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Research Paper

Sustainable Agricultural Practices in Andhra Pradesh: Innovations, Challenges, and Pathways for Enhancing Food Security

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Abstract
Agriculture remains the backbone of Andhra Pradesh's rural economy, but the conventional model that delivered the Green Revolution is now showing strain — rising input costs, declining soil health, water stress and climate volatility. The state's response has been an ambitious shift toward natural farming. The Andhra Pradesh Community Managed Natural Farming (APCNF) programme, launched in 2016 and operationalised through Rythu Sadhikara Samstha (RySS), set out to reach all six million farmers in the state across roughly eight million hectares (Bharucha et al., 2020; UNEP, 2018). This paper reviews where the programme currently stands, what the empirical evidence says about its impact, and where the practical challenges lie. Drawing on the FAO impact assessment of APCNF (FAO, 2021), the first peer-reviewed multi-site field trial of ZBNF in AP (Duddigan et al., 2022), and policy material from NITI Aayog and the Ellen MacArthur Foundation, we find that natural farming shows no short-term yield penalty in controlled trials and is associated with reduced costs of cultivation, better soil moisture retention and lower household health expenditure. The remaining challenges are practical: extension reach, transition-period working capital for smallholders, procurement channels for natural-farming produce, and alignment of mainstream agricultural policy. We argue that the next phase will require sustained extension investment, calibrated transition support and serious data infrastructure to track outcomes at farm level.
Keywords: *sustainable agriculture, natural farming, APCNF, ZBNF, food security, Andhra Pradesh*

I. Introduction

Agriculture has shaped Andhra Pradesh in two directions at once — it sustains millions of livelihoods, and it carries the weight of climate, soil and market stress. Conventional intensification has done what it was designed to do. It raised yields. It also concentrated risk. The technologies that lifted output through the late twentieth century — hybrid seeds, synthetic fertilisers, chemical pest control — have come with declining soil health, falling water tables and rising debt cycles for smallholders (Pretty, 2018). Climate variability has compounded the problem, with droughts in Rayalaseema and floods in coastal districts now appearing on cycles the older crop calendar was not built for.

Against this backdrop, the Government of Andhra Pradesh launched the Andhra Pradesh Zero Budget Natural Farming programme in 2016, renaming it the Andhra Pradesh Community Managed Natural Farming (APCNF) programme in 2020 to reflect its farmer-led character. The programme is implemented through Rythu Sadhikara Samstha (RySS), a parastatal company set up in 2014 to support farmer welfare. The objective is ambitious: transition the state's six million farmers, working roughly eight million hectares, away from chemical agriculture and toward agroecological practice (UNEP, 2018; Bharucha et al., 2020). This paper reviews what is now known about the programme — what works, what does not, and what needs to happen next.

1.1 Research questions and methodology

The review is organised around four questions. What sustainable agricultural practices are actually being adopted in AP, and at what scale? What does the empirical evidence — controlled trials, FAO impact assessments, programme records — say about their effects on yield, cost, soil and household welfare? What practical challenges are slowing scale-up? And what policy directions follow?

This is a structured review of secondary sources. The evidence comes from three places: peer-reviewed studies (Duddigan et al., 2022; Bharucha et al., 2020; Khadse et al., 2018), institutional impact assessments (FAO,

2021; CSTEP, 2020), and policy and programme material (RySS, 2020; UNEP, 2018; Ellen MacArthur Foundation, 2021; NITI Aayog, 2021). We do not present new primary fieldwork. State-level outcome data tracking individual farmers across years is not yet systematically published; this is a limitation we flag at the relevant points.

II. Sustainable Agricultural Innovations In Andhra Pradesh

2.1 The natural farming approach

APCNF rests on a small set of agroecological principles that are now well documented in policy literature. Soil should remain covered by crops for as much of the year as possible, ideally all 365 days. Synthetic fertilisers, pesticides and herbicides are not used. Nutrients are released and made bioavailable through microbial inoculants applied to seeds and soil rather than supplied externally. Tillage is minimal. Diverse crops are grown in mixed, layered and rotational patterns rather than monocultures (Ellen MacArthur Foundation, 2021).

Four core practices anchor the system on the ground: Beejamrutham, a microbial seed treatment; Jeevamrutham, a liquid soil inoculant; Acchadana, year-round mulching; and Waaphasa, soil aeration through structure and moisture management (FAO, 2021). Crop diversification then layers on top of these through 5-layer and 7-layer cropping models, intercropping, border cropping, bund cropping, and pre-monsoon dry sowing. Table 1 summarises the practices.

