Current Agricultural Practices in Andhra Pradesh

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Consultant Dryland Agriculture
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Executive summary

The present study “Current Agricultural practices in Andhra Pradesh” is a part of the program “Reversing Environmental Degradation and Rural Poverty through Adaptation to Climate Change in Drought Stricken Areas in South India: A Hydrological Unit Pilot Project Approach”, referred to as Strategic Pilot on Adaptation to Climate Change (SPACC) Project. Bharathi Integrated Rural Development Society (BIRDS) entered into an agreement with Food and Agriculture Organization (FAO) of the United Nations (UN) for implementing a project. This forms part of the baseline Study to establish pre-intervention scenario of the SPACC project, in 9 pilot Hydrological Units in 7 districts of Andhra Pradesh.

The present study focuses on the current practices in raising major crops in various hydrological units with respect to agriculture and natural resource management. Strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies. This report focuses on a brief Review of the issues of dryland agriculture, policy initiatives, and alternatives available. A brief look at the works carried out in the sphere of dry land agriculture, at central and state level, cropping patterns in seven districts of Andhra Pradesh covering 9 hydrological units, studies the existing crop management practices. From the broad concepts emerging out it draws some conclusions to throw light on the issues that need support.

The study focuses on the cropping pattern in respective hydrological unit, looks in to the existing farming practices regarding following issues.

1) Assessment of source of seed, varieties and storage with relation to major crops
2) Assessment of present crop diversity and crop intensity in the project area
3) Assessment of cropping system in the Project area
4) Assessment of Fertilizer and Manure Management in the project area (Source, type, dosage and method of application)
5) Assessment of Soil erosion management practices (cultural, physical and others)
6) Assessment of Crop residue management
7) Assessment of current crop yield and cost of cultivation
8) Assessment of prices for the major crops and marketing channel

The broad principles and approaches mentioned in recommendations section are based on the review of works from academic institutions, views of eminent scientists and grass root level NGOs, and farmers experiences; the approaches are broadly categorized as follows.
1) Long term approaches for strategic adaptation to climate change
   These approaches keeps in mind the natural resources availability, like soils, water bodies and animal and human populations and their dependencies on resources. This will consider the needs on the part of communities, opportunities available and policy and invest supports needed from academic and administrative bodies. These are strategic approaches with a perspective of checks and balances in the ecosystem.
   a. Farming system based approaches
   b. Resource conserving technologies
   c. Policy level initiatives
   d. Contingency crop plans
   e. Cropping system based approaches
   f. Researchable areas

2) Short term approaches for strategic adaptation to climate change
   These are mainly focused on bringing relief to the farmers, affected by the vagaries climatic factors on their resources as a result of the climate change. They are intended to give immediate solutions to problems but if followed would finally lead towards the sustainable alternatives discussed in the long term ecological approaches.
   a. Crop management strategies
   b. In season drought management
   c. Cropping system based recommendations

Supportive data and additional information are presented in the end of the report.
1.0.0. Introduction

Indian agriculture is traditionally a system of rainfed agriculture. India has a geographical area of 328.73 million hectares; of which reported area for land use is 306.04 million hectares. The net area cultivated is about 142.60 million hectares i.e. about 46.6 per cent of the total reported area. Since nearly 50 million hectares of area is sown more than once, the cropping intensity works out to 135.1. Forests account for about 68.97 million hectares i.e. 22.5 percent of the total reported land area. Also nearly 13.97 million hectares are cultivable wastelands and 9.91 million hectares are fallow lands. Only about 30 percent of the total cropped area is irrigated and the remaining area is rain fed. The available statistics further shows that only about 66 percent of the gross cropped area is under food crops and nearly 34 percent area under nonfood crops. Cereals and pulses account for 52.93 per cent and 12.64 percent of the total area respectively. Fruits and vegetables occupy nearly 4.24 percent of area (Haque 2003).

The potential for expanding irrigated agriculture is decreasing as it becomes more expensive or risky to further exploit water resources. It has been realized that even if the full irrigation potential of the country were to become operative, 50% of the net sown area would continue to be rain-fed. Hence, rain-fed agriculture is still high on India’s development agenda. Its contribution is vital to the food security and livelihoods of the poorest farming families and communities, who have no access to irrigated land (Fan and Hazell 2000). The agricultural census data (Govt. of India, Agricultural Census Division, Ministry of Agriculture, 2002) also reveal that about 78 percent of operational holdings in the country are marginal and small, having less than 2 hectares. About 13 percent holdings have 2 to 4 hectares and 7.1 per cent have 4 to 10 hectares of land. (Haque 2003). Moreover, dryland agriculture holds the key for future food security because the green revolution has reached its saturation point in enhancing land productivity. It has also been shown that returns on investment in rainfed agriculture are greater than those in irrigated agriculture.

1.0.1. Importance of dryland agriculture in India

About 70% of rural population lives in dry farming areas and their livelihood depend on success or failure of the crops. Dryland Agriculture plays a distinct role in Indian Agriculture occupying 60% of cultivated area and supports 40% of human population and 60 % livestock population. The contribution (production) of rainfed agriculture in India is about 42 per cent of the total food grain, 75 per cent of oilseeds, 90 per cent of pulses and about 70 per cent of cotton. By the end of the 20th century the contribution of drylands will have to be 60 per cent if India is to provide adequate food to 1000 million people. Hence tremendous efforts both in the development and research fronts are essential to achieve this target.
Majority of the districts in India are dry farming districts and covers 60 per cent of the total cultivated area. Most of this area is covered by crops like millets, pulses, oilseeds and cotton etc. These areas spread throughout the country i.e. Tamilnadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Maharatra, Gujarat, Rajasthan, Punjab, Haryana and Uttar Pradesh. In south India the Deccan plateau which is rain shadow area consisting of parts of Karnataka, (Bellary, Raichur, Kolar, Tumkur, Dharwad, Belgam, Gulberga) and Maharashtra (Sholapur, Parbani, Pune, Aurangabad). The dry farming areas in Andhra Pradesh are found in Kurnool, Anantapur, Kadapa, Mahabubnagar, Chittoor, and Nalgonda districts. About 84 districts in India fall in the category of low rainfall area and Providing irrigation to all the drylands is expensive and takes long time. Even after providing all the irrigation potential in India 55 per cent area remains as rainfed. (ANGRAU, Hyderabad. http://www.angrau.net/Publications.htm).

1.0.2. Climate change and rainfed agriculture
Climate change impacts on agriculture is witnessed all over the world, but countries like India are more vulnerable in the view of high population depending on agriculture, excessive pressure on natural resources and poor coping mechanisms. A large area of land under dryland agriculture is expected to undergo changes in rainfall patterns, temperature and extreme events over next several decades due climate change thus making rainfed agriculture more risk prone. Improved technologies and new policy initiatives are needed to enable framers cope with climate change impacts. (Singh, AK., and Venkateswarlu, BV., 2009)

1.1.0. Background of the study

The present study “Current Agricultural practices in Andhra Pradesh” is a part of the program “Reversing Environmental Degradation and Rural Poverty through Adaptation to Climate Change in Drought Stricken Areas in South India: A Hydrological Unit Pilot Project Approach”, referred to as Strategic Pilot on Adaptation to Climate Change (SPACC) Project. Bharathi Integrated Rural Development Society (BIRDS) entered into an agreement with Food and Agriculture Organization (FAO) of the United Nations (UN) for implementing a project. This is a Medium-sized Project (MSP) supported by The Global Environment Facility (GEF) Trust Fund. FAO provides co-financing under its project GCP 177. BIRDS and its partner Non Governmental Organizations (NGOs) also provide co-financing in the form of Local Contribution (LC), in kind.

In line with BIRDS mandate to conduct a Baseline Study to establish pre-intervention scenario of the SPACC project, in 9 pilot Hydrological Units; The Technical Report: “Current Agricultural practices in Andhra Pradesh” will be a key input into the Study Document “Local and Scientific knowledge on climate variability/change and its impact on natural resources in Andhra Pradesh”.
1.2.1. Objective of the study

The present study “Current Agricultural practices in Andhra Pradesh” focuses on the current practices in raising major crops in various hydrological units with respect to agriculture and natural resource management. Strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies. This report focuses on cropping patterns in seven districts of Andhra Pradesh covering 9 hydrological units working in partnership with 9 partners (Fig.1).

