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ALLs – Anantapur District

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This report summarizes key information about Agroecological Living Landscapes (ALLs) in India for the Initiative on Agroecology. The ALLs are based in Anantapur District of the southeastern coastal state of Andhra Pradesh (AP). In addition to providing information on the environmental, social, economic, and political context of the ALLs, the extent to which various agroecological principles are followed within the ALLs is discussed in detail.

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1 Bioversity International, Bengaluru, India

2 International Food Policy Research Institute (IFPRI), New Delhi, India

3 Watershed Support Services and Activities Network, Hyderabad, Telangana, India

4 International Water Management Institute (IWMI), New Delhi, India

5 Rythu Sadhikara Samstha (RySS), Guntur, Andhra Pradesh, India

6 World Agroforestry Centre (ICRAF), New Delhi, India

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Executive summary

Key highlights

- The Andhra Pradesh Community-Managed Natural Farming (APCNF) project began in 2016, expanding the scope of agroecological methods (natural farming) with the experiences evolving from field-level innovations.
- Within Anantapur, two blocks (mandals), Bathalapalli and Tadipatri, were chosen as the Agroecological Living Landscape (ALL) sites for this study, where a substantial number of farmers have reportedly adopted the natural farming methods promoted by APCNF.
- Anantapur is a dryland region affected by frequent droughts, with a normal rainfall of 552 mm per annum, significantly lower than the national average (1,160 mm). Both mandals also fall under semi-arid zones, with an average annual rainfall of 489 mm and 587 mm, respectively.
- The Vulnerability Atlas prepared by ICAR-CRIDA characterizes the exposure to climate change and consequent vulnerability in Anantapur as "very high." Apart from receiving low rainfall, the region has experienced high-intensity off-season rains as well and consequent loss of crops in the last five years, demonstrating unpredictable extreme climatic events.
- Bathalapalli is made up of poor red soils, while Tadipatri is made up of black cotton soils.
- About 54% of the total geographic area in Bathalapalli and 43% in Tadipatri represented the net sown area (NSA) in 2019–2020. These regions also have much fallow land at 26% and 33%, respectively, typical of dryland regions. Recently, there has been a decrease in NSA and an increase in fallow land, indicating distressed agriculture.
- The Chitravati River flows through Bathalapalli. Several dispersed water bodies can be seen in Bathalapalli, with one large water body (Appacheruvu) adjoining the ALL site. Tadipatri, in contrast, has a plain terrain, and the Pennar River transits through the mandal.
- Anantapur District has large deposits of dolomite, iron ore, limestone, gold, and diamond. The region has the potential for generating solar and wind power. Anantapur has been one of the main districts in Andhra Pradesh in harnessing electricity through wind.
- The ALL sites have relatively less land degradation than the district as a whole. Based on satellite data from 1990 to 2018, 31.93% of the land in Anantapur is facing land degradation and desertification (17.34% severe land degradation and 14.59% desertification).
- Bathalapalli mandal is categorized as "critical," and Tadipatri mandal is categorized as "overexploited" with respect to the state of groundwater development. Both mandals have a high correlation of groundwater with seasonal rainfall, which fills during September-October rainfall and falls rapidly from December-January onward because of high extraction levels through borewells.
- Anantapur District has witnessed a steep rise in tubewell/borewell irrigation since 2000, making tubewells the major source of irrigation. High investments in borewell irrigation, along with declining groundwater resources have been a major cause of farmers' distress.
- Anantapur traditionally used to have diversified crop systems in its rainfed areas before groundnut became the dominant monocrop: for instance, the *Navadhanya* system, which involved growing 5 to 10 crops with multiple harvests over the two seasons.
- But, by the early 1980s, there was a shift to monocropping of groundnut to promote its high-yielding varieties, which led to an increase in its area from 18% in 1960 to 74% in 2005 and decreased dependency on millets and pulses for household consumption in addition to depriving soils of biomass.
- The region has seen an increase in mixed farming methods. For instance, using groundnut haulms as fodder to promote the ruminant economy, compared to systems involving crop production alone, helps provide income stability. Also, to protect from climate variations, various government initiatives are also promoting the cultivation of millets along with *Navadhanya*.
- Moreover, relying on nine basic principles and based on an extension model centered in community organizations and with practicing farmers serving as extension agents, APCNF is spearheading a major agroecological movement in the district.
- The selected cluster of villages in the ALLs has good social capital in terms of organizing women into self-help groups (SHGs). There is a total of 107 SHGs from among the 872 households in the two clusters, with 40 SHGs in Bathalapalli and 67 in Tadipatri.
- In terms of area, the major crops grown in 2019–2020 in the district were groundnut (51%), pulses (25.4%) such as red gram (pigeon pea) and horse gram, cotton (6.5%), and rice (4.1%). Season-wise, groundnut is the major kharif crop in red soil under rainfed conditions, covering 60% of the area. Other kharif crops are cotton, red gram, and horse gram. The major rabi crop is gram, covering 56% of the area, followed by other crops such as groundnut (23%), rice (8.7%), and maize (5.4%).
- In Tadipatri, jowar (sorghum) and cotton in Kharif and Bengal gram in rabi are the major crops as per the district statistics, and the cropping intensity is low. In comparison, Bathalapalli, with predominant red soils and rainfed geography, has more rainfed crops, with horse gram and groundnut as the predominant crop systems.

- As per the Livestock census 2012, the total livestock population in the district was 4.4 million, including cattle, buffaloes, sheep, goats, pigs, and others. Tadipatri mandal has a significant dairy economy with more than 15,000 buffaloes, suggesting higher availability of fodder than in Bathalapalli, where the cattle population is predominant for draft and dairy purposes.
- The local market is within a radius of 5–6 km from the village. Agricultural inputs can also be purchased from local input dealer shops in the village, mandal (block) offices, KVK centers, Rythu Bharosa Kendra (RBK) centers, and Primary Agriculture Cooperative Societies (PACS) located near the village.
- Farmers usually sell their produce in local markets or at the farm gate. However, in recent times, big private companies have also entered the markets and are focusing on processing and marketing the produce.
- Pest incidence is also high, forcing farmers to rely excessively on chemical pesticides, especially because of excessive rainfall around the harvesting stage of the crop. In 20 rainfall-induced late leaf spot pest attacks in groundnut due to water stagnation, which caused massive yield loss.
- The district has had several traditional sources of credit and savings, such as commercial banks, regional rural banks, and cooperative banks. However, the bank-linked SHG-based microfinance program has been identified as a significant source of lending and saving in the state (and district).
- In 2015–2016, Anantapur had 0.77 million operational holdings, of which 72% were under marginal (0.5–1.0 ha) and small farmers (1–2 ha), 23% under semi-medium farmers (2–4 ha), and the rest under medium to large farmers (DES, 2015–2016). The average landholding in the district is 1.75 ha. Between the two mandals in the ALLs, 74% of Tadipatri farmers and 68% of Bathalapalli farmers have landholding of size less than 2 ha.
- As per the National Sample Survey Organization's (NSSO) 70th-round survey of land and livestock holdings, the state had about 2.45 million tenant farmers in 2013, of whom 0.63 million were landless.
- Livestock also play a major role in the district in providing draft power for farming, crop manure, food, meat, milk for household consumption, and industrial raw material.
- In terms of farm machinery, the district has about 28,000 tractors, 561 power tillers, nearly 4,000 threshers, and about 2.3 lakh agricultural pump sets (PLP, NABARD, 2021–2022). As per the fifth minor irrigation census (2013–2014), the district had 8,666 shallow tubewells, of which 89% were owned by farmers belonging to the Other Backward Classes, 4% by Scheduled Castes/Scheduled Tribes, and the rest by others.
- Both ALL sites are well connected by roads and highways through transportation by private and government-operated bus services.
- Limited storage options are available in the district and ALLs. In Bathalapalli town, a grain storage facility is available, but it is mainly used by traders.
- As per Census 2011, all 63 mandals in the district reported having access to a power supply. The main source of electricity is hydropower, which the government supplies. A few farmers have access to solar power.
- Because of overexploitation of groundwater and excessive reliance on borewells, the district becomes affected by drinking water shortages. The major source of water is through either pipelines connected through the local grid or overhead tanks (fed by groundwater).
- Since returns from agriculture have declined over time, large-scale outmigration of men has occurred to cities (Bengaluru, Mumbai, Tirupati, Hyderabad, etc.) to work in poultry, selling pilgrimage materials in Tirupati, papaya transporting and processing, etc. Most of this migration occurs during the lean period after groundnut harvesting and becomes exacerbated because of droughts.
- Agriculture wage employment is a major source of employment in both ALL mandals. The MG National Rural Employment Guarantee Scheme (MGNREGS) is a consistent source of part-time employment. In the two mandals, 0.24 and 0.33 million workdays have been generated in Bathalapalli and Tadipatri, respectively, representing INR 83.2 and 128.4 million in 2019 and 2020.
- About 89% of the population of Anantapur identify as Hindus, followed by 10% Muslims. Scheduled Castes and Scheduled Tribes make up 14% and 4% of the population, respectively (Census, 2011).
- Both ALL sites show poor literacy at 68% in Tadipatri and 59% in Bathalapalli.
- The government of AP has established two sets of local institutions called *Grama Sachivalayam* and Rythu Bharosa Kendra for access to inputs and information. These are intended to be single-window service centers located within a *Gram Panchayat*.
- Agriculture has always been an important concern in national and state elections given the importance of farmers in the vote share as well as national GDP.
- There is a legal provision of 50% reservation for women among members and *sarpanches* (village decision-makers) in Andhra Pradesh and one-third in any constitutional bodies to foster women's leadership.
- Another important cadre of women are those who have organized to form SHGs. They collectively help each other to solve their problems and give support in economic activities as well as provide access to schemes/benefits, exchange information, promote small savings among their members, and provide small loans to their members from the common fund.
- Various recycling measures are being adopted in the region, such as using groundnut husks for fodder and mulching, stacking biomass from various crops for animal feed, and using cow dung and urine to prepare biological inputs.

- Family labor is common when landholding is small, while hired labor is used for medium to large landholdings. A reduction in weeds is observed in the case of CNF farmers who practice live mulching. The lack of availability of labor and increasing costs involved drive the spread of weedicides, which is a major challenge for the CNF program.
- Conventional farmers use more than 60 different pesticides, including insecticides, fungicides, and herbicides, and procure them from local traders.
- CNF has moved the focus from vermicomposting and other external inputs to *in situ* regeneration of soil health through a package of measures such as using bio-inoculants, covering the soil for longer periods with live crops (called live mulch) to decrease exposure to sun, and applying *Ghana Jeevamrutam*, a dense nutrient value addition, to dung locally prepared.
- Pre-monsoon dry sowing (PMDS) is a system of tilling, sowing, and tending the land, wherein the farmer grows crops in the non-farming season or whenever there is no crop cover on the land. This is mainly before the advent of monsoon during summer and is an important water retention technique.
- Burning of crop residues in rice is not a prevalent practice in the district. But, in cotton and pigeon pea crops, the stalks are removed during land preparation and burned. Shredding of this biomass and using it for mulch could be an option, but its economic viability in an already stressed agricultural economy is the question.
- From 1999 to 2015, soil acidity increased by more than 4% and organic carbon in the soil decreased by 84%.
- In Bathalapalli, 48% of the land area has been affected by moderate water erosion and, in 24% of the region, signs of slight salinity have been observed. About 25% of the area is composed of gravelly uplands. Close to 68% of the land area in Tadipatri is affected by moderate to strong water erosion and 29% by salinity. However, the ALL site in Tadipatri is relatively plain with no serious erosion hazard, whereas Bathalapalli has several areas with salinity/alkalinity and extensive areas subject to water erosion.
- A shift to monocrop of groundnut at scale and leaving the land barren and exposed to hot sun after the harvest for the rest of the year is a major feature of Anantapur District's desertification. Soil compaction is further exacerbated by the shift away from draft animal power to tractors and from manual harvesting to combine harvesters. Increasing dependence on fertilizers and decreasing the quantity of manure application further complicates the process.
- Out of the 11 villages in Bathalapalli mandal, two have vet dispensaries within the village, seven villages have one within 2 to 5 km, and two villages have one at >5 km distance (Census, 2012). The recently formed RBKs have a veterinary assistant as one of the technical staff who liaises with the Animal Husbandry Department.
- Apart from agriculture, most households in the district own sheep, followed in numbers by goats, cattle, and buffaloes. The calves of sheep, goats, cows, and buffaloes are sold regularly and thus this is an ensured income every year. There is an active fish market. As of 2015–2016, the district had 22 milk cooperative societies that collected milk from individual households through their network of 606 pick-up centers located within the villages. Firewood is another important forest product in the district, followed by beedi leaves to some extent, along with neem and other minor forest products.
- About 35% of the rainfed farmers migrate after kharif and 21% of the total farmers are dependent on rainfed agriculture. The remaining farmers work as wage laborers in irrigated fields or take up other small-scale jobs within and around the village.
- The MGNREGA is one of the beneficial employment schemes, and as per the Report on district-level estimates for the state of Andhra Pradesh under the 5th employment/unemployment survey, 51.4% of the households were reported to benefit from the MGNREGA scheme.
- Earlier, jowar/maize roti comprised the main diet. In recent years, rice and wheat have replaced most of the traditional millet-based diets. However, the trend is reversing, especially post-COVID pandemic.
- Staple foods such as rice and ragi are widely consumed along with green leafy vegetables such as fenugreek and spinach. Consumption of fruits and pulses is low. Non-vegetarian food is mostly consumed once a month. Consumption of dairy is more common among large landowners than small farmers. The APCNF assessment of natural farmers showed that 87% of the women had achieved minimally adequate diet diversity (i.e., consumed more than five food groups under natural farming).
- The experience of natural farmers in the APCNF project, in terms of prices, is mixed. About 45% of the farmers who adopted the program reported obtaining higher prices for their CNF output than for non-CNF output. Natural farming also led to substantial cost savings but used more labor than chemical farming.
- Farmers use multiple sources to gather market information, such as newspapers, radio, peer groups, and traders. Large farmers have an advantage in volume and staying power and having connectivity to secondary-level aggregators for marketing.

Description of the Agroecological Living Landscapes (ALLs)

Figure 1. Map of Andhra Pradesh and the district of Anantapur (inset: India map with location of Andhra Pradesh)

Source: *Wikipedia. Credit: Adityamadhav83. (https://bit.ly/3GttL74), Blank map of Andhra Pradesh state and districts: https://bit.ly/46H8j9l*

Andhra Pradesh (AP) is the eighth largest state in India, with a geographical area of 0.167 million km^2, and it is the 10th largest state in population, accounting for more than 4% of the people (Figure 1). As per the last census available in 2011, Andhra Pradesh has a population of 49.5 million, with a decadal growth rate surpassing 9%, population density of 394/km^2, and literacy at 67% (Andhra Pradesh State Planning Society, 2021). The state has a predominantly rural population, with only 29.47% staying in urban areas as per the 2011 census, but this is expected to change substantially.

Administratively, the state is divided into 13 districts, 51 revenue divisions, 679 mandals, 17,464 revenue villages, and 13,385 Gram Panchayats (the local governance institutions with elected representatives) (Figure 2). The state is conventionally divided into the Coastal region, with districts along the coast (AP has a coastline of 974 km) receiving relatively higher rainfall and a large proportion with access to irrigation, and the drier Rayalaseema region, consisting of four districts (Anantapur [Anantapuram + Sri Sathya Sai], Kurnool, YSR, and Chittoor). The north coastal high-altitude tribal region also has a distinct geography.

The combined state of Andhra Pradesh was divided in 2014 into Telangana and Andhra Pradesh states. The administrative divisions are state, regions (3), districts (26), revenue divisions (77), and mandals (679). The 13 districts at the time of the state division were re-organized in 2022 into 26 districts.

The district of Anantapur (or Anantapuram) was divided into Anantapuram and Sri Satya Sai districts. The two ALL sites selected in the combined Anantapur District fall under these two districts (Anantapuram and Sri Sathya Sai; see Figures 1 and 2). The reorganization of states and districts brings complexity to the presentation of data. (Anantapur, Ananthapur, and Ananthapuramu are taken as synonyms in this document.) For reasons of data availability, we consider the undivided Anantapur District for our presentation.

The state has six diverse agro-climatic zones and five agroecological zones (districts before reorganization). The ALL sites are situated in the scarce rainfall zone with annual rainfall at 500 to 670 mm.

Anantapur District has vast areas of drylands with low population density at 213/km^2 vis-à-vis 304/km^2 at the state level. The district has a higher proportion of net sown area than the state and a low proportion classified as forests in land use. Typical of drylands, Anantapur District has a high percentage of fallow lands (cultivable waste, permanent pastures and fallows, other fallow lands, and current fallow (Figure 3).

The declining net sown area and increasing fallow lands are a matter of concern in the district, typically indicating farmers' disinterest in continuing with cultivation (Figure 3). Frequent failure of crops due to aberrations in rainfall and volatility in market prices are often the stated reasons.

Anantapur has shifted over the years from a diverse crop system to monocrop of groundnut. It is one of the most drought-prone districts in the state and is subject to frequent crop failures.

Community-Managed Sustainable Agriculture (CMSA) began in 2004 in the combined Andhra Pradesh. It is the first state-level program focusing on extension of agroecological methods to promote non-pesticidal management (NPM) approaches on the platforms of women's self-help groups (Madhuri, 2014).

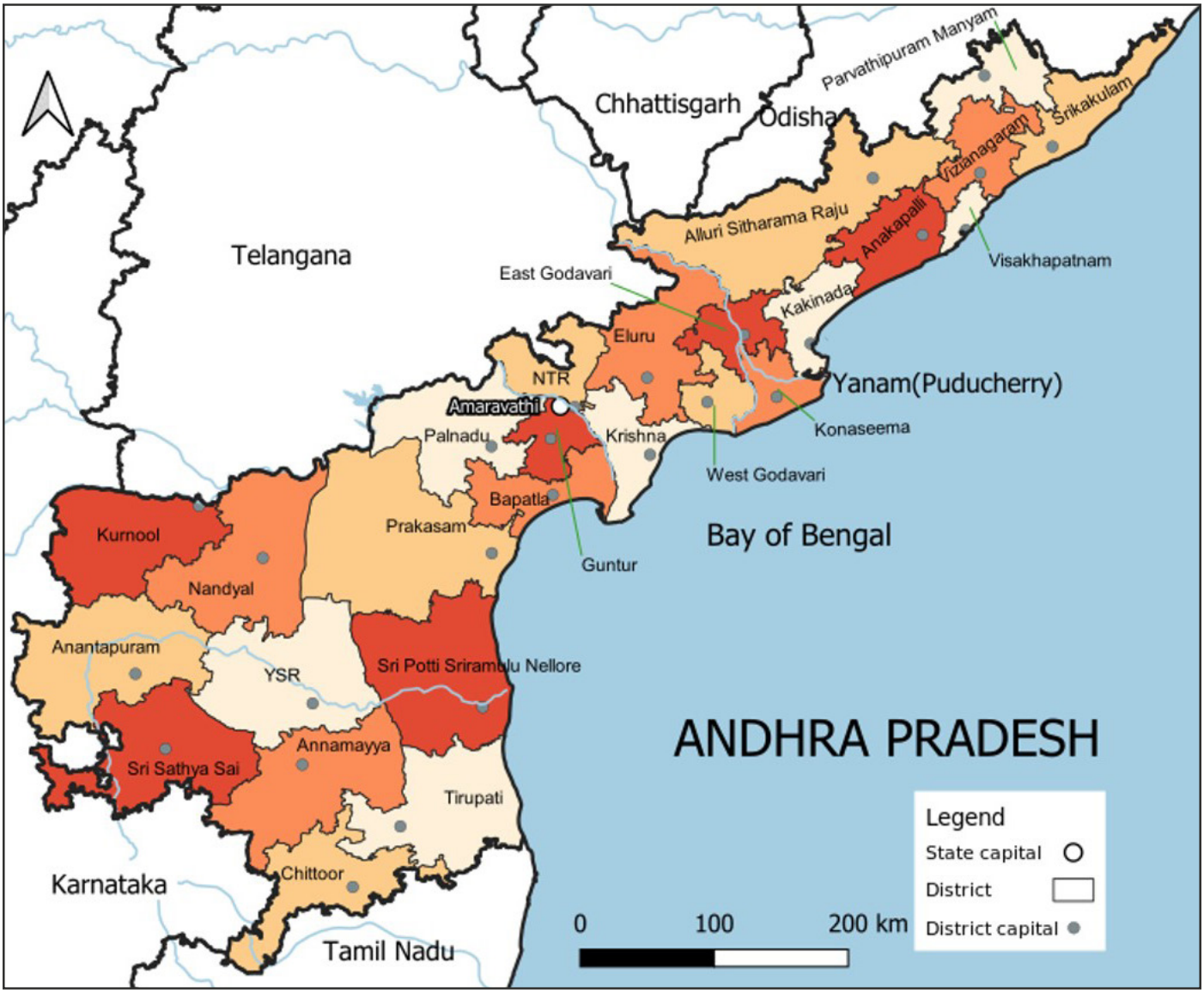
A more comprehensive program on spreading agroecology has taken shape in the form of Andhra Pradesh Community-Managed Natural Farming (APCNF), begun in 2016. The program was initially named Zero-Budget Natural Farming, focused on the principles enunciated by Sri. Subhash Palekar, and it later evolved into APCNF, expanding the scope of agroecological methods with the experiences evolving from field-level innovations.

The APCNF program is being implemented by Rythu Sadhikara Samstha (RySS), a not-for-profit company established by the Government of Andhra Pradesh.

RySS's mandate is to plan and implement programs for the empowerment and all-around welfare of farmers (NITI Aayog, 2021).

For our study, we have selected two mandals (Tadipatri, with 27 villages, and Bathalapalli, with 11 villages), within Anantapur District (one each in the newly formed Anantapuram and Sri Satya Sai districts), where a substantial number of farmers have reportedly adopted the natural farming methods promoted by RySS. Table 1 provides an overview of Anantapur District and the following sections provide the detailed context of the environmental, social, economic, and political context in addition to the status of the 13 agroecological principles followed in the region.

Figure 2. Andhra Pradesh with new district boundaries



Source: *Arjunaraoc (https://bit.ly/3TcMLhF; https://bit.ly/47x6CMV).*

Figure 3. Land use types in Anantapur and the trends in cropped area, recreated by WASSAN

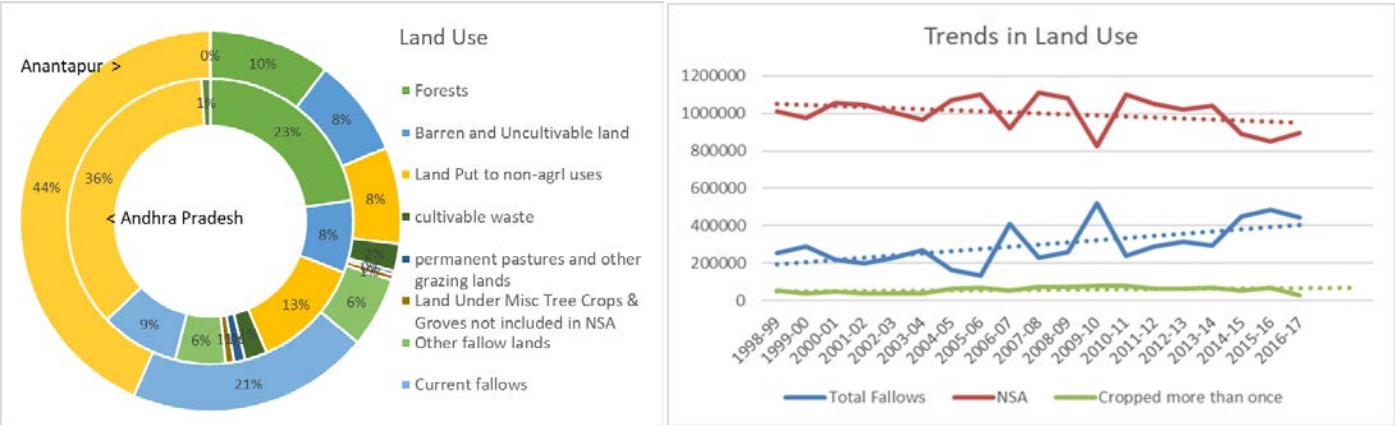


Table 1: Overview of Anantapur District

Overview of Anantapur District (MoA&FW, 2022)	
Location	13°30′ and 15°11' N and 75°45' and 78°15' E (Krishnan et al., 2003)
Geographic area	19,130 km^2
Cultivable area	10,150 km^2
Revenue mandals	63
Agroecological region/ sub-region (ICAR)	Karnataka plateau Rayalaseema as inclusive agroecological sub-region (3.0)
Agro-climatic region (Planning Commission)	Southern Plateau and Hills Region (X)
Agro-climatic zone (NARP)	Scarce rainfall zone of Andhra Pradesh (AP-6)
Average annual rainfall	560 mm
Soil type	Shallow red soils: 934,000 ha (78%) Black soils: 239,000 ha (20%) Others: 23,000 ha (2%)
Groundwater extraction	Overexploited: 28 blocks (12% of area) Critical: 12 blocks (8% of area) Semi-critical: 9 blocks (15% of area) Safe: NA (65% of area)
Irrigation	Net irrigated area: 108,900 ha Gross irrigated area: 137,400 ha Rainfed area: 81,4400 ha
Sources of irrigation	Canals: 22,400 ha (18.8%) Tanks: 4,300 ha (3.6%) Tubewells/filter points: 91,000 ha (76.3%) Other sources: 1,500 ha (1.3%)
Natural resources	Mineral deposits: dolomite, iron ore, limestone, gold, diamond Non-conventional energy sources: wind and solar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Environmental context

Climate/climatic zone of the ALLs

Anantapur District has a bimodal distribution of rainfall, receiving rains from the northeast and southwest monsoons. Anantapur is often deprived of monsoon rains during years when the monsoonal vigor is below normal. Thus, the district is a drought-prone area and is the district receiving the second lowest rainfall in the nation, with a normal rainfall of 552 mm per annum. The region receives much of its rain (57%) from the southwest monsoon (June to September) and 30% comes from the northeast monsoon (October to December) (APSAC, 2018). Monthly and annual rainfall data of 38 years (1980–2017) were analyzed to calculate the average rainfall for the study sites (Figure 4). Average annual rainfall of Bathalapalli is 569 mm and that of Tadipatri is 613 mm, while India's annual average is 1,160 mm (IMD 2022), thus clearly showing that the region is deprived of rain. Bathalapalli and Tadipatri receive most of their rain (~59% and ~62%) from the southwest monsoon and ~26% and ~25% from the northeast monsoon, respectively (Figure 5).

As can be seen from the isohyets map of Anantapur District (Figure 5), the two sites selected for ALLs are in different rainfall zones. Bathalapalli is drier, having an average annual rainfall of 489 mm, whereas Tadipatri has 587 mm, about a 100-mm difference in the isohyets; however, both sites are in a low-rainfall semi-arid zone.

Figure 4. Trends and return periods in analysis of rainfall (1980–2017) (IMD data). Author: Sudharsan Maliappan. Bathalapalli

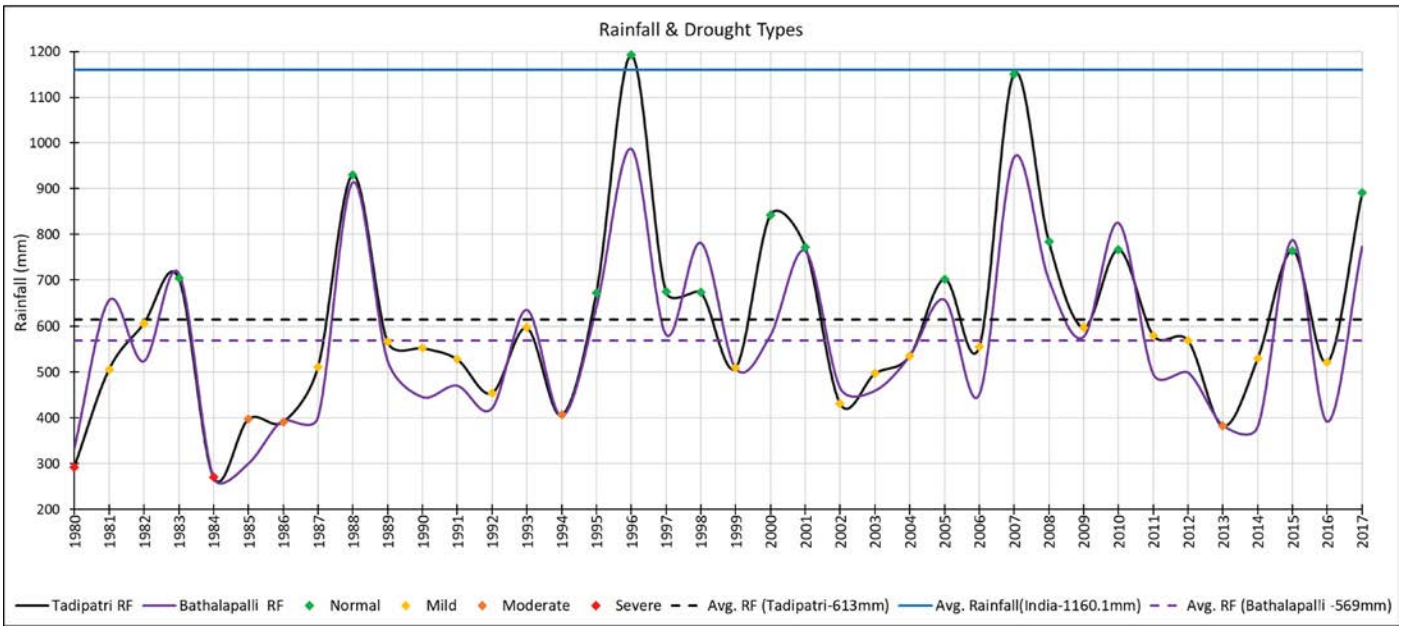


Figure 5. Seasonal and monthly rainfall trend (averages across 1980–2017) (IMD data). Author: Sudharsan Maliappan.

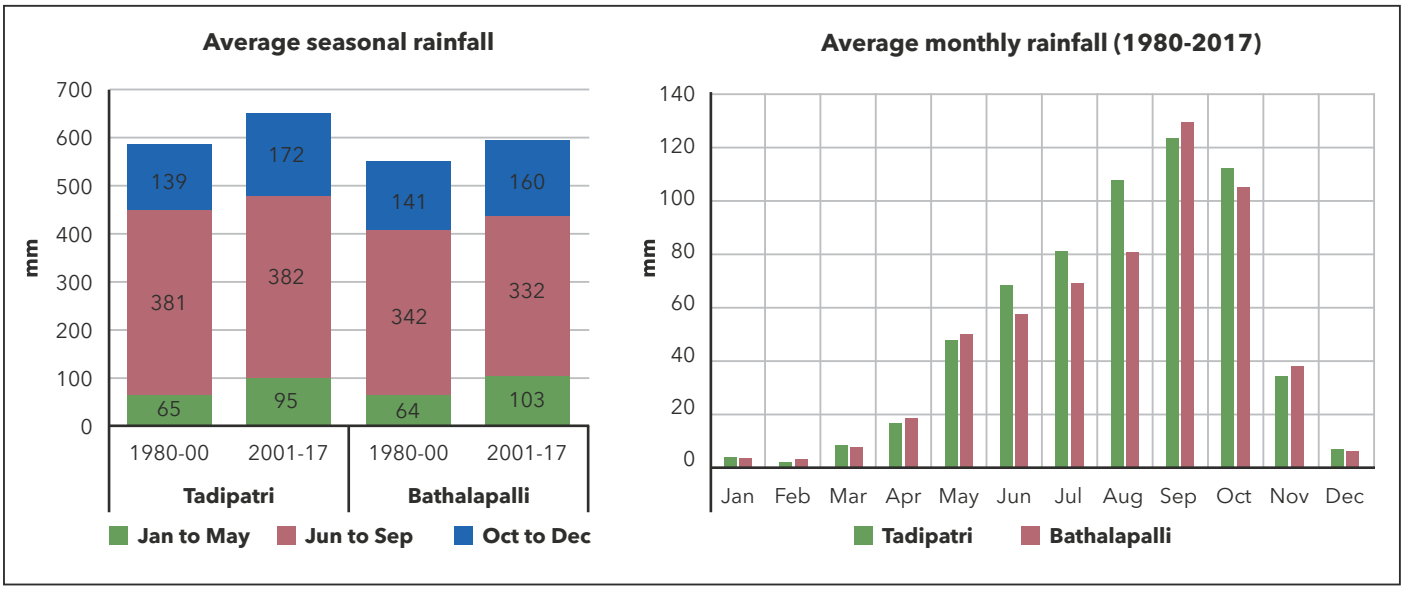
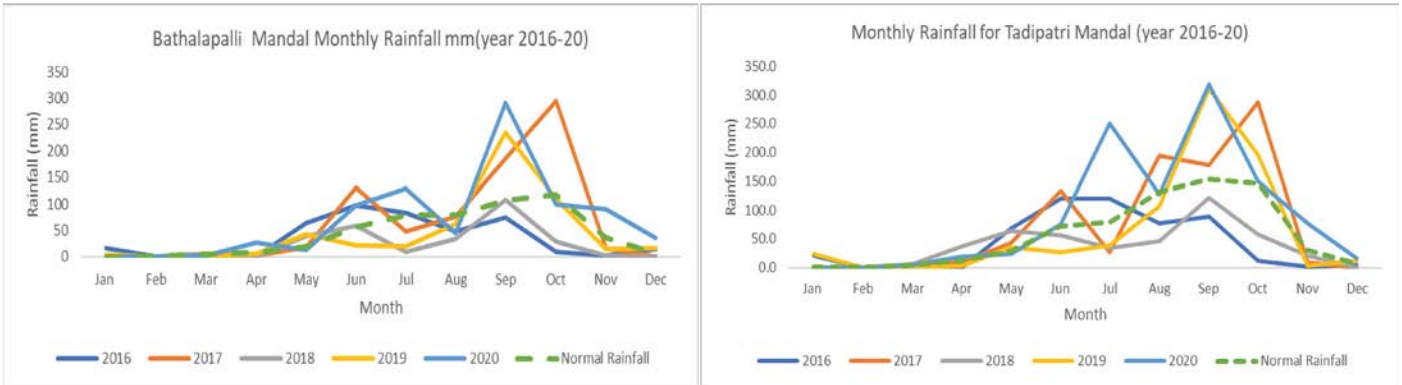


Figure 6. Monthly rainfall for 2016–2020 for the ALL mandals. Source: IMD, 2016–2020. Author: Prachi Patil



Bimodal rainfall can be discerned from the monthly rainfall of the two ALL sites (Figure 6). While the June to September window (with small pre-monsoon showers occasionally in May) receives rainfall from the southwest monsoon, rainfall in the September to November window comes mainly from the return/northeast monsoon. The monthly distribution of rainfall at the two sites (Tadipatri and Bathalapalli) during the last five years shows very high variability, with high-intensity rainfall events during the northeast monsoon (Figure 5). Increasing climate variability in terms of drought spells and increasing off-season rains with high peaks has been a disturbing trend in the district and at both ALL sites.

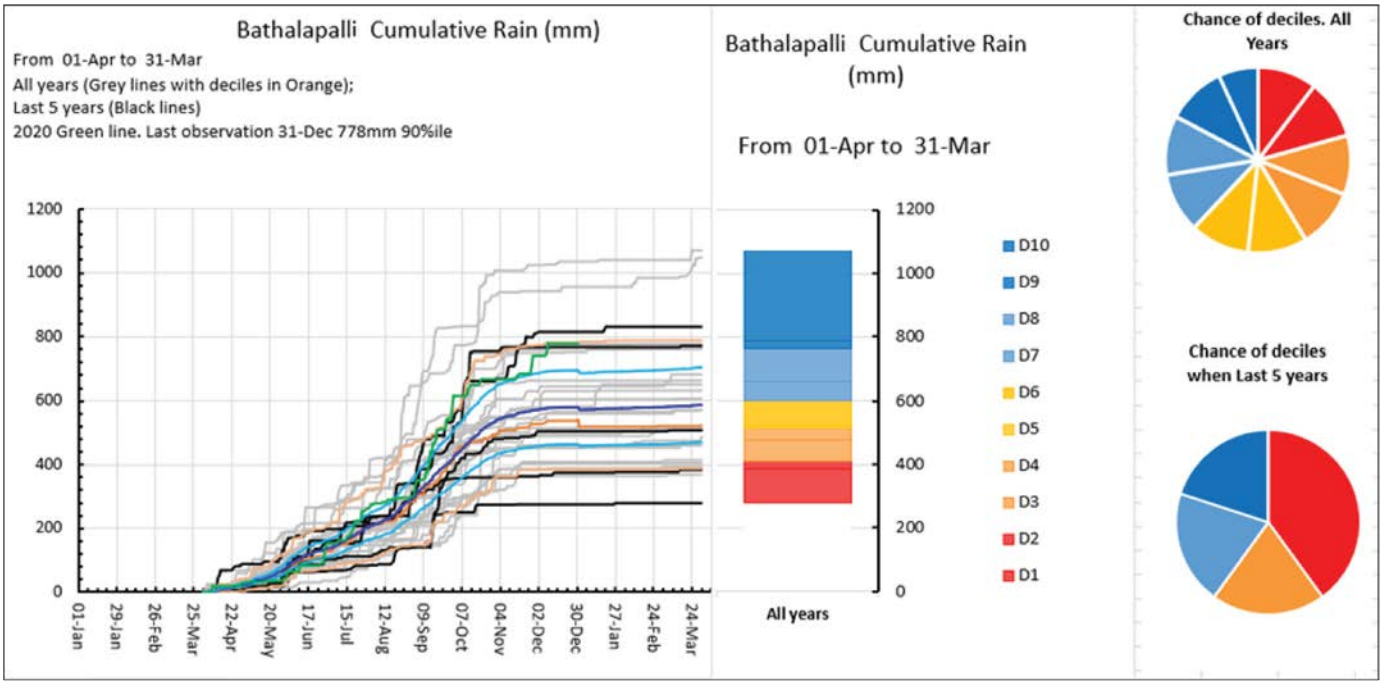
Rainfall trends and variability assessment of the ALL sites

Daily rainfall data for 1991 to 2020 from the IMD was plotted for the ALL sites. The rainfall Plume Tool developed by researchers from SARDI (South Australian Research and Development Institute) under the project "Water management in rainfed areas for improving livelihood security of smallholder farmers" was used to do the rainfall analysis. The cumulative rainfall is plotted for 30 years against daily rainfall data. The graph gives the following information:

- Average rainfall, +/- 20% average, median rainfall, +/-20% of median rainfall, and 1st and 9th decile rainfall
- Rainfall trend for past 5, 10, 15, 20, and 30 years
- Chances of rainfall occurrence in a specific decile for the above

The following analysis provides further insight into the rainfall variability at the ALL sites.