Table 1. Core APCNF practices and their stated purposes

Practice	Description	Purpose	Source
Beejamrutham	Microbial seed treatment using a fermented mix of cow dung, cow urine, lime and soil before sowing	Protect young roots from soil-borne pathogens; improve early establishment	FAO (2021); RySS (2020)
Jeevamrutham	Liquid microbial inoculant applied to the soil to release indigenous nutrients and stimulate microbial activity	Build soil microbiome; replace synthetic fertilisers	FAO (2021); RySS (2020)
Acchadana (mulching)	Year-round soil cover using crop residues, biomass and live cover crops to keep the soil shaded	Conserve moisture; suppress weeds; protect topsoil	FAO (2021)
Waaphasa	Aeration practice using soil structure and moisture management to improve oxygen availability in the root zone	Support root respiration and microbial life under low-tillage conditions	FAO (2021); RySS (2020)
Multi-tier cropping (5-layer / 7-layer)	Crop rotation, mixed cropping, intercropping, border cropping, bund cropping and pre-monsoon dry sowing in layered models	Spread risk; raise per-acre output; mimic natural ecosystems	FAO (2021); Bharucha et al. (2020)

2.2 Programme architecture

What makes APCNF distinctive is not just the practice set but the institutional design. Implementation runs through women-led Self-Help Groups (SHGs), which already cover the bulk of small-farmer households in AP, alongside a cadre of Community Resource Persons (CRPs) recruited from within the farming community (NITI Aayog, 2021). CRPs are themselves natural-farming practitioners; they spend three to five years handholding new farmers through the transition. Funding has been blended — state government resources alongside contributions from KfW, the Azim Premji Foundation, and through international visibility built by UNEP. The programme covered approximately 0.6 to 1 million farmers across 13 of the state's 26 districts as of the most recent published programme records (Bharucha et al., 2020).

III. Empirical Evidence On Impact

The empirical record on APCNF has thickened considerably between 2018 and 2022. Three sources matter most for an honest assessment.

Duddigan et al. (2022), published in Sustainability, present the first peer-reviewed multi-site field trial of ZBNF in AP. Twenty controlled field-plot experiments were established across six districts — Anantapur, Kadapa, Krishna, Nellore, Prakasam, and Visakhapatnam — and managed by locally based farmer-researchers. The headline finding cuts against the strongest claim from sceptics: there is no statistically significant short-term yield penalty when ZBNF is adopted in small-scale farming systems compared with conventional or organic

alternatives. Treatment responses varied across agro-climatic zones, and the authors are careful not to over-claim, but the result removes the central biophysical objection to scaling the system.

The FAO (2021) impact assessment of APCNF for Kharif 2019–2020 covers 13 major crops (paddy, maize, Bengal gram, groundnut, cotton, jowar, chillies, black gram, ragi, red gram, sugarcane, onion, turmeric). It documents reductions in input costs and credit-market dependence, higher net returns for most reporting farmers, and farmer-reported improvements in soil quality, crop resilience to weather anomalies and family financial condition.

The Ellen MacArthur Foundation (2021) policy review of APCNF reports that, in 2020, yields increased under natural farming methods in five of AP's top six crops, while farmers used less irrigation and less electricity than conventional cultivation required. Demand for natural-farming produce has begun to develop independently — in 2022, RySS facilitated supply agreements between APCNF farmers and thirteen Hindu temples, including a Tirumala temple order for 22,000 tonnes of natural-farming produce from 25,000 farmers.

Table 2. Empirical findings on APCNF outcomes

Outcome dimension	Finding	Evidence base	Source
Crop yield (short-term)	No statistically significant short-term yield penalty for ZBNF compared with conventional or organic alternatives in a controlled multi-site trial across six AP districts	20 field-plot experiments, 6 districts (Anantapur, Kadapa, Krishna, Nellore, Prakasam, Visakhapatnam)	Duddigan et al. (2022)
Cost of cultivation	Substantial reduction in input and credit-market dependence; higher net returns for most reporting farmers	Multi-crop FAO impact assessment (paddy, maize, groundnut, cotton, chillies, etc.)	FAO (2021)
Soil and environmental quality	Improved moisture retention through mulching; farmers report improved soil quality and crop resilience to weather anomalies	Field measurements + farmer-reported outcomes	Duddigan et al. (2022); FAO (2021)
Health and household economics	Farmer households report lower expenditure on health and improved family financial condition	FAO (2021) household survey	FAO (2021)
Adoption	APCNF reaches roughly 0.6–1 million farmers across 13 of the state's 26 districts; target of stated programme target of 6 million farmers and 8 million hectares	RySS programme records; UNEP (2018)	Bharucha et al. (2020); EMF (2021)