The chapters take a closer look at cropping pattern in representative dryland regions and their adaptation measures to cope with these climate variability changes. Finally, it synthesizes the key findings to recommend some strategic intervention priorities to address climate change adaptation that complement and support the Governments’ developmental objectives and effectively support farmers in the most sensitive areas. With this background the study is proposed to:

- Documenting existing cropping system / cropping patterns in the 9 hydrological units.
- Existing cultivation practices under cropping patterns and costs incurred.
- Recommend adaptation options for dryland practices to climate change.

The results shall thereby:

a) Assist the communities to become aware of future challenges and options to adapt to climate change
b) Give recommendations for which external support is needed for future adaptation in the communities.
c) The results will be spread through the BIRD S and other networks and thereby aid other smallholders / communities to adapt to climate change.

1.2.2. Methodology

The study was done between October 10th to December 20th and used mainly qualitative methods to collect data, which ensured maximum participation of the key stakeholders. The methodology adopted for achieving the stated objective was solely field based collection and collation of data. The methodology was designed as per the standards of Qualitative Research that included the formulation of a structured questionnaire, pre-testing and finally interviewing the subjects by visiting the identified sites. Qualitative research methods included participatory methods (PRA) involving focus group discussions and key informants at village level through workshops and direct observations among others. The key informants are heads of communities, community chiefs, the spokesmen, elders and other opinion leaders. These informants are privileged to know the communities very well. The information collected was to ascertain the present status of farming system, the traditional farming system practiced and its continuation, alternative sustainable agricultural practices to cope up with effects of climate change etc.

A. Preparation of Questionnaire: A detailed questionnaire was prepared by keeping the objectives as the central theme. The questions were formulated that sought information with respect to social data, farm holding etc. In addition to this, a detailed account of the topography, perception of soil fertility of the farm by the farmers, presence of water resources and its adequacy was collected. An entire section was devoted on the various aspects of farm management, wherein the performance of crops under mono and mixed farming were specified. Questions on the crop agronomy including farm inputs, maintenance of soil fertility both in mono-cropping and mixed cropping were discussed in detail. A separate section on Climate change information to collect data on farmer’s perception was present.

B. Identification and selection of sites: The scope of the study extended in seven districts of Andhra Pradesh among the various soil types and rainfall patterns to give the study a representative picture of the selected parts of the state. The regions that were identified and included in the project included three geographic areas in Andhra Pradesh: Prakasam district from Andhra region, Mahaboobnagar and Nalgonda from Telangana, and all the districts of Rayalaseema with most rainshadow region included from Kurnool, YSR Kadapa, Anantapur and Chittoor.
C. Data collection: The survey was designed to collect data on farm characteristics (e.g., type of production system, landholding size, agricultural practices, income sources etc.) and sensitivity impacts (e.g., frequency and extent of crop losses). Data is collected in direct interaction with group/individual farmers, grass root level workers that are involved in working on sustainable agricultural practices. Farmer practices and recommendations recorded in interaction with various departments connected with agricultural services, meteorological department personnel and researchers from the Agriculture Research Stations to collect relevant information. Data also collected from various publications from research institution at local, state and national level through libraries. Data also sourced from publications posted on worldwide web.

The selection of the study areas was done on the basis of association and guidance/advice from the BIRDS partners. The selected villages varied both in terms of irrigation as well as the socioeconomic parameters such as total land area; households, human and cattle population, literacy and average family income. Most of the villages selected for the survey were dependent on rainfed agriculture and had little to no irrigation facilities at their disposal.
2.0.0. Review on dryland agriculture in the context of climate change

2.0.1. Climate change
Climate change is a complex alteration of climate, subtle and continuous, yet extremely important through its consequences on vegetation of various types that thrived under constant or relatively unchanged climates. The effects of climate changes have reached such an extent that irreversible changes in functioning of the planet are feared. Some of the main effects of climate change with specific reference to agriculture and food production especially during the last decade are: increased occurrence of storms and floods; increased incidence and severity of droughts and forest fires, steady spreading out of frost free intervals and potential growing seasons, increased frequency of diseases and insect pest attacks and vanishing habitats of plants and animals. It is important for international scientific community to use all accessible knowledge to stop or reverse this trend to the maximum extent possible. There has been various attempts and viable measures in the past to bring down the atmospheric greenhouse gases to slow down the climate change (Boer et.al 2000).

However, if warming trend continues at its current pace, these may soon prove inadequate. Carbon dioxide emissions from agriculture are small but other important GHGs are emitted from agriculture. Agriculture accounts for about 60% of all nitrous oxide, mainly from fertilizer use and about 50% of methane mainly from natural and cultivated wetlands and enteric fermentation. Methane and nitrous oxide emissions are projected to further increase from 35-60% by 2030, driven by growing nitrogen fertilizer use and increased livestock production in response to growing food demand. As climate patterns shifts, significant impact on crop yields through changes in temperature, moisture and changes in distribution of pests and diseases. At the same time, agriculture proved to be one of the most adaptable human activities to varied climate conditions (Mendelsohn etal, 2001).

Climate change poses particular challenges for India, due to its immense diversity, geographical, physiographical, social and economic. In India, climate vulnerability and impacts are likely to vary substantially across regions and populations. Although many impact studies have been carried out for the agriculture sector (as discussed in the above section) one must acknowledge the fact that climate change, though a global phenomenon will be mainly faced by resource poor farmers. Agricultural production remains the main source of livelihood for rural communities in India, providing employment to more than 65 percent of the population. With likely long-term changes in rainfall patterns and shifting temperature zones, climate change is expected to significantly affect agricultural production, which could be detrimental to the region's food security and economic growth. The severe impacts of climate change have to be managed by these farmers, at a local level. It affects current conditions of production and their
access to resources, including land, water and seeds, as well as their capacity to apply acquired knowledge.

2.0.2. Climate Change – Impact on Agriculture: Indian perspective

Scientific evidence about the seriousness of the climate threat to agriculture is now unambiguous, although the exact magnitude is uncertain because of the complex interactions and feedback processes in the ecosystem and in the economy. The Fourth Assessment Report by the Inter-Governmental Panel on Climate Change (IPCC) in 2007, projects for India an acceleration of warming above that observed in the 20th century, a decrease in precipitation, and an increase in the occurrence of extreme weather events. Climate change is expected to have adverse effects on agriculture, the eradication of poverty, food security, and the water supply (IPCC, 2007).

Agriculture plays a prominent role in the Indian economy. India is a land of small cultivators and 80 per cent of its farmers owning less than 2 ha of land. In other words, the land provides livelihood security for 65 per cent of the people, and the small farmers provide food security for 1 billion people. Agriculture and allied sectors like forestry, logging and fishing accounted for 16.6% of the GDP in 2007, employed 60% of the total workforce (CIA Fact book, 2008) and despite a steady decline of its share in the GDP, it is still the largest economic sector. More than one billion people in India, directly or indirectly are involved in the agricultural sector.

Climate change is likely to affect all the natural ecosystems as well as socio-economic systems as shown by the National Communications Report of India to the UNFCCC (INC, 2004). Various studies have indicated a probability of 10 to 40 per cent loss in crop production in the country due to the anticipated rise in temperature by 2080. Studies conducted by Indian Agricultural Research Institute (IARI) have pointed to a possible loss of 4 to 5 million tonnes in the overall wheat production with every 1 degree centigrade increase in temperature throughout the growing period of the crop.