Figure 7. Bathalapalli mandal cumulative rainfall from 1991 to 2020 (IMD grid data). Gray lines indicate cumulative rainfall of the past 30 years, black lines indicate 2016 to 2020 cumulative annual rainfall, and blue lines indicate average rainfall and +/- 20% average cumulative rainfall. Author: Prachi Patil



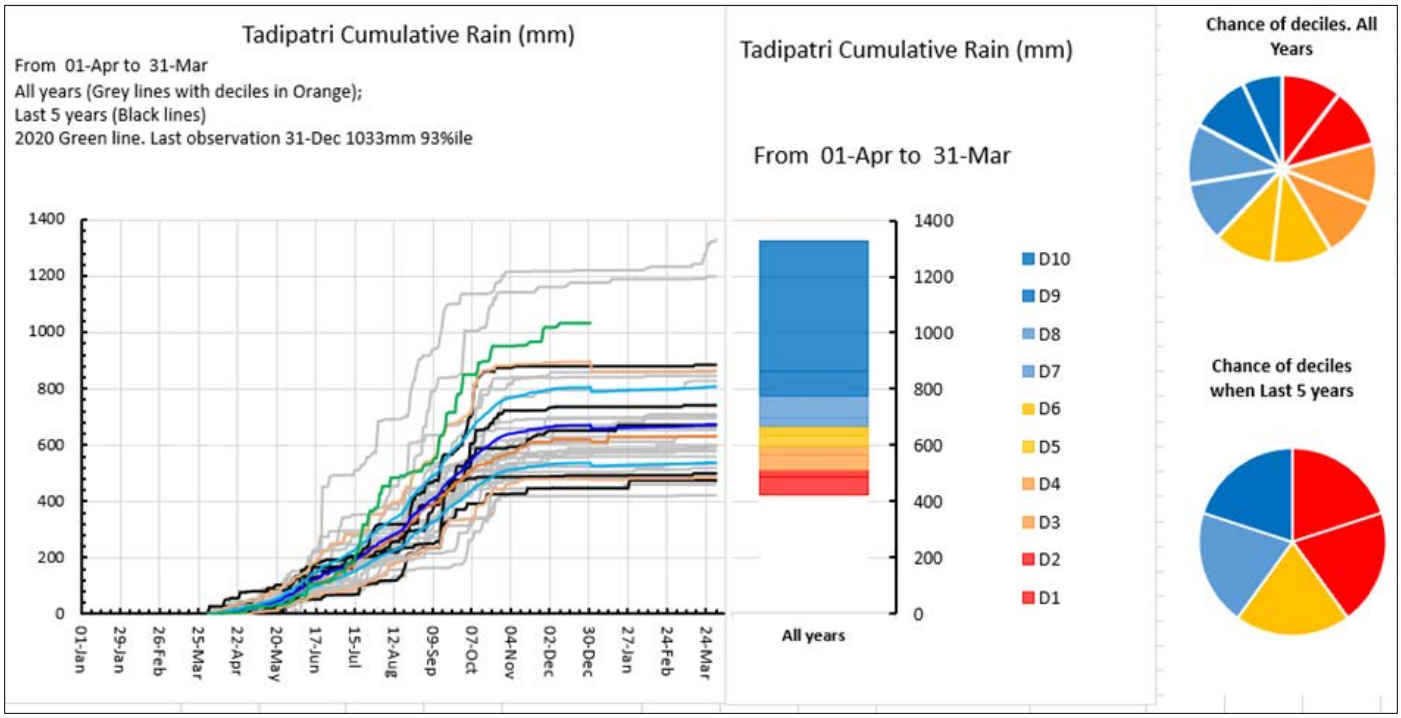
The 30-year average annual rainfall of Bathalapalli mandal is 587.6 mm. If the 2016 to 2020 cumulative rainfall is considered, 2016 and 2018 received 34% and 52% less than the average annual rainfall, while, in 2015, 42% excess of average cumulative rainfall was received (Figure 7). Table 2 indicates rainfall variability over the past 5, 10, 15, 20, and 30 years.

Table 2: Cumulative rainfall in Bathalapalli

	Chance of decile 1 (≅ 320 mm) cumulative rainfall	Chance of decile 9 (≅ 700 mm) above cumulative rainfall
Past 5 years	40%	20%
Past 10 years	30%	20%
Past 15 years	20%	20%
Past 20 years	15%	15%
Past 30 years	10%	17%

The chance of receiving low rainfall (below average) is increasing over time. At the same time, there is also an increasing trend in the chance of receiving rainfall higher than 700 mm, which is >100 mm above the average. This trend in variability in rainfall has been prevalent in the past 5 to 10 years.

Figure 8. Tadipatri mandal cumulative rainfall from 1991 to 2020 (IMD data). Author: Prachi Patil



The 30-year average annual rainfall of Tadipatri mandal is 672.6 mm. If the 2016–2020 cumulative rainfall is considered, 2016 and 2018 received 25% and 34% less than the average annual rainfall, whereas, in 2017, there was a 29% excess in average cumulative rainfall (Figure 8). In 2020, the rainfall was 51% higher than the average cumulative rainfall of the region. Table 3 indicates rainfall variability over the past 5, 10, 15, 20, and 30 years for deciles 1 and 9.

In Tadipatri mandal, rainfall variability has been especially high in the past 5 and 10 years. Bathalapalli receives lower rainfall than Tadipatri but has higher rainfall variability.

Tables 2 and 3 give an analysis on cumulative rainfall chances of occurrence less than or equal to 1 decile and greater than or equal to 9 decile values for ALL sites. If the past 5 years' rainfall for both locations is analyzed, it is observed that, in Bathalapalli for 2 years, the cumulative rainfall was less than 320 mm, whereas, for Tadipatri, the cumulative rainfall was less than 480 mm (less than 1 decile) for 1 year.

Table 3: Cumulative rainfall in Tadipatri

	Chance of decile 1 (≅ 480 mm) cumulative rainfall	Chance of decile 9 (≅860 mm) above cumulative rainfall
Past 5 years	20%	20%
Past 10 years	20%	10%
Past 15 years	13%	14%
Past 20 years	15%	15%
Past 30 years	10%	17%

Drought assessment

Anantapur District is one of the most severely drought-affected districts in India (Sainath, 1996). For assessing drought, the Standard Precipitation Index (SPI) (Sönmez et al., 2005) is used. SPI is the deviation of precipitation from the mean for a period (monthly, 3-monthly, etc.) relative to its standard deviation (Sönmez et al., 2005). SPI is calculated based on monthly rainfall data of the years 1980 to 2017. To assess seasonal and annual droughts, SPIs are calculated separately for annual, kharif season, and rabi season. The shorter periods (monthly to seasonal) evaluate agricultural droughts, whereas the annual period SPI assesses hydrological droughts. The seasonal and annual SPIs for the study catchments appear in Table 4. The analysis of trends and return periods of rainfall shows the likelihood of droughts. This information is useful for stakeholders to prepare for managing crop stress.

Main climate change impacts projected or currently experienced

Anantapur has been drought prone for more than a century according to rainfall data. There were only 3 years in the past two decades when the region received normal annual rainfall; however, the number of rainy days was fewer than normal (Mohan, 2019). The year 2018 received 556 mm of rain, which is normal annual rainfall (APSAC 2018), but, in 2019, the region received only 272.8 mm of rainfall, which is the least it has received in this century and which adds up to only about half of what it normally receives (APSAC, 2018). Different parts of the district experience one to three droughts every 5 years (Krishnan et al., 2003).

The Vulnerability Atlas prepared by ICAR-CRIDA characterizes the exposure to climate change and consequent vulnerability in Anantapur as "very high," the exposure factor being the projected decrease in July rainfall and the sensitivity factor being the low rainfall (Rama Rao CA et al., 2013). However, the region has experienced high-intensity off-season rains and consequent loss of crops in the past five years, which demonstrates the unpredictable extreme climatic events and thus furthers the factors of vulnerability.

Table 4: SPI calculation for different periods and tabular matrix of results

	Bathalapalli				Tadipatri			
	Jan-May	Jun-Sep	Oct-Dec	Annual	Jun-Sep	Oct-Jan	Feb-May	Annual
No drought	39%	45%	42%	45%	50%	42%	45%	37%
Mild drought	45%	37%	42%	42%	32%	47%	42%	47%
Moderate drought	16%	18%	11%	11%	16%	11%	11%	11%
Severe drought	0%	0%	5%	3%	3%	0%	3%	5%
Extreme drought	0%	0%	0%	0%	0%	0%	0%	0%

Source: *Author Sudharsan Maliappan's analysis (monthly data from 1980 to 2017 were analyzed for drought assessment)*

Main environmental challenges

The environmental challenges of Anantapur District are the following:

- Rainfall pattern: low and erratic rainfall, frequent droughts, and increasing variability.
- Desertification and climate change: Dwindling rainfall has led to an increase in aridity, deteriorating soil quality, and increasing desertification. Aridity has deteriorated soil productivity as well (Jitendra, 2019). With 18 droughts in the past two decades (until 2020), the region is gradually experiencing farmers' disinterest in cultivation, leading to desertification resulting in climate-induced mass migration (Bommakanti, 2021). About 110 kilometers from Tadipatri and Bathalapalli lies D. Honnur Village, where the landscape is dominated by sand and dunes. The community attributes the degradation of the sandy landscape, which they say it always was, to a change in the cropping patterns (shift away from millets and multi-cropping systems into groundnut monocropping) and change in intensity, timing, and frequency of rainfall (Sainath, 2019).
- Degradation of commons: The hillocks that are not under the forest department are subject to high degradation. Anantapur District and Bathalapalli have sizable area under commons.
- Increasing fallow lands: As discussed earlier, this is a serious concern because, as farmers discontinue cultivation, land degradation processes set in.
- Loss of soil fertility: Large areas of Anantapur District are under groundnut monocropping, thus limiting soil cover with crops up to October. As the plants along with roots with pods are taken out, not much biomass is left to mix with the soil.

Land use pattern

Bathalapalli and Tadipatri mandals depict two different terrains. While Bathalapalli has undulating terrain with varied geography, Tadipatri is flat with black soils and relatively homogeneous topography. Table 5 shows the land use for the two mandals.

Bathalapalli is mainly made up of poor red soils that are slightly sodic and classified as arid and treeless (Abrol et al., 1988). Chitravati, a tributary of the Pennar River, drains the mandal. About 1.5% of the total area of the mandal is classified as hilly.

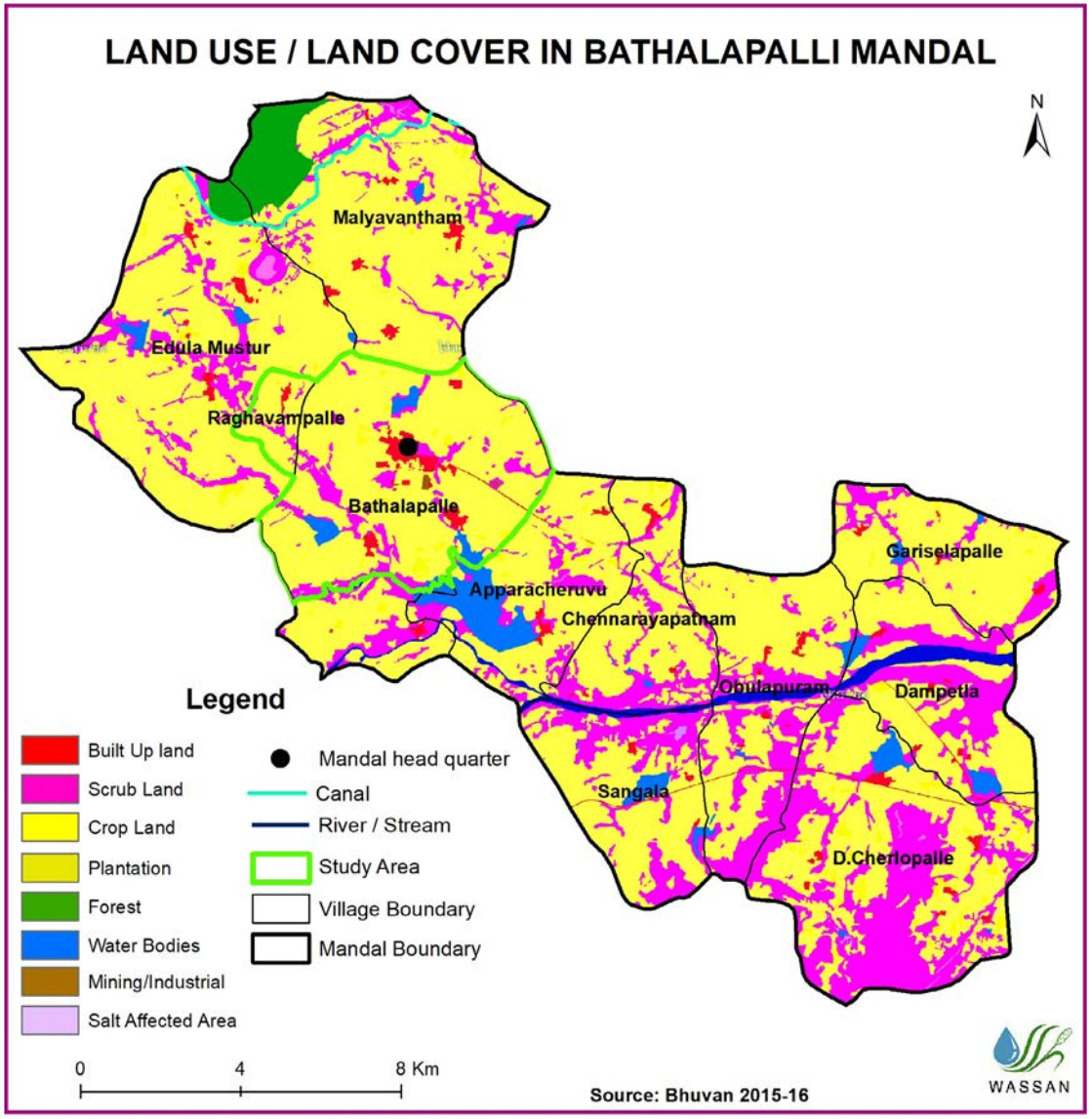
Tadipatri has an almost equal extent of black cotton soil and red soil. Some of the lowest points of Anantapur District are in this mandal at 274 m above mean sea level, where the slope is almost flat. Most of the mandal is drained by the Pennar River (APSAC, 2021).

- Predominance of single-cropped area and kharif orientation of the crop systems. Very poor development of a second (rabi) crop, with a meager percentage of land under area sown more than once. Only 6% and 3% of the total cropped area is sown more than once in Tadipatri and Bathalapalli mandals, respectively.
- Very low area under commons (forests, culturable waste, non-agriculture land, pastures and grazing, etc.).
- Very high incidence of current fallows, a feature typical of stressed rainfed agriculture (nearly 32% of the land is fallow in Tadipatri and 26% in Bathalapalli).
- The satellite data broadly corroborate the land use data. A very small area is under forests in Bathalapalli, while most of the area is under cultivation. The incidence of scrub lands is higher in Tadipatri (Figure 9).
- The Chitravati River flows through Bathalapalli mandal. Several dispersed water bodies can be seen in Bathalapalli, with one large water body (Appacheruvu) adjoining the ALL site. The Pennar River transits through Tadipatri with relatively plain lands adjoining the river.
- The ALL sites within the mandals are marked with a green boundary. While the Tadipatri ALL site is smaller with relatively uniform topography, the Bathalapalli site has landscape diversity, including a few water bodies.
- The ALL site in Tadipatri has deep black clayey soils, while the Bathalapalli ALL site has loamy to clayey and clayey to gravelly clayey soils (Figure 10).

Table 5: Mandal-wise land use, 2019–2020

	Area in ha			
Mandal-wise land use, 2019–2020	**Bathalapalli**		**Tadipatri**	
Geographic area	23,071	100%	36,408	100%
Forest area	360	2%	0	0%
Barren and uncultivable land	2,490	11%	3,120	9%
Land put to non-agricultural uses	1,142	5%	5,878	16%
Culturable waste	445	2%	1,002	3%
Permanent pastures and grazing land	34	0%	0	0%
Land under miscellaneous tree crops and groves not included in net sown area	286	1%	0	0%
Other fallow lands	1,467	6%	2,016	6%
Current fallow lands	4,658	20%	9,710	27%
Net sown area	12,189	53%	14,682	40%
Total cropped area	12,545	54%	15,604	43%
Area sown more than once	356	2%	922	3%

Figure 9. LULC maps of Bathallapalli and Tadipatri. Source: Bhuvan (2015-2016). Figure recreated by WASSAN



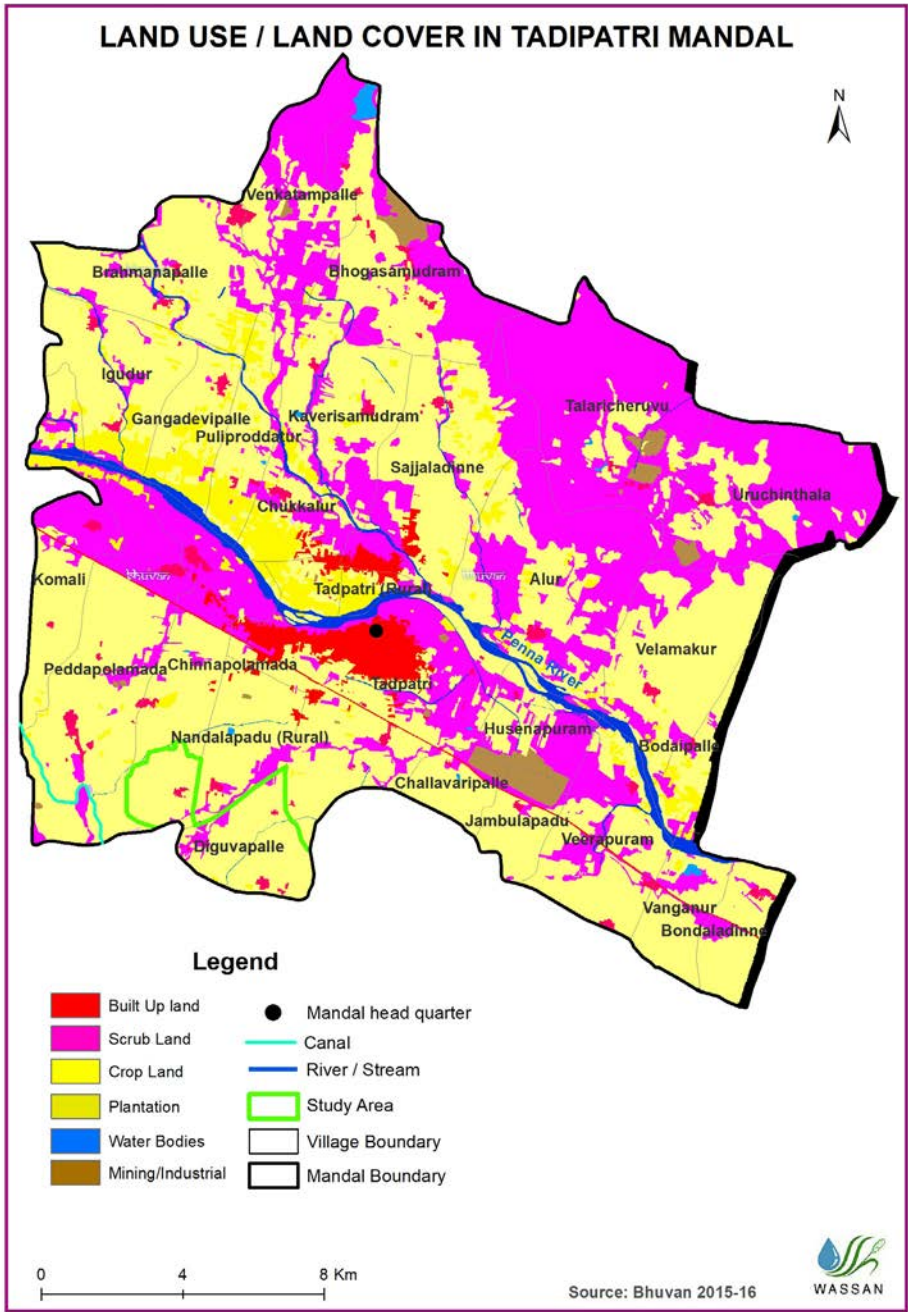
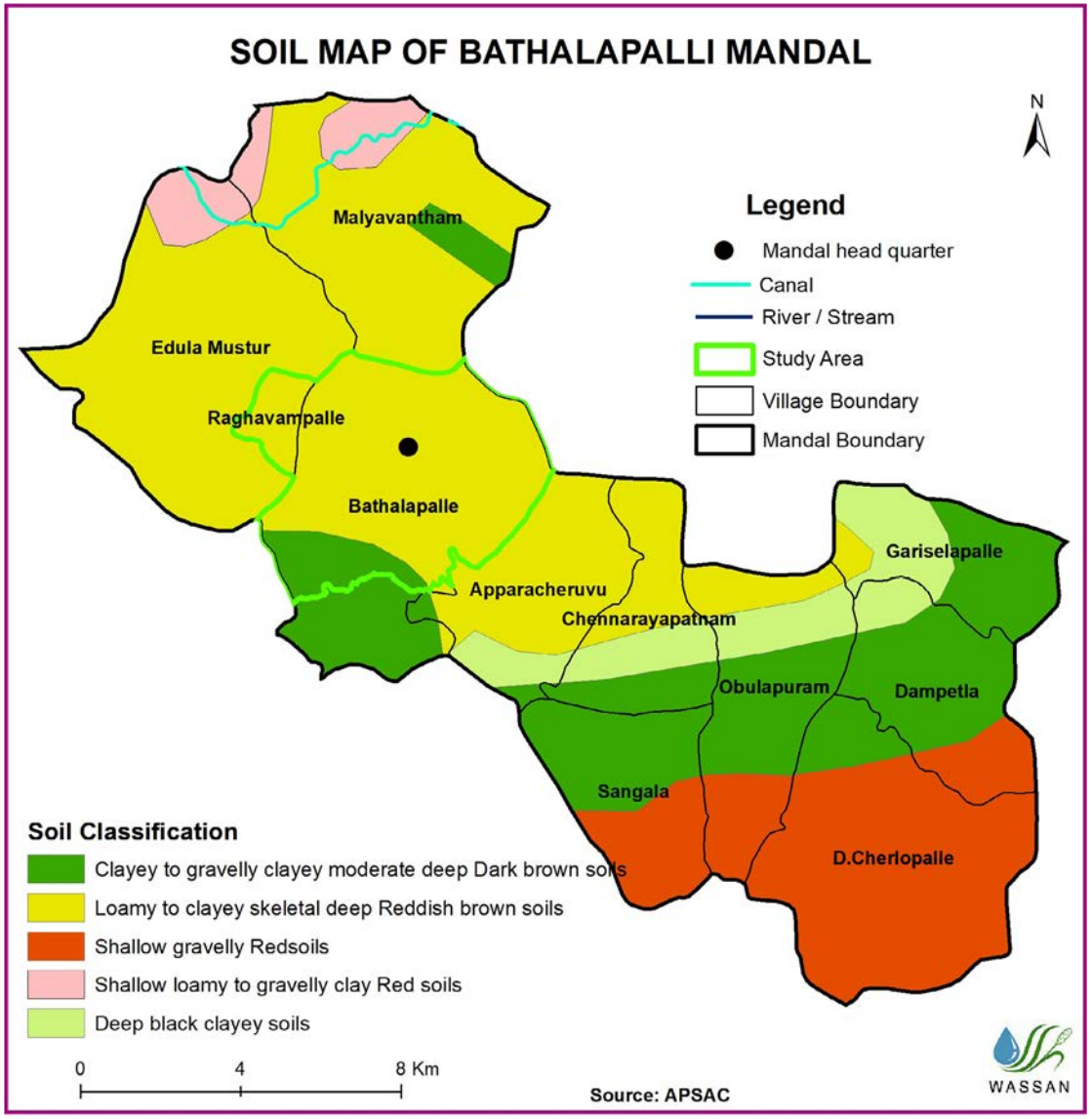
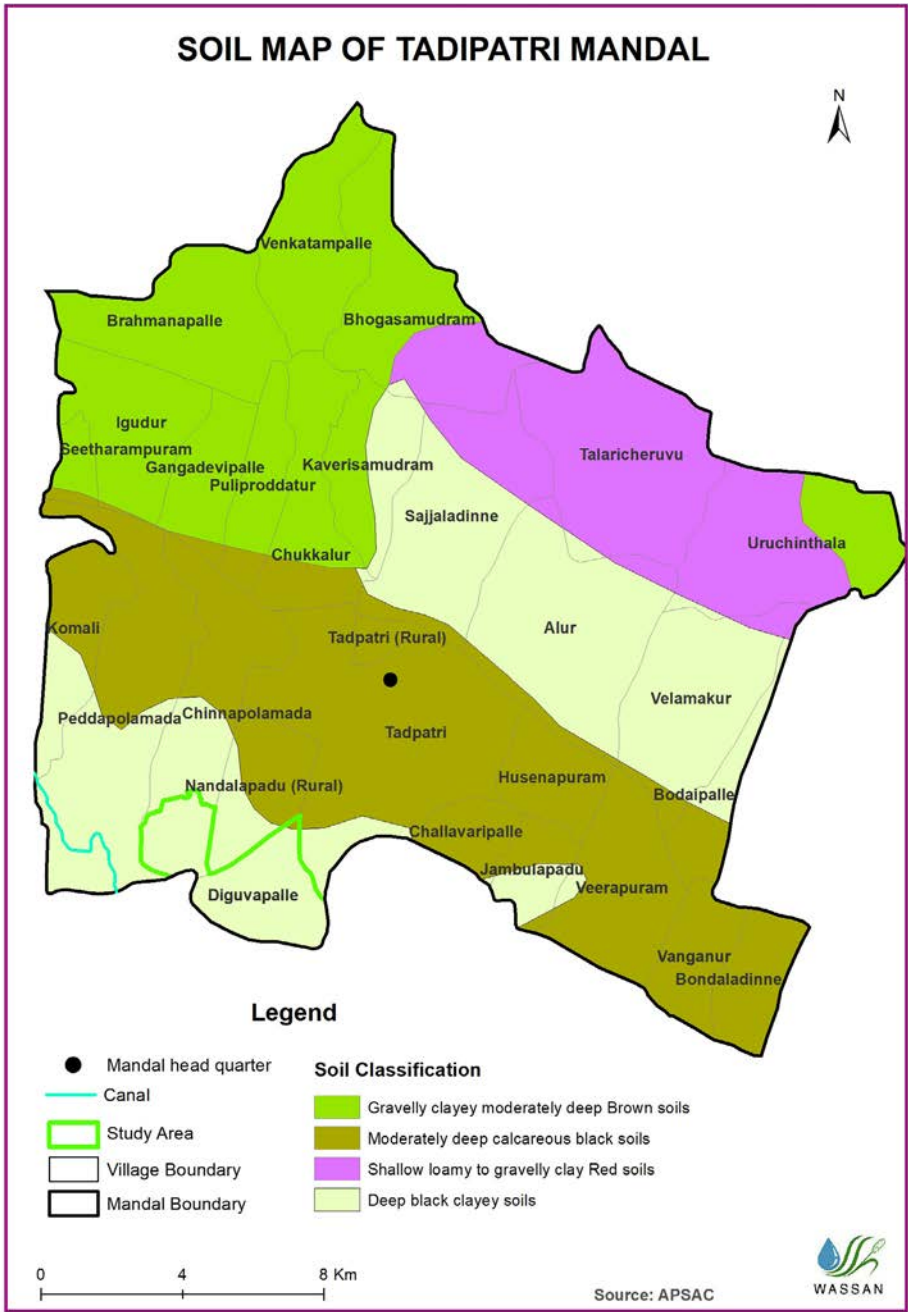


Figure 10. Soil maps of Bathalapalli and Tadipatri. Source: APSAC data, 2021. Figure recreated by WASSAN





Other natural resources

Large deposits of dolomite, iron ore, limestone, gold, and diamond exist in Anantapur District. The region also has potential for solar and wind power generation. Anantapur has been one of the main districts in Andhra Pradesh in harnessing electricity through wind. The average wind velocity is about 20 kmph and thus offers huge scope for harnessing this non-conventional energy source (APSRAC, 2018). A 500-acre, 100-MW solar power plant was established, which is expected to generate nearly 160 million units (kWh) of energy per year, thereby diminishing the load on the conventional grid and helping offset approximately 110,000 tons of CO2 annually (Tata Power Solar Systems Ltd, 2022).

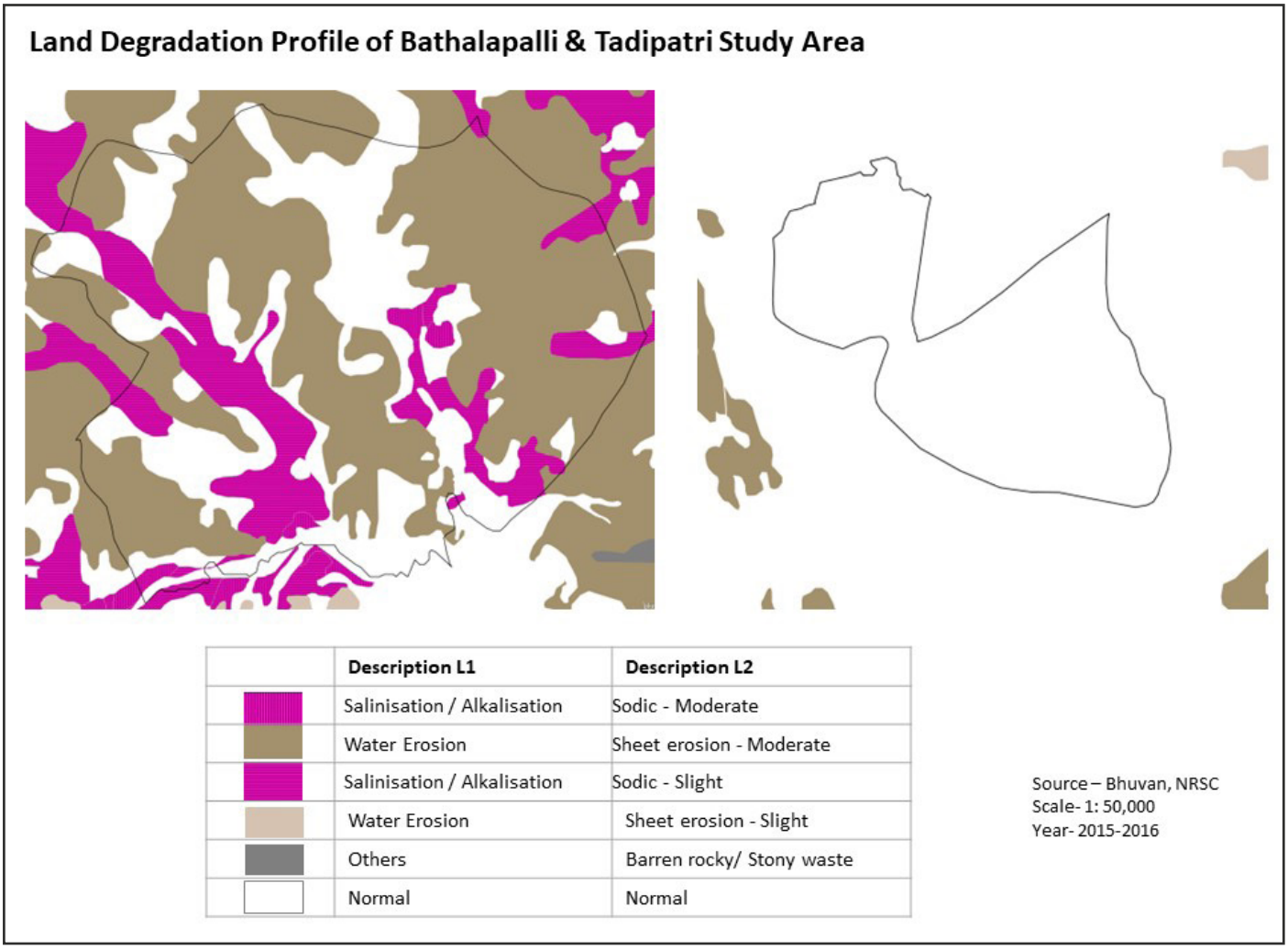
Land degradation

Extracts from the satellite data from Bhuvan on land degradation at the two ALL sites suggest a contrasting picture of no serious land degradation at the Tadipatri ALL site, while Bathalapalli has several areas with salinity/alkalinity and extensive areas subject to water erosion (Figure 11).

The ALL sites have relatively lower levels of land degradation than the district. Based on satellite data from 1990 to 2018, 31.93% of the land in Anantapur is facing land degradation and desertification, of which 17.34% faces severe land degradation and 14.59% has undergone desertification. Changes in land cover have led to vegetation degradation and waterlogging in part of the study area.

The low moisture index (-75.5% for the district) shows that the rainfall received is not sufficient to meet the potential evapotranspiration demand, which has deteriorated soil quality and thus led to an increase in desertification. Aridity has deteriorated soil productivity as well. From 1999 to 2015, soil acidity increased by more than 4% and soil organic carbon declined by 84%. Availability of nitrogen and potassium dioxide decreased by 55% and 43%, respectively, during the same period. Other essential micronutrients such as zinc, iron, phosphorus, and potash were deficient too (Jitendra, 2019).

Figure 11. Land degradation profile of the ALLs. Source: Bhuvan, NRSC 2015–2016). Figure recreated by WASSAN



Soil

The soil type in Anantapur District is predominantly of the red type except in a few mandals, including Tadipatri. About 76% of the district is covered with red soils and 24% with black soils (APSAC, 2018) (Table 6).

Table 6: Soil characteristics of Anantapur District

Soil type	Characteristics	Area in ha
Red soils	1. Clay content low 2. Water-holding capacity low 3. Depth shallow 4. Nutrients low	875,196 (87.4%)
Black soils	1. Clay content high 2. Water-holding capacity high 3. Depth shallow to deep 4. Nutrients medium	125,830 (12.5%)
Problematic soils	1. Saline or alkaline soils 2. Need reclamation	190 (0.1%)

Source:: *(ICAR, 2013)*

Biodiversity

The dominant species within forests are thorny shrubs such as *Acacia sandra* (Sundra), *Acacia leucophloea* (Tella Thumma), *Dichrostachys cinerea* (Nela Jammi), *Acacia latronum* (Paki Thumma), *Carissa spinarum* (Vaka), *Zizyphus* spp., etc. The non-thorny plants present are *Dodonaea viscosa* (Pulivailu), *Jatropha curcas* (Adavi Amudalu), and climbers such as *Abrus precatorius* (Gurivinda), etc. The main ground flora are grasses such as *Cymbopogon coloratus* (Bodha Gaddi) and *Heteropogon contortus* (Pandi Mallu Gaddi). The predominant exotic species outside the reserve forests are *Prosopis juliflora* (Sarcar Thumma) and *Acacia nilotica* (Nalla Thumma), while the native species include *Tamarindus indica* (Chinta), *Azadirachta indica* (Vepa), *Pongamia pinnata* (Kanuga), and *Albizia lebbeck* (Dirisona). *Phoenix sylvestris* (Etha Chettu), a palm, is also seen along the banks of streams and rivulets.

Important fauna are predators such as leopards, bears, hyenas, jackals, and wild dogs; ungulates such as black buck, spotted deer, sambar, etc.; and small mammals such as porcupines, squirrels, a variety of rats, etc. The blue jay, the Andhra Pradesh state bird, parakeets, red jungle fowl, bulbuls, woodpeckers, peacocks, including the endangered great Indian bustard, and migratory birds such as painted Siberian storks are notable among birds.

Forests, nature reserves, and protected lands

There are no national parks, sanctuaries, or biosphere reserves in Anantapur District, but it has 19,130 km^2 of reserve forests (Table 7).

