



STRATEGIES TO ADAPT CLIMATE CHANGE IN AGRICULTURE: A CASE STUDY OF INNOVATIVE RURAL DEVELOPMENTAL TECHNOLOGIES FOR VIKSIT ANDHRA PRADESH (SWARNANDRA) BY 2047

Bhanavathu Prathyusha¹, Dr.V. Divyathejomurthy²

¹Research Scholar, Dept. of Rural Development, Acharaya Nagarjuna University, AP.

²Professor and Head, Dept. of Rural Development, Acharaya Nagarjuna University, AP.

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ABSTRACT-----

Andhra Pradesh is one of the large agrarian states holding a major share in the Indian economy; now India is facing a dual threat of global climate change and declining agriculture production, similar to other nations. Similarly, the state of Andhra, with a long coastal belt of 974 km, increased vulnerability to sea-level rise, intensive cyclones, floods in semi-arid regions prone to desertification, and droughts increased in the past decade. To fight against climate change, AP state implemented the latest technological developments in rural areas such as Andhra Pradesh Community-Managed Natural Farming (APCNF), RSK Model, climate-wetted seeds, salt-tolerant cultivars, decentralized hubs, e-cropping, precision harvesting, digital soil mapping, nutri-cereal promotion to conserve soil health, water budgeting, and socio-economic empowerment of farmers, specifically women SHGs. This study observes how the agriculture sector is slowly shifting to regenerative models from traditional chemical agriculture practices but also observes limitations of these models' wide-scale use in rural areas. In line with global standards and action plans, it recommends scaling up those climate-friendly technologies and adaptations to meet food security and also to promote growth (15% AGR) of agriculture in statesrural areas to achieve the target of a 3 trillion economy and become Viksit (Swarna) Andhra by 2047.

1. Introduction

The Andhra Pradesh state is a primarily agrarian state, where agriculture only contributes nearly 25% to the Gross State Domestic Product (GSDP), with 58% of people dependent on agriculture-allied activities covering 70% of the cultivable land in the state. But, alarmingly, this sector is increasingly impacted by climatic change outlines such as weather and rainfall; the changes in weather in the past decade (2015-2025) started deviating from traditional patterns.

The government of Andhra Pradesh aimed to become a 3 trillion economy by 2047, to be Viksit Andhra Pradesh; the agriculture sector's contribution was targeted around a 15% annual growth rate. One among the ten guiding principles (Padi Sutras) of Swarn Andhra is a nature-positive approach toward development.

However, due to climate change phenomena, the rainfall pattern started shifting to pulse events with prolonged dry spells immediately followed by catastrophic rainfall; it is shifting from the earlier predictable monsoonal cycle pattern, which is having an impact on farmers and rural development in the state.

The cultivational practices and land vulnerability profile of AP are also not uniform. Increasing salinity intrusion and drainage failures are seen in the Godavari and Krishna delta regions. Whereas a permanent drought condition in the Rayalaseema region was seen in the past decade, here the groundwater table has gone below recharge depths. Conventional agricultural practices with heavy use of chemical inputs and extracting the groundwater seem to not be viable.

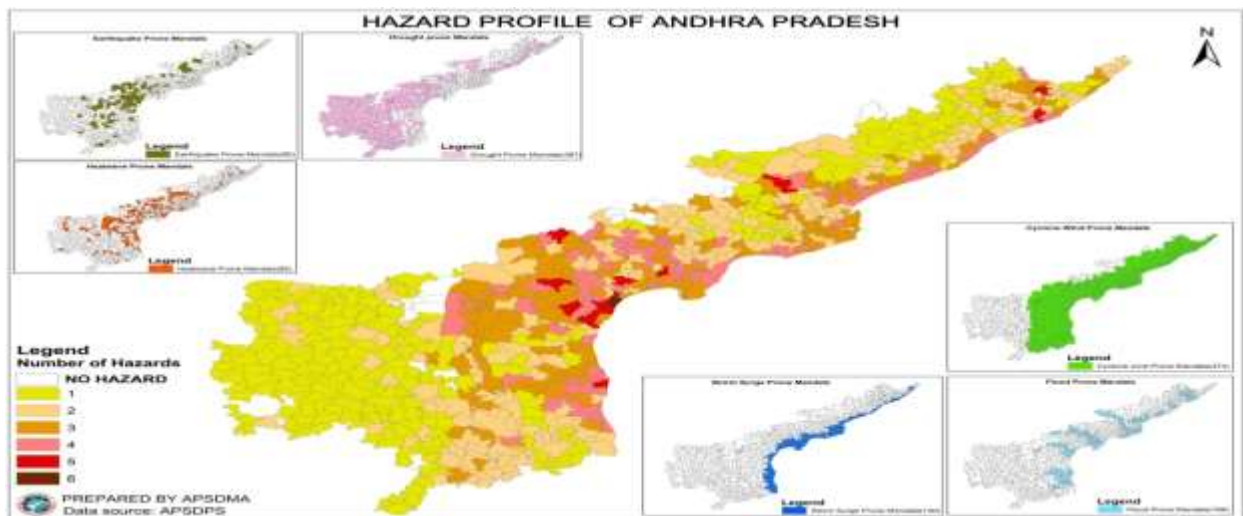
This study aims to multidimensionally review the current challenges faced by the agriculture sector and the latest innovative technologies adopted by the state government and local farming communities. It asks a deep question