With the growing evidence of climate change over the last few years, an increasing emphasis was put on studying the impact of climate change on Indian agriculture (Lal et al., 1998; Kumar and Parikh, 2001). A number of crop simulation modeling studies, based on future climate change scenarios, with a focus on the vulnerability of rice and wheat yields has been carried out. According to the latest results of the crop simulation modeling studies published in the AR4, the drop in yields of non-irrigated wheat and rice in India will be significant: a temperature increase beyond 2.5 °C would incur a loss in farm-level net revenue between 9 and 25 percent. Net cereal production in India is projected to decline at least between 4 and 10 percent by the
end of this century under the most conservative climate change scenario (Lal, 2007 cited in IPCC, 2007). While yields of important cereal crops like rice and wheat are expected to drop significantly with impacts of projected climate change, biophysical impacts on some of the important crops like sugarcane, cotton and sunflower are yet to be studied adequately.

India has a distinctive continental arid and semi-arid climate with hot cloudless dry summers and moist relatively warm winters in the south and cold winters and with severe frost in the north. India’s drylands will face not only increasing temperatures with climate change but also disruptions in their hydrological cycles resulting in less and more unpredictable rainfall that will worsen the already critical state of water scarcity and conflicts over water distribution. Nearly 80 m ha of India’s 143 m ha net sown area is rainfed. Rainfed farming area falls mainly in arid, semi-arid and dry sub-humid climate zones. About 15 million ha area lies in arid region which receives <500 mm rainfall; another 15 mha is in 500 – 700 mm rainfall zone, 42 mha is in 750-1150 mm rainfall zone and remaining 25 mha receives >1150 mm rainfall per annum. About 74% of the annual rainfall occurs during SW monsoon (June-Sept). This rainfall exhibits high coefficient of variation with frequent droughts. Over 87% of coarse cereals and pulses, 55% of upland rice, 77% of oil seeds and 65% of cotton are cultivated under rainfed farming (Singh, AK., Venkateswarlu, BV., 2009)

Agriculture is not only sensitive to climate change but is also one of the major drivers of it. Scientific evidence about seriousness of the climate threat to agriculture is now unambiguous, but the exact magnitude is uncertain because of the complex interactions and feedback process in the ecosystem and the economy. In India agriculture sector contributes ~22% of the total GHG emissions. The emissions are mainly due to methane emitted from rice paddies, enteric fermentation in ruminant animals, nitrous oxides from application of manures and fertilizers to agricultural soils (Sharma et al., 2006).

Studies so far suggest that following 5 main climate related factors would affect agricultural productivity in the coming decades: changes in temperature, precipitation, carbon dioxide, fertilization, short term weather variability and surface water runoff. Simulation results from IPCC, Cambridge (2007 indicate that average global surface temperature could rise by 0.6 – 2.5°C in next 50 years, and by 1.4 – 5.8°C in the next century. Simulation of future climate in India under A2 scenario by Indian institute of Tropical Meteorology (IITM), Pune, and Hadley Centre, UK indicate that by the last quarter of the present century the mean annual temperature in the country will almost likely increase by 3-5°C. The spatial average for the increase in annual rainfall during the period is 7 – 10% (Rupakumar, 2006). There will be disparity in the changes in distribution if rainfall and temperature. North India is expected to be warmer than the south but more importantly, night temperature and winter temperature would register higher of 5°C increased over the most part. It is also predicted that by 2071 the
overall summer monsoon rainfall in India will increase by 20%, extreme rainfall events would rise sharply especially in parts of Gujarat, Maharashtra, Madhya Pradesh, Karnataka and Andhra Pradesh. Incidence of tropical storms in Arabian sea coast is also likely to increase. The onset of summer monsoon could become more variable. Overall the changes are likely to have more adverse effects than benefits. Increase in temperature is likely to be less during the rainy season and more during winter season, whereas rabi rainfall will be more uncertain. The Kharif rainfall is likely increase by 10% (Joshi, NL., Amal kar., 2009).

At present we are able to harness only 29% of the precipitation. It is indeed a challenge to sustain 17% of the world population. With India’s share of 4.2% of water, 2.3% of land and 11% of livestock of the world, meeting the basic requirements; How effectively and judiciously we harvest water and increase its use efficiency and productivity is the key in the rainfed agriculture. In a country like with India with majority people dependent on agriculture, soil erosion at the rate of 16 tons per ha per year should be regarded as a colossal loss (Mangla Rai, 2007).

2.1. Government of India’s Initiatives (Poonam Pande and Kaspar Akermann, 2011)
The Government has been trying to mainstream climate change concerns into the relevant sector policies. Several ongoing efforts to promote sustainable agriculture, forestry and coastal zone development, address some of these vulnerability concerns, although they are primarily driven by the objective of sustainable livelihood and poverty alleviation. India faces the challenge of sustaining its rapid economic growth in order to lift large parts of its population out of poverty. Climate change represents a serious threat to India’s ambitious poverty reduction goals. The Government of India recognized the need for a national strategy to firstly, adapt to climate change and secondly, to further enhance the ecological sustainability of India's development path. Currently, India spends around 2.6% of its GDP on adaptation activities.

2.1.1. National Action Plan on Climate Change (NAPCC)
The National Action Plan on Climate Change (NAPCC), which was pre-pared by the Prime Minister’s Council on Climate Change and published in June 2008, is the government of India’s official response to address the upcoming climate challenges. The plan formulates the government’s climate strategy and addresses both adaptation and mitigation issues. The implementation of the Plan would be through appropriate institutional mechanisms suited for effective delivery of each individual Mission’s objectives and include public private partnerships and civil society action. The focus will be on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. The NAPCC
plans to institutionalize the identified eight national missions by the respective ministries. The eight missions are,

i) National Solar Mission
ii) National Mission for Enhanced Energy Efficiency
iii) National Mission on Sustainable Habitat
iv) National Water Mission
v) National Mission for Sustaining the Himalayan Ecosystem
vi) National Mission for a Green India
vii) National Mission for Sustainable Agriculture and
viii) National Mission on Strategic Knowledge for Climate Change.

In accordance with this, the concerned ministries were requested to submit their respective strategies with a definite plan of action and timeline to the Prime Minister’s Council on Climate Change. The National Mission for Sustainable Agriculture, supervised by the Ministry of Agriculture, has put special thrust on the following key aspects:

- Strategic Research on varietal improvement (through biotechnology).
- Sustained Increase in food-grain production (through environment friendly, organic, conserving farming practices)
- Improvement in water-use efficiency.
- Strengthening Risk Management Systems (through efficient early warning systems and easy insurance schemes)
- Measures for Capacity Building for farmers and Information Management at block levels.

2.1.2. National Farmers Policy 2007

The Ministry of Agriculture has brought out a comprehensive National Policy for Farmers in 2007, so far the only policy, which explicitly spells out the vulnerability of farmers to climate change. It has a full section devoted to Climate Change where it mentions forming “Climate Managers” to be trained to face floods, droughts and monsoon aberrations. The policy recommends “Proactive measures based on simulation models, contingency plans and alternative land-use and water-use strategies for each major agro-climatic zone, to reduce the vulnerability to climate change”.

The policy also emphasizes the fact that credit facilities need to be made available to the farmers. Financial services would be galvanized for timely, adequate and easy reach to the
farmers at reasonable interest rates. The policy also admits that the present National Agriculture Insurance scheme is not farmer-friendly and states: “Since agriculture is a high-risk economic activity, farmers need user-friendly insurance instruments covering production, right from sowing to postharvest operations. The insurance should also cover the market risks for all crops, in order to insulate the farmers from financial distress and in the process make agriculture financially viable. Steps would be taken to revamp the National Agricultural Insurance Scheme to make it more farmer-friendly”.

The National Agriculture Policy, 2002, seeks to achieve growth in a sustainable manner and with equity. The section most relevant from a climate change point of view is the Risk Management section. Price fluctuation and natural calamities are recognized as main factor for imparting instability to condition of farmers.

The NAP suggests putting emphasis on following aspects:
(1) enhancing flood proofing and drought proofing
(2) ensuring remunerative prices through announcement of Minimum Support Prices (MSP) and (3) future trading in agriculture products.

Risk proofing in agriculture through insurance is a very complicated process. Covering all crops and all farmers through this seems to be gigantic, rather ambitious task. Technological and infrastructural solutions are more appropriate in the Indian circumstances. Announcement of MSP in itself does not ensure that farmers get remunerative price or price above the ceiling level. Future trading is allowed with more and more agricultural products in India in order to minimize price fluctuations and for hedging price risk.