Table 7: Forest cover in Anantapur in 2019 in km². Source: Forest Survey of India (2019)

Forest cover in Anantapur in 2019 in km²							
Geographic area (GA)	Very dense forest	Moderately dense forest	Open forest	Total	% of GA	Change from 2017	Scrub
19,130	0	213.14	773.69	986.83	5.16	-0.17	1,116.68

Table 8: Bamboo area in Anantapur in hectares. Source: Andhra Pradesh Forest inventory report

Bamboo area in Anantapur in ha (part of National Bamboo Mission)					
Pure bamboo	Dense bamboo	Medium bamboo	Scattered bamboo	Total bamboo	Bamboo area in %
2021	0	2,021	5,052	9,094	2.3

The forests of Anantapur fall under tropical dry deciduous, tropical moist deciduous, tropical semi-evergreen, and tropical thorn forest types. The per capita forest area is 0.054 ha (Andhra Pradesh Forest Department, 2014). In addition to reserve forests, the region has several smaller forest fragments called sacred groves, which range in size from <1 ha to 200 ha. Sacred groves are forests protected because of cultural beliefs (Jayaprada, 1998). However, only a very small area of forests is in Bathalapalli. The incidence of scrub lands is higher in Tadipatri (see Figure 9).

Bamboo cultivation is being promoted under the leadership of the National Bamboo Mission and farmers are encouraged to grow bamboo (Table 8) (Globalgreen, 2021).

The Forest Department is using the MGNREGS to take up forestry operations in reserved forest areas and outside. A large number of nurseries are being raised under the Mahatma Gandhi Vana Nursery (MGVN) Program as a part of the MGNREGS in the state. These nurseries are being raised to produce good-quality seedlings of tree species that are preferred by the people and that are suitable to the agro-climatic conditions of the district concerned (APFD 2013). In July 2020, the government had taken up the task of planting 9.4 million saplings in the district (Anonymous, 2020).

Community forest management: There are 281 Vana Samrakshana Samities (VSSs) or Joint Forest Protection Committees (JFPCs) in Anantapur covering an area of 628.35 km², which constitutes 32% of the forest area.

Water resources

Figures 12 and 13 show the water resources of the two selected mandals along with the boundaries of the ALL sites. Bathalapalli, with undulating slopes, has a dense drainage network flowing into the Chitravati River. The mandal has a total of 2,821 water bodies with 158.95 mcft of storage capacity, of which 37.58 mcft has actual storage. Except for a canal on the northwest, most of the irrigation is through borewells. The 40 minor irrigation tanks have a cumulative command area of 955 acres.

The ALL site in Bathalapalli is in the catchment area of the Appara Cheruvu (a minor irrigation tank). The southern part of the mandal comes under the irrigation command area. Tadipatri mandal, in contrast, has relatively plain terrain with limited scope for water bodies. Much of the mandal comes under the Pennar River basin. The mandal has 13 irrigation tanks with a command area of 243 acres.

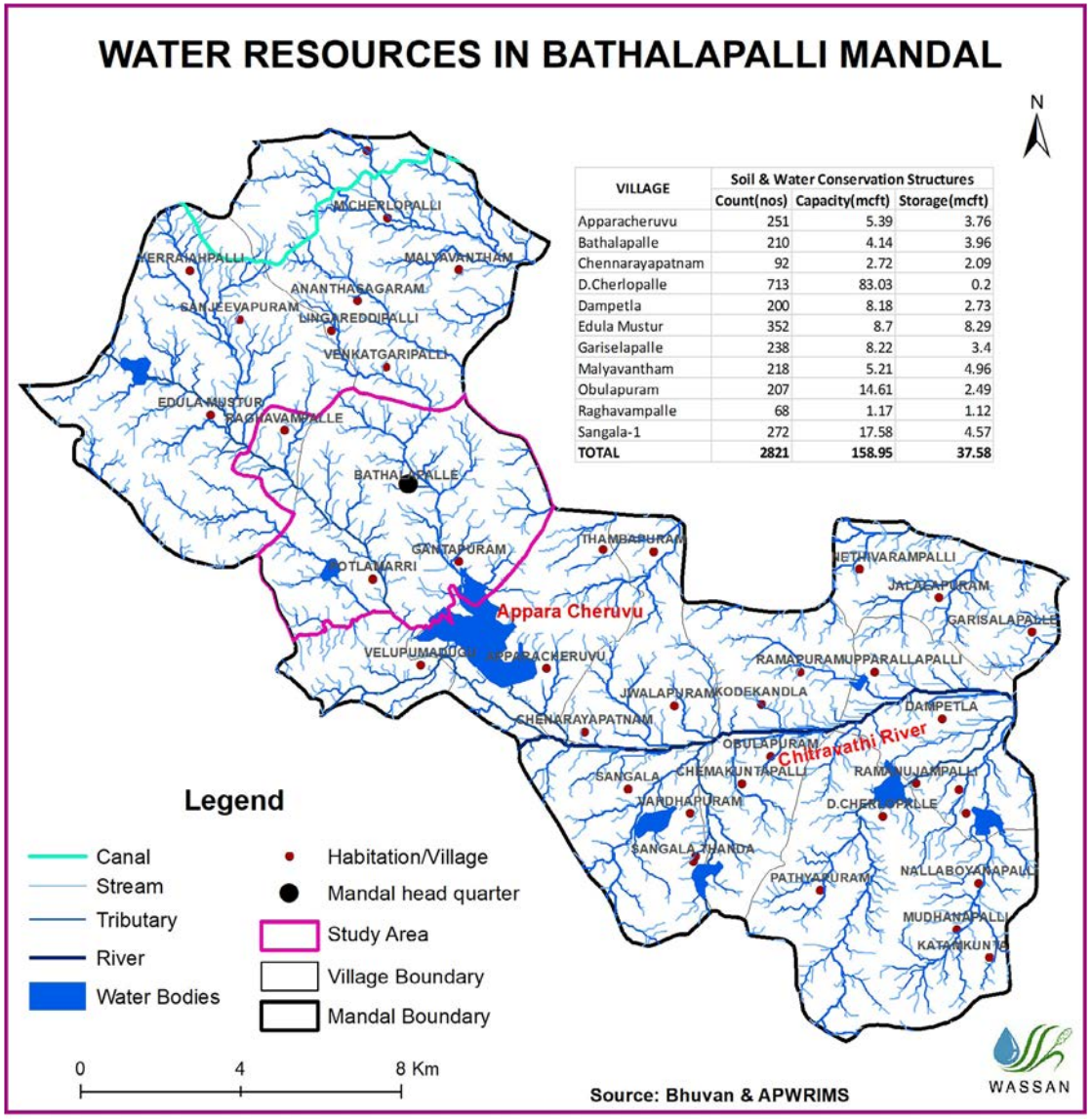
The Handari-Neeva Sujala Sravanthi project has been a political ambition for the people of Anantapur. The project pumps water from the backwaters of Srisailam dam traversing more than 500 km across the higher reaches of the district. The project is mostly used for filling up the tanks (water bodies) along its path. The project mandals are out of reach of the HNNS canals.

Groundwater

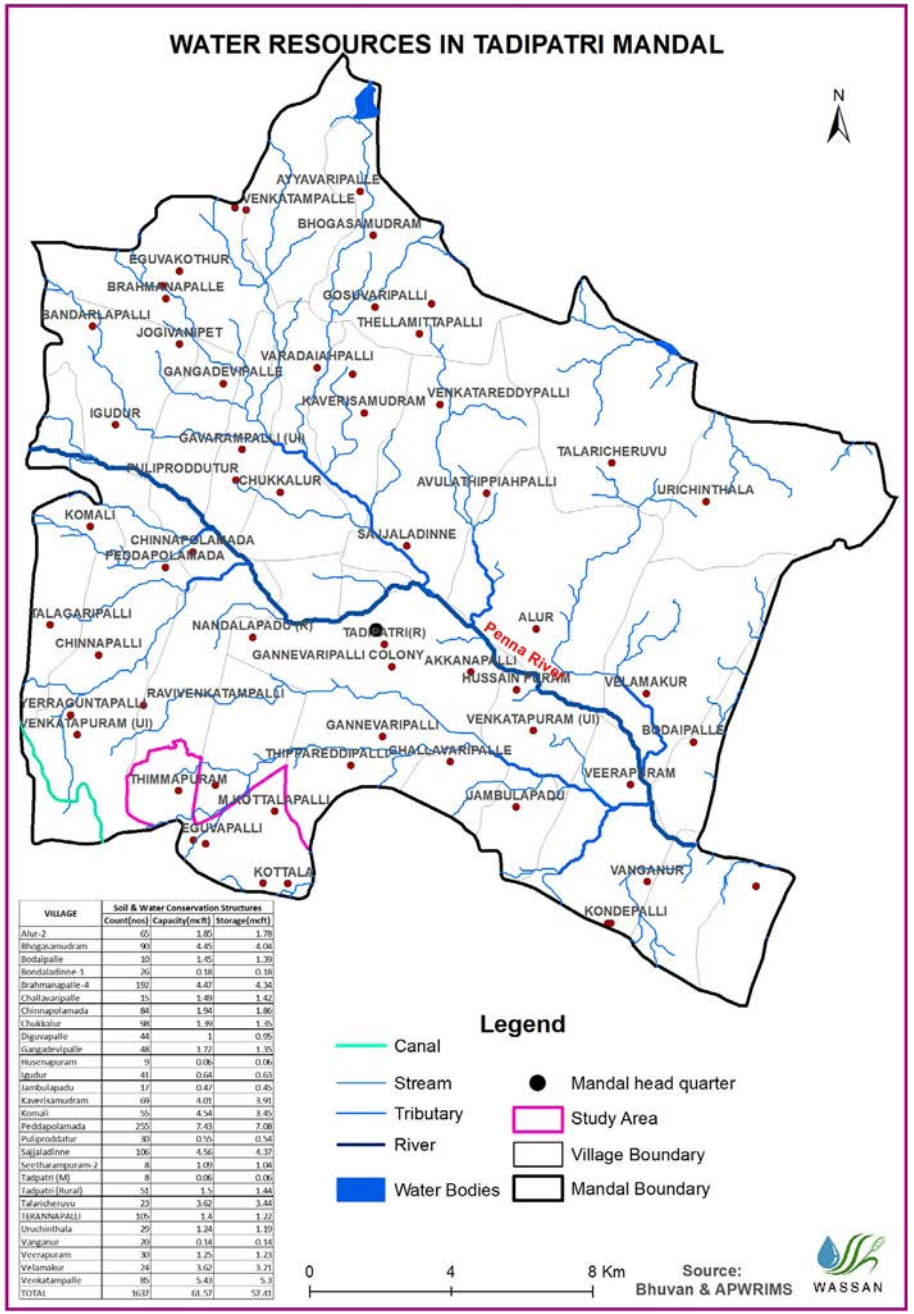
According to CGWB's block-wise groundwater resources assessment of 2022 (Central Ground Water Board, 2022), both Bathlapalli and Tadipatri fall under the safe category. The groundwater status of Tadipatri has shown improvement in recent years, as it was previously categorized as overexploited in 2017 (Central Ground Water Board, 2020) but is now classified as safe based on the CGWB's report.

Bathalapalli has a hard rock deep aquifer system, while Tadipatri, adjoining the Pennar River, has shallower water tables and aquifers. In both mandals, the groundwater table highly correlates with rainfall (Table 9). The groundwater level is relatively more consistent in Tadipatri because of the canal systems.

Figure 12. Water resources of Bathalapalli and Tadipatri

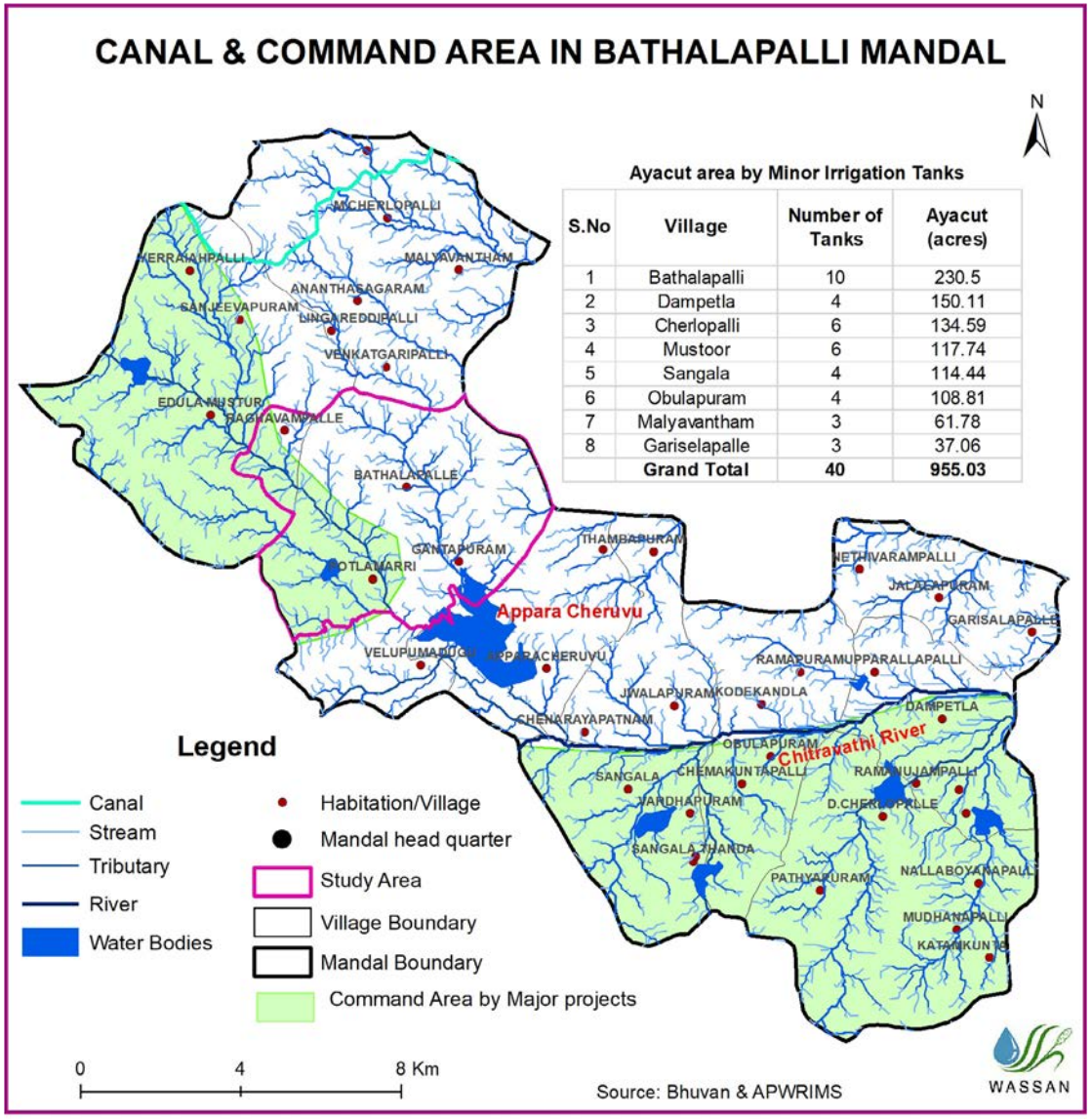


VILLAGE	Soil & Water Conservation Structures		
	Count(nos)	Capacity(mcft)	Storage(mcft)
Apparacheruvu	251	5.39	3.76
Bathalapalle	210	4.14	3.96
Chennarayapatnam	92	2.72	2.09
D.Cherlopalle	713	83.03	0.2
Dampetla	200	8.18	2.73
Edula Mustur	352	8.7	8.29
Gariselapalle	238	8.22	3.4
Malyavantham	218	5.21	4.96
Obulapuram	207	14.61	2.49
Raghavampalle	68	1.17	1.12
Sangala-1	272	17.58	4.57
TOTAL	**2821**	**158.95**	**37.58**



VILLAGE	Soil & Water Conservation Structures		
	Count(nos)	Capacity(mcft)	Storage(mcft)
Alur-2	65	1.85	1.78
Bhogasamudram	90	4.45	4.06
Bodaipalle	10	1.45	1.39
Bondaladinne-1	26	0.18	0.18
Brahmanapalle-II	192	4.47	4.34
Challavaripalle	15	1.49	1.42
Chinnapolamada	88	1.94	1.86
Chukkalur	98	1.39	1.35
Diguvapalle	44	1	0.95
Gangadevipalle	48	1.72	1.35
Husenapuram	9	0.06	0.06
Igudur	41	0.64	0.63
Jambulapadu	17	0.47	0.45
Kaverisamudram	69	4.01	3.91
Komali	56	4.54	3.45
Peddapolamada	255	7.43	7.08
Puliproddatur	30	0.55	0.54
Sajjaladinne	106	4.56	4.37
Seritharampuram-2	8	1.09	1.04
Tadpatri (M)	8	0.06	0.06
Tadpatri (Rural)	51	1.5	1.44
Talaricheruvu	23	3.62	3.44
TEKANNAPALLI	105	1.4	1.22
Urachinthala	29	1.24	1.19
Vanganur	20	0.14	0.14
Veerapuram	30	1.25	1.23
Velamakur	24	3.62	3.21
Venkatampalle	85	5.43	5.3
TOTAL	1630	61.57	57.41

Figure 13. Canal and command area in Bathalapalli and Tadipatri



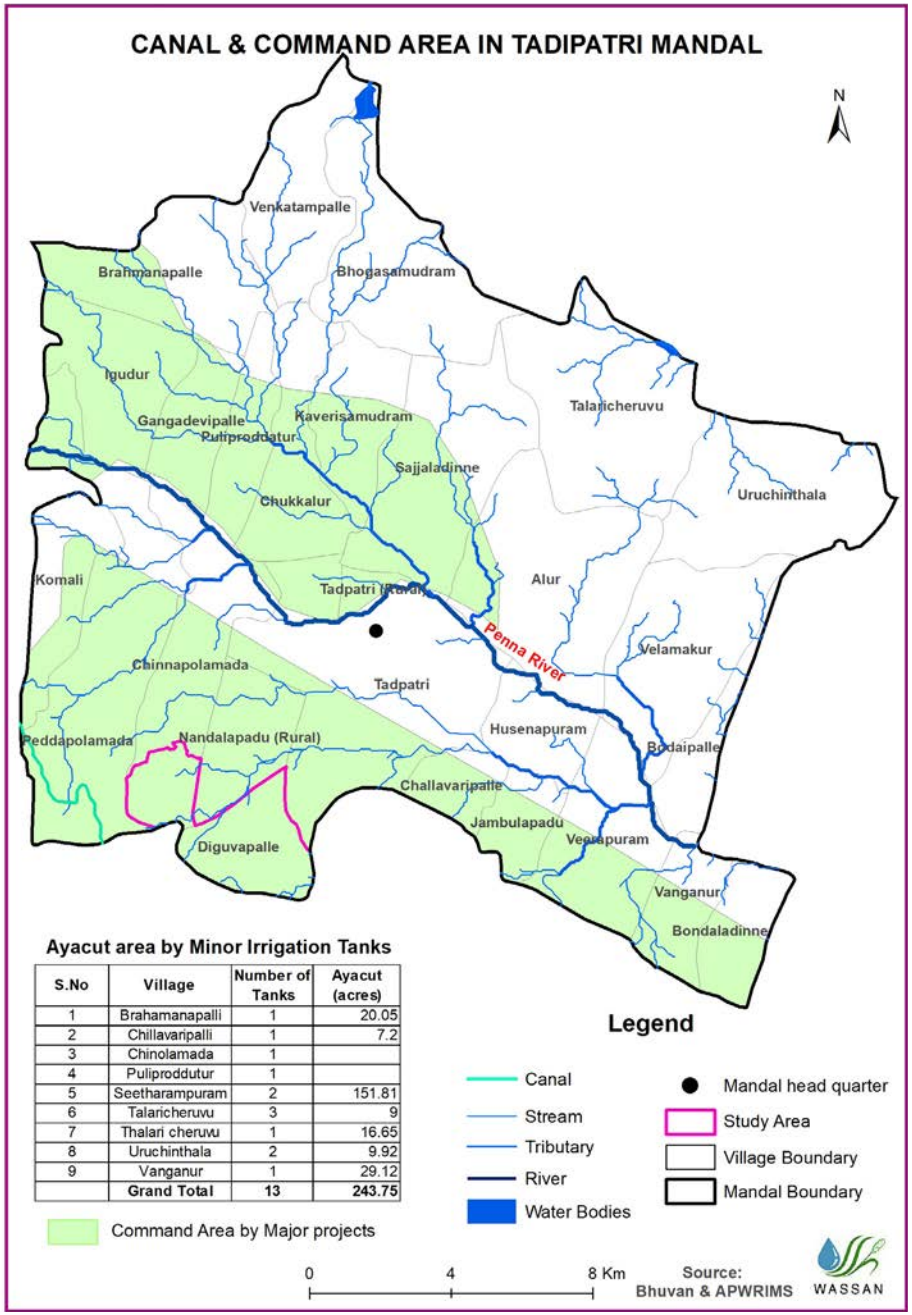


Figure 14. Groundwater status in 2019–2020 in Bathalapalli mandal. Source: CGWB (2022). Figure recreated by Sudharsan Maliappan.

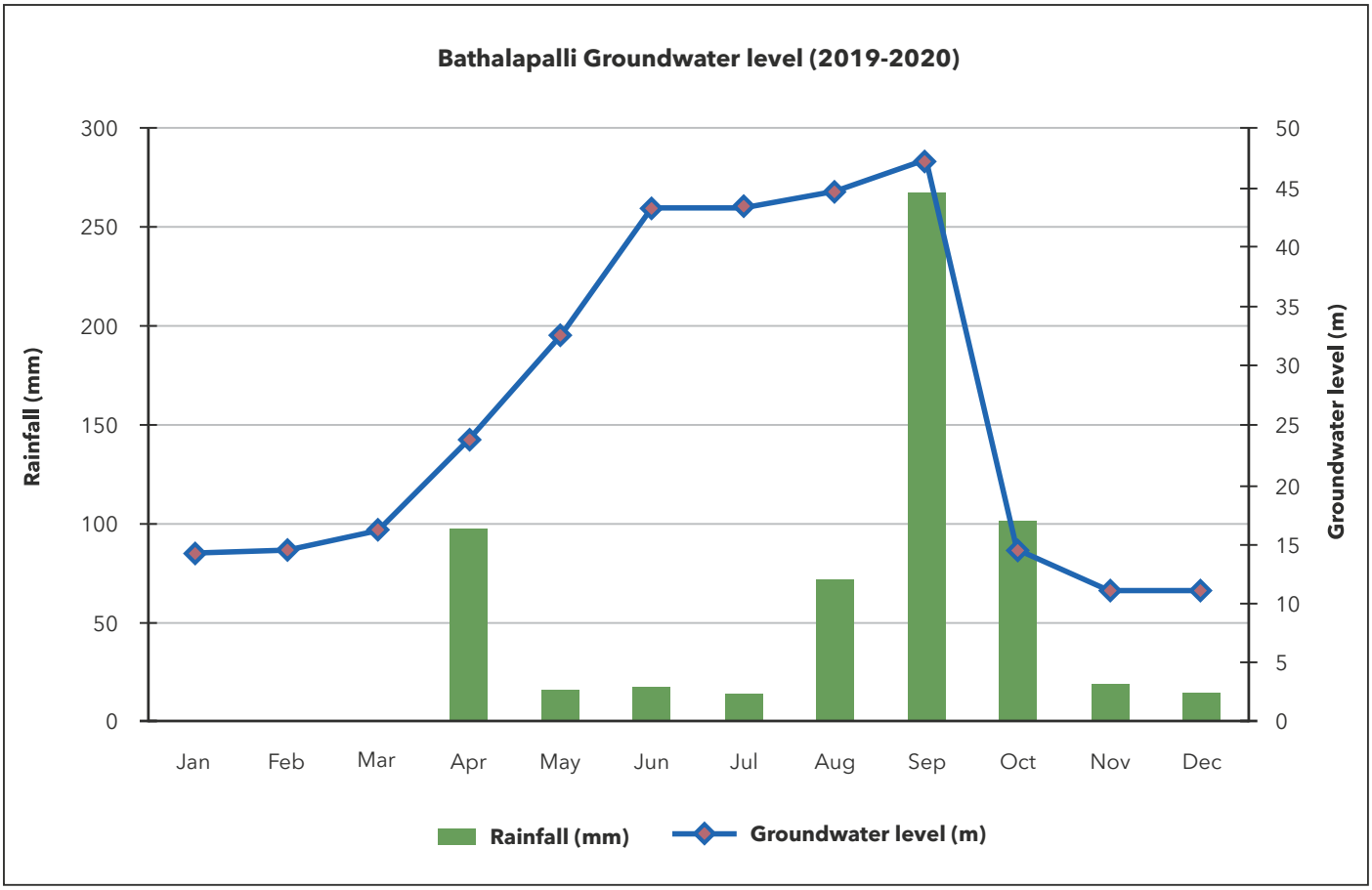


Figure 15. Groundwater status in 2019-20 in Tadipatri mandal. Source: CGWB (2022). Figure recreated by Sudharsan Maliappan.

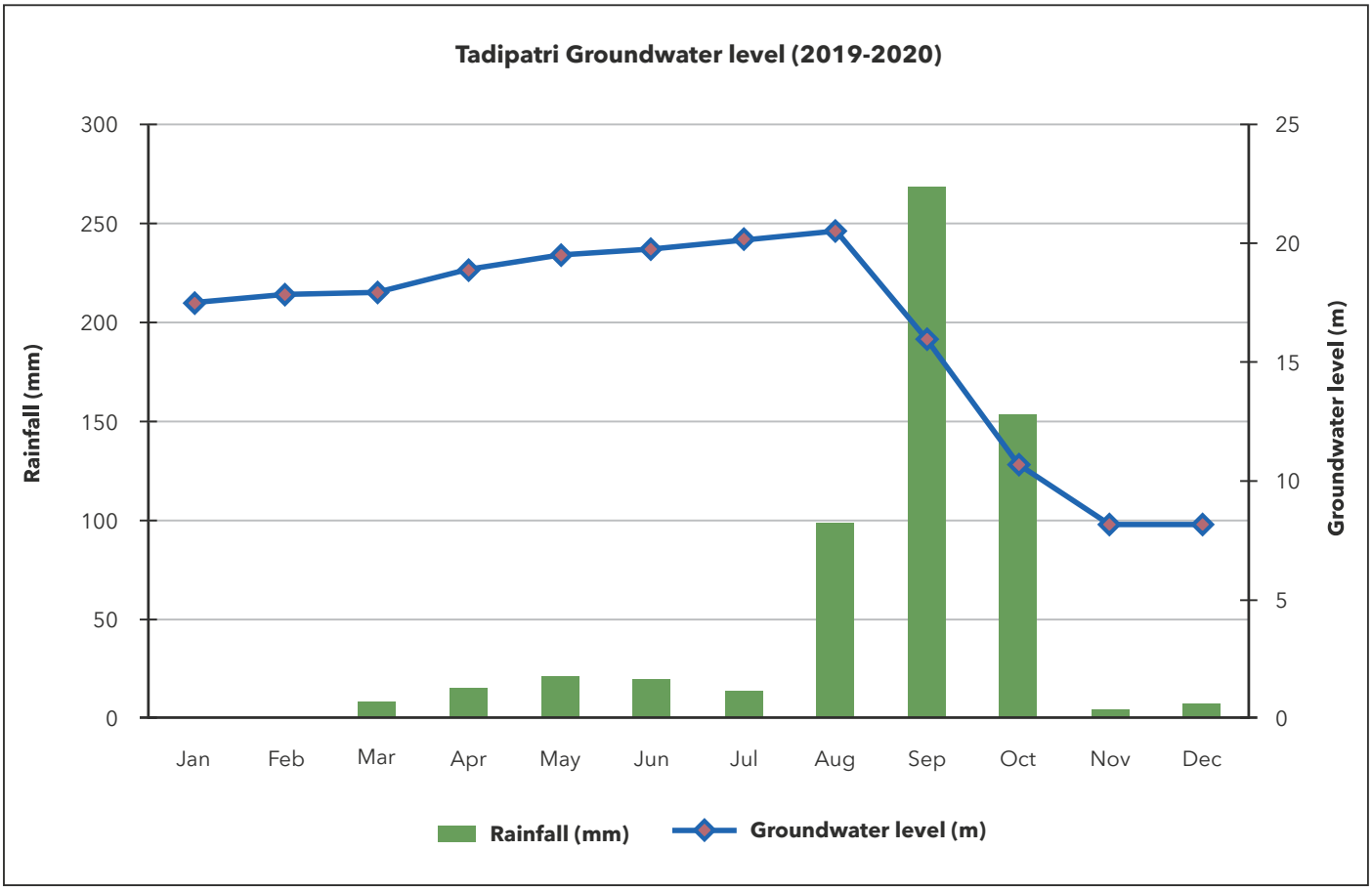


Table 9: Groundwater status and rainfall across the year in 2019–2020 in Bathalapalli and Tadipatri mandals

Tadipatri groundwater level 2019–2020		
Month	GW level (m)	Rainfall (mm)
Jan	17.5	0.7
Feb	17.9	0.0
Mar	18.0	8.4
Apr	18.9	15.4
May	19.5	21.1
Jun	19.8	19.5
Jul	20.2	13.5
Aug	20.5	99.2
Sep	16.0	269.2
Oct	10.7	152.9
Nov	8.2	4.6
Dec	8.2	7.6

Bathalapalli groundwater level 2019–2020		
Month	GW level (m)	Rainfall (mm)
Jan	14.2	0.2
Feb	14.6	0
Mar	16.2	1.1
Apr	23.8	98.0
May	32.7	16.3
Jun	43.3	18.4
Jul	43.4	14.2
Aug	44.7	72.0
Sep	47.3	267.1
Oct	14.6	101.6
Nov	11.2	19.3
Dec	11.3	15.2

The September-October rainfall fills up the aquifers while the groundwater level falls rapidly from December-January onward due to high amounts of extraction through borewells. Both mandals have similar rainfall patterns but, since Tadipatri is composed of plain black soils adjoining the Pennar River, the groundwater is relatively shallow.

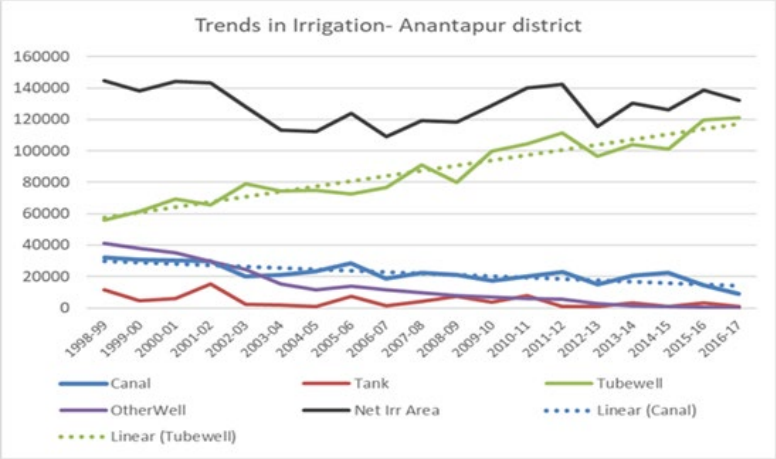
The groundwater status and quality in the two ALLs are summarized in Table 10.

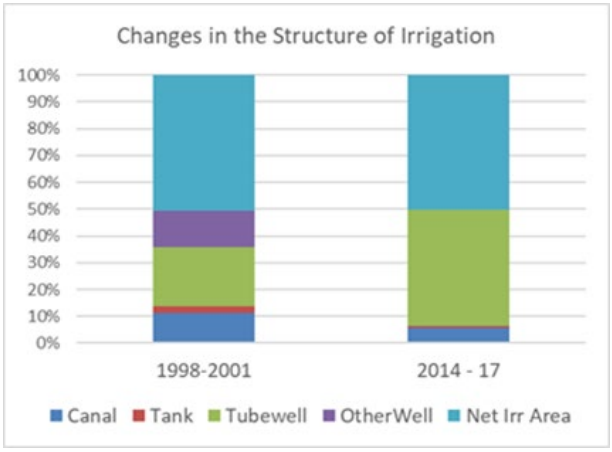
Table 10: Summary of groundwater status in the two ALLs

Sl. no.	Parameters	Bathalapalli	Tadipatri
1	**Basic rock**	Hard rock (Granite Gneiss) and found dolomite dikes in the block	Semi-consolidated Shale Cuddappa stone
2	**Porosity**	Medium (secondary porosity developed 6 to 9 meters weathered and horizontal and vertical fractures)	High (less than 3 meters weathered rock, horizontal fractures and minor vertical fractures)
3	**Aquifers**	Deep aquifers are in use with boreholes. Shallow aquifers are dried up (multiple aquifers present).	Deep aquifers are in use with boreholes. Shallow aquifers are dried up (multiple aquifers present).
4	**GW development status**	Safe	Safe
5	**Yield**	Medium	Low

Gross and net irrigated area

Figure 16. Trends in irrigation in Anantapur District. Recreated by WASSAN





Anantapur District has witnessed a steep rise in tubewell/borewell irrigation since 2000 (Figure 16). High investments in borewell irrigation along with declining groundwater resources have been a major cause for farmers' distress. The situation might change to some extent with the advent of the Handri-Neeva project. Mandal-wise, source-wise, and season-wise gross area irrigated, 2019–2020, is provided in Table 11, showing that the dependence on tubewells is high in the region.

Table 11: Mandal-wise, source-wise, and season-wise gross area irrigated, 2019–2020. Source: Directorate of Economics & Statistics, Vijayawada

	Total gross area irrigated (ha)			Area irrigated more than once (ha)			Net area irrigated (ha)			Source of irrigation
	Kharif	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	
Tadipatri	2,611	171	**2,782**	0	12	**12**	2,611	159	**2,770**	Tubewell
Bathalapalli	912	690	**1,602**	0	356	**356**	912	334	**1,246**	Tubewell

At the ALL sites, although some canal command areas are reported, the major source of irrigation is tubewells (Table 12).

Table 12: Minor irrigation census schemes

Mandal	Groundwater					Surface water		Grand total
	Dugwell	**Shallow tubewell**	**Medium tubewell**	**Deep tubewell**	**Total**	**S. flow scheme**	**S. lift scheme**	
Tadpatri	**336**	514	890	648	**2,388**	77	0	**2,465**
Bathalapalli	**234**	114	22	2,073	**2,443**	132	0	**2,598**

The data suggest a predominance of deep tubewells for irrigation; more so in Bathalapalli mandal.

General information about the ecosystem

A more detailed analysis of the ecosystem of the ALL sites will be carried out as the fieldwork starts in the ALLs.

Groundwater management is a major challenge. Although substantial efforts and investments were made on recharge structures, they did not provide a lasting solution as the rates of extraction far exceeded the recharge limits. There is also inequity in access to groundwater. Appropriate governance systems that not only regulate excessive extraction and enable sharing of groundwater for crop-saving irrigation for rainfed farmers are the need and precondition for aquifer recharge.

Promotion of APCNF has addressed the problem of water deficit in cropping systems in this region to some extent. In comparison with conventional farming methods, natural farming has improved soil moisture retention capacity, thus diminishing the usage of water for agriculture while also having the benefit of decreased GHG emissions (Rosenstock et al., 2020) and improvement in the status of soil fauna such as earthworms and other beneficial insects (RySS, personal communication).

Another major issue is managing common lands. As the sheep economy is predominant, regenerating hillocks by establishing social norms will not only help in recharging aquifers but will also benefit small-ruminant farmers as their fodder base improves. Social regulation around commons has been tried by several organizations and networks in Anantapur.

Economic context

Demographic features of the two ALL sites follow.

Table 13 depicts the key demographic variables of the villages Bathalapalli and Raghavampalle in Bathalapalli mandal and Chinnapolamada and Diguvapalle in Tadipatri mandal.

Table 13: Population in ALL villages

Parameter (Andhra Pradesh, India)	Chinnapolamada	Diguvapalle	Bathalapalli	Raghavampalle
Total population	4,181	1,921	12,697	1,043
Number of households	1,053	458	3,251	259
Average household size (4/4.45)	3.97	4.19	3.91	4.03
SC population (16.4%/16.6%)	25%	13%	17%	20%
ST population (5.6%/8.6%)	0%	0%	5%	0%
Female literacy rate (59.15% / 65.46%)	40.44%	41.08%	42.31%	43.40%
Male literacy rate (74.88%/82.14%)	59.56%	58.92%	57.69%	56.60%

Source: *Census (2011)*

Table 14: Agricultural laborers as percentage of population with more than 6 months of work (main workers)

Village (total main workers: females/males)	Chinnapolamada (604/1,048)	Diguvapalle (363/523)	Bathalapalli (1,389/3,032)	Raghavampalle (268/281)	India (in million) (89.35 /273.21)	Andhra Pradesh (in million) (11.57/21.46)
Female agricultural laborers (%) (no.)	53% (321)	81% (295)	32% (448)	43% (115)	35% (30.95)	55% (6.41)
Female cultivators (%) (no.)	5% (30)	8% (29)	20% (274)	53% (142)	26% (22.87)	16% (1.9)
Male agricultural laborers (%) (no.)	25% (267)	39% (204)	20% (601)	40% (111)	20% (55.25)	32% (6.78)
Male cultivators (%) (no.)	20% (214)	40% (209)	18% (551)	55% (155)	27% (73.06)	19% (4.18)

Source: *Census (2011)*

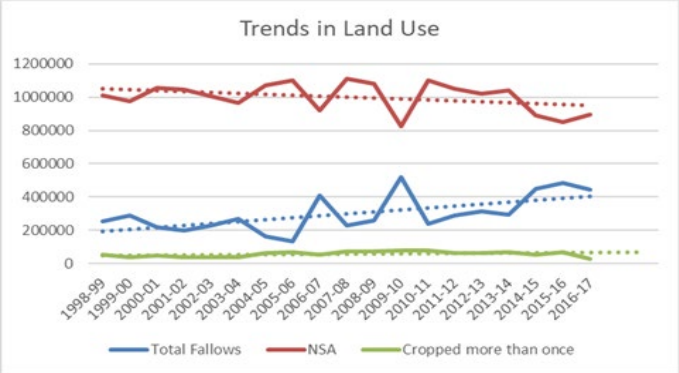
The preponderance of female agricultural laborers among main workers reiterates the feminization of agriculture in India (Table 14). The two villages of Tadipatri have a stark disparity between female and male cultivators, with the percentage of the latter being 4 to 5 times higher.

