S., & Cadman, T. (2020). Tribal and non-tribal farmers' land rights and food security promotion in Telangana. *Journal of Asian and African Studies*, *55*(3), 389–405. https://doi.org/10.1177/0021909619878994

Government Schemes and Initiatives

8. Ministry of Agriculture & Farmers Welfare. (n.d.). *Pradhan Mantri Fasal Bima Yojana (PMFBY)*. Retrieved from https://www.pmfby.gov.in
9. Ministry of New and Renewable Energy. (n.d.). *PM-KUSUM Scheme*. Retrieved from https://mnre.gov.in/pm-kusum
10. Ministry of Tribal Affairs. (n.d.). *National Scheduled Tribes Finance and Development Corporation (NSTFDC)*. Retrieved from https://tribal.nic.in
11. Ministry of Agriculture & Farmers Welfare. (n.d.). *National Horticulture Mission (NHM)*. Retrieved from https://midh.gov.in
12. Ministry of Tribal Affairs. (n.d.). *Tribal Co-operative Marketing Development Federation of India (TRIFED)*. Retrieved from https://trifed.tribal.gov.in
13. Government of Telangana. (n.d.). *Rythu Bandhu Scheme*. Retrieved from https://rythubandhu.telangana.gov.in
14. Ministry of Agriculture & Farmers Welfare. (n.d.). *Kisan Credit Card (KCC) Scheme*. Retrieved from https://pib.gov.in
15. Ministry of Rural Development. (n.d.). *Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)*. Retrieved from https://nrega.nic.in

Institutional Reports and Training Programs

16. ICAR-Central Research Institute for Dryland Agriculture. (2024). *Skill development of tribal farmers on resilience agriculture and contingency planning*. Retrieved from https://crida.icar.gov.in
17. ICAR-Central Research Institute for Dryland Agriculture. (2024). *Capacity building of tribal farmers under TSP*. Retrieved from https://crida.icar.gov.in
18. ICAR-CRIDA. (n.d.). *Capacity building of tribal farmers under TSP*. Retrieved from https://crida.icar.gov.in

NGO and Developmental Initiatives

19. Caritas India. (n.d.). *Organic farming boosting the income of tribal farmers in Adilabad*. Retrieved from https://www.caritasindia.org

Additional Resources

20. National Innovations in Climate Resilient Agriculture (NICRA). (n.d.). *NICRA Project Overview*. Retrieved from https://www.nicra-icar.in
21. Professor Jayashankar Telangana State Agricultural University (PJTSAU). (n.d.). *Research publications and resources*. Retrieved from https://www.pjtsau.edu.in
22. Indian Council of Agricultural Research (ICAR). (n.d.). *Research journals and publications*. Retrieved from https://icar.org.in
23. Ministry of Tribal Affairs. (n.d.). *Tribal Sub-Plan (TSP)*. Retrieved from https://tribal.nic.in
24. Department of Agriculture, Government of Telangana. (n.d.). *Agricultural schemes and programs*. Retrieved from https://agriculture.telangana.gov.in
25. National Bank for Agriculture and Rural Development (NABARD). (n.d.). *Schemes for tribal development*. Retrieved from https://www.nabard.org

***Corresponding Author:** Prof. B. Sudhakar Reddy