2.2. Climate change issues on agriculture in the state of Andhra Pradesh
In the arid study regions of Andhra Pradesh the climate projections indicate substantially higher temperatures (2.3°C -3.4°C on average) and a modest but more erratic increase in rainfall (of about 4% to 8% at the basin level). With high prevailing baseline temperatures these changes generate deteriorating agro climatic conditions, with declining yields for the major crops (rice, groundnut and jowar). Though all yields decline, conditions are more favorable to groundnut, which is already prevalent in the area, reflecting farm-level adjustments to arid conditions. Despite groundnut’s suitability to these harsh conditions there are well-recognized risks that prolonged monocropping brings: pests, disease, and fertility loss. Projections suggest that declining yields of major dryland crops are mirrored in lower agriculture incomes. In the harsher climate change scenarios, farm incomes could decline substantially (by over 20%), suggesting that agriculture as currently practiced may not be capable of sustaining large populations on small rain-fed farms (World Bank Report, 2008).
Agriculture plays a pivotal role in the economy of Andhra Pradesh with paddy, millets and cotton being the major crops (State Action Plan on Climate Change for Andhra Pradesh, July, 2011. Ministry of Environment and Forests, Government of India, New Delhi).

2.2.1. Rainfall
Erratic and decreased rainfall especially winter rainfall has a negative impact on Rabi crops, especially in the rainfed areas. The NE Monsoon deviated from normal by -45% in 2008-09, -27% in 2006-07, 45% in 2005-06 etc. Rainfed agriculture is risky due to unpredictable rains. For example in Mahabubnagar in the year 2005-06, there was 61% excess rainfall while in Anantapur it rained 43% more than normal. However in the year 2008, districts like Mahaboobnagar, Srikakulam, Adilabad and Nalgonda recorded deficit rainfall in the range of 60-99%.

2.2.2. Temperature
Temperature fluctuations affect Rabi crops severely. Studies show that every 1°C rise in temperature reduces wheat production by 4-5 million tons on a national scale. This would have severe implications for the crop production in Andhra Pradesh also. Heat waves result in dehydration of plants which is not regained by night. Damaging effect appears to be caused by rapid dissipation of reserve carbohydrates that slow down new leaf production and poor recovery from defoliation.

2.2.3. Power availability for agricultural purposes
Farm power intensity in the State is yet to achieve the envisaged level due to relatively slow adoption of tractor and other mechanical devices. The government has a target of 3.2 kWh/ha, 3.6 kWh/ha and 4 kWh/ha in 2009-10, 2010-11 and 2011-12 respectively. Dependency and vulnerability of the sector on natural climatic events has caused crop failures and distress among the farmers.

Key issues:
- Decrease in winter rainfall has a negative impact on winter crops (Rabi crops) especially in the rainfed areas.
- Temperature fluctuations affect Rabi crops severely.
- Heat waves result in dehydration of plants
- The decrease in area under crops on account of insufficient rainfall, particularly in the South-West Monsoon period.
- Rainfed agriculture has become risky due to unpredictable rains.
• Due to loss in vegetation, heavy run-off takes place resulting in wastage of water and soil erosion.
• Dryland areas (parts of Anantapur, Kurnool, Kadapa, west Guntur, east Mahaboobnagar, Prakasam, Nalgonda) exist in the State where annual rainfall is less than 550 mm and farming is not viable.
• Loss in fertility of soil in many areas due to excessive use of fertilizers and pesticides.

The purpose of mitigation and adaptation measures is therefore to attempt a gradual reversal of the effects caused by climate change and sustain development under the inescapable effects of climate change. Here it is important to understand the subtle difference between mitigation and adaptation, which are related to the temporal and spatial scales on which they are effective. The benefits of mitigation activities carried out today will be evidenced in several decades because of the long residence time of greenhouse gases in the atmosphere, whereas the effects of adaptation measures should be apparent immediately or in the near future (Kumar and Parikh, 2001). Besides, mitigation has global in addition to local benefits, whereas adaptation typically takes place on a local or regional scale. Adaptation measures include establishing disaster risk management plans and risk transfer mechanisms, such as crop insurance and diversified livelihood systems (Reilly and John, 1996). Mitigation options include carbon sequestration in agriculture and forestry. The IPCC estimates that the global technical mitigation potential for agriculture will be between 5500 and 6000 Mt CO₂ equivalent per year by 2030, 89% of which are assumed to be from carbon sequestration in soils. The potential benefits of carbon sequestration are: 1. Mitigation is done when CO₂ is removed from the atmosphere. 2. Adaptation is achieved when higher organic matter levels in soil increases agro-ecosystem resilience and 3. Income generation and livelihood is sustained when improved soil fertility leads to better yields. (Venkateswarlu and Arun, 2009).

2.3.0. Dryland agriculture in India
In the country with low and precarious rainfall two types of agriculture systems are usually met, one is crop production on arable farming land and other is animal husbandry, including management of grazing areas. Dry farming is an improved system of cultivation in which maximum amount of moisture is conserved in low and untimely rainfall for the production of optimum Quantities of crop on economic and sustained basis. Dry farming in short, is a programme of soil and water management designed to conserve the maximum quantity of water on a particular piece of land. In a more specific way dry farming may be defined as an efficient system of soil and crop management in the regions of low land and uneven distributed rainfall. Another term used some times synonymously is rainfed farming that sounds close but variation is as follows (Source: http://www.agriinfo.in/?page=topic&superid=1&topicid=421).
Table 1. Dry land Vs Rainfed farming.

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Dryland farming</th>
<th>Rainfed farming</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rainfall (mm)</td>
<td>&lt; 750 mm</td>
<td>&gt;750 mm</td>
</tr>
<tr>
<td>2. Moisture</td>
<td>Shortage</td>
<td>Enough / Sufficient</td>
</tr>
<tr>
<td>3. Growing season</td>
<td>&lt;200</td>
<td>&gt;200</td>
</tr>
<tr>
<td>4. Growing regions</td>
<td>Arid and Semiarid &amp; up lands of sub humid &amp; humid regions.</td>
<td>Humid and sub humid regions.</td>
</tr>
<tr>
<td>5. Cropping system</td>
<td>Single or intercropping</td>
<td>Intercropping or double cropping.</td>
</tr>
</tbody>
</table>

Table 2.: Classification of ‘dryland’ regions in India using Thornthwaite Classification

<table>
<thead>
<tr>
<th>Region</th>
<th>Annual avg rain fall in mm</th>
<th>Moisture index</th>
<th>Growing period in days</th>
<th>Total area In mha</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Glaciers &amp; Others</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.2</td>
<td>1.5</td>
</tr>
<tr>
<td>2 Hyper Arid</td>
<td>&lt;100</td>
<td>-83.3</td>
<td>0 - 60</td>
<td>22.9</td>
<td>7.0</td>
</tr>
<tr>
<td>3 Typic Arid</td>
<td>100-500</td>
<td>-66.7 - 83.2</td>
<td>60 - 90</td>
<td>22.7</td>
<td>7.0</td>
</tr>
<tr>
<td>4 Semi-Arid (dry)</td>
<td>500-750</td>
<td>-50 to - 66.6</td>
<td>90 -120</td>
<td>51.2</td>
<td>15.6</td>
</tr>
<tr>
<td>5 Semi-Arid (moist)</td>
<td>750-850</td>
<td>-49.9 - 33.4</td>
<td>120 -150</td>
<td>72.2</td>
<td>22.0</td>
</tr>
<tr>
<td>6 Sub-humid (dry)</td>
<td>850-1000</td>
<td>-33.3 - 0</td>
<td>150-180</td>
<td>54.1</td>
<td>16.5</td>
</tr>
<tr>
<td>7 Sub-humid (moist)</td>
<td>1000-1500</td>
<td>0 - 20</td>
<td>180-270</td>
<td>39.8</td>
<td>12.1</td>
</tr>
<tr>
<td>8 Dry/Moist Sub humid transition</td>
<td>1000-1500</td>
<td>0 - 20</td>
<td>210-270</td>
<td>21.0</td>
<td>6.4</td>
</tr>
<tr>
<td>9 Humid</td>
<td>21 - 99.9</td>
<td>210-330</td>
<td>16.6</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>10 Perhumid</td>
<td>&gt;2500</td>
<td>&gt;100</td>
<td>&gt;300</td>
<td>20.5</td>
<td>6.3</td>
</tr>
<tr>
<td>11 Transition Humid/Per humid</td>
<td>-do-</td>
<td>&gt;100</td>
<td>-do-</td>
<td>1.8</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>327.9</td>
<td></td>
</tr>
</tbody>
</table>

2.3.1. Dryland agriculture - history and work in India

Earliest evidence available on rainfed agriculture is almost 400 BC (Krishi-Prasa in Sanskrit) which was translated by Sadhale (1999). The area dealt in the booklet is mid-west and North-west of the present India. As farming in these regions depends on rainfall, prediction of rainfall based on the types of clouds, behavior of insects and animals. Several issues like soil fertility management using cow dung, ploughing, planting, water retention and weeding were elucidated intertwined with culture and traditions as calendar of operations for various crops.