Key farming systems

Area and major crops

There has been a decline in net sown area (NSA) over the past two decades in the district and the increasing area under fallow lands is striking (Figure 17). The increasing trend in abandoning agriculture/leaving the land fallow is a sign of distress in agriculture.

Figure 17. Trends in land use. Recreated by WASSAN



The net sown area in Anantapur District in 2020–2021 was 0.85 million ha, which forms 45% of the total area (1.9 million ha) (DES, 2020–2021). The total cropped area in the same years was about 0.91 million ha, out of which 6.3% was sown more than once.

Dominance of monocropping

Anantapur traditionally used to have diversified crop systems in its rainfed areas before groundnut became the dominant monocrop. The diverse multi-crop system (termed *Navadhanya*) uses 5 to 10 crops (one-time sowing) with multiple harvests over the two seasons; it covers soil from June to February or March. This method uses the bimodal rainfall effectively and harvests crops beyond the monsoon crop season. The mixed farming system (Figure 18), common in the past, facilitated harvesting the rainfall and allowing for percolation into the soil profile by retaining ground covering for a large part of the year. However, by the early 1980s, there was a shift to groundnut monocrop (promoting high-yielding varieties of groundnut, which led to an increase in its area from 18% in 1960 to 74% in 2005), which decreased dependency on mixed farming systems that included millets and pulses for household consumption in addition to depriving soils of biomass. However, because of repeated droughts and groundnut crop failures, there was a slight increase in crop diversification in some areas (Accion Fraternia Ecology Centre, 2017). The government has also recognized the importance of millets as a climate-friendly crop and initiated steps to revive millet cultivation (Hemalatha, 2017). Nearly 4.6% of the area is under millets such as jowar, bajra, and ragi (Directorate of Economics and Statistics., 2020). And, from 80% to 90% of the millet seeds are farmer-saved (Reddy, 2006).

Rice is the main crop where surface irrigation is available (i.e., in tank irrigation systems and even under borewells). Promotion of subsidized sprinkler and drip irrigation systems by the government has increased the area under irrigated horticulture while the focus on mango orchard promotion under the MGNREGS has increased the area under orchards.

Figure 18. Diverse vs. monocropping systems. ©WASSAN

Mixed farming methods

Typical of the drylands with substantial common grazing land (with the private current fallows and postharvest fallows also used as common grazing lands), the small-ruminant economy has increased substantially. Groundnut haulms available at scale also supported small-ruminant expansion, mostly of sheep. Recent years have seen a shift from animal draft power to mechanization, thus decreasing the dependence on bullocks substantially over time.

These mixed farming methods, as compared to systems involving crop production alone, provide income stability, especially during drought years (Gopinath et al., 2012). Various initiatives such as National Innovations on Climate-Resilient Agriculture (NICRA) and Rainfed Area Development (RAD) and policy interventions such as the Mahatma Gandhi National Rural Employment Guarantee Act and Zero Budget Natural Farming (ZBNF) in Andhra Pradesh have enhanced the uptake of climate-smart agricultural practices (Vincent & Balasubramani, 2019). The district has also taken up community-managed seed systems (CMSS) in a big way, for which the Agriculture Department partnered with farmers' producer organizations (FPOs) in establishing seed systems centered in groundnut. Efforts to revive the *Navadhanya* system by subsidized distribution of multi-crop seeds as a package were also taken up at scale facilitated by WASSAN (Watershed Support Services and Activities Network), an NGO active in the region (also our project implementing partner).

Natural farming promoted by the APCNF project

The major driver for crop diversification and movement toward agroecology methods is the APCNF program promoting "natural farming," a term used synonymously with agroecology. Based on an extension model centered in community organizations and practicing farmers serving as extension agents, APCNF is spearheading a major agroecological movement in the district. APCNF promotes the following natural farming principles:

1. Cover soil with crops 365 days (living root principle).
2. Use diverse crops (15–20 crops), including trees.
3. Keep the soil covered with crop residues whenever living plants are absent.
4. Minimally disturb soil.
5. Use indigenous seed.
6. Integrate animals into farming.
7. Use bio-stimulants as necessary catalyst.
8. Manage pests through better agronomic practices and botanical extracts.
9. Do not use synthetic fertilizers, pesticides, herbicides, and weedicides.

To the above principles, a recent addition is pre-monsoon dry sowing (PMDS). A package of practices is evolving around these principles that are promoted across the district and state by farmer resource persons.

The selected clusters (Figure 19) have good social capital in terms of organizing women into self-help groups. There are a total of 107 SHGs from among the 872 households in the two clusters, with 40 and 67 SHGs, respectively, in Bathalapalli and Tadipatri mandals (Table 15).

Figure 19. Distribution of farmers as classified by APCNF, recreated by WASSAN

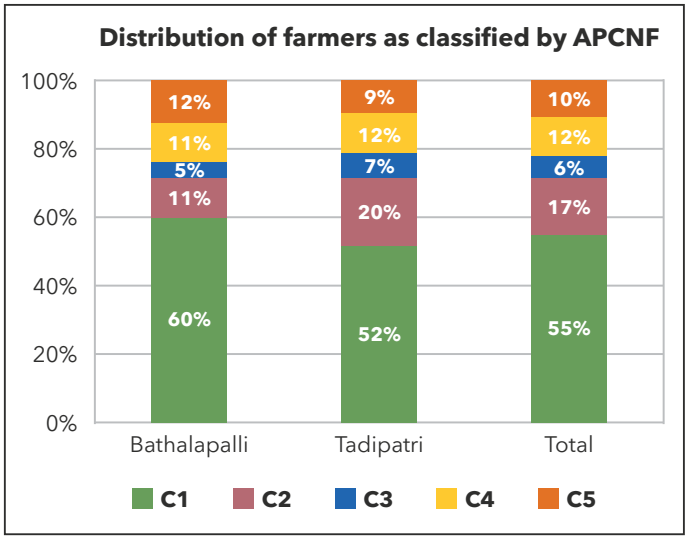


Table 15: Spread of the APCNF program in the ALL villages. Source: MIS of APCNF (Anantapur)

Location	Total SHGs	Total households	C1	C2	C3	C4	C5	Total members	Lead farmers	ICRPs	Master farmers
Bathalapalli	**40**	**329**	**260**	**49**	**20**	**49**	**53**	**431**	**3**	**2**	**5**
Bathalapalli	25	174	134	30	10	23	21	218	2	1	3
Raghavampalle	15	155	126	19	10	26	32	213	1	1	2
Coverage of farmers			60%	11%	5%	11%	12%	100%			
Tadipatri	**67**	**543**	**357**	**137**	**49**	**82**	**64**	**689**	**4**	**2**	**6**
Chinnapolamada	48	413	265	101	47	57	32	502	3	2	5
Diguvapalle	19	130	92	36	2	25	32	187	1	0	1
Coverage of farmers			52%	20%	7%	12%	9%	100%			
Grand total	**107**	**872**	**617**	**186**	**69**	**131**	**117**	**1,120**	**7**	**4**	**11**

Note: *C1: farmers practicing natural farming (NF); C2: farmers who have just started/are willing to practice; C3: farmers still working as chemical farmers; C4: non-cultivating farmers; C5: agricultural labor/landless. ICRPs = internal community resource persons*

Major agricultural commodities and livestock

Major crops

In terms of area, the major crops grown in 2019–2020 in the district were groundnut (51%), pulses (25.4%) such as red gram and horse gram, cotton (6.5%), and rice (4.1%) (Figure 20). Season-wise, groundnut is the major kharif crop in red soil under rainfed conditions, covering 60% of the area. Other kharif crops are cotton, red gram, and horse gram. The major rabi crop is gram, covering 56% of the area, followed by other crops such as groundnut (23%), rice (8.7%), and maize (5.4%).

In Tadipatri, jowar and cotton in kharif and Bengal gram in rabi are the major crops according to the district statistics. The cropping intensity is low (Table A1). In comparison, Bathalapalli, with predominant red soils and rainfed geography, has more rainfed crops, with horse gram and groundnut as the predominant crop systems (Table A2).

Livestock

As per the Livestock census 2012, the total livestock population in the district was 4.4 million, including cattle, buffaloes, sheep, goats, pigs, and others (Table A3).

The livestock data suggest a predominance of small ruminants in the livestock economy of both ALL mandals. The current fallows and the higher incidence of single-cropped area and the larger stressed agricultural economy are the enabling factors for the spread of the small-ruminant economy in the region. Table 16 details the livestock population in the two mandals. The poultry population is significant in Tadipatri mandal, mostly due to access to larger markets in Tadipatri Town.

Figure 20. Trends in crop area in Anantapur District. Recreated by WASSAN

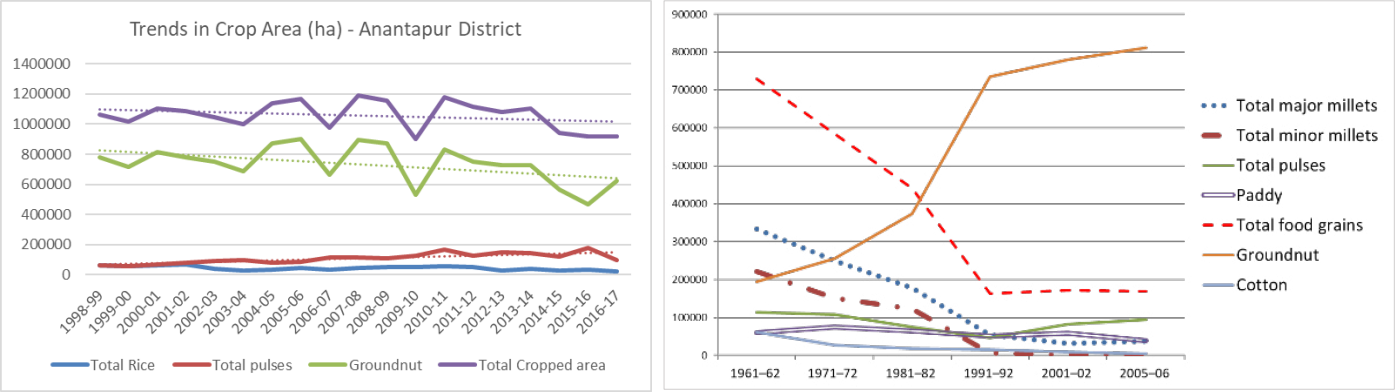
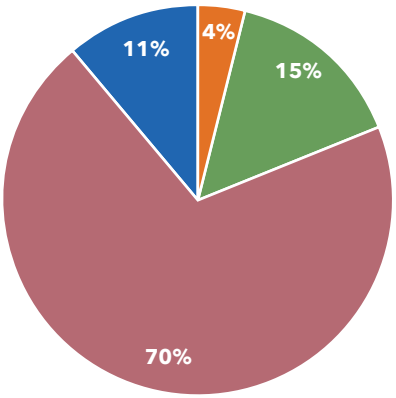
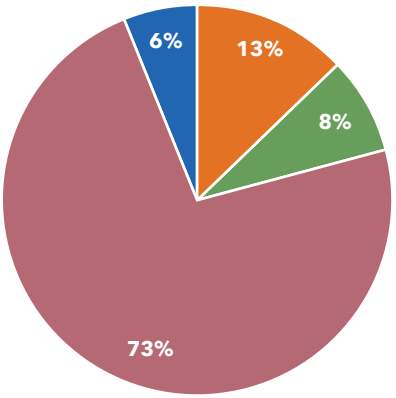


Table 16: Mandal-wise livestock and poultry population, 2012 Census. Source: Directorate of Economics & Statistics, Vijayawada. Figure recreated by Prachi Patil.

Livestock	Tadipatri mandal	Bathalapalli mandal
Cattle	4,421	14,957
Buffaloes	15,073	8,906
Sheep	73,574	82,407
Goats	11,409	6,989
Poultry	35,934	8,834





Tadipatri mandal has a significant dairy economy with more than 15,000 buffaloes, suggesting higher availability of fodder than in Bathalapalli, where the cattle population is predominant for draft and dairy purposes.

Market information for both inputs and outputs

The local market in the village is within a radius of 5–6 km from which basic household and food items can be locally procured from private stores. For others, farmers need to travel to the nearest town, which is within 15–20 km. Anantapur (district market) is 30–50 km away.

Agricultural inputs can also be purchased from local input dealer shops in the village, mandal (block) offices, KVK centers, RBK centers, and PACS located near the villages. Currently, as per official records, about 6,000 PACS are operating in the state, of which 286 are in Anantapur District (Cooperative Dept., AP). The state also has a very active network of more than 7,000 private input dealers (Gupta et al., 2020). At the district level, about 500 outlets are selling fertilizer, close to 1,000 are selling seeds, and about 700 shops are selling pesticide (National Bank for Agriculture and Rural Development, 2020).

Farmers usually sell their produce in local markets or at the farm gate. However, in recent times, big private companies have also entered the markets and are focusing on processing and marketing the produce. Anantapur has the strategic advantage of being in proximity to metropolitan areas such as Bengaluru (200–250 km away) and Hyderabad and Chennai (390–430 km away). Market players such as Big Basket, Flipkart, and several others have established procurement centers in Anantapur, which are gradually diversifying into multiple commodities such as millets, pulses, fruits, vegetables, and oilseeds. For transportation of agricultural produce, a well-laid-out system of private trucks and tractors also exists.

Key factors affecting agricultural productivity

The NICRA initiative conducts a vulnerability assessment and identifies climate-vulnerable regions across the country. According to its assessment, a total of 121 are climate-vulnerable districts in India, of which five, including Anantapur, are in Andhra Pradesh. The following are some of the key challenges hampering agricultural productivity in the district.

Extreme climatic events and crop failure

This district's position in the peninsula is such that it cannot reap the benefits of either the northeast or southwest monsoon and it is the second driest region in the country after Jaisalmer (Rajasthan) (APSAC (Andhra Pradesh Space Applications Centre), 2021). This makes the region subject to seasonal droughts. Out of the 8.8 lakh hectares of gross cropped area in 2019–2020, only 19.5% of the area was irrigated, while the rest was rainfed (Directorate of Economics and Statistics., 2020). However, it has also experienced unusually high rainfall in recent years, especially during the vegetative and harvesting stage of the crops. Exposure to drought spells and high intensity off-season rainfall are the major climatic problems that impede food production.

Low groundwater levels

Access to groundwater is aspirational in Anantapur. Competitive digging of borewells in a situation in which the strike rate in successfully accessing a good aquifer is limited and drying up of borewells, which forces further deepening or digging of new borewells, result in draining of capital resources. Even migrant families invest their hard-earned savings in borewells.

According to Malla Reddy, Director of the AF Ecology Centre, it was estimated that, in 2019, the district had about 270,000 borewells against a carrying capacity of 70,000 (RDT, 2019). Some 41% of the irrigated gross cropped area in 2019–2020 was irrigated using groundwater and the rest by other sources such as canals, tanks, etc. (Directorate of Economics and Statistics, 2021). Because of this, there have been several incidents of borewell failures resulting in farmer suicides (Bommakanti, 2021), high indebtedness (Radhakrishna, 2017), and a shrinking number of farmers in the district (The Hindu, 2017). Nonetheless, the government has undertaken various groundwater management activities such as periodic estimation of basin-wise groundwater resources, delineation of potential groundwater zones, water quality monitoring, and special groundwater monitoring using GIS, among others. Currently, out of the total of 63 mandals, the number of mandals categorized as safe in terms of groundwater resources rose from 12 in 2007–2008 to 45 in 2019–2020, which includes both Tadipatri and Bathalapalli in this study (Central Ground Water Board, 2021). There are several initiatives in Anantapur District to encourage farmers to move toward shared groundwater use for extensive life-saving irrigation, such as the Indra Jalprabha Scheme, which involves linking all borewells with a network of pipelines and outlets to ensure availability of water for rainfed crops (Dasgupta, 2016). However, these initiatives too have been a cause for depleting groundwater levels.

Pest attacks

Pest incidence is also high, forcing farmers to rely excessively on chemical pesticides, especially because of the excessive rainfall around the crop's harvesting stage. In 2020, rainfall induced late leaf spot pest attacks in groundnut because of water stagnation and this caused massive yield loss (Susarla, 2020). Excess rainfall during the vegetative period and harvesting stage leads to low groundnut yield. The postharvested dried-up groundnut is usually used as fodder for livestock, which become affected because of fungal infections. So, steps in the early identification of the fungus and proper field management might help in mitigating this problem.

Monocropping

Groundnut monocropping increased farming risk. Crop failure due to drought spells leaves farmers without any income and investment made on the crop is lost.

Agricultural financing

The district has had several traditional sources of credit and savings such as commercial banks, regional rural banks, and cooperative banks. As of 2020–2021, the banking network consisted of 26 commercial banks, one regional rural bank (Sree Anantha Grameen Bank), one district central cooperative bank (Ananthapuramu DCCB), and AP State Financial Corporation, with 330, 123, 28, and 1 branch, respectively. Of the total of 481 branches, 184 are rural branches, 121 are semi-urban, and 176 are urban. Along with banks, 120 PACS play a huge role in financial inclusion (National Bank for Agriculture and Rural Development, 2020).

However, the bank-linked SHG-based microfinance program has been identified as a major source of lending and saving in the state (and district). Among all the states in India, Andhra Pradesh is the third largest in terms of number of SHGs (8.2 lakh), after Bihar (9.9 lakh) and West Bengal (9 lakh) (Rafi et al., 2021). There are three broad models of this method: (1) banks provide loans to SHGs, (2) NGOs form an SHG and obtain loans for them from banks, and (3) NGOs act as both facilitators and microfinance intermediaries (Madineni, 2013). This linkage has synthesized formal institutes with informal institutes.

SHG-bank linkages are well established in Andhra Pradesh. SHGs provide loans to their members internally at low interest rates at 8–12% per annum. The government provides an interest subvention if the SHGs repay the loans taken from the banks in time, and these loans come at a much-reduced rate of interest. The SHG loans are mostly taken for daily needs, special needs of health/marriage/education, or purchase of inputs. By the end of 2019–2020, about 65,000 SHGs were credit linked and an amount of INR 184 million was loaned. As per RBI guidelines, commercial banks provide loans to SHGs at 7% interest rate (RBI). These SHGs then extend these loans to their members at an interest rate of 12% per annum (Rafi et al., 2021).

A major issue with credit is the annual cycle of credit. In an environment where droughts are frequent, farmers become easily indebted. Many of the crop loans are often "recycled," that is, used to pay old debts, thus pushing farmers to approach the interlocked credit markets. Many of the input loans are taken from the input dealers who also sell chemical inputs.

Financial education of farmers

Information needs to be collected.

Land tenure situation

Operational holdings

In 2015–2016, there were 0.77 million operational holdings in Anantapur, of which 72% were under marginal (0.5–1.0 ha) and small farmers (1–2 ha), 23% under semi-medium farmers (2–4 ha), and the rest under medium to large farmers (Directorate of Economics and Statistics, 2016). Average landholding in the district is 1.75 ha. Additionally, almost all these 0.77 million operational holdings were wholly owned/self-operated.

Among the two mandals in the ALLs, 74% and 68% of Tadipatri and Bathalapalli farmers, respectively, have landholding size less than 2 ha (Tables 17 and 18). Less than 1% of the farmers have landholding greater than 10 ha in both mandals. Land is relatively more evenly distributed with a low incidence of any high landholdings compared to other regions in general. About 93% of the farmers have 73% of the landholding. While 6% of the farmers hold 27% of the land in Tadipatri, land in Bathalapalli is relatively more equally distributed.

Table 17: Categories of landholding size for Tadipatri mandal

Tadipatri mandal (ha)	No. of farmers	% of farmers	Area (ha)	% Area
Marginal farmers (less than 1 ha)	5,559	41	2,994	13
Small farmers (1–2 ha)	4,485	33	6,502	29
Semi-medium farmers (2–4 ha)	2,577	19	6,879	31
Medium farmers (4–10 ha)	793	6	4,423	20
Large farmers (10 ha & above)	65	0	1,626	7
Total	**13,479**	**100**	**22,424**	**100**

Source: *Directorate of Economics & Statistics, Vijayawada*

Table 18: Categories of landholding size for Bathalapalli mandal

Bathalapalli mandal	No. of farmers	% of farmers	Area (ha)	% Area
Marginal farmers (less than 1 ha)	3,288	30.3	2,032.34	11
Small farmers (1–2 ha)	4,184	38.6	6,206.25	32
Semi-medium farmers (2–4 ha)	2,817	26.0	7,368.84	39
Medium farmers (4–10 ha)	528	4.9	2,841.45	15
Large farmers (10 ha & above)	36	0.3	689.17	4
Total	**10,853**	**100**	**19,138.05**	**100**

Source: *Directorate of Economics & Statistics, Vijayawada*

Tenancy

As per the National Sample Survey Organization's (NSSO) 70th-round survey of land and livestock holdings, the state had about 2.45 million tenant farmers in 2013, of whom 0.63 million were landless (RSV, 2022). The Andhra Pradesh Crop Cultivators' Rights Act was launched in 2019, which provides each tenant with a Crop Cultivator Rights Card (CCRC) and ensures their inclusion in various government benefit programs for farmers, which are otherwise mostly linked with land ownership. However, a recent analysis by RSV shows that, out of the estimated 1.6 million tenants in 2021, only 26% were issued CCRCs. The CCRCs are generally for one season of tenancy. For Anantapur District, this number was even lower: only 2% of the tenants out of 54,000 tenant farmers were issued cards. The success of the act is also diminished by many other factors such as lack of awareness among tenant farmers and lack of consent by the owner farmer, among others (Mohan, 2019; Rythu Swarajya Vedika, 2022).

No primary data are available on the extent of tenancy in the ALL villages. This will be explored in due course.

Farm assets and income

As mentioned earlier, the average landholding is 1.75 ha or 4 acres, which is not very different from the recent interaction of the Agroecology India team with farmers in October 2022. There were about 0.3 million farm implements used in the district such as ploughs, sugarcane crushers, animal carts, water-lifting devices, etc. (Directorate of Economics & Statistics, 2007).

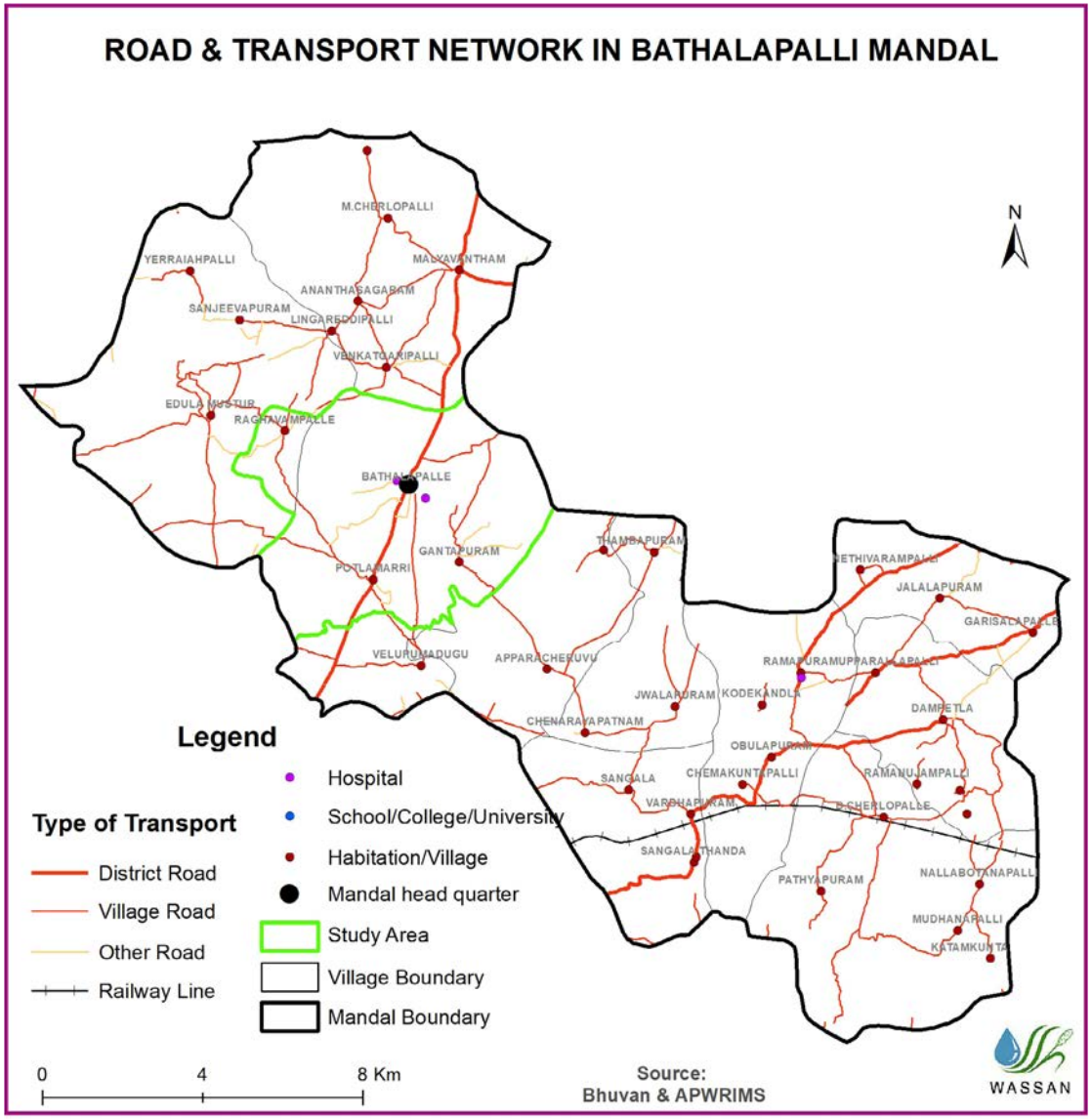
Livestock also play a major role in the district in providing draft power for farming, crop manure, food, meat, milk for household consumption, and industrial raw material. Tractors are available for hiring mainly for ploughing and transportation. Combine harvesters are increasingly taking over the harvesting services, especially for rice.

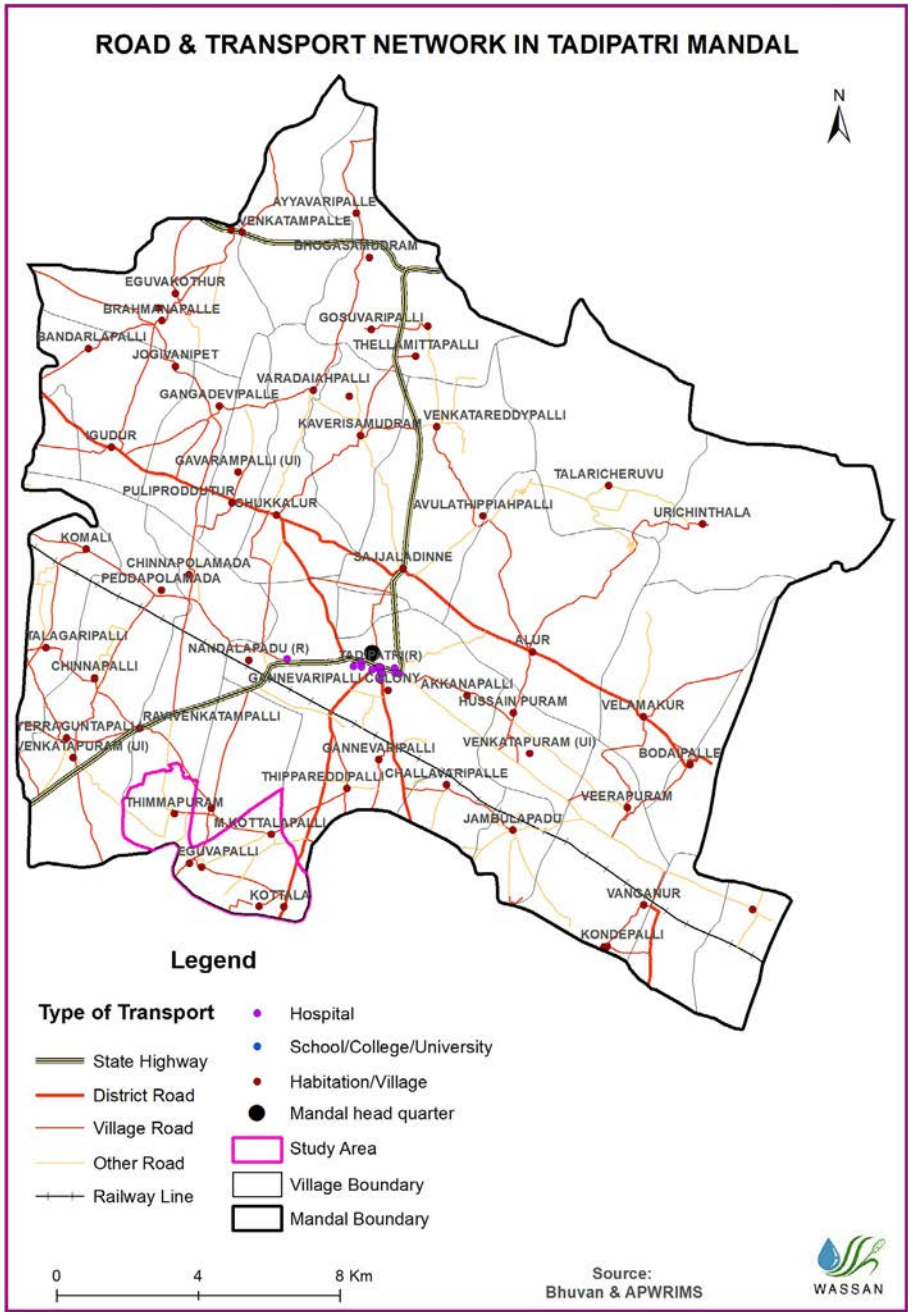
In terms of farm machinery, the district has about 28,000 tractors, 561 power tillers, nearly 4,000 threshers, and about 2.3 lakh agricultural pump sets (National Bank for Agriculture and Rural Development, 2020). As per the fifth minor irrigation census (2013–2014), the district had 8,666 shallow tubewells, of which 89% were owned by farmers belonging to the OBC, 4% by SC/ST, and the rest by others. About 2,500 medium tubewells and 242 deep tubewells were also reported in the district in the same year, of which the majority are again owned by the OBC. Drips and sprinklers have gained substantial spread with the government's subsidized programs.

Supportive infrastructure (roads, electricity, storage, agro-industry, etc.)

Roads

Figure 21. Road and rail network in the two mandals. Source: Bhuvan and APWRIMS. Figure recreated by WASSAN





Tadipatri is a big town while Bathalapalli is an emerging one. Both ALL sites are well connected by roads and highways through transportation by private and government-operated bus services (Figure 21). As mentioned before, the region is well connected to major cities such as Bengaluru in Karnataka and Hyderabad in Telangana. Well-connected railway networks are also present. The smaller "auto rickshaws" are the common means of transportation from villages to the road heads/towns. The nearest town is within 15–20 km. Anantapur (district market) is 30–50 km away. Bangalore is approximately 200–250 km away and Hyderabad is 390–430 km away. The ALL sites are connected to the nearest towns of Bathalapalli and Tadipatri. The areas have access to a rail network within 40–50 km.

Storage

In Bathalapalli Town, a grain storage facility is available, but it is mostly used by traders. The district has 77 godowns, with a capacity of 50,000 MT (PLP, NABARD, 2021–2022). Anantapur District has a few cold storage facilities available, with a storage capacity of 3,000 MT. Information on access to storage facilities at the ALL level will be explored further.

Electricity

As per Census 2011, all 63 mandals in the district reported having access to a power supply. The per capita electricity consumption in 2009–2010 was 90 kw for domestic use and 378 kw for agricultural use (Directorate of Census Operations Andhra Pradesh, 2014). The main source of electricity is hydropower, which is supplied by the government. A few farmers have access to solar power. The region has many windmills and solar panels for harnessing renewable energy. Both ALL sites/villages are connected to the grid with a good electricity supply.

Drinking water sources

Because of the overexploitation of groundwater and excessive reliance on borewells, the district is affected by drinking water shortages (Nagabhushanam, 2019). But the HNSS and Tungabhadra project high-level main canal system (HLMC) are two projects that play a crucial role in providing irrigation and drinking water fed by the Krishna and Tungabhadra rivers (Govt. of Andhra Pradesh, 2016).

The Anantapur Drinking Water Supply Project was taken up by Sri Sathya Sai Central Trust tapping water from various sources and providing piped water supply to 773 villages in the district. The project was handed over to the government in 1997 (Sri Sathya Sai Central Trust, n.d.).

The major source of water is through pipelines connected through either the local grid or overhead tanks (fed by groundwater). Lately, RO plants have proliferated and have become the major source of drinking water. Distinct drinking water markets evolved through these RO plants established as local enterprises.

As per Census 2011, untreated tap water is the main source of drinking water for rural households, followed by treated water. This is in sharp contrast to urban households, in which treated water is the major source for 73% of them (see Table A4 for a full list of sources of drinking water).

Migration situation

Because of concurrent droughts, the region has experienced widespread migration in the past few years. In 2017, about 500,000 farmers were reported to have migrated, which is 10% of the district's population (India Today, 2017). Since returns from agriculture have declined over time, large-scale outmigration of men to cities (Bengaluru, Mumbai, Tirupati, Hyderabad, etc.) has occurred, where they are engaged in poultry, selling pilgrimage materials in Tirupati, papaya transporting and processing, etc. Most of this migration occurs during the lean period after groundnut harvesting and becomes exacerbated because of droughts.

Employment opportunities (on- and off-farm)

Agricultural wage employment is a major source of employment in both ALL mandals. The MGNREGS is a consistent source of part-time employment (Table 19). A total of 0.24 and 0.33 million workdays have been generated in Bathalapalli and Tadipatri, respectively, spending INR 83.2 and 128.4 million in 2019–2020.

Table 19: Implementation of the MGNREGS, 2019–2020

Location	No. of job cards issued	No. of families provided with employment opportunities	No. of workdays generated	Amount spent (INR in lakhs)
Bathalapalli	8,235	4,468	246,762	832.32
Tadipatri	8,251	5,668	333,446	1,284.03
Sri Sathya Sai District	256,609	142,777	8,197,944	25,202.02
Anantapur District	322,678	197,440	333,570	36,951.01

Social context

Household structure and size

A typical household size is 4.2 members. This will be explored in detail in due course. Table 21 provides details regarding the population.

Table 20: Social status

Variables	Rural/ urban/ pooled	Sex	District population (in million)
Population	Total		4.08
		Males	2.06
		Females	2.02
	Rural		2.94
		Males	1.49
		Females	1.45
	Urban		1.15
		Males	0.58
		Females	0.57
Sex ratio	Total		977
(Number of females per 1,000 males)		Rural	971
		Urban	991
Population density (persons/km²)			213
Literates	Total		63.6%
		Males	73%
		Females	54%
Scheduled Castes			14.3%
Scheduled Tribes			3.8%

Source: *District Census Handbook: Anantapur, 2011 (Directorate of Census Operations Andhra Pradesh, 2014)*

Anantapur language: Telugu villages: 1,681; population: 5.286 million.

Anantapur District consists of 31 mandals.

ALL locations selected for the study: Tadipatri and Bathalapalli.

Tadpatri: 28 villages.

Bathalapalli: 11 villages.

Gender relations

The emergence of SHGs and their federations has made a substantial impact on the household gender relationship. Much credit is now accessed by families through the women's SHGs. APCNF and several other government programs have their basis in the women's SHGs. Training and participation in institutional processes has helped women's leadership to evolve over time. Their role in electoral politics has also become substantive. However, the core issues of land titles in the name of women and their equal representation in decision-making and institutions are still to be resolved.

Ethnicity (when there are no barriers to refer to it)

About 89% of the population of Anantapur identifies as Hindus, followed by 10% Muslims. Scheduled Castes and Scheduled Tribes make up 14% and 4% of the population, respectively (Census, 2011). Much of the tribal population was migrants from Lambada community who settled in the district. The Scheduled Caste people (called broadly Dalits) have gained strength over time in the power structure and in the articulation of their interests.

Literacy of farmers and other food system actors in the ALLs

Both ALL sites show poor literacy levels at 68% in Tadipatri and 59% in Bathalapalli (Table 21). Furthermore, the literacy rate among women is even lower than that of men as per the 2011 Census.