3.1 Synthesis

Three observations follow. First, the biophysical evidence is now strong enough to defend the system on yield grounds; this was not true five years ago. Second, the household-level economic case is more developed than the macroeconomic one — cost reductions, debt reductions and family welfare improvements are documented, but state-level GDP contribution figures are not yet on the public record. Third, the long-term picture is still incomplete. Duddigan et al. (2022) explicitly note that long-term impacts of ZBNF adoption "are still unknown and will require more long-term study." The system's soil-restoration claims, in particular, will need a 5-to-10-year window to settle empirically.

IV. Challenges In Implementing Sustainable Agriculture

If the empirical evidence is strengthening, the practical barriers to scale are also clearer than they were. Four challenges sit on the critical path.

Knowledge and extension reach is the first. Reaching the remaining majority of AP's farmers requires sustained handholding — each farmer needs three to five years of CRP support to fully transition (NITI Aayog, 2021). The CRP-and-iCRP cadre is the engine of that handholding, but its capacity has to grow alongside the programme. Without it, scale-up risks becoming registration without practice change.

Economic transition cost is the second. Natural farming is low-input over time but not zero-input in the first season — it requires labour, biomass and learning time before the cost-of-cultivation savings materialise.

Smallholders with limited working capital are most exposed to this transition cost, and existing institutional credit channels are still oriented to chemical-input cycles.

Policy alignment is the third. The mainstream agricultural support architecture in India remains substantially oriented to chemical-input agriculture — fertiliser subsidies, MSP procurement structures, extension training. Procurement and price-discovery channels for natural-farming produce, while emerging (the Tirumala temple order is a good example), are still ad hoc rather than systemic.

Climate exposure is the fourth, and the one most outside any single programme's control. AP faces increasing extreme-weather events, particularly in dryland Rayalaseema. Natural farming systems are reported to be more climate-resilient than chemical-input systems (FAO, 2021), but transition years can themselves coincide with shock years, and that compounds risk for farmers crossing over.

Table 3. Implementation challenges and most-affected groups

Challenge	Description	Most-affected groups	Source
Knowledge and extension gap	Reaching the remaining majority of AP's farmers requires sustained 3–5-year handholding through Community Resource Persons and Self-Help Groups	Smallholders outside the existing 13 covered districts	NITI Aayog (2021); Bharucha et al. (2020)
Economic transition cost	Initial transition involves labour and biomass investment before the cost-of-cultivation gains materialise; smallholders with limited working capital are most exposed	Marginal and small farmers	FAO (2021); Khadse et al. (2018)
Policy and procurement gap	Mainstream agricultural support remains oriented to chemical-input agriculture; price discovery and procurement channels for natural-farming produce are still developing	All natural-farming households	NITI Aayog (2021); EMF (2021)
Climate exposure	AP faces increasing extreme-weather events; natural farming is climate-resilient but transition periods can coincide with shock years	Rainfed and dryland districts (e.g. Anantapur)	FAO (2021); Pretty (2018)

V. Discussion, Policy Implications And Conclusion

The picture that comes out of the available evidence is reasonably consistent. APCNF is one of the largest agroecological programmes anywhere in the world, and after roughly six years of implementation the case for its biophysical viability is no longer a leap of faith — the controlled-trial evidence is on record. What remains is a delivery problem and a policy-alignment problem, not a science problem.

Three policy directions follow from the review. The first is sustained investment in the extension cadre. CRPs and iCRPs are the binding constraint on scale, and their numbers, training and pay structures need to grow alongside coverage targets. The second is transition-period working capital for smallholders. Credit products designed around the natural-farming cash-flow cycle, rather than retrofitted from chemical-input lending, would directly address the most binding economic barrier. The third is data infrastructure. Periodic surveys and longitudinal household tracking, ideally co-designed by RySS and an independent research partner, would provide the evidence base on which the next phase of policy can be calibrated.

What the available evidence shows is that natural farming in AP has moved from contested experiment to defensible practice. What it does not yet show — and this is the honest gap — is the long-term soil-restoration trajectory and the macroeconomic contribution at state level. With sustained extension investment, calibrated transition support and serious data infrastructure, AP can convert its current head start into a durable model for the rest of India and for comparable smallholder economies. The work of the next decade is implementation, not invention.

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