The repeated and frequent crop failure in the past, resulting in short food grain supply, attracted the attention of our scientists and administration. Thus the scarcity of food grains in India was made the subject of enquiry in the year 1880 and the first Famine Commission was appointed in the same year. The commission after thorough study of the situation recommended the establishment of protective irrigation projects in South India and formation of department of agriculture in all the states. But nothing could be done till 1923 when the first systematic and scientific approach to the dry farming problem in India was made. (Work on dry farming in India. Website: http://www.world-agriculture.com/dry-land-farming/work-on-dry-farming-in-india.php)

2.3.2. The chronology of events in dryland agricultural research in India is as follows.

- 1920 Scarcity tract development given importance by the Royal Commission on Agriculture
- 1923 Establishing Dryland Research Station at Manjri (Pune) by Tamhane
- 1933 Research Stations established at Bijapur and Solapur
- 1934 Research Stations established at Hagari and Raichur
- 1935 Research Station established at Rohtak (Punjab)
- 1942 Bombay Land Development act passed
- 1953 Establishing Central Soil Conservation Board
- 1954 Establishing Central Soil Conservation Centres
- 1970 Research Centres established under AICRPDA in 23 locations
- 1972 Establishment of ICRISAT
- 1976 Establishment of Dryland Operational Research Projects
- 1983 Starting of 47 model watersheds under ICAR
1984 Initiation of World Bank assisted Watershed Development Programmes in four states. Establishing Dryland Development Board in Karnataka

1985 Birth of Central Research Institute for Dryland Agriculture at Hyderabad


Earliest record of importance to support dryland agriculture is with Royal commission on agriculture (1928) in its report made a following observation “in the earlier years of history department of agriculture applied themselves first to research on those crops which offer the best prospects of success and which, in the main, were crops grown under irrigation. It happens more over that those crops that have received least attention such as millets are amongst the typical crops in most of un irrigated districts. The problems of cultivation in such tracts in which crops are entirely dependent upon rainfall are in our opinion, deserving far more attention than they have received from Agriculture departments”. Thus, as a beginning, Bombay research scheme on dry farming was started in 1934 at Solapur and Bijapur after the establishment of Indian Council of Agricultural Research (ICAR) New Delhi in 1929. After some time the work on dry farming was started in Punjab, Madras and Hyderabad. Dry farming work in U.P. started in Jhansi and Agra at dry farming centres established 1943-44 and 1948-50, respectively.

Research efforts on rainfed agriculture were initiated in the early nineties by Imperial council of Agricultural Research. The six schemes in operation in different scarcity areas are given in table.3.

Table.3 Earliest schemes on dryland agriculture in Pre Independent India

<table>
<thead>
<tr>
<th>Name of the scheme</th>
<th>Period of the scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The Bombay dryfarming scheme, Sholapur</td>
<td>Oct 1933-Mar 1942</td>
</tr>
<tr>
<td>2 The Madras dryfarming research scheme, Bellary</td>
<td>April 1934- mar 1943</td>
</tr>
<tr>
<td>3 The Madras dryfarming development scheme, Bellary</td>
<td>April 1943- mar 1948</td>
</tr>
<tr>
<td>4 The Hyderabad dryfarming research scheme, Raichur</td>
<td>Dec 1933 – June 1943</td>
</tr>
<tr>
<td>5 The Hyderabad dryfarming development scheme, Raichur</td>
<td>July 1943 – June 1957</td>
</tr>
<tr>
<td>6 The Punjab dryfarming research scheme, Rohtak</td>
<td>July 1935 – June 1943</td>
</tr>
</tbody>
</table>

Research studies under these schemes yielded several tentative indications for further large scale trials and some states notably Madras and Hyderabad launched new ‘development’ schemes for extending the useful cultural practices in the rural areas. The findings were on slowing the runoff water from rainfall, ploughing and harrowing to preserve soil moisture, strip cropping inclusion of legumes and grasses/fodder crops.
National commission on agriculture (NCA, 1976) reported that for improving productivity in rainfed areas, there is a need to identify areas according to total rainfall. In the low rainfall areas (250-750 mm per year) where rainfall is highly variable with regard to quantity and distribution, there is a need to introduce forage legumes in rotation with field crops to provide a base for animal husbandry, with good breeds of cattle and sheep would also help in buildup of organic matter of soil. These areas need plan for

1. Monitoring weather to help early identification of aberrant season.
2. Implementing alternative cropping strategy like growing fodder crops when season no longer suitable for growing field crops.
3. Capitalising on normal and above normal rainfall periods. In areas with high rainfall(750-1500 mm) where rice dominates, there is a considerable scope for adjusting to cropping systems approach and develop intercropping and relay cropping practices to grow crops such as maize, cotton and soybean etc. In slopy areas emphasis should be on forestry, fruit crop cultivation, dairy farming.

NCA made a special reference to integrated plant nutrient management system(IPNS). All India Coordinated Research Project for Dryland Agriculture (AICRPDA) started as a collaborative project between and ICAR and Canadian International Development Agency (CIDA) during 1970-71. It was initiated at 23 centres selected on agroclimatic basis in collaboration with agricultural universities and ICAR institutes. To give its due importance, ICAR granted the project an institutional status as Central Research Institute on Dryland Agriculture (CRIDA), in 1985, with Hyderabad as its headquarter. The project started with the identification of the constraints responsible for lower yields in different regions; and then to develop a relevant location specific research program to solve production constraints.

It was also felt by government that after introducing High Yielding Varieties Program (HYVP, 1966), there should be immediate follow up steps to fill the gap between irrigated and dry tracts. As a part of Fourth Five Year Plan only dryland agriculture development program was launched with an outlay of INR. 147.5 lakhs, to promote research in improved dryland technology and its application to dry farming areas.

2.4.0. Drought programs existing at state level
2.4.1. Risk financing programs

a. Crop Insurance
The National Agriculture Insurance Scheme has been implemented in Andhra Pradesh since 1999-2000. The schemes are a mix of voluntary and compulsory participation. They are voluntary at the state level in terms of specific areas and crops. Once the specific area-crop combinations have been notified, participation is compulsory for farmers in those areas cultivating the specific crops and taking agricultural loans. In the case of loanee farmers the sum insured may be at least equal to the crop loan advanced. All farmers can insure to the value of the threshold yield of the insured crop. Eighteen crops are currently insurable under NAIS during Kharif season (e.g., rice, maize, sunflower, groundnut, sugarcane, and cotton) and ten crops during Rabi season (e.g., rice, maize, sunflower, and groundnut). The standard area yield insurance scheme has recently been extended to farm income insurance and rainfall insurance. The XI Finance Commission noted the need to strengthen the crop insurance scheme as a supplementary measure to what is done by the government for providing relief at the time of natural calamity.