Table 21: Literacy status

Mandal	Population literacy	Male literacy rate	Female literacy rate	Gap in male/female literacy rate
Tadipatri	67.89%	77.99%	57.80%	20.19
Bathalapalli	58.70%	68.38%	48.69%	

General health conditions of the ALL population

Figures 22 and 23 present some of the health problems faced by the people in the two mandals.

The district has serious nutritional issues with 40% of the children below 5 years being stunted, 15% wasted and 39% under-weight and 53% have Anemia. Among the women of reproductive age 54% are anaemic and 20% women have BMI less than 18.5 kg/ sq.m. The relation between food systems-crop systems change and ecological degradation and human nutrition will be further explored in due course.

Figure 22. Undernutrition in Anantapur, figure recreated by Smitha Krishnan

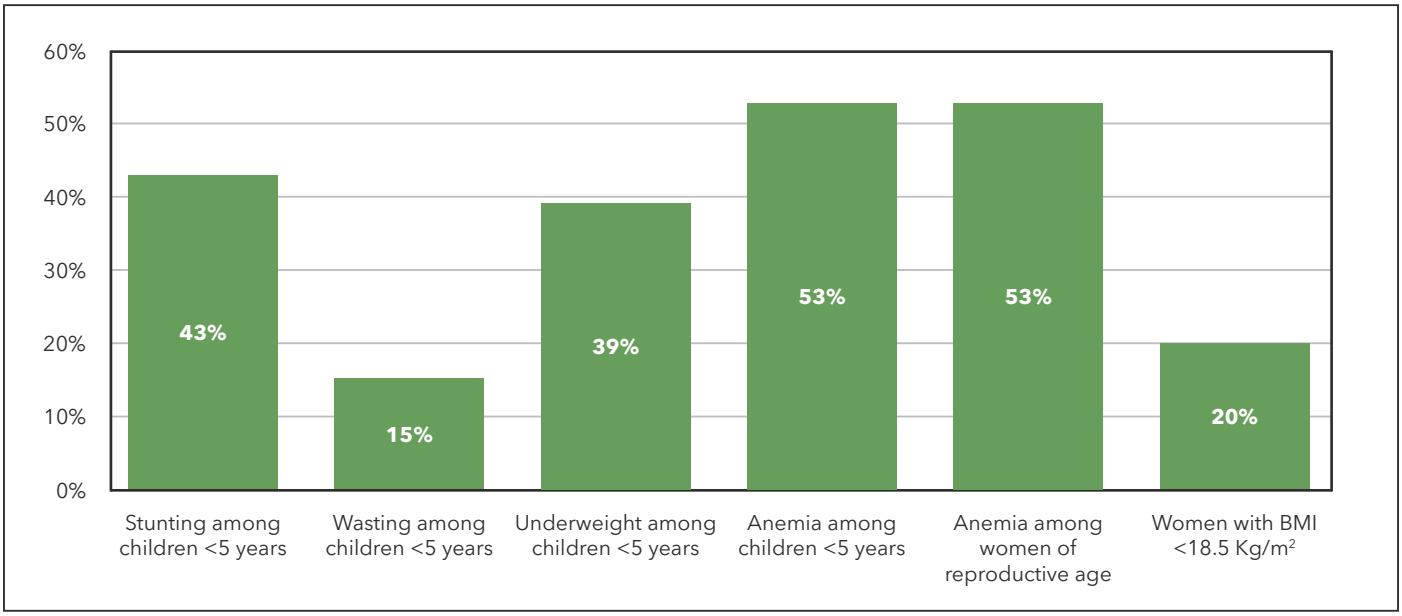
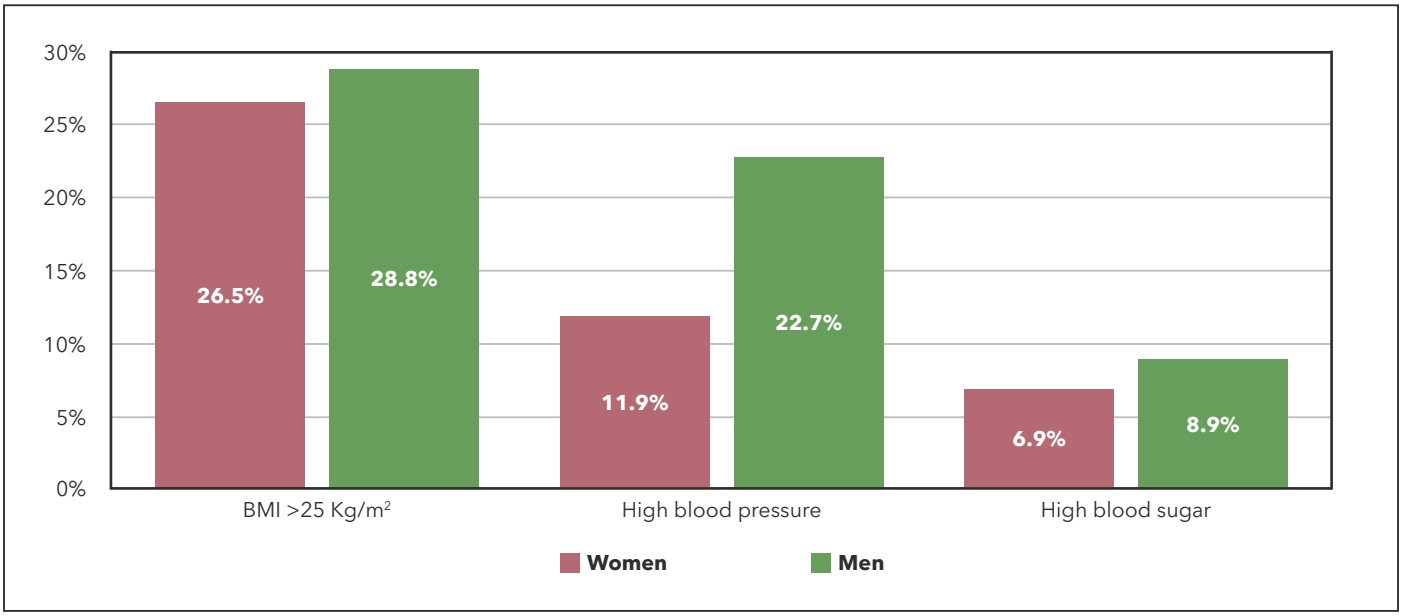


Figure 23. Overweight/ obesity and non-communicable diseases (15-49 years), figure recreated by Smitha Krishnan



Knowledge sharing

The Government of Andhra Pradesh has established two sets of local institutions called *Grama Sachivalayam* and Rythu Bharosa Kendra (RBK) for access to inputs and information. These are intended to be single-window service centers located within a Gram Panchayat.

RBKs provide pre-tested quality inputs (seeds, fertilizer, and pesticide) and government scheme-related services to the farmers' doorstep. They are resourced by placing various technical people from different fields liaisoning with their respective departments.

Traditional links with input dealers are still strong as they offer inputs on credit and market linkages. SHGs and their federations at the village level and *Mandal Mahila Samakhyas* at the mandal level are also important sources of agricultural inputs and information.

Community leadership (in the ALL context)

Information to be collected.

Power relations in the ALL

Information to be collected.

Political context

Background

Political discourse in the Rayalaseema region consisting of Anantapur has historically prioritized regional concerns over debates in national politics. This resonated in the calls for a separate polity for the Rayalaseema rather than a joint state with Coastal regions even as the Andhra Pradesh statehood movement gathered momentum during the 1930s (M. S. Reddy, 2010). Many large farmers in the Rayalaseema region belong to the Reddy community and regularly found a place in the successive governments of Andhra Pradesh after its formation (Roohi, 2020). In 2014, Andhra Pradesh was bifurcated to form another state, Telangana, comprising the 10 northwestern districts of the state. This ultimately led to the distribution of water resources, especially irrigation sources, between the two states (Kumar, 2021).

Agriculture has always been an important concern in national and state elections given the importance of farmers in the vote share as well as national GDP. The Telegu Desam Party (TDP) came into power in 2014 in Andhra Pradesh and was followed by the *Yuvajana Sramika Rythu* (YSR) Congress in 2019. Both these parties have prioritized agriculture and focused on issues such as farmers' indebtedness and land degradation, which ultimately cause farmer suicides and distress migration in the region. The TDP government introduced a direct cash transfer program for all cultivators in the state in 2017, which was later modified by the YSR Congress. Every family is provided with INR 13,500 per year under this, including tenant farmers.

Community representation in politics

Information to be collected.

Local participation in policy-making decisions

Information to be collected.

Women's participation in local leadership

There is a legal provision of 50% reservation for women among members and Sarpanches in Andhra Pradesh and one-third in any constitutional bodies to foster women's leadership. Another important cadre of women are the women who have organized to form SHGs. They collectively help each other to solve their problems and provide support in economic activities as well as access to schemes/benefits, information exchange, etc. SHGs promote small savings among their members. They provide small loans to their members from the common fund. Several activities and access to credit are channeled through SHGs. Bathalapalli mandal has 750 SHGs with 11 members on average. Tadipatri has 1,200 SHGs across 37 Gram Panchayats with a total of 20,000 members. The education levels within the SHGs are low; the challenge is to get more educated younger women into the SHG leadership.

Inclusion of all social groups in political decisions

No such exclusions exist *de jure*. Political decision-making is around voter numbers and allegiance to a particular leader or political party. SHGs and their federations, though, are *apolitical* wields, with a significant political clout as all the political parties will promise some benefits to them to build into their election manifesto. However, the women's groups per se have mixed political membership.

Policies in favor of agroecological transition

Tracing the history of agroecology in the state, we understand that it first began in the early 2000s when farmer suicides were at an all-time high because of high input costs and indebtedness. Most farmers were moving out of agriculture as it was no longer profitable and the government saw agroecology as a means of promoting livelihood security during this time, especially for smallholder farmers, primarily because of its focus on decreasing the cost of cultivation. Women's self-help groups formed through the Society for Elimination of Rural Poverty (SERP) also helped in operationalizing this initiative at the ground level. This helped farmer communities become active participants in improving their condition rather than being passive recipients of development programs. Thus, acceptability for chemical-free agriculture was somewhat achieved in the state (Veluguri et al., 2021), further emphasizing that the nature of power with the executive during this time provided the necessary institutional structure for the adoption of natural farming, and the presence of a political champion with appropriate resources provided a window of opportunity.

Policies hindering agroecological transition

One characteristic feature of the Rayalaseema political landscape is factionalism. Power dynamics within and between the political parties have been detrimental to the implementation of irrigation projects in the region. A lack of consensus among these rival groups has led to stalling of water resource development in the region (Radhakrishna, 2017; Susarla, 2020). However, there are claims from within the government of factionalism having ended.

Current state of agroecological principles in the ALLs

Recycling

Traditionally, there was an integration of agriculture with livestock in the district, but, because of the dominance of monocropping and chemical use, such integration is dwindling. However, some integrated practices are still followed in the region. For instance, groundnut haulms (after removal of the pods) are an important source of fodder for livestock and are even sold to villagers. There is also a practice of stacking biomass from multiple crops (pulses and rice) to balance the diets of animals. However, the spread of combine harvesters for paddy harvesting has a trade-off with using rice straw for fodder.

The practice of community natural farming has also contributed to the recycling of crop residues such as groundnut husks for mulching. The use of animal dung for preparation of manure such as *Ghana Jeevamrutam* (GJ) using fresh cow dung only, GJ using mixed dungs that are fresh or old, and *Drava Jeevamrutam* (DJ) with dung and urine is being promoted. The use of dung and urine from traditional breeds of cattle is preferred for preparing manure and other concoctions. Details of these preparations are in Field Report 1 attached as an Annexure. Traditionally, the crop residues (sorghum, bajra, rice straw, etc.) are spread underneath the cattle as bed material and the residues soaked with dung and urine are dumped into the manure heap or pit for decomposition, after which they are processed and used as manure.

The processing facilities for most of the agricultural produce are distant from the villages. The by-products (husk, bran, shells, etc.) that are useful for livestock feed or for soil are thus not recycled often back into the production landscape. Crop stubble is recycled through open grazing of private lands postharvest by large flocks of sheep and herds of cattle. The dung and urine from the grazing animals are used as fertilizer for the soil. "Penning" (staying with the flock in a particular farmer's field) is traditionally practiced; farmers will also pay for such services.

Moreover, while the stalks of pigeon pea have been used for fuel, the proliferation of LP gas as fuel is significantly decreasing the demand for wood for fuel. Monocrops and pesticides also diminish the availability of greens collected from farms used for cooking.

From 80% to 90 % of the millet seeds are seeds saved by farmers. The seed systems for diverse pulses are mostly informal, and farmers also save seed for the next crop. Native traditional varieties of seeds are promoted under APCNF methods.

Findings of a study carried out by Rosenstock et al. (2022) on crop residue use, nitrogen, and carbon in the residues across APCNF sites in Andhra Pradesh are displayed in Tables 22 and 23.

Table 22: Crop residue use and nitrogen in crop residues across APCNF sites in Andhra Pradesh

			Conventional				APCNF		
Crop	Harvest index	N in residue (g/kg)	Use	% of farmers	Residue (kg/acre)	Residue N (kg/acre)	% of farmers that mulch	Residue (kg/acre)	Residue N (kg/acre)
Bengal gram	0.49	6.5	Removed	60	538	3.5	26	681	4.4
Chillies	0.50	7.6	Burned	44	1,951	14.8	26	2,714	20.6
Cotton	0.30	10.0	Burned	69	2,161	21.6	39	2,324	22.4
Groundnut	0.27	9.7	Removed	78	1,871	18.1	12	2,249	21.8
Maize	0.50	6.0	Livestock	38	5,079	30.5	53	3,481	20.9
Rice	0.40	6.0	Livestock	63	2,813	16.9	21	3,375	20.3

Harvest index and N in residues are based on yield and respondents in the farmers' survey. Conventional use of residues represents the most frequent response among farmers of that crop. For APCNF, the results report only the number of farmers that use mulching recommended by APCNF. Adapted from Rosenstock et al. (2022).

Table 23: Carbon inputs in residue across APCNF sites in Andhra Pradesh. Rosenstock et al. (2022).

	Carbon concentration in residue (kg/t)	Carbon in residue (kg/acre)	
Crop		Conventional	APCNF
Bengal gram	409	220.0	278.5
Chillies	430	838.9	1,167.0
Cotton	510	1,102.1	1,185.2
Groundnut	411	772.3	924.3
Maize	411	2,088.0	1,430.7
Rice	368	1,035.2	1,242.0

Farm ponds were established under the MGNEREGA initiative. Rainwater collected during 3–4 months per year is used for growing crops such as maize, black gram, and green gram. About 30–40% of the farmers have farm ponds. Village-wise data are available in the baseline data report.

Possible interventions

- Establishment of a community seed bank.
- Solar power can be harnessed to generate electricity, which can be used for irrigation, but excess power can contribute to the local domestic carbon credit market, which is being promoted by the government (Pandey, 2023) (*https://bit.ly/3RAXRMh*).
- Possibility to use black soldier flies for kitchen waste management and use of the larvae as poultry feed/fish feed and the compost on the farm.

Input reduction

Type of inputs used for production and how producers acquired such inputs (at a cost or not; generated on-farm or not)

The Agriculture Department has been providing seeds, fertilizer, pesticide, etc., through RBKs. Because of the shortage of farm labor, a wide range of farm operations are being mechanized. The Agricultural Technology Management Agency (ATMA) conducts demonstrations, exposure visits, exhibitions, dissemination of technology, etc., to enhance farmers' capacity. The Southern Region Farm Machinery Training and Testing Institute (SRFMTTI), Anantapur, provides training for the benefit of farmers and tractor users/owners/technicians, etc., on maintenance of various agricultural machinery.

The prevalence of input dealers in credit-interlocked markets is still predominant in the economy but the CNF program has been making substantial progress in decreasing this dependency. Bullocks are used for ploughing traditionally but are now fast being replaced by hiring of tractors. The CNF program encourages zero ploughing but the practice hasn't gained momentum to reach scale. As per the Livestock Census 2012, 1,656 wooden ploughs and 605 steel ploughs were being used in Tadipatri. This is in addition to 1,492 cultivators and 877 seed-cum-fertilizer drills or seed drills. For Bathalapalli, the corresponding numbers are 1,177 wooden ploughs, 1,131 steel ploughs, 1,298 cultivators, and 1,151 seed drills (Government of Andhra Pradesh, 2016).

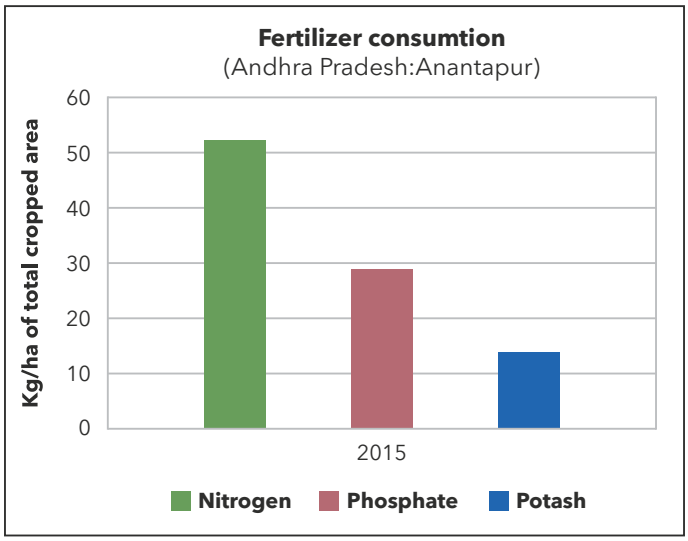
Seed: Groundnut seed is a recurring issue in Anantapur as it is required in bulk quantity (about 70 kg/acre). Crop failures during cyclical droughts leave farmers without adequate seed. The trend of farmers purchasing seed from the market is increasing. The government distributes groundnut seed with a subsidy every year, on the order of 2.0 to 3.0 lakh quintals

for the district. This is supplied through the AP State Seed Corporation, which procures seed from various locations in the state. The Community-Managed Seed Systems (CMSS) program was tried by the department in the region. CMSS is owned by farmers of FPOs and aims to ensure a timely supply of good-quality seeds at affordable prices in rainfed areas by institutionalizing the process of production, processing, procurement, and distribution of subsidized seeds to eligible farmers (Planning Department, 2022; WASSAN, 2022). Most of the vegetable seeds are hybrids purchased from the market. The seed systems for diverse pulses are mostly informal and farmers also save seed for the next crop. Rice seed is also mostly purchased from local markets.

Weeding: Family labor is common when landholding is small, while hired labor is used for medium to large landholdings. A decrease in weeds is observed for CNF farmers who practice live mulching. The lack of availability of labor and increasing costs drive the spread of weedicides, which is a major challenge for the CNF program.

Fertilizer: Cow dung in the form of farmyard manure (FYM) is usually applied on fields in rotation across farm plots as it is a scarce resource. Farmers often use DAP/complex fertilizers. Figure 24 represents fertilizer consumption in terms of the primary macronutrients: nitrogen, phosphate, and potash.

Figure 24. Fertilizer consumption in terms of primary macronutrients nitrogen, phosphate, and potash. Source: ICRISAT (2020)



A study by Rosenstock et al. (2022) reported that conventional farmers (Table 25) use more than 60 different pesticides, including insecticides, fungicides, and herbicides, and procure them from local traders.

Table 24: Percent of farmers by land holdings in the ALLs

Farmer type	Tadipatri	Bathalapalli
Marginal farmer (less than 1 ha)	41.24%	30.29%
Small farmer (1–2 ha)	33.27%	38.55%
Semi-medium farmer (2–4 ha)	19.11%	25.95%
Medium farmer (4–10 ha)	5.88%	4.86%
Large farmer (10 ha and above)	0.48%	0.33%
Total farmers	13,479	10,853

Source: *District Handbook, Anantapuramu (2020)*

Water: Small and medium farmers predominate. More than farm size, access to irrigation is a major differentiator in cropping decisions. Free electricity for pumping in addition to subsidized micro-irrigation equipment and subsidies in horticulture have helped medium to large farmers to gain access to irrigation and adopt irrigated horticulture. Banana plantations with drips as islands in parched dryland landscapes are gradually increasing.

There is an increasing tendency to leave the rainfed uplands fallow, particularly with medium to large farmers. The CNF program has a component to bring these lands into cultivation by facilitating land leasing by marginal or landless farmers. This is an important facet in improving the landscape ecosystem.

The CNF program has been promoting multi-species plantations through a five-layer model in which diverse plantations (in accordance with the canopy) are planned in a plot integrated with vegetable production in the last layer. As these are investment heavy, the spread is slow.

Limitations and options available to farmers to decrease dependence on synthetic fertilizers and pesticides

Farmers who follow CNF use dung and urine as farm inputs for fertilization, preparing manure as described previously. However, since the farmers function as a community, substantial inter-familial exchange and support among each other occur. Farmers who have a deficit procure the manure preparations from other farmers. Some SHG members sell herbal preparations that are used in pest control. CNF also uses locally available inputs. As described above, crop residue is used as mulch to increase organic content and thereby the moisture holding capacity of the soil.

CNF has moved the focus from vermicomposting and other external inputs to *in situ* regeneration of soil health through a package of measures such as using bio-inoculants, covering the soil for longer periods with live crops (called live mulch) to decrease exposure to sun, and applying *Ghana Jeevamrutam*, a dense nutrient value addition, to dung locally prepared.

An innovation by WASSAN on automating a scale-unit of GJ preparation by a grid of pipelines connecting the cattle sheds and automating the fermentation process is spreading slowly to make it available in large quantities for sale as a community enterprise. This method also decreases the labor involved in preparing the input.

Promotion of non-pesticidal management shops set up within the villages is meant for making the alternative inputs for pest and disease control easily available within the villages. Although several botanical extracts for pest and disease control are prepared and sold in such shops, they are yet to gain commercial momentum. The multi-cropping system followed in CNF diminishes incidences of pests and diseases and thus the need for pesticides.

Water use for production in irrigated production systems and an inventory of various techniques used for irrigation

Rainfed farms account for about 70%, while 30% are irrigated (borewell). Availability of water for pumping in surface water bodies is rather limited. Borewells are approximately 300 m apart, fixed with a pump of 5.0 to 7.5 hp in capacity, depending on borewell yield. One can see the solarization of these borewells dotting the landscape mainly promoted through subsidized schemes.

Soil and water conservation structures now have good coverage with the watershed development and MGNREGS schemes taken up over the past two decades. There is substantial proliferation of micro-irrigation for borewells with subsidized schemes. A majority of the CNF farmers use drip irrigation to maximize the utility of water given that the region is highly water deficient. Private borewells and competitive extraction and expansion of irrigation area result in islands of intensively irrigated areas even when rainfed farms suffer from drought spells for want of one or two life-saving irrigations. A large campaign on protecting rainfed areas from drought spells was once taken up in the district but is no longer the case. Accion Fraternia Ecology Centre also promoted life-saving irrigation for rainfed crops using water tankers and thus bringing mobility to water usage. The tank irrigation systems went through a phase of participatory irrigation management and two dedicated schemes were taken up for revival of the tank irrigation systems. Many of the tanks' sluices are closed to retain water in the tank to allow for groundwater recharge.

Inventory of water retention techniques that enhance water availability in production systems and decrease the frequency of irrigation, without significant impact on ecosystem services

- Farm ponds are used for rainwater harvesting but retain water only during the monsoon periods. A larger effort at low-cost lining of farm ponds was promoted by AFEC using earth and cement in a ratio of 6:1. Watershed development projects and MGNREGS cover most of the district intensely.

- Pre-monsoon dry sowing (PMDS) is a system of tilling, sowing, and tending the land, wherein farmers grow crops in the non-farming season or whenever there is no crop cover on the land. This is mainly before the advent of monsoon during summers. In addition, it is being taken up after the kharif crop in rainfed situations and in irrigated lands the dry-sowing crop is being grown after the harvest of the rabi crop. The principle is that all agricultural lands should always be covered with diverse crops. There are special natural farming protocols to be undertaken from land preparation to sowing to farm maintaining post-sowing to ensure seed germination and crop growth. This ensures that soil fertility increases. This also results in higher yields of the main crops. This technique decreases farmers' dependency on rain and is being explored as a solution for drought-proofing in regions such as Rayalaseema. Intercropping, seed pelletization, and other methodologies followed ensure soil moisture retention. Soil organic carbon increases within a short duration because of maintenance of year-round green cover. This

also decreases the risk of flood and erosion. Natural farming through PMDS enables soil aggregation through fungal hyphae, bacteria, and root exudates coming together and thus making the soil more porous and permeable. With more than 300,000 farmers practicing PMDS and with lessons from the past five years, year-round green cover has become a crucial element in the success of natural farming. (Source – APCNF transformation team).

- Mulching. Groundnut shells and all crop residues after crop harvest are used as mulch. The foliage of trees such as *Pongamia* is also used for mulching.
- Multi-crop systems with PMDS as a precursor harvest a large part of rains in the soil profile and green biomass, lower soil temperature, and increase soil biomass. Desiccation of organic matter due to high temperature is a major problem. Soil cover with live biomass significantly decreases soil temperature. This is an indigenous system practiced in Anantapur but it has given way to monocrops.

Sources of energy used at the farm level

Less than 1% of the farmers having access to irrigation use solar irrigation installed through subsidized schemes. Others use the general grid power supplied by the government, which is available free of cost. The larger solar energy plant (discussed in the section on Other natural resources) setups supply electricity to the grid. Much of the farm mechanization uses diesel as fuel. Draft animal power usage is significant even now, although on a declining trend with the steep increase in the prices of bullocks and lack of viability for farmers to manage them. Hire services of draft animal power are increasing.

Substitution of fossil energy by renewable energy on-farm (e.g., solar panels)

The potential to use solar energy for operating pumps for electricity is low without heavy subsidies. Continued deepening of borewells to access the dwindling groundwater resources requires an increasing energy load for pumping that makes solar irrigation unviable. Also, the solar infrastructure is usually used for only a limited number of days for pumping, thus limiting its effective usage. As water bodies are dispersed, seasonal wells and borewells being distant from the dwelling require a different way of using/packaging solar energy modules. A mobile Energy Cart driven by bullocks was tried out by WASSAN recently to provide energy for pumping from dispersed water bodies.

In rainfed conditions, livestock are used for farming operations and a tractor is used for land preparation. Weeding and inter-cultivation are mostly done by bullocks or manual labor.

Possible interventions

- Currently, banana cultivation is using huge amounts of precious water in this water-scarce landscape. The introduction of drought-tolerant banana varieties might be an option to consider.
- For horticulture crops, we are developing a D4R tool for them in India. This can be developed for arid to semi-arid regions, which will include Anantapur. If other priority objectives exist, they can be included in the tool, for example, for erosion control, fodder, fruit trees to address nutrition, etc. See https://www.diversityforrestoration.org/tool.php. (Check the tab Burkina Faso. This tool is already functional for Burkina Faso and Peru and is being developed for India.) By choosing the right kind of crops (trees), one can also decrease the input required to manage such farms.
- Use solar power for irrigation and connect the existing solar panels to the general grid to upload excess unused solar energy in exchange for revenue (as described in the recycle principle).

Soil health

Existing practices to maintain soil organic matter

Sheep are allowed to graze on farmlands postharvest (i.e., from December to May). Their droppings are retained on the field. Additionally, any available organic waste is added to the soil along with the dung and urine. Excess cow dung collected from the cattle shed that is not used in the preparation of inoculants is added to the farm and cattle urine is sprayed. Ground cover maintained for 365 days a year in PMDS and CNF methods decreases erosion and increases soil organic matter.

Estimate of fires, grazing, and compaction

Burning of crop residues in the case of rice is not a prevalent practice in the district. But, in cotton and pigeon pea crops, the stalks are removed during land preparation and burned. Shredding of this biomass and using it for mulch could be an option, but its economic viability in an already stressed agricultural economy is the question.

The increasing usage of tractors and proliferation of combine harvesters further lead to compaction of soils. A recent initiative of APCNF to obtain bullocks in the Goshala (cattle camp) of Tirumala Tirupati Devasthanam, a temple trust distributed to farmers free of cost, is a move to bring back bullocks into the farming system.

Animal grazing postharvest, though, is an irritant for expanding crops to the rabi season, which positively contributes to nutrient recycling at the landscape level in addition to bringing biomass into commons. Institutional and economic systems that help individual households to spend time on grazing animals and their off-season maintenance can be a strategy to bring animals back into the farming system.

Farming practices to enhance and protect soil health

In the past, when farmers were following conventional practices, rainfed crop lands were fallow after kharif (monsoon crops) until the following rainy season. Since the involvement of RySS, farmers have adopted the *Navadhanya* method, which involves one-time sowing of multiple crops (15 to 20 varieties with a combination of cereals, pulses, oilseeds, fodder, vegetables, tubers, creepers, leafy vegetables, and flowers, many of which are traditional varieties), thus allowing for multiple harvests and improving crop diversity. Harvests start in September and continue to February. Since there is ground cover throughout the cropping months (about 6 months), the soil is not exposed to the elements, thus protecting it from erosion. A multi-tier cropping system allows for the maximum use of sunlight and this method uses the rains from the southwest and northeast monsoon to the maximum. The first crop is harvested in 3 months and harvesting goes on for up to 6 months. Farmers use live mulching after kharif to retain ground cover, thus decreasing incidences of weeds. In conventional rainfed systems, the farm is cropped for 4 months and remains fallow for 8 months. In the APCNF method, the land is rarely fallow for as many as 10–15 days. In addition to benefiting from multiple produce across the year (giving farmers financial security throughout the year with lesser impact of market price fluctuations if dependent on a single crop), farmers benefit from decreased inputs such as weedicides, pesticides, and fertilizer; do not need to buy fodder for cattle; and improve their household nutritional security since a diversity of crops is available in fields, including vegetables. The APCNF method also follows minimal tilling and mandatory fencing for all PMDS plots. Fencing is often carried out using live fencing with species such as *Sesbania*,

Glyricidia, or *Moringa oleifera* (Drumstick), which are nitrogen fixers and fodder for cattle, and serve as an excellent green manure.

Soil physical, chemical, and biological properties as affected by farming practices

From 1999 to 2015, soil acidity increased by more than 4% and the organic carbon in the soil declined by 84%. Similar trends were observed in the availability of nitrogen and potassium, which declined by 55% and 43%, respectively. Other essential micronutrients such as zinc, iron, phosphorus, and potash were deficient too (Jitendra, 2019). However, since farmers started adopting CNF, a study by Rosenstock et al. (2022) documented that from 13% to 66% of CNF farmers leave crop residues on the field. This could have a direct positive implication for soil organic carbon as recorded on CNF farms. CNF uses manure-based inoculants to stimulate soil fauna and mobilize existing soil nutrients. However, concerns exist about soil nutrient mining since it is a common problem in low-input systems (Rosenstock et al., 2022).

Soil erosion situation

Degradation of soil due to various natural and human-induced processes such as floods, excessive irrigation, deforestation, overgrazing, and excessive use of chemical fertilizers and pesticides can lead to a decline in soil productivity. In Bathalapalli, 48% of the land area has been affected by moderate water erosion, 24% of the region shows signs of slight salinity, and about 25% of the area is composed of gravelly uplands. Close to 68% of the land area in Tadipatri is affected by moderate to strong water erosion and 29% by salinity. However, the ALL site in Tadipatri is relatively plain, with no serious erosion hazard, while Bathalapalli has several areas with salinity/alkalinity and extensive areas subject to water erosion (see also Environmental context under the sub-heading Land degradation).

Soil acidification potential as related to farming practices

From 1999 to 2015, soil acidity increased by more than 4% (Jitendra, 2019).

Soil compaction

The shift to groundnut monocrop at scale and leaving land barren and exposed to sun and wind after the harvest for the rest of the year are a major feature of Anantapur District's desertification. The resulting soil erosion and compaction limit the potential to harvest pre-monsoon and early-monsoon rains into the soil profile. Soil compaction is further exacerbated by the shift away from draft animal power to tractors and manual harvesting and to combine harvesters. Increasing dependence on fertilizer and decreasing quantity of manure application further aggravate the problem.

Covering soil for longer periods with crops and residues decreases soil temperature and prevents desiccation of organic matter to help improve soil health. Emphasis on PMDS before monsoons, the shift to multi-crop systems to cover soils with live mulch for longer periods, raised beds with no-till, and mulching are the practices integrated with the natural farming methods promoted by the CNF program that can improve soil conditions.

Soil aggregation

The methods packaged in natural farming in the CNF program are built upon improving soil aggregation by enhancing soil biology. Adding organic matter and introducing microbial inoculants are the two critical strategies for improving soil aggregation. This is also part of the knowledge extension system modules of APCNF.

Nutrient balance

On farms that do not use chemical inputs, manure is usually applied to provide sufficient plant nutrients to support growth and development and improve soil health. However, in APCNF, animal dung is converted into manure-based inoculants, which are used to stimulate soil fauna and mobilize existing soil nutrients. These nutrients are supplied in small quantities (e.g., 5–8 kg N/acre), which leads to concerns about soil nutrient mining since it is a low-input system. Studies suggest that APCNF is likely to provide only 52–80% of the nitrogen requirement of the crop; therefore, potential exists for nutrient mining (Rosenstock et al., 2022). However, CNF suggests that inherent nutrients are in abundance in soil and can be potentially used by plants if the soil biology is improved. Sustained yields of diverse crops can be an indicator.

Soil fertility/productivity

A detailed inventory of the land and soil types and the issues in improving their productivity is planned in subsequent exercises to be taken up at the ALL sites. Table 25 shows the status of plant-available nutrients in soils of the ALL mandals. In Bathalapalli, the soils are low in available nitrogen (<0.5% OC) and high in available phosphorus (>50 kg/ha) and potassium (>300 kg/ha), while in Tadipatri they are low in nitrogen (<0.5% OC), medium in phosphorus (20-50 kg/ha), and high in potassium (>300 kg/ha).

Table 25: Soil characteristics

Soil characteristics	Range	Batalapalli	Tadipatri
Nitrogen (% OC)	Low: <0.5, medium: 0.50–0.75, high: >0.75	Low	Low
Phosphorus (P_2O_5 in kg/ha)	Low: <20, medium: 20–50, high: >50	High	Medium
Potassium (K_2O in kg/ha)	Low: <150, medium: 50–300, high: 300	High	High
Available zinc (in ppm)	Low: <0.5, marginal: 0.50–0.75, adequate: 0.75–1.50	Marginal to adequate	Marginal to adequate

Source: *NBSS & LUP, ICAR*

The status of soil-available nutrients (P and K in particular) reinforces the need to improve soil biology to increase the availability of nutrients to plants.

Soil degradation

Degradation of soil due to various natural and human-induced processes such as floods, excessive irrigation, deforestation, overgrazing, and excessive use of chemical fertilizers and pesticides can lead to a decline in soil productivity. In Bathalapalli, 48% of the land area has been affected by moderate water erosion and in 24% of the region signs of slight salinity have been observed. About 25% of the area is composed of rock lands. Close to 68% of the land area in Tadipatri is affected by moderate to strong water erosion and 29% by salinity. However, the ALL sites have relatively low levels of land degradation compared to the district and the rest of the mandal within which the ALLs are located.

Soil biota and their activity

The use of CNF methods is expected to stimulate microbial activity. Organic carbon in the soil is low (<0.5%), indicating poor soil biological processes. Not much information is available on the characterization of soil biota.

Soil productivity based on crop performance

Land capability is classified based on the grouping of soil map units to depict the capability of soils to produce field crops or have other uses on a sustained basis, based on the limitations of climate (c), problem of drainage (w), erosion (e), and soil

factors (s = soil depth, gravelliness, heavy/light texture, salinity/alkalinity) affecting plant growth. Soils suitable for agriculture are grouped under classes I to IV and soils unsuitable for agriculture are grouped into classes V to VIII for pasture/forestry/wildlife/recreation.

Most of the land in Bathalapalli is good to moderately good cultivable land (71%), but with limitations such as soil status, erosion, or drainage. A large proportion of the uncultivable lands are the rocky areas. In Tadipatri, more than 60% of the land is categorized as suitable for agricultural purposes, a majority of which is good to moderately good cultivable land but limited by soil status, erosion, and drainage, and to a lesser extent by climate-related limitations.

Possible interventions and gaps

- CNF uses manure-based inoculants to stimulate soil fauna and mobilize existing soil nutrients. However, concerns exist about soil nutrient mining since it is a common problem in low-input systems (Rosenstock et al., 2022). Long-term studies are required to understand the implications of CNF for soil nutrient status. However, CNF argues that the inherent nutrients in abundance in soil can be potentially used by plants if the soil biology is improved. Studies are required to validate these claims. Scientific validation can initiate a many-fold uptake of this method of farming, if the claims are true. If not, alternative solutions need to be considered.
- Not much information is available on soil acidification processes. This data gap needs to be investigated.
- Studies on soil aggregation are required to understand the status in CNF vs conventional farms.

Animal health

Livestock health care services

Of the 11 villages in Bathalapalli mandal, two have vet dispensaries within the village, seven villages have one within 2 to 5 km, and two villages have one at >5 km distance (Census, 2012). The recently formed RBKs have a veterinary assistant as one of the technical staff who liaises with the Animal Husbandry Department. *Gopal mitras* (trained para-workers) assist the veterinary department in vaccination and primary health care on a contractual basis. Vaccination services against communicable diseases are carried out every year but this is very ad hoc. Integration of the processes of disease surveillance, vaccination scheduling, and vaccine indenting is yet to be synchronized. The dependency on veterinary medical shops for prescriptions and supply of drugs is still higher. Certain diseases among livestock have a higher frequency of occurrence than others such as *peste des petis* ruminants (viral disease), intestinal worms, and contagious ecthyma in sheep and goats (Tables A5 and A6). Diseases are common during rains.