rather than a simple description of climate-smart tools; it also studies whether these adaptations are truly resilient or they act as just temporary survival for the farming community under extreme stress now.

2. REVIEW OF LITERATURE

Historical Context of Climate change in Andhra Pradesh (2015-2025)

- 2.1 Hydrological profile shift:** According to meteorological Data in past decade (2015 to 2025). A 12 to 15 days shift in onset of monsoon (OoM) observed in Andhra Pradesh. This condition forcing farmers to planting late karif cycle (Monsoon) Subsequent exposure of Matured crops to unseasonal Rains during Harvest period. A Research Study conducted by (IITM) Indian Institute of Tropical Meteorology says that Bay of Bengal becoming a new Hot Bed of High-Intensity Cyclones (HICs), More Frequent occurrence of these cyclones (HICs) Resulting massive crop lodging and heavy soil salinisation in coastal Andhra districts like Nellore and Vishakhapatnam whereas due to lack of sufficient rain fall in other districts causing shift in ground Hydrological table.
- 2.2 Soil degradation:** After several Decades of Green Revolution (1960 – 2020) model with objective of high Crop Yields leading to heavy use of fertilizers such as Urea, and DAP (Di-Ammonium Phosphate), resulted in the depletion of soil organic carbon falling below 0.5 % which is now ICAR categorized as low organic carbon levels. These Degraded soils lack water holding capacity like normal soil with good organic carbon .The Heat dome effect witnessed in the summers of 2023 to 2025 is due to Temperature rise of climate change factors in this condition crops wilt faster than they would in carbon content rich soil.
- 2.3 Heat (Thermal) stress:** This soils lack water holding capacity like normal soil with good organic carbon .However literature on climate adaption gives more emphasis on Soil carbon sequestration is the primary mitigation strategy against the thermal stress.



(Map Source: APSDMA official website)

3 INNOVATIVE RURAL DEVELOPMENT TECHNOLOGIES ADOPTED

A Global Benchmark initiative:- APCNF.

The APCNF Model:- A New Initiative by the government of Andhra Pradesh, made Global Head lines by winning Gulbenkian Prize for Humanity for its community manged Natural Farming (APCNF) initiative. It focuses on Zero Budget principles which is economical unlike, Organic farming which can be expensive. APCNF utilises local microbial preparations and available moisture (water) majorly. APCNF also seen as a social shift rather than a just Agriculture shift, as majorly relaying on women self Help Groups (SHGs) to impart Rural Agricultural knowledge. But critical gaps observed in the scalability of this APCNF model for commercial crops like chilly and tobacco.

4 THE CURRENT SOCIO-ECONOMIC DIMENSIONS OF CLIMATE ADAPTION

- 4.1.1 Social Dimension: -** According to socio economic surveys (2025) in Andhra Pradesh 80% of farmers are



small or marginal with less than 2 hectares of own land. The cost of cultivation for these farmers leads to increased indebtedness for purchase of seeds, drip irrigation tools, harvesting structures such as seeds, drip irrigation tools, harvesting structures etc., This adoption is majorly economically viable, not seen as technical challenge.

- 4.1.2 Economic Dimension:** - In the current crop insurance schemes namely Weather-Based Crop Insurance Schemes (WBCIS) later renamed as Pradhan Mantri Fasal Bima Yojana (PMFBY) shows that while coverage significantly increased but the basic risk to the farmer that is gap between insurance pay out and actual filed loss always remains high this review paper argues that for successful adoption of climate change strategies must be complimented by reforms in market and institutional credit.

5. RESEARCH METHODOLOGY AND DATA COLLECTION

5.1 Mixed Method: - In this study a Mixed Methods Approach was used to analyse the efficiency of climate adaption in Andhra Pradesh. The real time data gathered from observations at grass root levels with longitudinal climate data. Mainly is to analyse the transition of events from reacting (defensive adaptation) to building shock resilient systems (proactive resilience).