b. Calamity Relief Fund (CRF)
This fund was established separately for each state on the basis of recommendations of the IX Finance Commission and has since been approved for continuation by the X and XI Finance Commissions. This fund should be used for meeting the expenditure for providing immediate relief to the victims of cyclone, drought, earthquake, fire, flood and hailstorm. This fund came into effect in 2000-01 and continues to be in operation till the end of financial year 2004-05. National calamities of cyclone, drought, earthquake, fire, flood and hailstorm considered to be of severe nature requiring expenditure by the State government in excess of the balance available in its own CRF qualify for relief assistance under NCCF scheme. The initial corpus of the National Fund is Rs.500 crores provided by the Government of India. National Centre for Calamity Management (NCCM) is constituted by the Ministry of Home Affairs, Government of India, to monitor the occurrence of natural calamities relating to cyclone, drought, earthquake, fire, flood and hailstorm on a regular basis and assess their impact on area and population. The assistance from NCCF is only for immediate relief and rehabilitation. Any reconstruction of assets or restoration of damages is financed through plan funds. The unspent balance of NCCF at the end of the financial year 2004-05 will become available to the Central Government to be used as a resource for the next plan.
2.4.2. Drought Proofing Programs

a. Drought Prone Areas Program (DPAP)

DPAP, a centrally sponsored scheme, in operation since 1973, aims at restoring ecological balance in the drought prone areas and mitigation of the adverse effects of drought on crops and livestock through integrated development of natural resources by adoption of appropriate technologies. However, the program fell short of its initial objectives despite large expenditure.

DPAP is aimed at developing the drought prone area with an objective of drought proofing by taking up of soil land moisture conservation, water harvesting structures, afforestation and horticulture programs on a comprehensive micro watershed basis. During 1994-95 the program was implemented in 69 blocks of 8 districts. From 1995-96 the program is extended further: 11 districts with 94 blocks under the scheme and Anantapur with 16 blocks under Desert Development Programs (DDP). So far, 3518 watersheds were taken up covering 110 blocks in 12 districts covering an area of 17.6 lakh hectares. Almost 30 percent of the total watersheds in country are located in Andhra Pradesh. Total Rs.507.57 crores are spent towards implementation of the program from 1995-96 to 2002-03. The expenditure for this program is shared by center and state governments in the ratio of 75:25.

b. Joint Forest Management / Community Forest Management

The Government of Andhra Pradesh adopted in 1992 the Joint Forest Management program which envisages a strategy for production, improvement and development of forest with the involvement of local communities by forming them into Vana Samrakshana Samithies (VSS). There are 7090 VSS actively involved in protection and development of forests. 8.71 lakh hectares has been treated so far out of 17.40 lakh hectares of forest area under VSS. The Joint Forest Management program is being supported by the World Bank funded A.P. Community Forest Management Project, NABARD assistant for RIDF schemes and Government of India funded Forest Development agencies.

c. Water Harvesting Structures

Forest Department has taken up large-scale water conservation structures in forest areas under Neeru-Meeru (Water and You) Program. The structures such as continuous Contour Trenches, Checkdams, Rockfilldams, Percolation tanks and sunken gully pits etc., 6 Phases of Neeru-Meeru have been completed and the 7th phase has just been completed. So far, including the 7th phase water storage capacity of 1566 lakh Cubic Meters has been created in forest areas incurring an amount of Rs. 309.72 Crores in execution of the water conservation structures in forest areas.
d. Micro Irrigation Project
The state of Andhra Pradesh has been experiencing severe water stress due to continuous
drought situation over the last 3 years. There is therefore an imperative need to promote
judicious use of water, particularly in respect to agricultural activities. With this in view the
Government has launched a massive Micro Irrigation Project in 2003-04 throughout the
state, with special emphasis on water stress mandals. The project envisages installation of
sprinklers, drip irrigation and rain guns to use the irrigation water available underground in
the most efficient manner while improving productivity. It is contemplated that in the first
phase an extent of 2.50 lakh ha would be covered at an outlay of nearly Rs. 1200 Cr. The
farmers will be given 50% state Government subsidy on the unit cost.

e. Andhra Pradesh Rural Livelihood Project (APRLP)
The Andhra Pradesh Rural Livelihoods Project provides critical support to the on-going
watershed movement in five drought prone districts in Andhra Pradesh. The mandate is to
position livelihood concerns strategically in watersheds for the inclusion of women, the
poor and the landless. The project advocates innovation, lesson learning, convergent
actions and policy influence. APRLP will invest in a new stream of approaches and ideas for
bringing about a positive change in the well-being of the rural populace. APRLP has initiated
a paradigm shift in watershed development Program by adopting sustainable livelihoods
approach. This site is to share the saga of promoting the poor and women into mainstream
development through conscious policies, effective implementation and sustainable
management. Moreover, this platform is to inform, educate and inspire all concerned
stakeholders in the project.

The development of semi-arid and rainfed drought prone areas is one of the priority areas
of Government of Andhra Pradesh and it is also established that development of natural
resources in these areas will lead to sustainable rural livelihood. Participation of the
committee of resource poor and landless as primary stakeholders is precondition of
sustainable rural livelihood. Therefore, the Government of Andhra Pradesh has entered into
an agreement with Department for International Development (DFID, UK), who shares this
vision, for implementing AP Rural Livelihoods Project (APRLP) in Anantapur, Kurnool,
Mahabubnagar, Nalgonda and Prakasam districts. The APRLP will facilitate the objective of
people centered development input to the ongoing watershed Program of government
including 500 new innovative watersheds, sustainable rural livelihood initiatives in 2000
ongoing watersheds, capacity building of various stakeholders, research and lesson learning
for policy initiatives, and infrastructure support.
f. **Watershed Development**
National Agriculture Bank for Rural Development (NABARD) finances a watershed development fund. Due to watershed development Program, the proportion of area under irrigation has increased by 19 to 129 percent among all households. Total employment has gone up by 11 to 29 percent. Yield rates have gone up for irrigated as well as un-irrigated crops. Only 50 percent of the watersheds studied are economically viable in terms of incremental returns. The equity effect is not clearly known, though the impact on rich and medium households possessing of lands seems higher. Drinking water situation improved substantially. Ground water levels improved to a limited extent. Migration of labor decreased during execution period. But in majority of cases, this is not sustained after the executing period. Household’s preference for education increased. The role of women in financial matters has improved substantially.

g. **Integrated Wastelands Development Program (IWDP)**
Rapid depletion of green cover and vast stretches of marginal lands lying fallow, found to be causing enormous ecological imbalance. Productivity is also negligent on account of soil erosion and marginalization of lands. To arrest this, massive integrated wasteland development project was undertaken during 1991 with 100% central assistance. The project is being implemented in 17 districts, in Andhra Pradesh, with 38 projects covering an area of 362985 ha with an outlay of Rs. 17784.28 lakhs.

h. **Rural Infrastructure Development**
A fiscal package has been developed for the purpose of rural infrastructure development. In Andhra Pradesh the Department of Rural Development, Forest, Panchayat Raj, Minor Irrigation have availed this scheme. In this program, each district has selected certain villages for treatment. The implementation at village level is through user groups who are formed on the basis of drainage line. These groups decide treatment of drainage line or common lands. The scheme excludes private land treatment.

i. **Sampoorna Grameen Rozgar Yojana (SGRY)**
The Sampoorna Grameen Rozgar Yojana (SGRY) will have the following objectives:
- **Primary Objective***---The primary objective of the Scheme is to provide additional wage employment in all rural areas and thereby provide food security and improve nutritional levels.
- **Secondary Objective*** ---The secondary objective is the creation of durable community, social and economic assets and infrastructural development in rural areas.
The programme is self-targeting in nature with special emphasis to provide Wage Employment to women, scheduled castes, scheduled tribes and parents of children withdrawn from hazardous occupations. The works to be taken up must be labor intensive, leading to the creation of additional wage employment, durable assets and infrastructure, particularly those which would assist in drought proofing such as soil and moisture conservation works, watershed development, afforestation, etc.

j. Employment Programs
There are many other self employment programs, based on income generation, to improve the livelihood of the affected population. These programs are based on people’s participatory approach. Andhra Pradesh government has created various employment generation programs to eradicate poverty. While considering self employment schemes the government has given priority for mini and micro enterprises. These programs can be considered as mitigation measures at the time of drought.