Types of feed and quality

A combination of crop residues, grazing, and supplementation during the work periods (for bullocks) and milking time for cattle is prevalent. Small ruminants are mainly on open grazing, tree fodder, groundnut haulms, and some supplementation. Dairy farmers use commercial cattle feed supplied by companies in addition to open grazing for a few hours (if local breeds). Mainly jowar/maize/paddy straw is used for fodder and farmers having access to irrigation produce some Napier grass for green fodder in addition to commercially available feed, especially for milch cows. Fodder scarcity exists during summer, which forces farmers to buy from elsewhere, usually as tractor loads. Scarcity is a recent trend since many fields are fallow.

Animal-rearing conditions and feeding regimes

The animals are allowed to graze in the open common lands during the day for at least 2–3 hours. During summer, they are fed in cattle sheds (April/May).

Water used for animal feeding and its quality

Drinking water for livestock is a serious problem, particularly in grazing tracks; this becomes a serious constraint during summer when surface water bodies dry up.

Biodiversity

As mentioned previously, forests have many species of shrubs and plants, along with ground flora and fauna (see Biodiversity section in Environmental context).

Plant/crop diversity (including genetic diversity)

As mentioned earlier, the two regions are producing a variety of crops (see Major agricultural commodities and livestock section above). *Navadhanya* is locally known as nine crops grown together. The *Navadhanya* system, a method followed in the past, was introduced, thus increasing crop diversity at the farm level. This cropping system combines pulses, oilseeds, and vegetables sown together in June. Multiple harvesting of crops is necessary as each *Navadhanya* crop matures asynchronously, thus providing some returns throughout the cropping season. Earlier, red gram, castor, or cluster bean was sown with groundnut in a 7:1, 9:1, and 15:1 ratio, respectively. Monocropping became ubiquitous in the 2010s and groundnut yield declined after that. Farmers are slowly reverting to their traditional diverse systems.

Livestock and aquatic animal breeds (including genetic diversity)

Hallikar is a popular cattle breed, which is mainly used for draft purposes. A variant of Deccani breed of sheep (white in color with black spots) is popular in the district. Local fish in the district include Murrel, Malabar trevally, and Vetri fish, among others.

Efforts by farmers to maintain natural biodiversity

Common lands (not private and not under the forest department) are the lifeline for the poor in Anantapur. They sustain the larger sheep population of the district. A network of civil society organizations has made several efforts to regenerate these degrading lands through community management initiatives such as APPS *(Anantha Paryavarana Parirakshana Samithi)*, a network of CSOs. The Foundation for Ecological Security (FES) specializing in community restoration of commons and *Timbaktu* Collective have had long-term involvement in this initiative in this district. *Thimmamma Marrimanu*, a banyan tree located within Anantapur District, is the world's largest single-tree canopy spread over 5 acres and is more than 550 years old (Anonymous, 2021). The tree is visited by Painted Siberian storks every year (Anonymous, 2014) and harbors a huge diversity of mammals, birds, and insects. Several programs on soil and water conservation were taken up under the MGNREGS.

APCNF's natural farming approach is also premised on biodiversity and bringing indigenous varieties back into the system as they are believed to be better adapted to natural farming methods. The *Navadhanya* crop system, as mentioned earlier, helps maintain crop diversity.

Access to agricultural genetic material, improvements, modifications, and local practices

No formal seed exchange mechanism is in place. Farmers exchange seeds among each other.

Soil microbial diversity

Currently, no proper information on this is available for the ALLs.

Diversity of species and resistance to biotic and abiotic stresses

There are anecdotal reports on populations of insects, birds, and animals improving in fields since the adoption of APCNF methods.

Invasive species

Parthenium weed, which was not present 30–40 years ago, is widely distributed in the region now.

Gaps

- Documentation of agrobiodiversity, crops (including trees), beneficial fauna, and other biodiversity is missing.
- Varietal diversity and maturation times are especially important for the *Navadhanya* method.
- Documentation of microbial diversity of CNF vs CF is needed. Similarly, the diversity of birds, bees, and animals in fields needs to be documented in addition to the services that they provide. Pest incidences comparison and predators too are needed.
- Invasive species need to be documented.

Possible interventions

- Develop community seed banks.
- Explore markets – native cow milk A2 is in demand. Market linkages will promote native breeds that are better suited locally.
- Increase tree diversity within the landscape. Explore forages, fruits, and biofuels. Explore fruits such as dragon fruit, which is in high demand and suited for the climatic conditions.
- Bee keeping in the region could not only increase on-farm crop yield but also provide additional income through honey production and eventually loaning of colonies for pollination services on other farms on a rental basis. However, we would need to identify the barriers to uptake since it is not popular currently.
- Documentation of crops, their traits, and their maturation period would be useful when preparing a *Navadhanya* plot. Is there a provision to improve existing combinations? Can a tool be developed to identify suitable mixes of crops based on farmer priorities?

Synergy

Mixed farming, including animal manure for crop production

About 56% of the net sown area of the Anantapur region is rainfed, supporting the 0.9 million bovine population (i.e., nearly 9% of the total state's bovine population as per the National Dairy Development Board report of 2018). Traditionally, farmers in the rainfed region of Anantapur practice mixed crop-livestock farming systems, which provide stability during drought years, thus minimizing their risk. It's a traditional practice of farmers to collect dung in pits along with crop residues used as litter and apply this to the field before the sowing season during kharif. The major source of fodder comes from groundnuts and red gram. Of the total gross sown area, 0.57% is under fodder crops.

Comparing APCNF and chemical farms indicates that APCNF decreases the impact of agriculture on the climate system as compared to conventional techniques. The GHG budget on APCNF farms was lower than that of the conventionally grown crops. The difference ranged from 23% for rice to 60% for maize. For three of the six crops (Bengal gram, cotton, and maize), emissions on typical APCNF farms could be expected to be less than 50% of conventional farm emissions (Rosenstock et al., 2022).

In the APCNF method, the land is rarely fallow for as many as 10–15 days. In addition to benefiting from multiple products across the year (giving them financial security throughout the year with a lesser impact of market price fluctuations if dependent on a single crop), farmers benefit from decreased inputs such as weedicides, pesticides, and fertilizer, do not need to buy fodder for cattle, and improve their household nutritional security since a diversity of crops is available in fields, including vegetables. The usage of water has declined since soil organic matter has substantially increased through residue addition and mulching. Although farmers notice that there are positive effects of cultivating diverse crops in the same field, one has yet to understand the synergies among the diverse crops that are grown (National Dairy Development Board, 2018).

Occurrence of agroforestry and shade enhancement

Many farmers grow horticulture fruit crops along with vegetables or other crops. Farmers who have some source of irrigation mostly go for agroforestry; this is more in the nature of irrigated horticulture. Pure agroforestry is rare. APCNF is promoting a five-layer model in which multiple tree species are integrated into a system along with vegetable production.

Water to support natural ecosystems and for irrigation, including irrigation techniques

About 10% of the farmers use sprinklers, the majority of which were installed about 3 years ago when there was a government subsidy on the installation of drip and sprinkler systems. This subsidy was reinitiated a couple of months ago. Farmers with access to irrigation mainly cultivate vegetables or horticulture crops. Rainfed farmers who follow APCNF methods follow the *Navadhanya* method, thus benefiting from both the southwest and northeast monsoon. The crop covers the soil for 7 to 8 months under rainfed conditions.

Integrated production of crops/livestock/aquatic animals/NTFPs (can be integrated at plot, farm, or landscape scale): Many of these interactions are already detailed in the earlier sections. The commons and forests have a range of NTFP products. These will be documented in due course.

Possible interventions

- Build water supply augmentation interventions such as check dams, farm ponds, and infiltration ponds.
- Use demand-side interventions to effectively use available resources such as drip and sprinkler irrigation.
- Improve soil moisture storage: cover crops, mulching, contour/vegetative bunds and conservation tillage.

Economic diversification

Income from agriculture and livestock

As discussed earlier, a variety of crops are grown in the district such as groundnut, rice, pigeon pea, maize, chickpea, cotton, sorghum, and pulses. Horticultural crops such as grapes, papaya, pomegranate, mango, sugar apple, etc., are grown on irrigated farmlands. Of late, farmers have started experimenting with dragon fruit and date palms.

Most households in the district own sheep, followed in numbers by goats, cattle, and buffalo. The calves of sheep, goats, cows, and buffaloes are sold regularly, thus providing an assured income every year. There is an active fish market. In 2019–2020, 9,565 individuals were engaged in inland fishing activity in Anantapur. Additionally, about 8,200 are involved in marketing fish. The Indian carps (Catla/Rohu/Mrigala) are the predominant species in terms of fish production, followed by common carps and catfishes (District handbook, Ananthapuramu, 2016). Inland fish and prawn production in Anantapur was 8,194 tons in 2017–2018, increased to 9,147 tons in 2018–2019 and fell to 6,824 tons in 2019–2020 (Statistical Abstract, 2020).

As of 2015–2016, there were 22 milk cooperative societies in the district that collected milk from individual households through their network of 606 pick-up centers located within the villages. Average monthly procurement of milk in 2015–2016 was 1.62 million liters.

Other agro-based income sources

Firewood is another important forest product in the district, followed by Beedi leaves, neem, and other minor forest products. However, the revenue from firewood has decreased considerably, from INR 3.98 million in 2013–2014 to INR 1.48 million in 2015–2016. Revenue generated through the sale of seedings increased from INR 0.21 million in 2013–2014 to INR 1.55 million in 2014–2015.

Under e-NAM (an electronic common platform promoted by the Government of India to integrate all primary markets across the country for online participation in agricultural trade for assuring true prices to farmers), a primary processing center for sweet lemon has been established in Anantapur (Planning Department, 2021).

Wage employment and migration

About 21% of the total farmers depend on rainfed agriculture, of which 35% migrate after kharif. The remaining farmers work as wage laborers in irrigated fields or take up other small-scale jobs within and around the village. In the past, small-scale home-run enterprise units that prepared pickled mango, lemon, chilli, and tomato were common. Such units are usually managed by family members but are fast disappearing owing to the small family sizes due to migration and thus labor shortages (Table 26).

Table 26: Per 1,000 distribution of workers aged 15 years and above by broad activity (according to usual principal and subsidiary status approach)

	Per 1,000 distribution of workers according to activity			
	Self-employed	Wage/ salaried employee	Contract worker	Casual labor
Anantapur (overall)	317	81	12	590
Anantapur (rural)	407	63	16	514
Anantapur (urban)	502	342	17	139

MGNREGA is one of the beneficial employment schemes, and as per the "Report on district-level estimates for the state of Andhra Pradesh under 5th employment/unemployment survey (Government of India, 2015–2016), 51.4% of the households were reported to have benefited under the MGNREGA scheme.

Anantapur was also recently identified as a technology hub under the government's initiative for promoting ease of doing business. Under this, a technology/business park will be set up in the district (Socioeconomic Survey, 2020–2021).

Possible studies/gaps

- Assessment of creating market linkages for agroecological output.
- Assessment of farmers' views on doing conventional vs natural farming as perceived by them.
- Understanding the challenges to an integrated farming approach (that is, farming + livestock model), for example, lack of family members to look after cattle and lack of money/credit to meet regular expenses.
- Financial constraints in adoption of agroecology.
- The nature of risk averseness of farmers in making this transition: it could be that farmers fear yield loss or losing out on other income (for putting in extra time in making natural inputs).
- Opportunity cost of making natural inputs, that is, an evaluation of the time cost of making them, including income from other sources.

Possible interventions

- Currently, the farmers are making various inputs themselves (using cow dung, cow urine, and other natural inputs, fermented for 10–15 days). This process does involve manual labor, which increases as land size increases. For many farmers, these inputs are available at the community level for free. On the output side, there is no price premium for this output over the conventionally produced output. Therefore, a cost-benefit assessment is needed that considers all actual and imputed costs and net gains from such a transition.
- Creating awareness about the benefits of mixed farming and intercropping methods to promote them as against monocropping.
- Introducing key machines to speed up the process of key activities such as mixing of natural inputs by way of either custom-hiring services or government loans, etc.
- Bee keeping in the region could not only increase on-farm crop yield but also provide additional income through honey production and, eventually, loaning of colonies for pollination services on other farms on a rental basis.

Co-creation of knowledge

Government-run agricultural department extension units have been active in the co-creation of knowledge in recent years. As part of the APCNF program especially, information sharing happens at various levels such as SHGs, village organizations, mandals, districts, and states for various roles such as demonstrating the transition toward natural farming to others and building awareness about natural farming practices (see Table A8). The program has appointed paid government workers called community resource persons (CRPs) on the ground to educate farmers about NF practices. The CRPs specifically train either the SHG leaders or active members of the group. Then, these trained members educate other group members. Information is also passed on from the higher to the lower organizational units. Along with SHGs, FPOs are emerging in several locations in the district. Anantapur has a dense and vibrant civil society organization. Several networks and collaborations take shape for specific purposes, and some of them are initiated by donors.

Moreover, there is an active alliance among farmers, local communities such as SHGs, the KVK centers (with a group of scientists from various backgrounds), and government and private extension agents to add value to traditional and indigenous knowledge, and for participatory learning.

The SHG platforms and the APCNF cadre evolved from the relatively economically weaker sections of society and these have also become solidarity platforms of the vulnerable for negotiation of power. These platforms open wider and more participatory platforms for non-dominant communities. Also, being exclusively women-based platforms, positive discrimination is created against men. But a detailed analysis of this will be undertaken by WP 5 of the Initiative on Agroecology.

Possible interventions

- Evaluate the performance of alternative awareness-generating tools/methods such as pictures, video-based information, demonstrations, etc.
- Identify farmers' needs in terms of types of information needed to move toward agroecology.

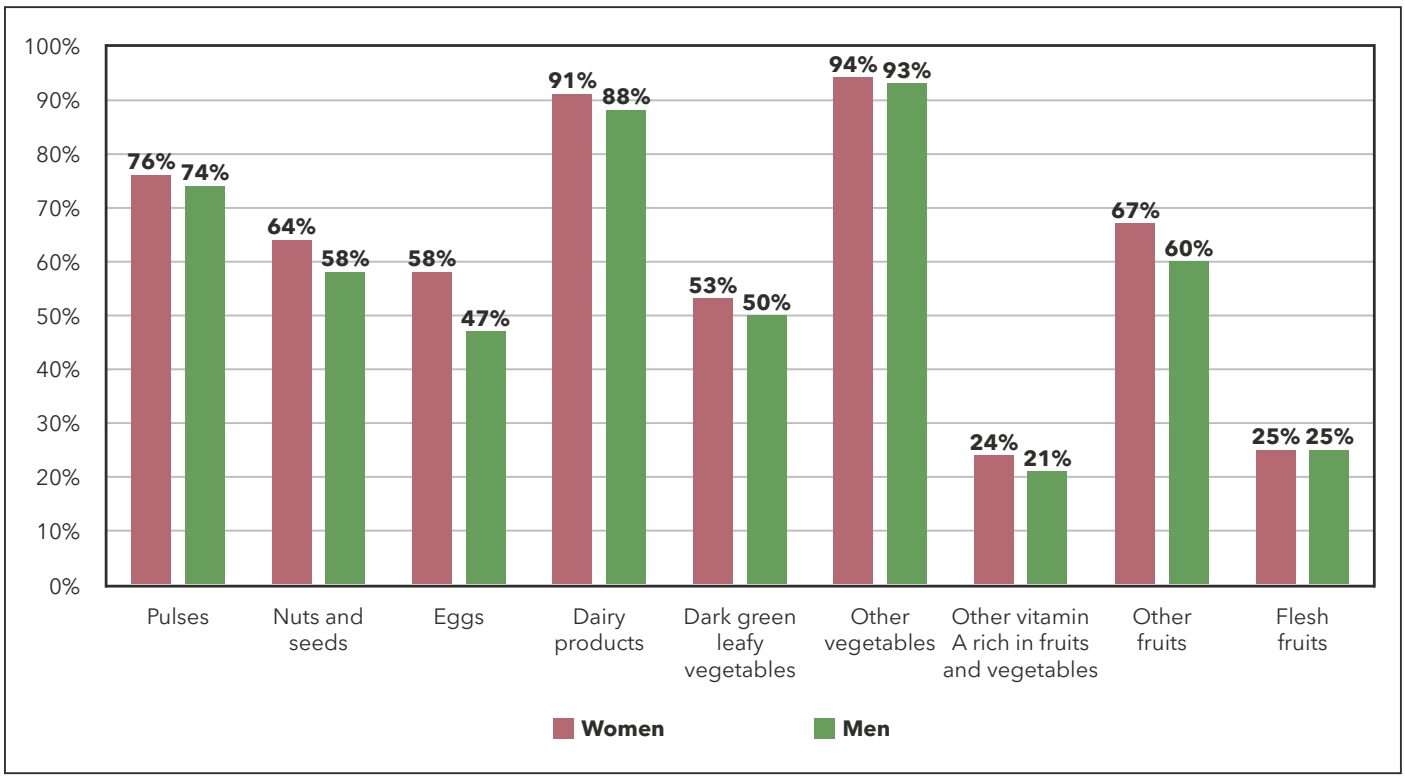
Social values and diets

Consumption patterns, dietary diversity, and equity

Staple foods such as rice and ragi are widely consumed along with green leafy vegetables such as fenugreek and spinach. Consumption of fruits and pulses is low. Non-vegetarian food is mostly consumed once a month (CIFOR-ICRAF and RySS, 2021). Zamindar communities (large landholding farmers) consume various milk-based products (which include ghee and curd) on a regular basis. Farmers with small holdings (0.5 to 2.0 acres of land) do not have the provisions to maintain livestock and hence often do not include dairy in their diets. Women are more likely to consume naturally farmed dairy, eggs, dark green leafy vegetables, and vitamin A-rich fruits and vegetables than men.

According to the findings of an assessment carried out under APCNF for health and nutrition integration, vegetables and dairy products are the most widely consumed food groups (Figure 25). Consumption of vitamin A-rich fruits and vegetables and flesh foods was found to be low. About 87% of the women had achieved minimally adequate diet diversity (i.e., consumed more than five food groups). The corresponding figure for men was 83%.

Figure 25. Consumption patterns of women and men under APCNF. Source: APCNF data. Figure recreated by Smitha Krishnan



Further, it was found that consumption of naturally farmed foods, particularly starchy staples (grains, roots, and tubers), pulses, dark green leafy vegetables, vitamin A-rich fruits and vegetables, and other fruits and vegetables, was higher in nutri villages (villages that are part of a government initiative that aims to improve health of women and children) than in control villages.

Changes in diets over time

About 30–40 years ago, jowar/maize roti comprised the main diet. Ragi was consumed as a health drink porridge (with milk or water) in the morning. In recent years, rice and wheat have replaced most of the traditional millet-based diets. However, some farmers have started switching to old food habits, especially after the COVID pandemic, cultivating healthy millets such as ragi, jowar, kora, and maize to include them in their diet.

Knowledge of the nutritional facts of such food products

During the field visits conducted by the India team in October 2022, the women farmers mentioned that 15–17 different types of leafy vegetable and millets were available for consumption 30–50 years ago. This has now narrowed down to only six to seven types in village markets. Although farmers are aware of the health benefits of natural farming as well as the problems associated with chemical farming, their consumption patterns are also largely determined by external factors such as markets and labor availability. As part of the APCNF project, various actions are taken to educate farmers about the health impacts of agroecology, such as growing kitchen gardens with a variety of crops (known as *Surya mandal*), having a nutritional fellow for each cluster of villages to fill knowledge gaps about natural farming, CRPs in fields for implementation of such interventions, spread of information about anemia in adolescents, the need to move to natural food consumption, etc.

Dependence on imports of food

The rural population mostly depends on the market for food. A total of 75% buy food grown externally and only 25% grow their own food. They are also highly dependent on the Public Distribution System (PDS) to meet their needs (CIFOR-ICRAF and RySS, 2021), which makes rice and wheat available to the poor at affordable prices. Although wheat is procured from other states of India, rice is usually cultivated on their farms or procured from neighbors or neighboring villages. The findings of an assessment carried out under APCNF suggest that 43% of the respondents covered in this assessment had nutri-gardens and another 7% said that they used to have them. Moreover, 92% of the respondents with backyard poultry also consumed some of the produce.

Possible studies/gaps

- Determining current consumption patterns and how agroecologically aligned they are.
- Determining how consumption of natural produce varies among various NF adopters on the gradient: Is only production lower but consumption higher or both production and consumption are low, and among which groups of farmers?
- Women's empowerment as a source of improvement in dietary diversity.
- How does providing information to school students as part of school campaigns about health benefits have an impact on farmers' adoption of NF and consumption of naturally made food?

Fairness

Prices

The experience of natural farmers in the APCNF project, in terms of prices, is mixed. As per the internal assessment reports by the project, about 45% of the farmers who adopted the program reported obtaining higher prices for their CNF output than for non-CNF output, varying from as high as 14% for groundnut and 12% for cotton (Table A9). However, most farmers sell their produce in local markets, where no price differential is observed. Likewise, there is no separate minimum support price (the price paid by the government if it procures output from farmers) for natural output.

Profitability

Production cost includes expenditure on plant nutrients and protection inputs (PNPIs) and paid-out costs such as seeds, human labor, machine labor, bullock labor, implements, farmyard manure, and irrigation. According to the study conducted by IDS, it is estimated that each CNF farmer has saved INR 11,944 in agrichemicals and INR 12,177 in paid-out costs. Each CNF farmer obtained an additional gross value of output of INR 15,493 and additional net value of output of INR 27,670 for their participation in CNF. While it is shown that APCNF decreases expenditure on PNPIs, yields obtain a mixed impact. However, the savings are negligible in one crop, moderate in a few crops, and substantial in others. It is also observed that the scope for a decrease in expenditure on PNPIs is limited to less input intensive crops (also see figure below, Galab et al., 2022).

Figure 26. Crop-wise expenditure on PNPIs under CNF and non-CNF. Data source: IDSAP Field Survey, 2020-21. Figure recreated by Smitha Krishnan

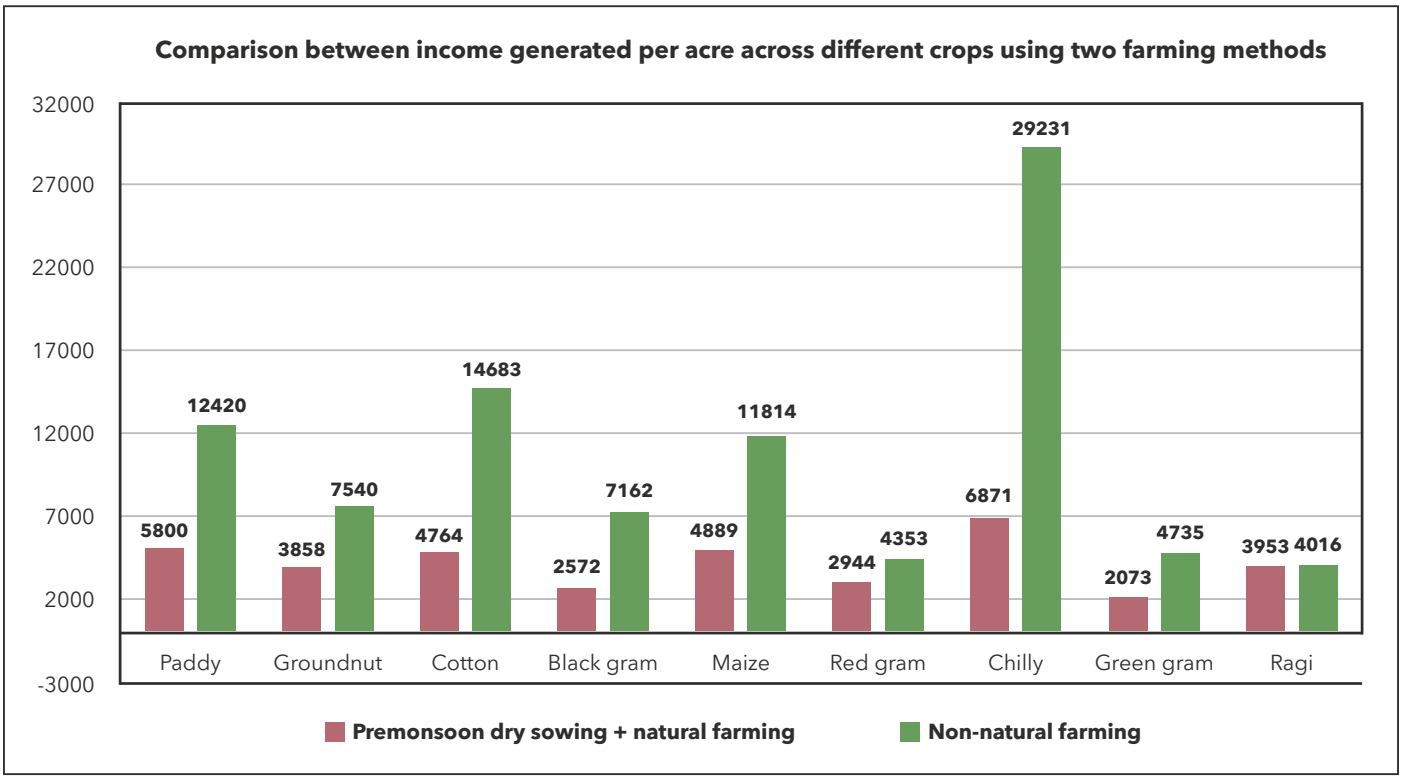
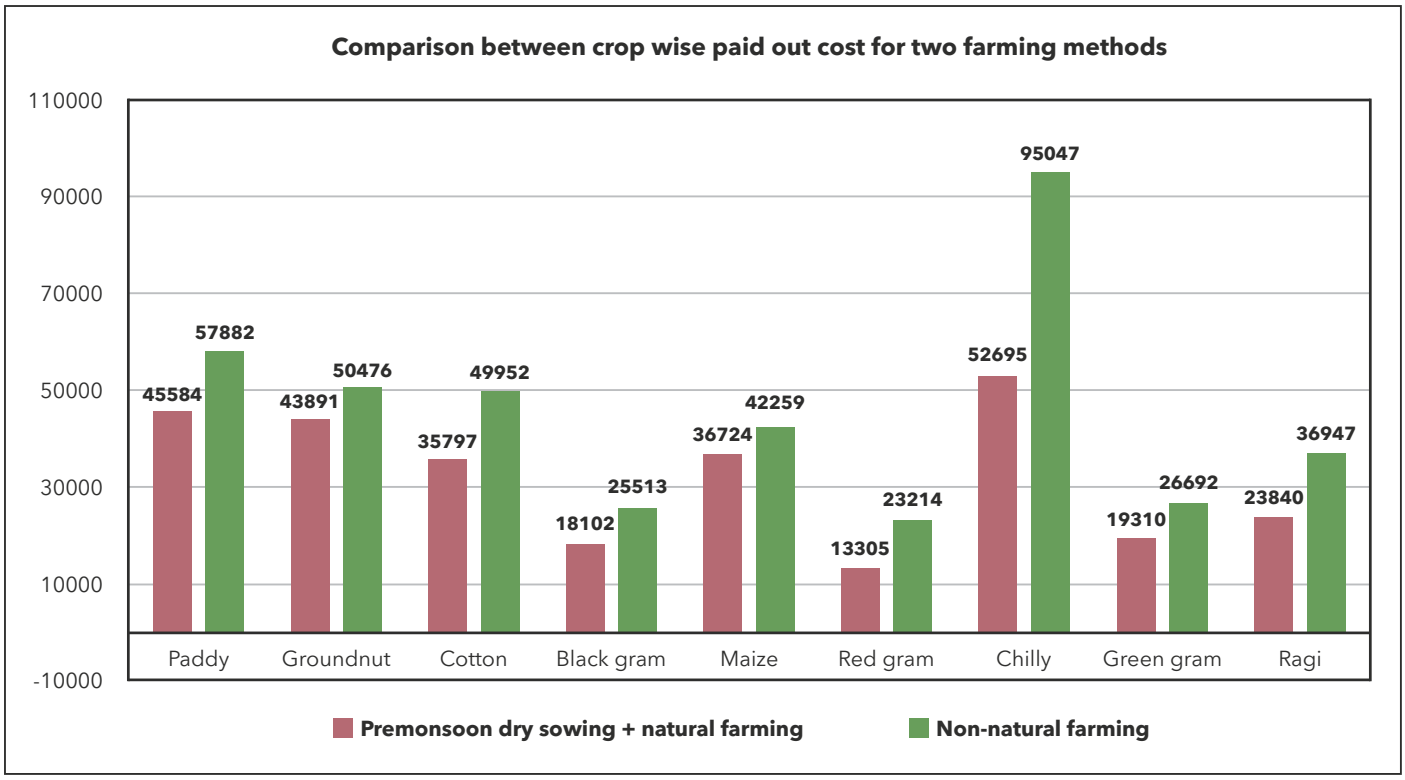


Figure 27. Crop-wise paid-out cost for nine crops. Source: IDSAP Field Survey 2020-21. Figure recreated by Smitha Krishnan



Wages

The IDSAP survey showed that labor use in naturally farmed rice was more than in non-naturally farmed rice in both the kharif and rabi seasons. It was specifically higher among the landless (tenant) and medium-large farmer categories, by a difference of 60–90 days (about 3 months) per hectare. Moreover, the use of family labor in CNF rice was more than in non-CNF rice. While no proper information is available on the actual wage rates paid, the IDSAP report showed that the reliance of CNF farmers on other livelihood options was also decreased by enhancing the income of farmers through naturally farmed produce spread across the year owing to staggered crop maturation (since multiple crops are grown in the same field) across a large part of the year (Galab et al., 2022).

Intermediaries

The primary agricultural products are sold to local aggregators linked to processors/larger traders. One of the main reasons is the lack of distributed primary processing facilities within the district and the difficulties in getting into the processed food value chains. For example, it is easier for farmers to sell groundnut pods than processed kernels as the markets are distant and demand high volumes with regular supply. Lack of market infrastructure/access and wherewithal to operate in commodity markets limits the scope of market participation of small and marginal farmers. MARKFED, a state agency, is called in to facilitate the market linkages of NF farmers with TTD trust. It brings i-finance and professional capacity to handle the process lines.

Warehousing finance is at present mostly available for traders operating in large volumes. Volatility in market prices and inability to withstand risks are the other factors limiting farmers' participation in value- added markets. Warehouse development is very poor in the region and often requires 50 to 100 km of travel. The warehouses use pesticides to control storage pests and thus are not useful for natural farming produce.

Information

Farmers use multiple sources to gather market information, such as newspapers, radio, peer groups, and traders. The local/nearest mandi prices often become the reference point for negotiation with local aggregators. But, in practice, the local aggregators and the competition among them will determine farm-gate prices for farmers. Large farmers have an advantage of volume and staying power and connectivity to secondary-level aggregators for marketing. However, the markets are open and may not discriminate against ethnic considerations.

Employment

The MGNREGA is an important program to enhance the livelihood security of people in rural areas, guaranteeing 100 days of wage employment in a financial year to rural households whose adult members volunteer to do unskilled manual work. As per the Ministry of Rural Development (2020–2021), according to the total job cards issued, an average of 64.96 person-days of employment were provided in Anantapur District. Women person-days accounted for 57.3% of the total person-days for Andhra Pradesh State as per the management information system (MIS) data of the Ministry of Rural Development.

Potential studies/gaps

- We need to study consumers' willingness to pay for natural produce vis-à-vis chemical produce, focusing on rural diets for now. This will not only inform us about the price premium for natural output but will also highlight the valuation placed by the rural population on the health and nutritional benefits of natural output.
- We need to determine the division of labor in the context of natural farming within a household and contrast it with chemical farming: Does natural farming improve the division of labor among men and women within a household?

Potential interventions

- Create market linkages and improved infrastructure to enable sale in urban/peri-urban markets.
- Enable consolidation of produce and bulk sales in key markets.

Connectivity

Types of distribution chains

At the primary level, there are three main modes of distribution chains: (1) no intermediary and farmer-to-farmer contact, (2) farmer to middlemen or local aggregators, and (3) farmer to agribusiness. At the secondary level, small aggregators link to processors, who in turn operate with the large commodity buyers supplying finished products to wholesale consumer markets. Farmer to agribusiness is now catching up, particularly for natural farming products as significant dispersed urban demand exists for such produce. With the formation of FPOs, and incentivizing corporate groups to link with FPOs, several players such as Flipkart and BigBasket are venturing into tying up with FPOs for regular supply. This, however, is an emerging market as the FPOs are still in a nascent stage in the business.

Infrastructure to facilitate market access

As mentioned previously, the ALLs are well connected to local and external markets through roads and railways. Five to ten farmers jointly rent a truck to take their produce to market. Warehouses set up by private individuals are preferred over government, as the government facilities are not maintained properly. Such warehouses are generally low in number and mostly accessed by traders at secondary-level aggregation. However, most of this is for conventionally grown output. Bulk storage is still at a shortage for natural output; such output is prone to perish faster because of the absence of any preservatives in it, unlike chemically produced output.

Existence of communication channels between food system actors

The communication channels between producers and consumers can be broadly classified as direct and indirect. Direct channels are through local markets (village and mandal level). There are no formal communication channels established and this is mostly self-discovery. WhatsApp groups are most active in marketing of natural farming produce by enterprising farmers.

Potential interventions

- The bulk of the improvement in this principle could be achieved by targeting any of the above principles such as improving market linkages, establishing more communication channels among key players, and spreading more awareness about natural/agroecological farming and its benefits, to name a few.

Land and natural resource governance

Land and natural resource governance encompasses a diverse array of schemes and programs pertaining to agroecology, which exert a substantial influence on the agroecological transition in India (see Table A10). Nationally, notable initiatives such as the MGNREGA, which facilitates the management of natural resources; the Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sectors Rejuvenation (RKVY-RAFTAAR), which enables decentralized planning in the agricultural sector through the initiation of the State Agriculture Plan (SAP) and District Agriculture Plans (DAPs); the Bharatiya Prakritik Krishi Paddhati (BPKP), which focuses on indigenous cropping systems and supports practices such as on-farm biomass recycling, use of cow dung-urine formulations, and the exclusion of synthetic chemical inputs; as well as the Agriculture Infrastructure Fund (AIF) collectively foster an enabling environment for agroecology on a broader scale by facilitating its implementation under the MGNREGA framework.

Furthermore, various state-specific agricultural schemes, including the YSR Rythu Bharosa Scheme (YSR RBS), the Rashtriya Krishi Vikas Yojana (RKVY), and the Dr. YSR Polambadi (farmer field school), which is a field-oriented training program in Andhra Pradesh, serve to bolster agroecology by providing financial assistance to farmer

families and supporting the holistic development of agriculture and allied sectors, including organic farming and the production of organic inputs.

However, to identify existing gaps, a comprehensive understanding of the policy-institutional framework is crucial. To this end, conducting text analysis regarding the agroecological principles underlying both state-specific and national policies, and examining the institutional arrangements available to promote the effective participation of all actors within food systems in the management of natural and land resources, will be valuable.

Participation

The current phase of the APCNF project does try to enhance participation among various groups of farmers. The program especially targets small and marginal farmers by including them in training and giving them leadership roles based on their learning about, capacity for, and adoption of NF practices. Moreover, women's SHGs, as mentioned before, are a key group of actors who are involved in taking the project further. Not only are the farmers provided with knowledge about farming practices; they are also a source of constant feedback to learn about the challenges and constraints to adoption. However, some information exists regarding the participation of various food system actors, including farmers, traders, and even consumers, in value chains and their role in transitioning to natural farming (see Table A8).

Possible interventions

To further improve this principle, a multi-stakeholder platform can be established that will present a significant opportunity to foster collaboration, address challenges, and create an enabling institutional environment for agroecology. By bringing together diverse stakeholders, we can collectively contribute to the success and sustainability of natural farming in Andhra Pradesh, thus paving the way for a more resilient, inclusive, and environmentally friendly food system.

Concluding remarks

Exploitation of the findings for the establishment of the ALLs based on the preliminary transition pathways being considered

All the above information was used to base the ALLs in Anantapur District of Andhra Pradesh. This information is also going to help us in undertaking multiple stakeholder interactions such as vision to action, HOLPA training, and studies to determine the key factors influencing behavior regarding agroecology.

The existing information on the ALLs highlights that great potential exists among farmers to transition to natural farming. The APCNF project, though, hasn't reached the desired scale. It provides interesting insights into the experience of farmers with natural farming and points out various gaps that can be filled. For instance, the practices of multi-cropping, pre-monsoon dry sowing, and use of animal manure have beneficial consequences for the soil, along with optimal use of available water resources and integrated farming with livestock, among others. However, certain practices in the program are labor intensive and might not be profitable for all crops. The women's self-help groups, which have been largely responsible for the success of this program, are a unique feature that can be exploited further to identify challenges in their scalability.