5.2 Real Time Quantitative Data: collected from the Indian Meteorological Department (IMD) for the period 2015–2025 about rainfall deviation patterns. By mapping above against yield parameters for key crops in the area i.e. Rayalaseema (Groundnut) and Coastal Andhra (Paddy) we can establish a correlation between economic instability and precipitation volatility.

5.3 Qualitative Data Framework: this study assessment majorly focuses on the reduction in farmer anxiety and early-stage crop growth stabilization was taken up. Incorporated case study of the Pre Monsoon Dry Sowing technique (PMDS), In PMDS, all farmers utilize soil mulching and biological stimulants to sow the crops in dry soil till 60 days before monsoon.

6. COMPARATIVE DATA ANALYSIS OF REGIONS: COASTAL AP VS RAYALASEEMA:-

6.1 The Arid frontier-current surviving Rayalaseema:- In the present Rayalaseema region large districts namely Anantapur, Kadapa, Chittoor, and Kurnool (before district reorganization), major problems are majorly low ground water availability problem and prolonged drought conditions with scarce rainfall. Innovative intensive technological adoption taken up in this region of scarce resources.

6.1.1 Saturation Mode in Micro- Irrigation: in drip irrigation coverage in terms of acreage Andhra Pradesh leads the nation. However this drip technology encourages farmer to grow high value, water demanding crops such as sweet orange, capsicum potentially minimizing the water saving impact, its called as “Rebound effect “ in farm economics.

6.1.2 Nutri- cereals promotion: By failure of water intensive crops to grow in the dry and arid zone (Rayalaseema) the state government recognized the nutri cereals as good solution, This research finds out that nutri cereals with lower cost of cultivation (input cost) by 40% compared conventional crops, even when the rain fall is low (deficit is more than 30%) in the areas for ensuring food security for the local people.

Best practice/case study : Community Based Water Tank (Anantapur,AP)

A collective decision taken by the farmers groups in the district Not drill new bore wells instead they chosen the **Water budgeting** mechanism, this proven to be more effective when compared to top down government regulations on stabilizing local water ground water tables in several villages.

6.2 Excess salinity and Drainage management: current situation in coastal Andhra:

In the coastal Andhra Pradesh majorly comprising Krishna and Godavari districts here the challenges are very different from Rayalaseema region, too much water logging on the surface throughout the year is the major problem observed that resulting in heavy soil salinization.

6.2.1 New salt tolerant varieties: With the intensive research at research stations led to release of variety “*swarna sub -1*” and other saline resistant paddy varieties grown in the areas where tidal ingress observed and abandoned in the past. But this study critically analyses such technological advancements may have their limits as the sea levels continue to rise through 2030.



- 6.2.2 **Coastal aquaculture vs Commercial agriculture:** A new adaptive trend observed in the Godavari region that is conversion of paddy fields (food crops) in to ponds (shrimp, fish, crab) it may increase family income for a short term, but it creates permanent environmental damage in that locality such as salinizing the soil, soil pits, crust formation heavy antibiotics usage, pollution making it as soil degraded finally not suitable for growing food crops, in future if market prices for aqua products are non remunerative farmers are left with no choice.

7.0 FUTURE TECHNOLOGY INTEGRATION:- REMOTE SENSING AND AI:

Andhra Pradesh vision 2047 document emphasizes on integration of technology will be a foundational pillar for rural development by 2026 4 industrial revolution technologies made a part of above strategies.

- 7.1 **Precision Harvesting:** Farmers now will receive hyper local weather alerts to their smart phones such as thunder storms, heat wave, cyclones, etc., predictive analytics through real time governance system adopted by department of agriculture for precision harvesting before any natural hazards will occur i.e., cyclone, floods for saving food resources in order to avoid potential food losses.
- 7.2 **e-soil Maps:** New digital soil health cards given to the farmers, to know about soil health that will allow farmers to understand about physical characteristics, chemical parameters, biological health of their land that is soil health. This digital health cards is a paradigm shift from past simple chemicals analysis only.