k. Mission based approach to employment generation
The Government of AP has established Employment Generation Mission to coordinate activities of all the concerned departments in employment generation and manpower planning. The Mission will prepare a time bound action plan for implementation. The Government will act as facilitator and would identify and prioritize key sectors with employment potential and ensure successful implementation.

l. Empowerment of poor women
Self Help Groups of Women (thrift groups) Program has mobilized and organized 48 lakh poor women in the rural areas into 3.7 lakh groups. These women groups have built up a corpus fund of Rs 750 crores consisting of their savings, borrowings from banks and Development of Women and Children in Rural Areas (DWCRA) revolving fund from government. The empowerment process has enabled the DWCRA and thrift group members in addressing all of poverty’s dimensions. DWCRA movement has contributed to the augmentation of incomes, improvement of nutrition, better child care of the poor women, and enhanced the status of women in rural households. A similar program for the urban areas has now been started under the name of Development of Women and Children in Urban Areas (DWCUA). 5523 DWCUA groups have been formed and developed in urban areas.

m. Food for Work Programs (FFW)
India has launched an ambitious food-for-work program aimed at helping millions of the rural poor stave off hunger and unemployment. The basic principle of FFW is to provide
employment to the poor during hard times, to create community assets through labor-intensive work and to pay the laborers in food grains or other food items.

n. Chief Minister's Empowerment of Youth (CMEY) Program
CMEY Program had the main objective of economic development of youth by empowering them with sufficient skills and infrastructure. This was to be achieved by extending financial assistance to the eligible youth associations by way of subsidy and margin money loans besides group savings for taking up economic activity of their choice.

2.5.0. Problems with dryland agriculture(ANGRAU)

a) Climatic constraints: rain fall characteristics lie at the heart of the problems. In these tracts not only just rain fall variability over seasons, but its intensity, distribution matters. Late onset of monsoon, early withdrawal, prolonged dry spells added with high atmospheric temperature and low relative humidity effects the cropping season. Drought is the foremost important constraint in dry land farming.

b) Soil related constraints: soil moisture level and its duration have profound effect on soil texture and structure, since weathering process and microbial population are directly related to it. This culminates in low soil fertility and accelerated erosion over years.

c) Traditional cultivation practices: Ploughing along the slope, Broadcasting seeds/ sowing behind the country plough leading to poor as well as uneven plant stand. Monsoon sowing, limited choice of crops based on rainfall and application FYM in limited quantity are major issues.

d) Lack of suitable varieties: Research and investments in dry land agriculture are meager compared to irrigated agriculture, leaving limited choice in seed and inputs.

e) Socio economic constraints: the farmers are resource poor and access to inputs and credit is very less. In case of recurring crop failures owing to droughts, farmers cultivating input intensive crops are getting in to debt traps.
2.5.1. Drought

Drought occurs in high as well as low rainfall areas. Farmers term drought as deficient rainfall, lack of moisture or a dry spell resulting in low crop yields including crop failure. They realize that seasonal variations in precipitation and temperature are much more important in farming than annual averages. Regardless of variability in perspective, it is clear that drought is a normal feature of climate and its recurrence is inevitable. Drought is a condition relative to some long-term average condition of balance between rainfall and evapo-transpiration in a particular area, a condition often perceived as normal. Yet average rainfall does not provide an adequate statistical measure of rainfall characteristics in a given region, especially in the drier areas.

Dry lands are areas which receive an annual rainfall of 750 mm or less and there is no irrigation facility for raising crops. Dry land Agriculture is scientific management of soil and crops under dry lands with out irrigation in areas that receives an annual rainfall less than 750 mm. Drought is a regular weather phenomenon that occurs in such areas resulting in insufficient moisture supply to the plants under which they fail to develop and mature properly. It may be caused by soil, atmosphere or both. Based on its time of occurrence, such rainless periods/ agricultural drought may be termed as early season drought, mid season drought and terminal drought.

**Early season drought** generally occurs either due to delayed onset of monsoon or due to prolonged dry spell soon after the onset of the rainy season. This may at times result in seedling mortality needing re-sowing or may result in poor crop stand and seedling growth. Further, duration of the water availability for crop growth gets reduced due to delayed start and the crops suffer from acute shortage of water during reproductive stage due to early withdrawal of monsoon.

**Mid season drought** occurs due to inadequate soil moisture availability between two successive rainfall events during the crop growth period. Its effect varies with the crop growth stage and intensity and duration of dry spell. Stunted growth takes place if it occurs at vegetative phase and in case it occurs at flowering or early reproductive stage it will have an adverse effect on crop yield.

**Late season or terminal drought** occurs as a result of early cessation of monsoon rains and can be anticipated to occur with greater certainty during the years with late commencement or weak monsoon activity. Terminal droughts are more critical as the final grain yield is strongly related to water availability during the reproductive stage. These conditions are often associated with an increase in ambient temperatures leading to forced maturity. Probability of getting affected by drought at terminal stage of crop is high in the regions of northern, western and central India (Sharma et al., 2008).
Drought differs in three essential characteristics: intensity, duration and spatial coverage. Intensity refers to the degree of the precipitation shortfall and/or the severity of impacts associated with the shortfalls. Intensity is generally measured by the departure of some climatic index from normal and is closely linked to duration in the determination of impact. Impacts are, in turn, related to the timing (e.g., delays in the start of the rainy season, occurrence of rains in relation to principal crop growth staged) and effectiveness of rainfall (e.g. number of rainfall events). Other climatic factors such as temperature, wind and humidity can significantly aggravate its severity. Droughts are categorized as meteorological, hydrological, agricultural and socio-economic (Nagarajan 2003).

**Meteorological drought** is related to the deficiency of rainfall compared to long-term average amounts on monthly, seasonal or annual tile scales. Another definition if meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some pre-determined thresholds. The India Meteorological Department (IMD) uses a meteorological definition of drought based entirely on rainfall deficiency from normal of the mean annual, mean summer monsoon, mean monthly and mean weekly rainfall. This classification covers special scales from meteorological sub-divisions of India as a whole. As per IMD, meteorological drought is defined as occurring when the seasonal rainfall received over an area is less than 75% of its long-term average value. It is further classified as moderate drought if the rainfall deficit is 26-50% and severe drought when the deficit exceeds 50% of normal. A year is considered to be a drought year for the country if the area affected by the drought is more than 20% of the total area of the country.

**Hydrological drought** is associated with the effects of periods of precipitation shortfalls on surface or subsurface water supply (e.g., stream flow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological droughts. Water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, hydropower), further complicating the sequence and quantification of impacts. Although climate is the primary contributor to hydrological drought, other factors such as changes in deforestation, land degradation and the construction of dams all affect the hydrological system of the basin.

**Agricultural drought** links various characteristics of meteorological and hydrological droughts to agricultural impacts. It is related to precipitation shortages, differences
between actual and potential evapotranspiration, soil water deficits, etc. Plant water requirements depend on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. Agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield.

**Socio-economic drought** is associated with the supply and demand of economic goods such as water, forage, food grains, fish, hydroelectric power, etc. Socio-economic drought occurs when the demand for an economic good exceeds supply as a result of a water-related shortfall in water supply.

Farmer is the first to be affected by drought followed by other sections of the society. Drought is the single most important weather related natural disaster often aggravated by human actions like deforestation, excessive grazing, over exploitation of ground water etc. drought has serious impacts on natural resources, food security and economy since it affects a very large area for months and sometimes successive years. Over 29 % of the country’s total geographical area is drought prone that experiences drought every second and third year approximately 50 million people are annually affected by drought. About 20-25% percent of the districts suffer from droughts of varying intensities almost every year in India. But, droughts of severe intensities occurred on an average once in 25 years such as 1877, 1899, 1918, 1972, 2002 and 2009. The impacts of these major droughts on socio economic and bio physical resources varied across regions and years (Osman, M., et al., 2010).