Identification of entry points to test agroecological innovations of interest based on knowledge gaps

This is being explored by WP 3 and will be clearer after field activities. We do see various entry points such as creating a market for naturally made inputs (input value chains); enhancing market linkages for natural output for key crops such as groundnut and Bengal gram; finding opportunities to enhance aggregation based on sales of output with the help of self-help groups; solving issues of potential risk aversion by providing credit options; exploring the role of farm mechanization; studying decision-making behavior of different stakeholders involved in natural farming; and developing a timeline of key events in the country's agroecological transformation that considers how agency, behaviour change, and representation/inclusion/participation of various actors were affected. Additional information pertaining to each principle is provided under the designated sub-headings.

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Annexes

1) Supplementary information

Table A1: Crop systems in Tadipatri mandal

	Tadipatri mandal (ha)			
Crop	**Kharif**	**Rabi**	**Total**	**% GSA**
Rice	190	36	226	1
Jowar	4,755	8	4,763	31
Maize	149	1	150	1
Horse gram				
Red gram	228	0	228	1
Bengal gram	0	3,860	3,860	25
Total pulses	**232**	**3,891**	**4,123**	**26**
Food grains	**5,532**	**3,936**	**9,468**	**61**
Food crops	**7,948**	**3,949**	**11,897**	**76**
Cotton	2,850	0	2,850	18
Groundnut	81	119	200	1
Sunflower	487	16	503	3
Castor	101	2	103	1
Total oilseeds	**669**	**183**	**852**	**5**
Gross area sown	11,472	4,132	15,604	100
Net area	**11,472**	**3,210**	**14,682**	**94**

Table A2: Crop systems in Bathalapalli mandal

	Bathalapalli mandal (ha)			
Crop	**Kharif**	**Rabi**	**Total**	**% GSA**
Rice	110	136	246	2
Jowar	339	0	339	3
Maize	0	2	2	0
Horse gram	2,450	0	2,450	20
Red gram	150	0	150	1
Green gram	658	0	658	5
Black gram				0
Cowpea	405	1	406	3
Total pulses	**3,663**	**1**	**3,664**	**29**
Total food grains	**4,212**	**139**	**4,351**	**35**
Total food crops	**4,974**	**252**	**5,226**	**42**
Cotton	0	0	0	0
Groundnut	6,598	420	7,018	56
Castor	49	0	49	0
Total oilseeds	**6,647**	**420**	**7,067**	**56**
Total fodder	**210**	**8**	**218**	**2**
Total non-food crops	**6,881**	**438**	**7,319**	**58**

Table A3: Livestock population of Anantapur, 2012

Type of livestock	Number	Percentage
Cattle	790,026	17.8
Buffaloes	126,328	2.8
Sheep	575,046	13.0
Goats	212,300	4.8
Pigs	4,725	0.1
Poultry	2,726,062	61.5
Total	**4,434,487**	**100**

Source: *Animal Husbandry Department, Livestock census, 2012; https://bit.ly/3Ti2fRs*

Table A4: Major source of drinking water for households in Anantapur

Source	Rural households	Urban households	Total households
Tap water (treated)	37.25%	73.11%	47.06%
Tap water (untreated)	46.07%	17.37%	38.22%
Covered well	0.25%	0.15%	0.22%
Uncovered well	0.67%	0.13%	0.53%
Handpump	9.82%	1.80%	7.63%
Tubewell/borewell	5.35%	2.39%	4.55%
Spring	0.07%	0.02%	0.06%
River/canal	0.06%	0.01%	0.05%
Tank/pond/lake	0.03%	0.01%	0.02%
Other sources	0.42%	5.00%	1.67%
Total no. of households	**698,439**	**262,726**	**961,165**

Source: *District Census Handbook, Census of India, 2011*

Table A5: Common diseases of sheep and goats in Anantapur

S. no.	Disease name	Season	Frequency of occurrence
1	**Enterotoxemia (ET)**	May/June	***
2	**Peste des petis ruminants (PPR)**	Sept/Oct	*****
3	**Sheep pox**	December	**
4	**Contagious ecthyma**	Throughout the year	*
5	**Foot and mouth disease**	Sept-Dec	****
6	**Blue tongue**	December	**
7	**Diarrhea**	Rainy season	*
8	**Bloat**	Throughout the year	*
9	**Colic**	Summer	*
10	**Abortions**	Sept/Oct	**
11	**Intestinal worms**	June	****
12	**Anthrax (occurring for the past 8 years)**	April-June	*
13	**Goat pox**	December	*
14	**Mange (skin disease)**	Summer	***

Table A6: Common diseases of cattle in Anantapur

S. no.	Disease name	Season	Frequency of occurrence
1	**Hemorrhagic septicemia and black quarter**	May/June	*
2	**Foot and mouth disease**	August	***
3	**Mastitis (dairy animals)**	All seasons	***
4	**Ticks and lice**	Rainy and winter	**
5	**Wounds**	All seasons	**
6	**Ephemeral fever**	All seasons	*
7	**Colic**	Summer	**
8	**Diarrhea**	Rainy and winter	***

Source: *From WASSAN's livestock program reports*

Table A7: Major crops grown in the two mandals

	Bathalapalli mandal (ha)					Tadipatri mandal (ha)			
Crop	**Kharif**	**Rabi**	**Total**	**% GSA**	**Crop**	**Kharif**	**Rabi**	**Total**	**% GSA**
Paddy	110	136	246	2	**Paddy**	190	36	226	1
Jowar	339	0	339	3	**Jowar**	4,755	8	4,763	31
Maize	0	2	2	0	**Maize**	149	1	150	1
Horse gram	2,450	0	2,450	20	**Horse gram**				
Red gram	150	0	150	1	**Red gram**	228	0	228	1
Green gram	658	0	658	5					
Black gram				0					
Bengal gram					**Bengal gram**	0	3,860	3,860	25
Cowpea	405	1	406	3					
Total pulses	**3,663**	**1**	**3,664**	**29**	**Total pulses**	**232**	**3,891**	**4,123**	**26**
Total food grains	**4,212**	**139**	**4,351**	**35**	**Food grains**	**5,532**	**3,936**	**9,468**	**61**
Total food crops	**4,974**	**252**	**5,226**	**42**	**Food crops**	**7,948**	**3,949**	**11,897**	**76**
Cotton	0	0	0	0	**Cotton**	2,850	0	2,850	18
Groundnut	6,598	420	7,018	56	**Groundnut**	81	119	200	1
Castor	49	0	49	0	**Castor**	101	2	103	1
Sunflower					**Sunflower**	487	16	503	3
Total oilseeds	**6,647**	**420**	**7,067**	**56**	**Total oilseeds**	**669**	**183**	**852**	**5**
Total fodder	**210**	**8**	**218**	**2**					
Total non-food crops	**6,881**	**438**	**7,319**	**58**					
					Gross area sown	11,472	4,132	15,604	100
					Net area	**11,472**	**3,210**	**14,682**	**94**

Source: *District Handbook, Anantapuramu, and Sri Sathya Sai Districts, 2020*[1]

1 https://des.ap.gov.in/jsp/social/DHBAnantapuramu2020.pdf

Table A8: Sector actors, their current status with respect to natural farming, and their future transformation potential and impact

Sector	Actors	Current roles in ALLs	Responsibility in ALLs	Transformation potential
Farmer (land holding)	Small and marginal	Smaller landholding helps farmers to manage and transform the farm in natural farming easily.	To transform the field to NF and demonstrate the transition with other farmers.	Not all farmers having small landholding have shifted to NF practices. Potential exists that most of these farmers can transform if bio-inputs, market rate for produce, etc., are developed. IL: high
	Medium to large	Agriculture is a commercial enterprise. Landholding >4 ha to >10 ha. Availability of ready-to-use bio-inputs is an issue. No or partial differentiation in market prices for NF or chemical produce prevents farmers from this transition.	To transform the field to NF and demonstrate the transition with other farmers.	Skeptical on NF performance for certain crops. Current labor requirement in NF is high compared with that of chemical farming. Limited availability of bio-inputs in local or mandal shops. IL: medium
	Tenant farmer	Tenant farmers lease land. Investing in soil health improvement is long-term process. Because of uncertainty in land-lease conditions, tenant farmers would be interested in maximizing short-term gains.		Assurance for long-term agreement for land use. IL: medium
	Fallow land	Migrating families in search of other source of income, smaller family size.	Fallow land farmers have potential to transform the land to NF practices.	Linking landless families with farmers keeping land fallow. Reviving fallow lands. IL: high
	Women-headed farmer household	Linkages to self-help group women practicing NF.	Platform to share information on NF practices.	Scope to increase scale. IL: high
Farmer types with irrigation condition	Irrigated	Commercialized agriculture. Skeptical on performance of NF in some crops. Ease of input availability and reliability.	Decreasing the use of chemicals in agriculture.	Potential to transfer part of land to NF if they have higher chemical usage pattern. IL: medium
	Rainfed	Low usage of chemicals in rainfed conditions.	Higher responsibility to transform fields to NF and create awareness.	By default, rainfed farmers use fewer chemical inputs due to uncertainty in rainfall; therefore, they have higher potential to change to NF. IL: High

Sector	Actors	Current roles in ALLs	Responsibility in ALLs	Transformation potential
Chemical inputs	Chemical	Skeptical of NF performance. Lack of easy availability of bio-inputs. Negligible difference in market value of NF vs chemical produce.		Household consumption. Part of land can be transferred to NF. IL: medium to high
Bio-inputs	Farmer-to-farmer sharing	Group or individual farmers prepare the bio-inputs and share them among themselves. Unorganized, labor intensive due to manual preparation of bio-inputs.	Building awareness of NF practices.	Automation in equipment used for preparation of bio-inputs and small enterprises for selling of produce. IL: high
	RBK and village-level NPK shop and mandal-level shops	Lack of inputs available for preparing bio-inputs. Shorter-duration shelf life of some bio-inputs. Limited scope for net profit by selling of bio-inputs.	Making bio-inputs easily available for farmers.	Constant supply of inputs for preparing bio-inputs. Developing local enterprises for testing bio-inputs and their market linkages. IL: high
	Existing shops selling chemical inputs	Some bio-input products are currently available in the market.	Making bio-inputs easily available for farmers.	Potential to replace chemical inputs by bio-inputs if demand increases, shelf life of products increases, etc. IL: medium
Credit	Farmer-to-farmer credit	Current potential of farmers to bear the risk of transition from chemical farming to NF is less.	Making bio-inputs easily available for farmers.	Low cost of inputs, obtaining high price in market for produce, increasing the risk-taking potential of farmers. IL: low
	SHG, VO, and bank	Currently, the SHG, VO, and bank are making credit easily available for farmers.	Making credit available for farmers.	Scope to increase the influence some farmers have that are not part of an SHG or VO. IL: high
Market for produce	Local market and RBK	NF is not differentiated from chemical farming. Consumer preference for low-cost produce. Local demand is low since most farmers are producers and consumers.	Enabling market to give farmers better price for NF produce.	Developing linkages with commercial markets where higher rates for NF produce can be obtained. IL: high
	Trader	No difference in market value of NF produce and conventional produce.	Facilitating a higher price for NF produce.	Higher price for NF produce. IL: medium

Sector	Actors	Current roles in ALLs	Responsibility in ALLs	Transformation potential
Knowledge	NF cadre	Cadre interact, encourage farmers to shift toward NF practices. Demonstration by practicing in own field is seen (low influence).	Generating awareness.	If the guarantee in case of failure during transition from chemical farming to NF is taken by cadre, this increases the confidence level of farmers. IL: high
	Govt. Dept. (agriculture, horticulture)	Interactions and extension services are currently present.	Generating awareness and new technologies for farmers.	Extension services can be enhanced more. IL: medium to high
Labor	Agricultural labor	Labor-intensive activities High cost of labor and unavailability of labor.		Can be linked to setting up local bio-input outlets, can lease fallow land, automation in preparation of bio-inputs. IL: high
Consumer		Awareness on NF produce is increasing.	Demanding NF produce for consumption.	Ready to buy NF products even if they cost more than chemical produce. Demand for NF produce.

Table A9: Crop-wise realized price for CNF and non-CNF output and the difference in INR per quintal

Crop	PMDS + CNF	Non-CNF	Absolute difference (%)	Relative difference (%)
Rice	1,753	1,684	69	4
Groundnut	5,140	4,500	640	14
Cotton	4,128	4,698	-570	-12
Black gram	6,446	6,619	-172	-3
Maize	1,655	1,498	157	11
Red gram	5,132	5,053	79	2
Chillies	9,784	9,739	44	0
Green gram	6,146	6,315	-169	-3
Ragi	3,204	3,570	-366	-10

Source: *IDSAP Field Survey, 2020-21*

Table A10: List of policies supporting/hindering agroecological transformation

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
1	***PM Krishi Sinchayee Yojana – More Crop per Drop*** ***(PMKSY – PMDC)***	MoAFW	2015 INR 2,000 crores (USD 243.9 million) (FY 2021–2022)	All-India	Extending coverage of irrigation *Har Khet ko pani* and improving water use efficiency ("More crop per drop") in a focused manner with end-to-end solution on source creation, distribution, management, field application, and extension activities. PMKSY has been formulated amalgamating ongoing schemes: 1. Accelerated Irrigation Benefit Programme (AIBP) of water resources ministry (MoWR, RD, & GR) 2. Integrated Watershed Management Programme (IWMP) of Department of Land Resources (DoLR) 3. On-Farm Water Management (OFWM) of Department of Agriculture and Cooperation (DAC)	Link
2	***National Food Security Mission*** ***(NFSM)***	MoAFW	2007 INR 1,540 crores (USD 187.8 million) (FY 2021–2022)	All-India	Increase production of rice, wheat, and pulses through area expansion, productivity enhancement, restoring soil fertility and productivity, creating employment opportunities, and enhancing farmer-level economy. 1. Increase production of rice, wheat, and pulses through area expansion and productivity enhancement in a sustainable manner. 2. Restore soil fertility and productivity at the individual farm level. 3. Create employment opportunities. 4. Ensure farm-level economy to restore confidence to farmers.	Link Guidelines: Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
3	***National Mission on Horticulture (NMH)***	MoAFW	2005 INR 1,589 crores (USD 193.8 million) (FY 2021–2022)	18 states and 6 union territories (Link)	The NMH's key objective is to develop horticulture to the maximum potential available in the state and to augment production of all horticultural products. Objectives are 1. To provide holistic growth of the horticulture sector through an area-based regionally differentiated strategy. 2. To enhance horticulture production, improve nutritional security, and provide income support to farm households. 3. To establish convergence and synergy among multiple ongoing and planned programs for horticulture development. 4. To promote, develop, and disseminate technologies through a seamless blend of traditional wisdom and modern scientific knowledge. 5. To create opportunities for employment generation for skilled and unskilled persons, especially unemployed youth.	State plans: Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
4	***National Mission for Sustainable Agriculture*** ***(NMSA)***	MoAFW	2014–2015 (FY 2021–2022) NBM: INR 70 crores (USD 8.5 million) RAD & climate change: INR 110 crores (USD 13.4 million)	All-India	NMSA focuses on judicious use of natural resources through community-based approach and aims at promoting sustainable agriculture. Enhancing agricultural productivity, especially in rainfed areas, focusing on integrated farming, water use efficiency, soil health management, and synergizing resource conservation. NMSA has three sub-missions. NMSA has the following four major program components or activities: 1. **Rainfed Area Development (RAD):** increase agricultural productivity in rainfed areas and promote integrated farming systems, water use efficiency, soil health management, and synergizing resource conservation. 2. **Sub-Mission on Agroforestry (SMAF):** encourage tree plantation on farm land (*Har Medh Par Ped*), along with crops/cropping system. 3. **Soil Health Management (SHM):** crop-specific sustainable soil health management. 4. **Climate Change and Sustainable Agriculture Monitoring, Modeling, and Networking (CCSAMMN):** focusing on climate-smart sustainable management practices. 5. **National Bamboo Mission (NBM):** to increase the area under bamboo plantation on non-forest government and private lands to supplement farm income and contribute toward resilience to climate change as well as availability of good-quality raw material requirements of industries.	Link Guidelines: Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
5	***National Project on Soil Health and Fertility*** ***(NPSHF)***	MoAFW	2008–2009 INR 100 crores (USD 12.20 million) (FY 2021–2022)	All-India	Soil health management aims at promoting location- as well as crop-specific sustainable soil health management, including residue management; organic farming practices by way of creating and linking soil fertility maps with macro-micro nutrient management; and appropriate land use based on land type. This scheme also includes the Soil Health Cards scheme, which provides information to farmers on soil nutrient status and recommendations on appropriate dosage of nutrient to be applied for improving soil health and its fertility. NPMSF comprises three main components: 1. Strengthening of soil testing laboratories (STLs). 2. Promoting use of integrated nutrient management. 3. Strengthening of fertilizer quality control laboratories.	Link Guidelines Link
6	***National Project on Organic Farming*** ***(NPOF)***	MoAFW	2004 INR 6 crores (USD 0.73 million) (FY 2021–2022)	All-India	1. Human resource development by providing training for state government officers, fertilizer inspectors, organic fertilizer analysts, organizing certificate course for field functionaries'/ extension officers' training on organic farming. 2. Statutory quality analysis of biofertilizers and organic fertilizers under Fertilizer Control Order (FCO) and testing of other organic inputs for study purposes. 3. Capacity building for low-cost alternative, farmers' group-centric certification system: PGS. 4. Support for organic input production units under Capital Investment Back-Ended Subsidy Scheme through NABARD. 5. Awareness creation through publicity, publications, and other print and electronic media.	Guidelines: Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
7	***Mission on Organic Value Chain Development for Northeastern States*** ***(MOVCD-NER)***	MoAFW	INR 174.8 crores (USD 21.32 million) (FY 2021–2022)	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim Tripura	Development of Commercial Organic Farming in Northeastern States. The scheme promotes third-party certified organic farming of niche crops of the northeast region through Farmer Producer Organizations (FPOs), with a focus on exports. Farmers are given assistance of INR 25,000 per hectare for three years for organic inputs, including organic manure and bio-fertilizers, among other inputs. Support for formation of FPOs, capacity building, and postharvest infrastructure up to INR 2 crore is also provided in the scheme.	Guidelines: Link
8	***New National Biogas and Organic Manure Program*** ***(NNBOMP)***	MNRE		All-India	Continuation of National Biogas and Manure Management Program (NBMMP). To provide clean cooking fuel for kitchens, lighting, and meeting other thermal and small power needs of farmers/dairy farmers/users, including individual households, and to improve organic manure system based on bio-slurry from biogas plants in rural and semi-urban areas by setting up small-sized biogas plants of 1 to 25 m^3 capacity.	Link
9	***Atal Bhujal Yojana*** ***(ABhY)***	MoJS	2019 INR 6,000 crores (USD 731.7 million) For FY 2022–2023: INR 700 crores (USD 85.37 million)	Seven states: Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh	Sustainable groundwater management with community participation in select overexploited and groundwater-stressed areas. Activities: 1. Monitoring and disseminating groundwater data, aquifer mapping, water harvesting and artificial recharge, and surface-water harvesting are key components. 2. Bottom-up planning of groundwater interventions through community-led Water Security Plans (WSPs). 3. Community-level groundwater quality monitoring. 4. Developing climate-resilient agricultural practices. Building institutional capacity at the central and state levels.	Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
10	***National Project on Aquifer Management (NAQUIM)***	MoJS	2012 NA	All-India	Mapping of aquifers and their characterization and development of Aquifer Management Plans to facilitate sustainable management of groundwater resources. Groundwater management through community participation. The motto is "Know your Aquifer, Manage your Aquifer." Key project goals are to 1. Promote participatory groundwater management. 2. Delineate and characterize aquifers in three dimensions. 3. Identify and quantify issues. Develop management plans to ensure the sustainability of groundwater resources.	Link In AP: Link
11	***Jal Jeevan Mission (JJM)***	MoJS	2019 INR 60,000 crores (USD 7,317 million) (FY 2022–2023)	Quality-affected areas, DPAP, DDAs, aspirational districts, Sansad Gram Panchayat Yojana villages, revenue villages, etc.	Mission ensures functionality of existing water supply systems and water connections, water quality monitoring and testing, as well as sustainable agriculture. It also ensures conjunctive use of conserved water, drinking water source augmentation, drinking water supply system, gray water treatment, and its reuse.	Link In AP: Link
12	***Namami Gange***	MoJS	2014 INR 2,800 crores (USD 341.46 million) (FY 2022–2023)	Ganga Basin	An integrated conservation mission. Aiming to accomplish the twin objectives of effective abatement of pollution, along with conservation and rejuvenation of National River Ganga. The main pillars of the Namami Gange program follow: 1. Sewage treatment infrastructure 2. River-front development 3. River surface cleaning 4. Biodiversity 5. Afforestation 6. Public awareness 7. Industrial effluent monitoring 8. Ganga gram	Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
13	***PM Krishi Sinchayee Yojana (PMKSY)***	MoAFW	2015 INR 10,954 crores (USD 1,335.8 million) (FY 2022–2023)	All-India	Umbrella scheme covering various aspects. PMKSY acts as convergence of investments. It aims 1. To expand the cultivable area under assured irrigation *(Har Khet ko Pani)*. 2. To improve on-farm water use efficiency to decrease wastage of water. 3. To enhance the adoption of precision irrigation and other water-saving technologies ("More crop per drop"). 4. To enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal-based water for peri-urban agriculture and attract greater private investment in a precision irrigation system.	Link Guidelines: Link Link Link
13-a	***PMKSY – Har Khet ko Pani***		INR 785 crores (USD 95.73 million) (FY 2022–2023)	All-India		
13-b	***PMKSY – Command Area Development and Water Management***		INR 1,044 crores (USD 127.32 million) (FY 2022–2023)	All-India		
13-c	***PMKSY – Accelerated Irrigation Benefit Program and National/ Special Projects***		INR 3,237 crores (USD 394.76 million)(FY 2022–2023)	All-India		
13-d	***PMKSY – Flood Management and Border Areas Program***		INR 450 crores (USD 54.88 million)(FY 2022–2023)	All-India		

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
14	***National River Conservation Plan***	MoJS	1995 INR 250 crores (USD 30.49 million) (FY 2022–2023)	All basins except Ganga basin	It aims for abatement of pollution in identified stretches of rivers in the country, excluding those in Ganga basin, by providing financial and technical assistance to the states/ union territories on a cost-sharing basis.	Link
15	***Interlinking of rivers***		INR 1,400 crores (USD 170.73 million) (FY 2022–2023)	All-India	Interlinking of major rivers in India.	Link Link
16	***National Hydrology Project*** ***(NHP)***	MoJS	2016 INR 800 crores (USD 97.56 million) (FY 2022–2023)	All-India	To improve the extent, quality, and accessibility of information on water resources and to strengthen the capacity of targeted water resource management institutions in India. The project envisages establishment of the National Water Informatics Centre (NWIC) to be taken up in two stages. The components of the proposal are the following: 1. In situ hydro-met monitoring system and hydro-met data acquisition system. 2. Setting up of National Water Informatics Centre. 3. Water resource operation and management system. 4. Water resource institutions and capacity building.	Link
17	***National Water Mission: Catch the Rain***	MoJS		All-India	It aims (i) to nudge all stakeholders to create rainwater harvesting structures (RWHS) suitable for the climatic conditions and subsoil strata to store rainwater and (ii) to engage people at the grassroots through effective campaigning and information, education, and communication activities for implementation of the campaign.	Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
18	***National Policy for Management of Crop Residues (NPMCR)***	MoAFW	2014 NA	All-India	1. Protecting environment from air pollution and preventing loss of nutrients and soil microorganisms caused by burning of crop residue. 2. Promoting management of crop residue by retention/ incorporation into the soil or collection for further use through the use of appropriate mechanization inputs. 3. Promoting farm machinery banks for custom hiring of crop residue management machinery. Creating awareness among stakeholders through demonstration, capacity-building activities, and differentiated Information, education, and communication strategies for effective use and management of crop residue.	Guidelines: Link
19	***Agriculture Infrastructure Fund (NIF)***	Ministry of Agriculture and Farmers' Welfare	2020–2021 INR 500 crores (USD 60.98 million) (FY 2022–2023)	All-India	NIF aims at providing a medium-/ long-term debt financing facility until 2025–2026 through 3% interest subvention and credit guarantee support on loans for creation of postharvest management infrastructure and community farming assets. Creating required pre- and postharvest management structures in agricultural sector. Infrastructure developed at farm gate and aggregation points such as Primary Agricultural Cooperative Societies, Farmer Producer Organizations, agricultural entrepreneurs, start-ups, etc.	Link Guidelines: Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
20	***Soil Health Card***	MoAFW	2015 INR 568 crores (USD 69.27 million)	All-India	Promote soil health services, issue soil health cards, and develop nutrient health management practices. A Soil Health Card is provided to all farmers in the country at an interval of 3 years to enable them to apply recommended doses of nutrients based on soil test values to realize improved and sustainable soil health and fertility, low costs, and higher profits. Farmers can track their soil samples and obtain their Soil Health Card report. It is a field-specific detailed report of soil fertility status and other important soil parameters that affect crop productivity. The main activities follow: 1. To issue Soil Health Cards every 3 years to all farmers in the country so as to provide a basis to address nutrient deficiencies in fertilization practices. 2. To strengthen functioning of soil testing laboratories (STLs) through capacity building, involvement of agriculture students, and effective linkage with Indian Council of Agricultural Research/ state agricultural universities. 3. To diagnose soil fertility-related constraints with standardized procedures for sampling uniformly across states and analyzing and designing taluqa-/block-level fertilizer recommendations in targeted districts. 4. To develop and promote soil test-based nutrient management in the districts for enhancing nutrient use efficiency. To build capacity of district- and state-level staff and of progressive farmers for promotion of nutrient management practices.	Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
21	***National Mission on Horticulture***	Ministry of Agriculture and Farmers' Welfare	2015 INR 1,594 crores (USD 194.39 million) (FY 2021–2022)	All-India	It aims for holistic growth of the horticulture sector covering fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa, and bamboo.	Link
22	***National Mission on Sustainable Agriculture*** ***Paramparagat Krishi Vikas Yojana (PKVY)***	Ministry of Agriculture and Farmers' Welfare	2015 INR 100 crores (USD 12.20 million) (FY 2021–2022)	All-India	PKVY aims at supporting and promoting organic farming, in turn resulting in improvement of soil health. The scheme promotes the Participatory Guarantee System (PGS). For India (PGS-India), two forms of organic certification are built on mutual trust, are locally relevant, and mandate the involvement of producers and consumers in the process of certification. PGS-India operates outside the framework of third-party certification.	Guidelines: Link
23	***Kisan Urja Suraksha evam Utthaan Mahabhiyan*** ***(PM-KUSUM)***	MNRE	2019 INR 1,715 crores (USD 209.15 million) (FY 2022–2023)	All-India	Install solar power plants and incentivize farmers to use off-grid solar pumps and "solarize" grid-connected pumps. It aims at furthering the production of solar power in India and gives the benefits of solar farming to farmers. It has three components: 1. Component A: 10,000 MW of decentralized ground-mounted grid-connected renewable power plants. 2. Component B: installation of 17.50 lakh stand-alone solar-powered agricultural pumps. 3. Component C: solarization of 10 lakh grid-connected solar-powered agricultural pumps.	Link

	Policy name	Ministry/ Department	Beginning year & budget	Coverage	Objectives/activities	Website/ links
24	***National Energy-Efficient Agricultural Pumps Program/ Agriculture Demand-Side Management (AgDSM) Programme***	Ministry of Power	2018–2019 INR 400 crores (USD 48.78 million)		The objective of the program is to decrease the energy intensity of the agricultural pumping sector by carrying out efficiency upgrading of agricultural pump sets. Carried out awareness and promotion campaigns to secure farmer participation; employed local firms to provide installation and repair services to remove existing pump sets and install new ones; and provided incentives such as free repair and maintenance.	Link Dashboard: Link
25	***National Action Plan on Climate Change***	MoEF&CC	INR 30 crores (USD 3.66 million) (FY 2022–2023)	All-India	It aims at creating awareness among the representatives of the public, different agencies of the government, scientists, industry, and communities on the threat posed by climate change and the steps to counter it.	Link
26	***NICRA – National Innovations on Climate-Resilient Agriculture***	MoAFW	2011 INR 30 crores (3.66 million) (FY 2022–2023)	All-India	ICAR has launched the network project NICRA, which aims at enhancing the resilience of Indian farming systems to fluctuating climatic changes and vulnerability by strategic research policies and technology demonstration. State-of-the-art research facilities have been developed under NICRA along with significant features and applications to monitor and carry out advanced scientific research to strengthen climate-resilient agriculture.	Link

MoAFW = Ministry of Agriculture and Farmers' Welfare, MoJS = Ministry of Jal Shakti, MoEF&CC = Ministry of Environment, Forest, and Climate Change, MNRE = Ministry of New and Renewable Energy, MoP = Ministry of Power, MoRD = Ministry of Rural Development.

Budget links: https://www.indiabudget.gov.in/

INR to USD conversion (USD 1 = INR 82).

2) Additional maps

Soil degradation:

Figure 28. Soil degradation of Dharmavaram. Source: NBSS and LUP

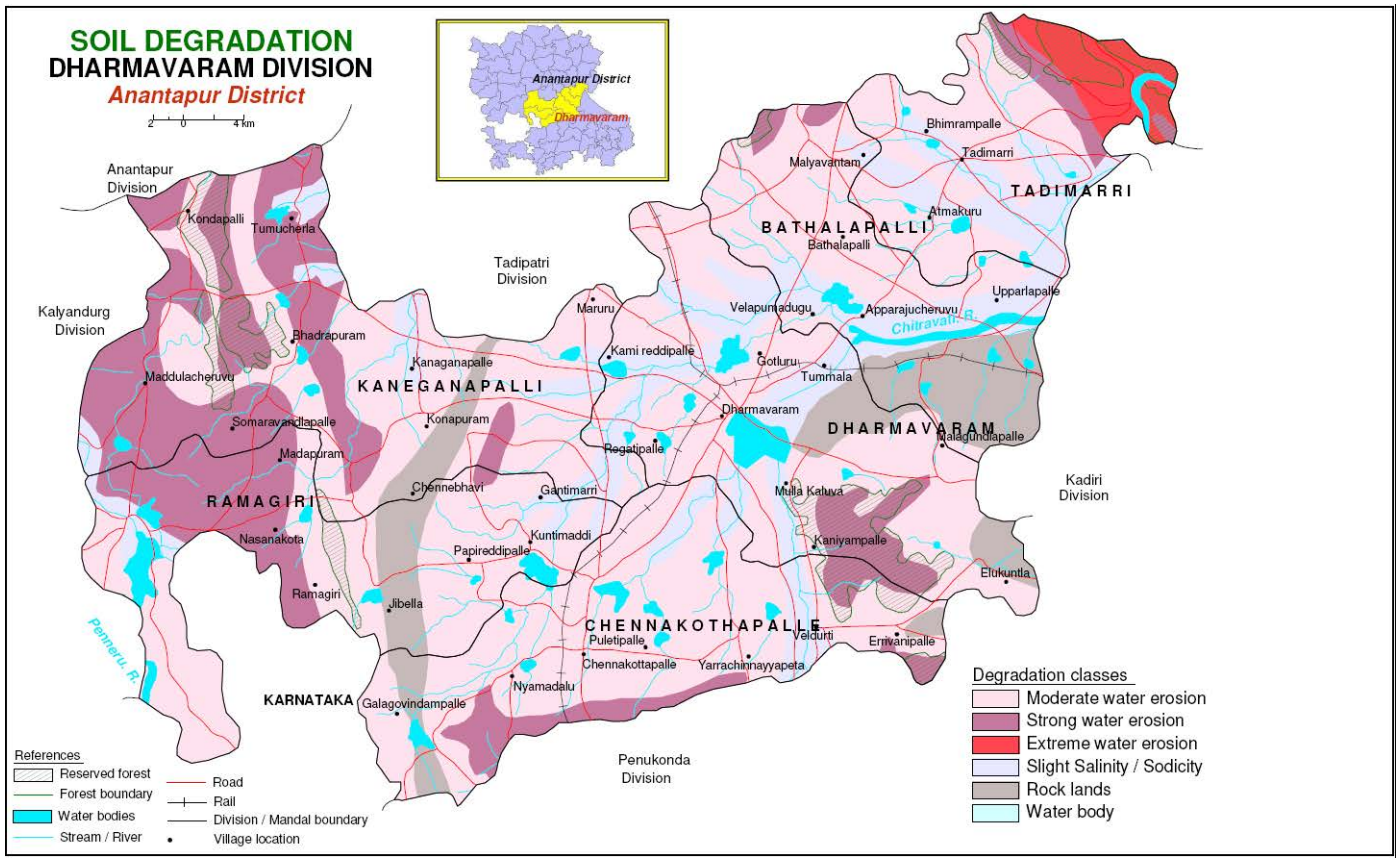
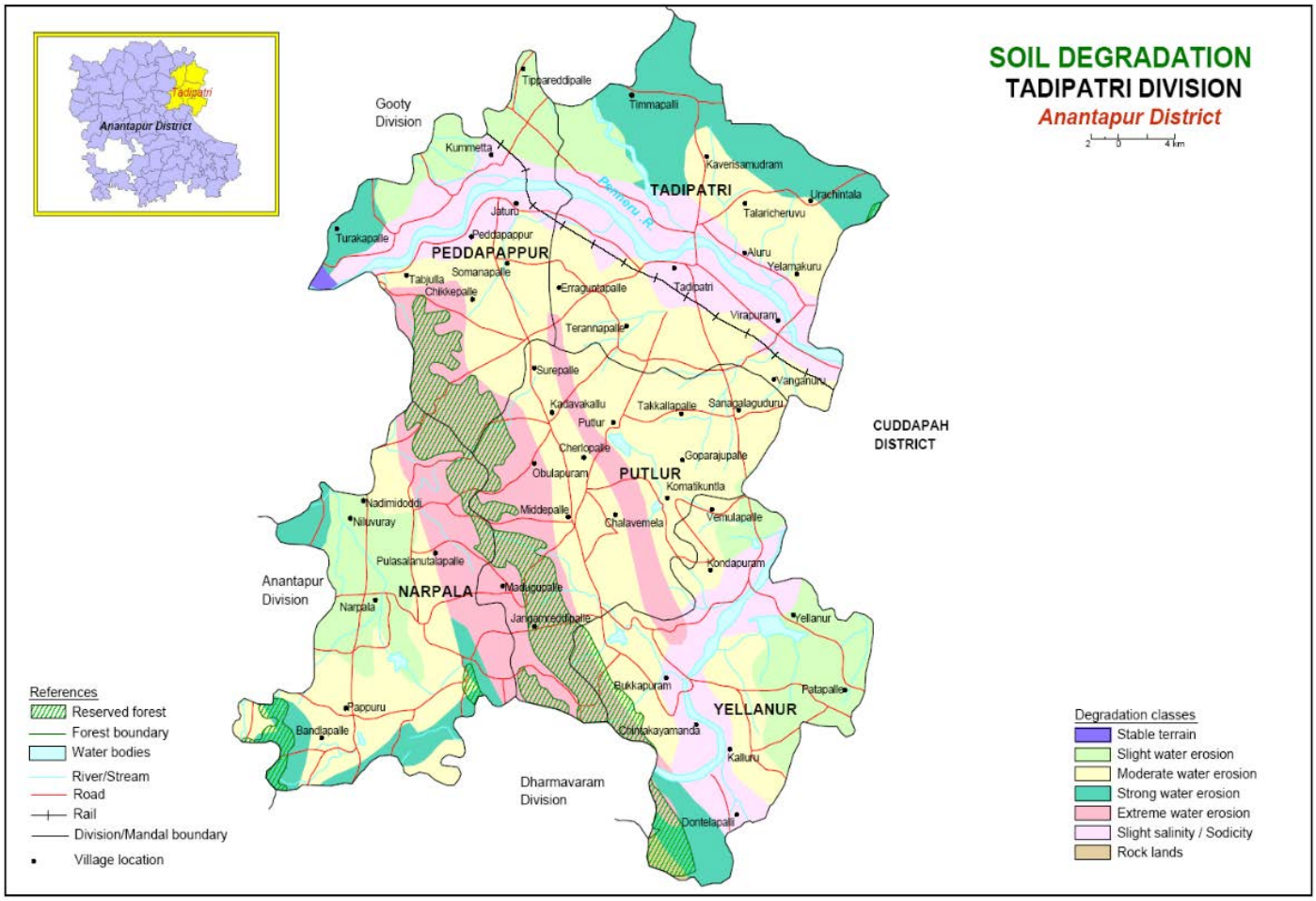