8.0 POLICY FRAMEWORK EVOLUTION AND INSTITUTIONAL GUIDING SUPPORT

- 8.1 **The (RSK) Model:** earlier RBK renamed as Rythu seva Kendra's (RSK) or farmer service centers aimed at foundational change in agricultural practices and management, which earlier suffering from climate induced agricultural production issues. Now RSKs directly connected information to the farmer at village level through decentralized mechanism
- 8.2 **Hub and spoke service model :** In past farmer need to travel district and mandal head quarters where they will receive information from KVKs, DAAT centers now RSKs are providing real time advisory activities such as pest outbreak, pest management, rainfall prediction, availability of pesticides and fertilizers etc., this model proven to be economically viable to the farmers.
- 8.3 **e-cropping (panta) integration:** E-crop system acts as digital backbone to the rural agriculture by creating verifiable records such as crop name, date of sown, input subsidy, crop insurance which allows transparency in the system faster insurance claim settlement window. Earlier it was 18 months now less than 6 months (2025).
- 8.4 **Thermal Resilience Certified Seeds:** climate wetted or thermal resilient seeds provided by the RSKs to the farmers with the mandatory certification, this ensures food security to the farmers even in climate adverse conditions there by adopting to the climate change.

9.0 THE CLIMATE ADAPTATION :- A GENDER PERSPECTIVE

As climatic instability in the Andhra Pradesh drives male population in to the distress migration, to the near urban centers like Hyderabad, Chennai, vizag there by imposing double burden of maintaining home and farm land disproportionately falls on women, above pattern clearly shows that climate change in Andhra Pradesh is deeply inter linked with gender dynamics.

- 9.1 **Women as experts of natural farming:** A deep Analysis APCNF program reveals that 70% of active farmers were women. When compared to male farmers women farmers prioritize on house hold food security long term soil health by incorporating biodiversity, male farmers majorly focus on high risk, high reward chemical methods. APCNF program made women as master farmers.
- 9.2 **Institutional Gaps:** The female farmers hold less than 15 % of land titles on their own name this condition looks like structural glass ceiling despite their role as primary adopters in rural farming above condition prevents them to access collateral loans (mortgage), green loans (solar power pump), low interest loans (kisan credit card) for climate resilient live stock housing (cattle shed loans).



10. CRITICAL GAPS FOR SCALING THE ADAPTION

Andhra Pradesh innovative rural development technologies are globally recognized , This critical analysis identifies significant gaps that prevents universal up scaling.

- 10.1 **Present Disconnected Markets :** Paddy and wheat Commodity based system followed in the market i.e., minimum support price (MSP) scheme, if korralu(foxtail millet) grown by a farmer in rayalaseema as a climate smart choice but with out robust MSP where can he sell ?, to give a solution to this problem state guaranteed procurement system for all other crops similar to rice - wheat cycle to be adopted for financial security this promotes nutritional security also.
- 10.2 **Knowledge Deficit Adaptions:** Farmers in kadapa and Kurnool district adopting faulty practices such as large scale promotion of solar parks on fertile lands, earlier these lands are used for grazing grounds for live stock which is a vital secondary income source for climate stressed farmers.
- 10.3 **Missing Last mile connectivity:** Digital illitearacity promotes digital divide. Older farmers and farmers in tribal pockets of eastern ghats such as srikakulam, vizag, east and west Godavari often miss hyper local weather alerts by the state government through digital push but poor net work connectivity or lack of smart phone made them most vulnerable to climate shocks.

11. STRATEGIES FOR VIKSIT ANDHRA: THE FUTURE ROAD MAP RECOMMENDATIONS (2026-20247)

- 11.1 **Universal coverage:** field level satellite monitoring should be replaced with high risk model of weather stations to protect most vulnerable famers from natural disasters such as pest damage, cloud burst, etc.,
- 11.2 **Scaling soil carbon credit:** by quantifying carbon sequestration with natural farming practices can be remitted from the carbon market place as soil carbon credit.
- 11.3 **Climate defensive infrastructure:** Concrete sea walls can be replaced with investment in bio mimicry coastal defense such as mangrove belts to protect agriculture deltas from higher salinity in coastal areas.

12. CONCLUSION

In this current analysis Andhra pradesh Agricultural landscape in 2026 says that state has built some of world's most innovative rural development technologies such as APCNF, RSK Model, climate wetted seeds, salt tolerant cultivars, decentralized hubs, e cropping, precision harvesting, digital soil mapping, Nutri cereals promotion. Above technologies transitioning In to new and more complex phase however the present adoption is currently stratified and localized rich farmers are utilizing technology heavy solutions like AI , real time data, predictive analysis for higher returns ,while marginal farmers mostly rely on natural farming that is biological reliance methods, those two paradigms must be integrated into integrated policy frame work to dive to attain 15 % growth rate in the Agriculture sector and rural development for Andhra state to achieve Vikasit Andhrapradesh by 2047 and also long term food security (SDG 1) and nutritional support to the population (SDG 2).

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