Figure 29. Soil degradation of Tadipatri. Source: NBSS and LUP



Potential soil loss: areas vulnerable to different degrees of soil loss

Figure 30. Potential soil loss of Dharmavaram. Source: NBSS and LUP

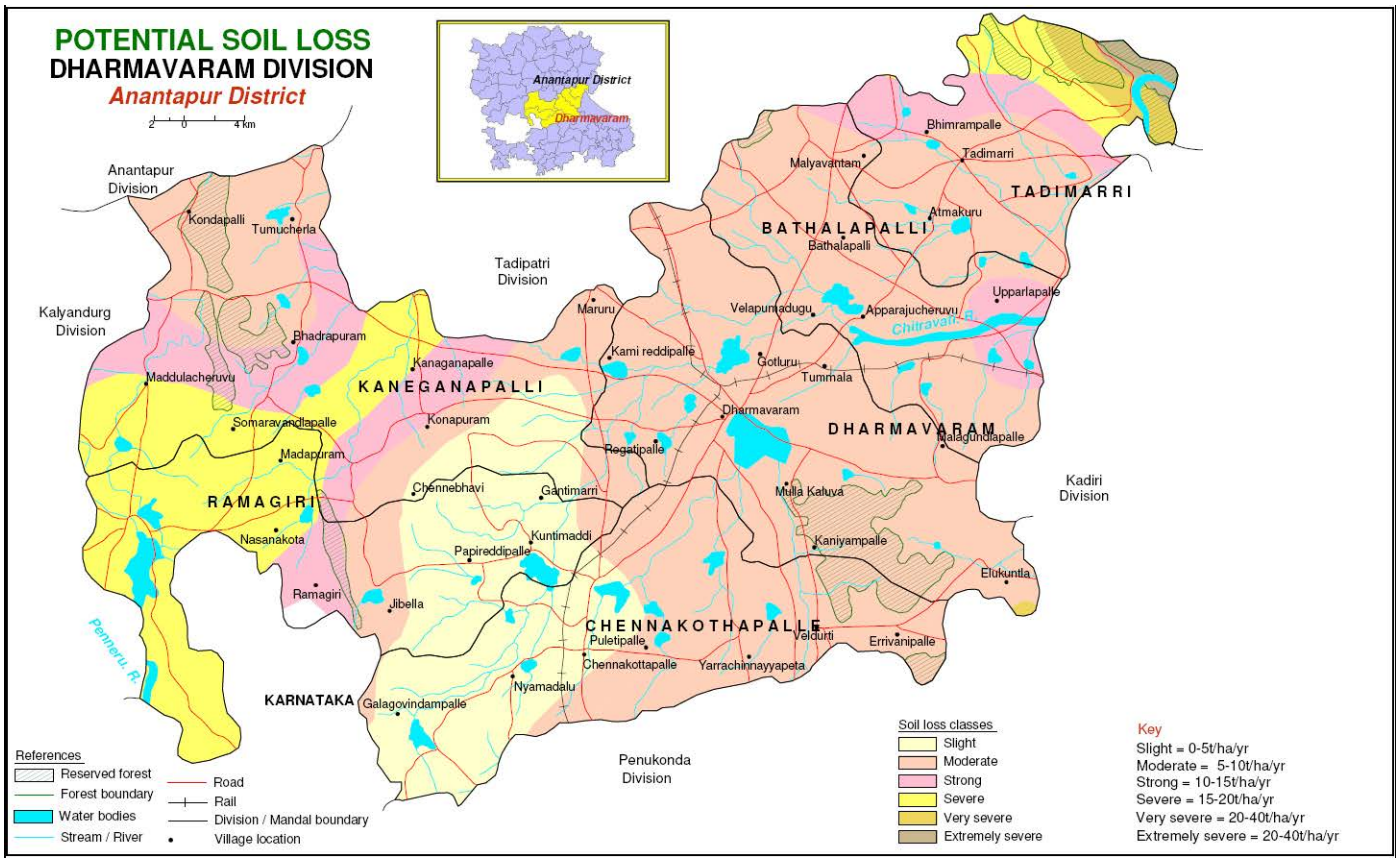


Figure 31. Potential soil loss of Tadipatri. Source: NBSS and LUP

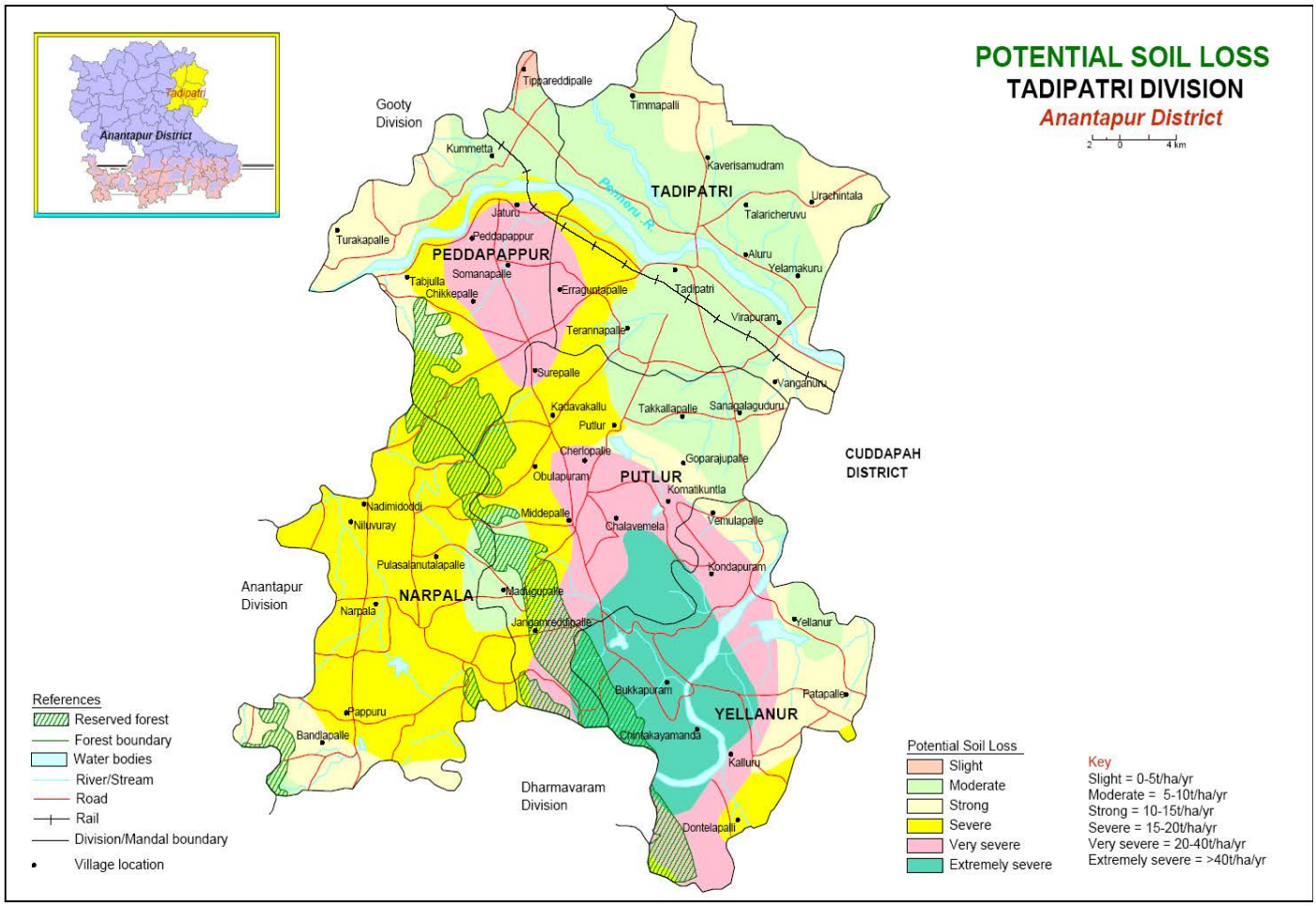


Figure 32. Soil fertility of Dharmavaram. Source: NBSS and LUP

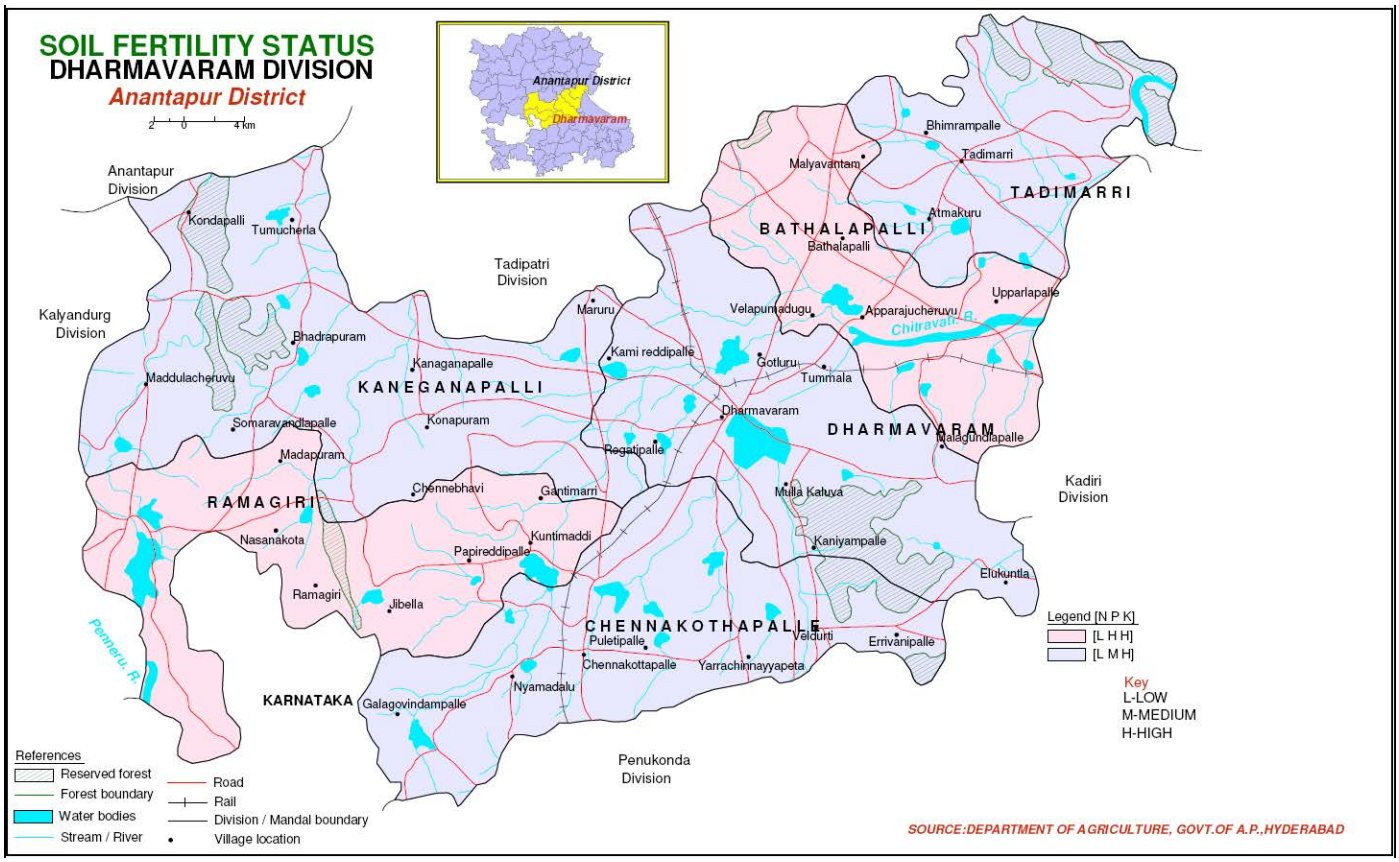


Figure 33. Soil fertility of Tadipatri. Source: NBSS and LUP

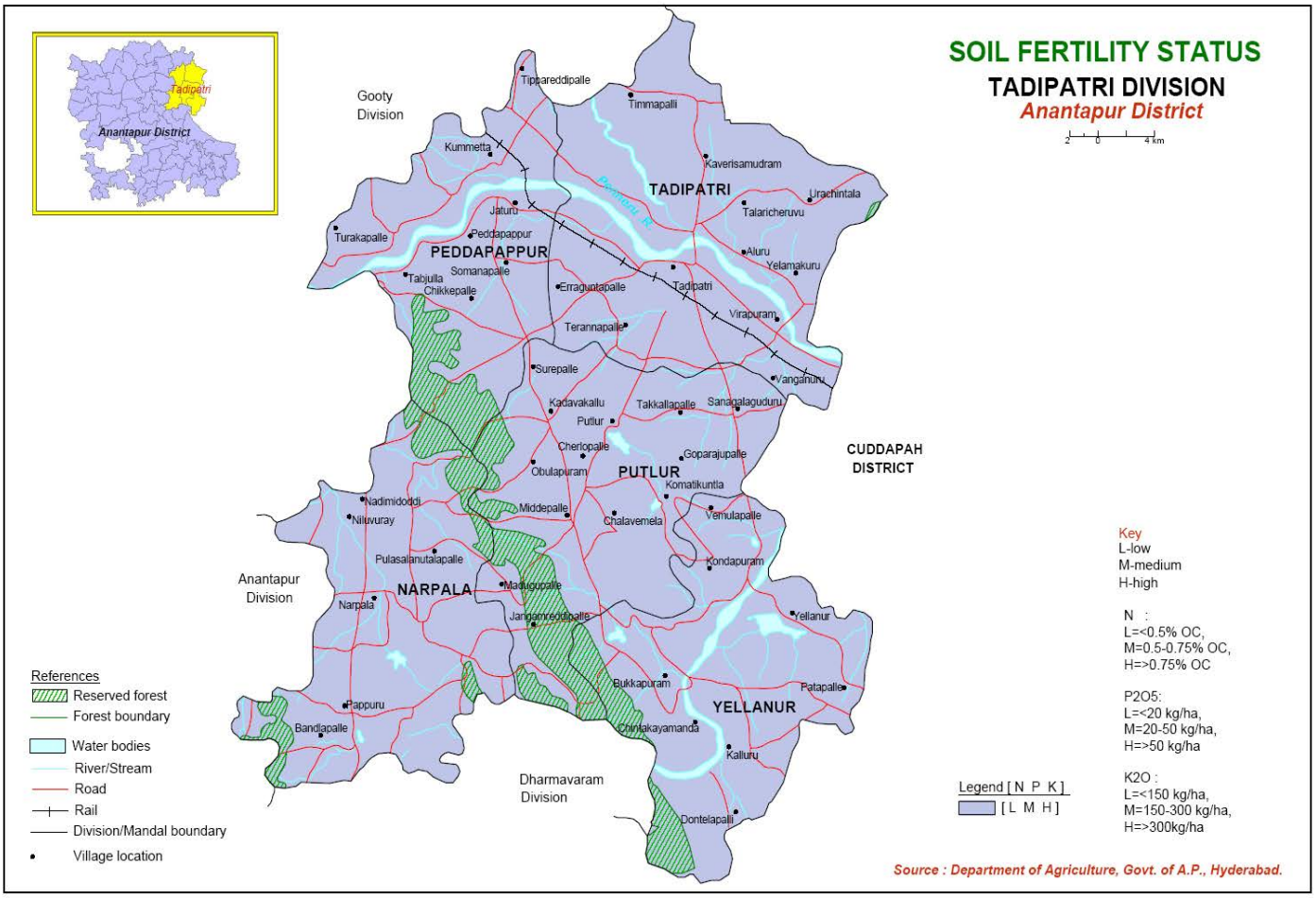


Figure 34. Availability of zinc in Dharmavaram. Source: NBSS and LUP

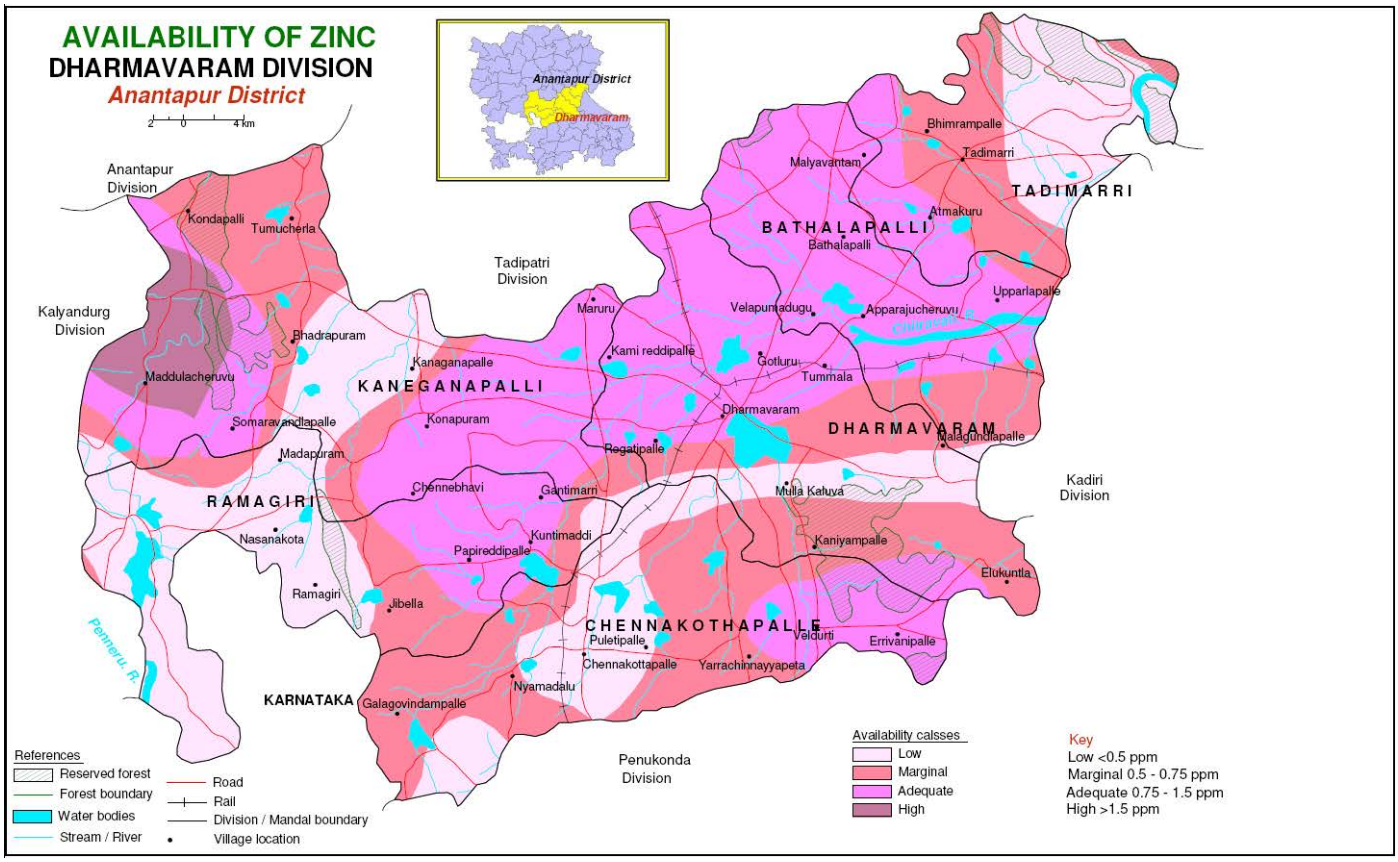


Figure 35. Soil-available zinc in Tadipatri. Source: NBSS and LUP

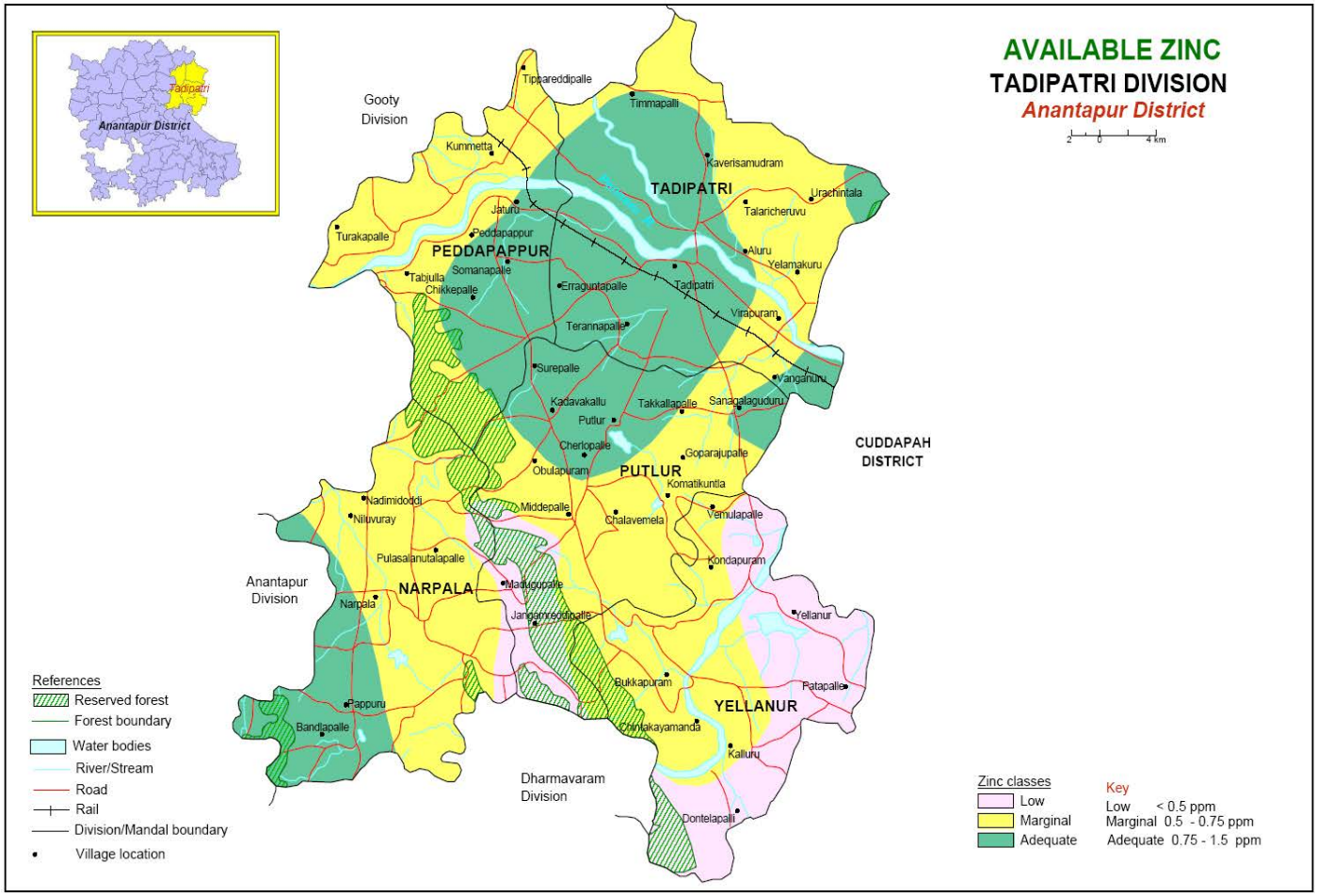


Figure 36. Soil degradation in Dharmavaram. Source: NBSS and LUP

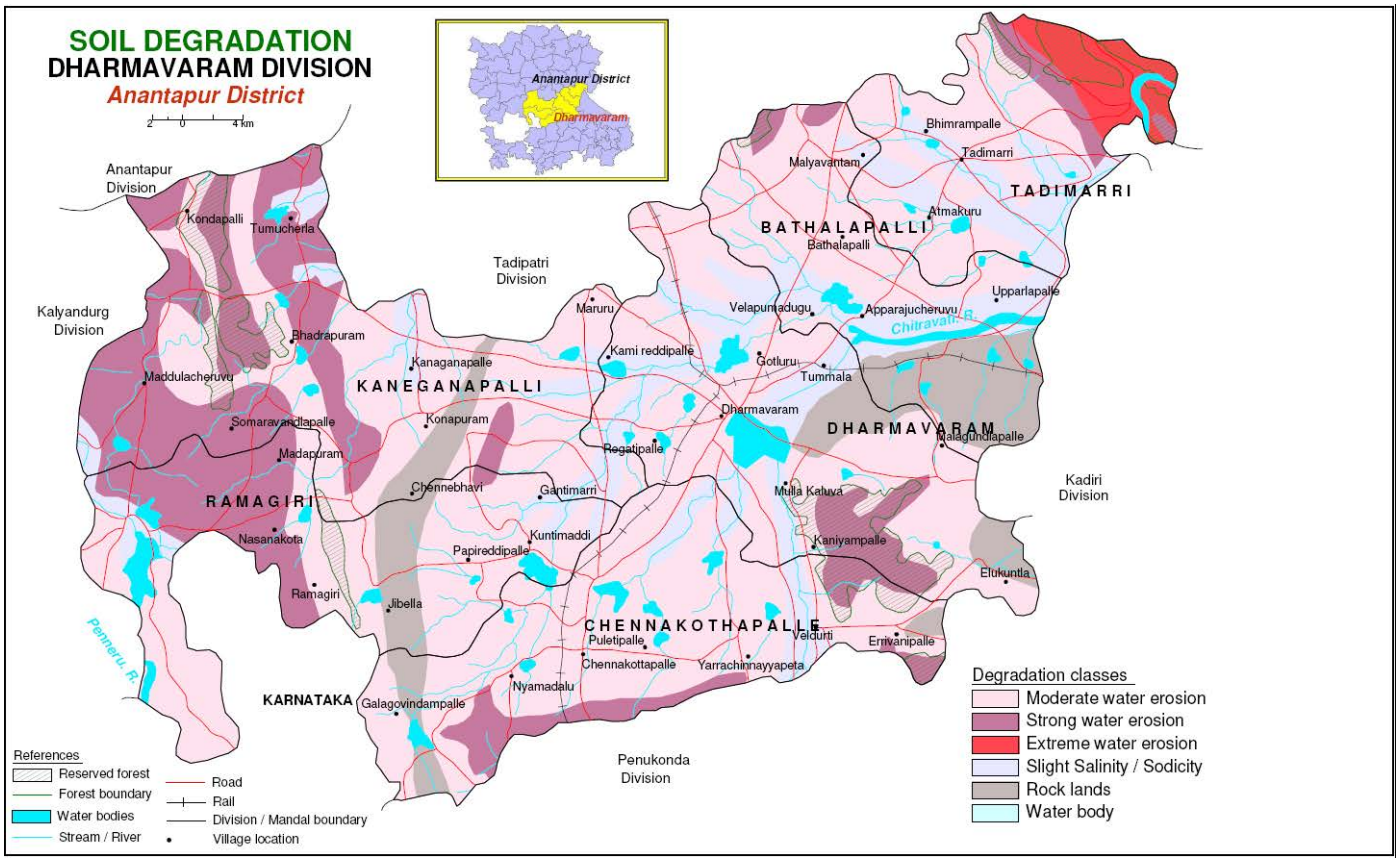
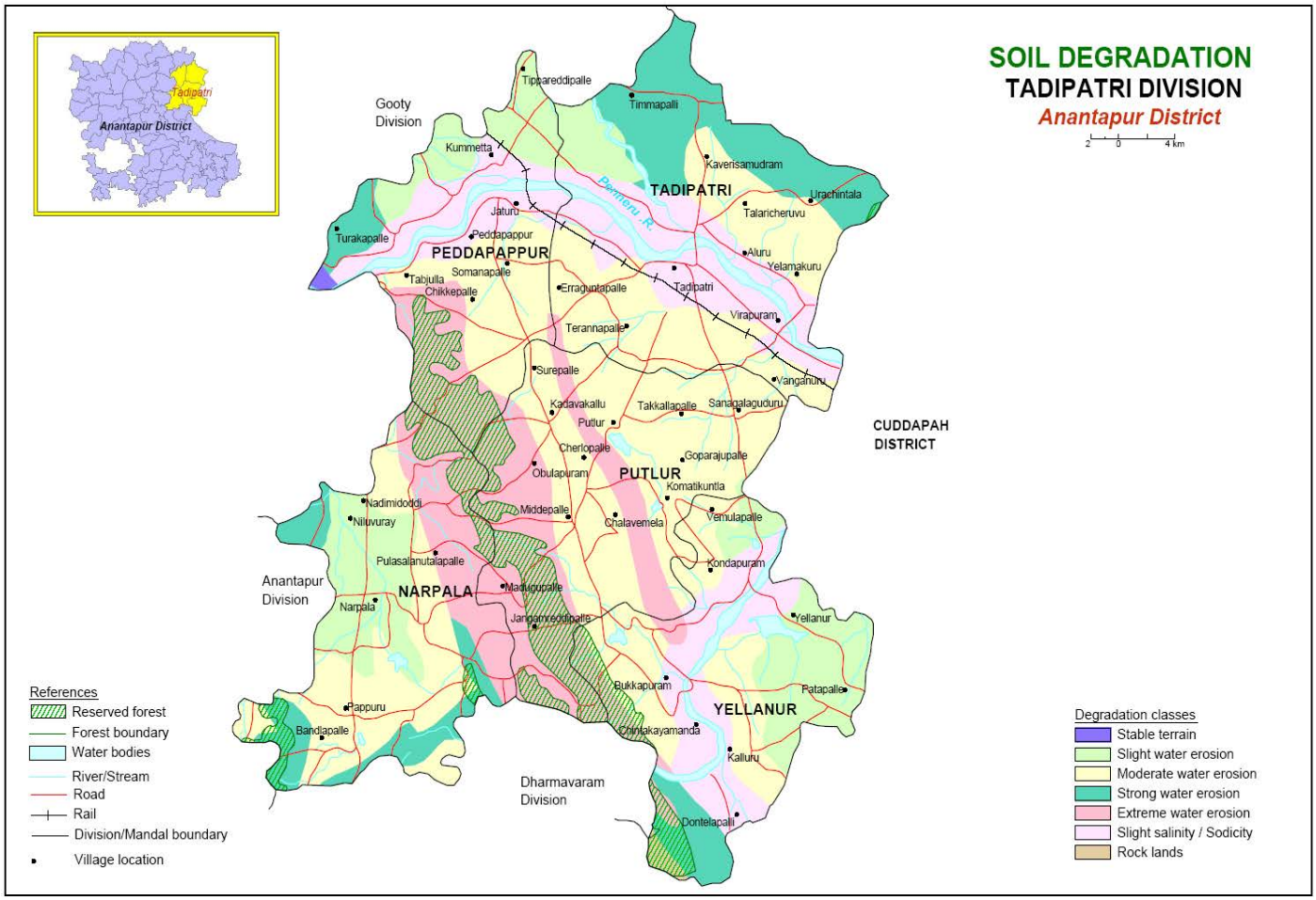


Figure 37. Soil degradation in Tadipatri. Source: NBSS and LUP



Land capability: capability of soils to produce field crops

Figure 38. Land capability in Dharmavaram. Source: NBSS and LUP

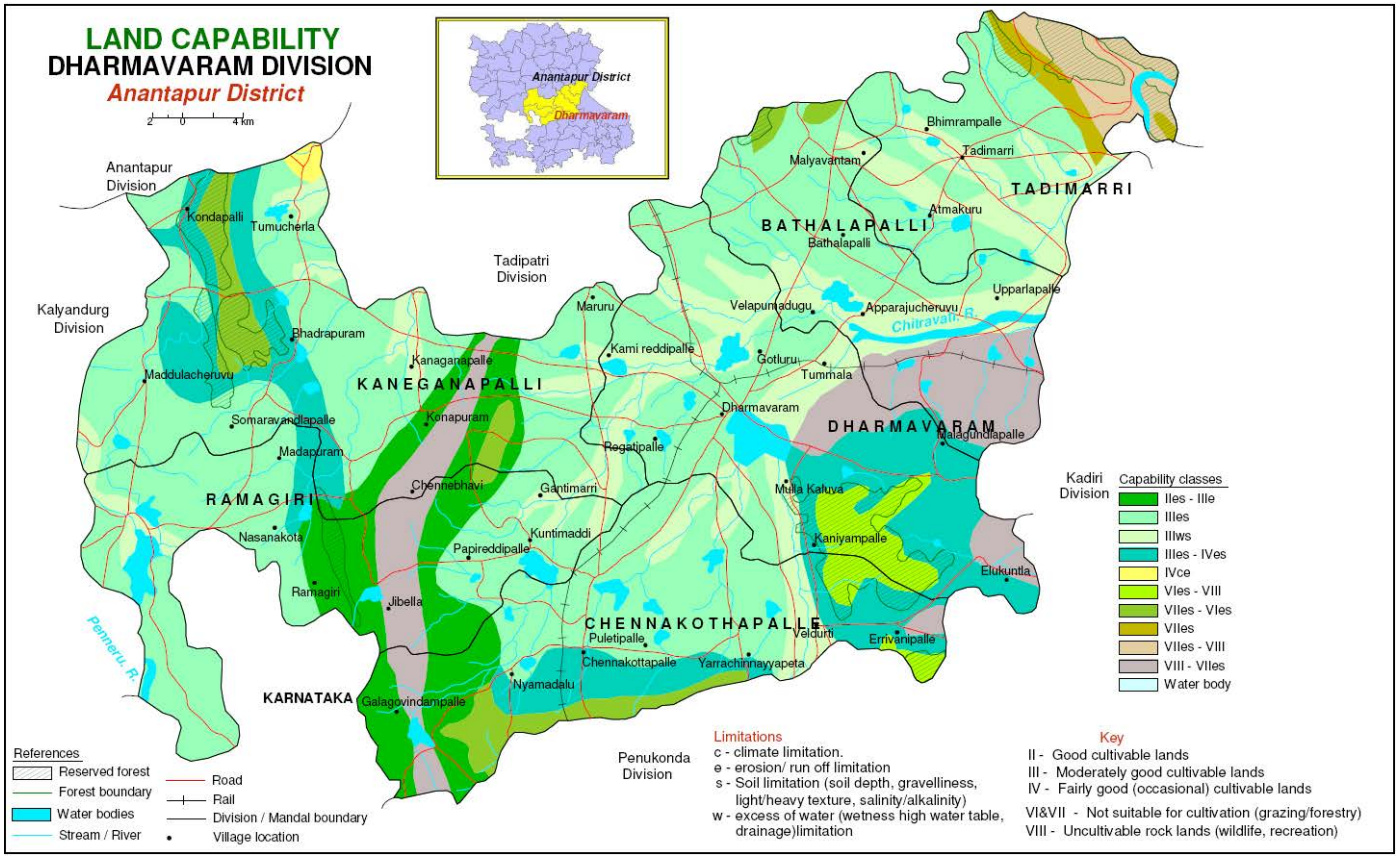
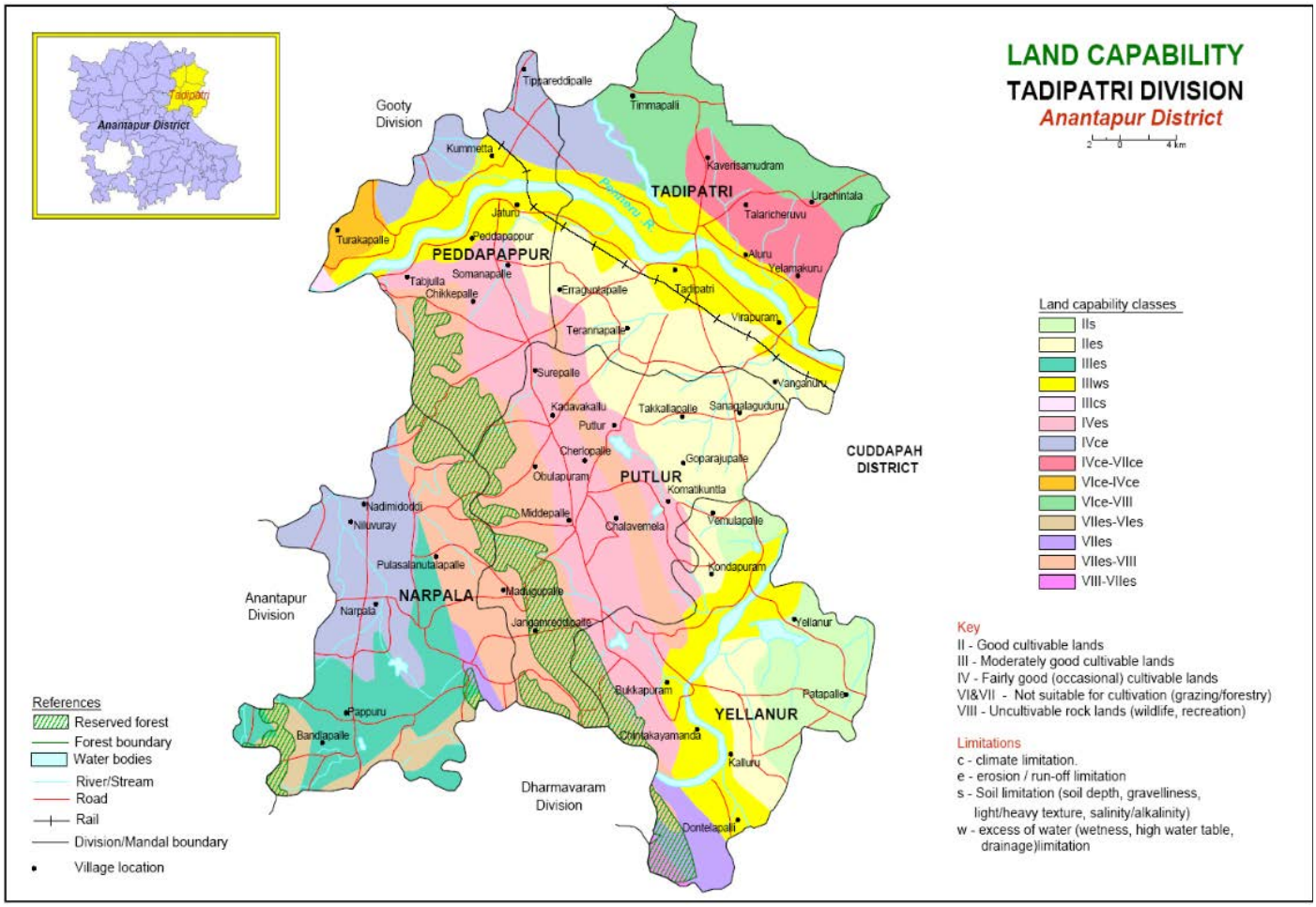


Figure 39. Land capability in Tadipatri. Source: NBSS and LUP



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