Andhra Pradesh ranks third in terms of drought prone state after Rajasthan and Karnataka in India. The state has an area of 274.85 lakh ha. It has arid and semiarid and sub-humid climatic conditions. The average maximum and minimum temperatures are 39.0°C and 15.7°C respectively. There are six major soil types namely red soil(66%), black soil(25%), alluvial clay loam soil(5%), coastal sands(3%) and problem soils(1%). Average annual rainfall of the state is 911 mm, two thirds of it is received during SW monsoon period. The distribution of rainfall is erratic resulting in frequent droughts. Coastal Andhra and Telangana receive rains mainly through south west monsoon (80%), while Rayalseema to a large extent by north east monsoon. On an average thee state of Andhra Pradesh receives 602 mm of rain during SW monsoon (June- September) and 203 mm during north east monsoon (October-December). (Osman, M., et al., 2010).

Agricultural drought is usually defined as a period when insufficient water is available to support the normal activities of a crop over a fairly normal long period of time of a fortnight or
more depending on stage of crop. Drought is distinguished from aridity and it may be expected that both very wet and very dry regions experience drought. From an agricultural standpoint, a drought indicator should record crop management on the phenological drought sensitivity. Weather technology should be collineated. Thus, the partition between weather effect on yields and technology should be diffused. Emphasis should be placed on identifying periods within a given growing season when drought related weather conditions have greatest effect like yield altering impacts and crops. An operational definition would be one that compares daily precipitation values to evapotranspiration rates to determine the rate of soil moisture diffusion and express these relationships in terms of drought effects on plant behaviour at various stages of crop development. Thus, intensity of drought is a ratio of actual evapotranspiration (AET) to potential evapotranspiration (PET) during the growing season.

2.5.2. Impact assessment of drought

Impact of drought 2002-03 on the economy of rural society was assessed with the help of primary data, which is categorized into five major capitals using sustainable rural livelihoods framework, viz., natural, social, human, physical and financial. The impact of drought over a region varies and this in turn impairs the level of economic activities. (Hounam, 1975).

Rural communities largely depend on natural resources like land, water and forests for their livelihoods. Loss of yield of crops, loss in area sown, shortage of fodder, shortage of drinking water for humans and livestock and loss in production of livestock would be major categories under natural capital. Social capital is reflected in instances like dropping out of children from school, poor credit worthiness, postponement of social obligations like marriages and increase in conflicts and crime rate among rural communities. Human capital effects includes the skills, ability to labor and good health to pursue different livelihood strategies increase in level of migration. Physical capital reflects in poor access to basic inputs for agricultural production such as seed and fertilizers, equipment and water resources etc. financial capital impact is clearly observed in reduction in sources of income and cushioning effect to mitigate drought. Farmers are forced to purchase inputs on higher rate of interest from non formal sources like money lenders and traders. This pushes farmer into different paths of vicious cycles of mounting debts, low standard of living, and children being forced to work and eke out living. The rural poor are increasingly dependent on common pool resources (CPR), such as pastures and forests for grazing their animals. This has cumulative adverse effect on the forest ecosystem and accelerated desertification process in dry regions. In all the three regions of Andhra Pradesh, viz., Rayalaseema, Telangana and coastal Andhra, it is concluded that major constraint from drought are decline in cattle population, followed by increase in level of migration. (Osman, M et al., 2010).
2.6.0. Cropping pattern changes

In a study on cropping pattern changes and various factors responsible in 175 districts of Semi Arid Tropics (SAT) in India, form 1968-1994, it is observed a dramatic shift away from coarse grains in favor of wheat, paddy and oil seeds with declining share in cereals 53-47%, oil seeds 10-19%. Where as traditional SAT crops price/profit, yield and fertilizer prices have highest impact on changing cropping pattern in major crop zones (Ashok and Tim, 1999).

Crop diversification between 70-90’s parts of Maharashtra, Andhra Pradesh and Madhya Pradesh agricultural production system has transformed from subsistence to semi commercial. There is considerable potential for crop intensification and diversification in rainfed areas (Joshi, 2002).

Of the 84 dryfarming districts in India Nalgonda with 732.2mm rainfall is having total irrigated area 16.6% of the net cropped area with principal crops castor (39.44%), Bajra (29.45%), Jowar (17.22%) and Redgram (2.78%). Average size of farm is 14.72 acre with an average investment for cultivation Rs. 504 and on large farms with average area of 36.2 acre the investment is Rs. 474.90 only. On the basis of net returns castor ranked first followed by Bajra, Jowar and Red gram. The cost benefit ratio of small farms were higher than larger farms and better operated also (Balreddy. K., 1974).

There was gradual increase in non agricultural area (2.48%), net sown area (0.63%) and double cropped area (12%) per year by 1966-67 with 1954-55 as base year. At the same time there was steady decline in uncultivated land(0.15%), cultivated waste land (7%), permanent pasture (1.45%) and current fallow(3.61%). A trend of change in cropping pattern with major crop as paddy(6.76%), jowar (2.6%), pulses (0.3%), fibre crops (6.32%) and chillies (16.32%), and at the same time declining trend was observed with bajra (4.7%), minor millets (5.2%) and oil seeds (1.89%) per year (Amruth Reddy. G., 1968). Key role need to be played by government through introduction of pro poor policies and linking small producers with large processors along with proper institutional arrangements for improving crop livestock systems in dryland parts of India.(Rao and Birthal, 2004).

Coarse cereals, millets continue declining trend, whereas slow down or retreat of oil seed acreage after GATT trade liberalization measures was implemented. Cotton was one major crop that continued increased share during 90’s. Release of non irrigation land under millets was simply leading higher incidence of fallows and these cropping pattern changes may have high implications for seasonal migration by dryland farmers (Kubo 2004).
Agricultural diversification of small farms of Nizamabad district of Andhra Pradesh from subsistence to semi commercial farming over a period of time, but further diversification is possible with promoting milch animals, goat/sheep and poultry as backyard enterprises. But constraints here found to be availability of information, water facility, capital, proper management capabilities and institutional arrangements (Choudary et al 1996).

Cropping pattern diversified over time with advancements in mechanization, road density and % increase in irrigation area, in Prakasam district from jowar to pulses like red gram and chickpea. Whereas in Mahaboobnagar district area under jowar diversified in to maize, castor and groundnut. In Anantapur district context rainfall, fertilizer application and mechanization favored specialization in groundnut (Kumaracharyulu, 2007).

In semi-arid regions, dryland farmers have developed cropping practices ranging from summer ploughing to crop rotations that are suited to the harsh agroclimatic conditions they have to deal with (Pionetti and Reddy 2002).

2.7.0. Natural Resource Management and Sustainable agriculture

The key resource conservation based technologies are in situ moisture conservation, rain water harvesting and recycling, efficient use of irrigation water, conservation agriculture, energy efficiency in crop production and irrigation and use off poor quality water. The suggested strategies are (Kapoor, 2006).

- Characterization of biophysical and socio-economic resources utilizing GIS and remote sensing;
- Integrated watershed development;
- Rainwater harvesting, storage and reuse;
- contingency crop planning to minimize loss of production during drought /flood years.
- Zero tillage has reduced the demand for water in rice wheat cropping systems in Indo-gangetic plains.
- Bed planting is another proven technology in this region with better water use efficiency, inter row cultivation, banding of fertilizers, less lodging and reduced seed rates.
- In coastal salinity, Doruvu technology for managing sea water intrusion in coastal areas in Andhra Pradesh and Tamilnadu. System of Rice Intensification (SRI) has key benefits under present climatic situation. This technology minimizes anaerobic conditions, improves root growth and needs less water and seed.
• Integrated nutrient management (INM) and site specific nutrient management (SSNM) also have potential in increased rice yields and thereby increased net CO$_2$ assimilation, 30-40% increase in nitrogen use efficiency.

One of the key emerging technologies to reduce GHG emissions from paddy fields is the use of zymogenic bacteria, acetic acid and hydrogen producers, methanogens, CH$_4$ oxidisers and nitrifiers and denitrifiers which help in maintaining the soil redox potential in a range where N$_2$O and CH$_4$ emissions are low. (Hou et al., 2000). the application of urease inhibitors, hydroquinone (HQ) and nitrification inhibitors, Dicyandiamide (DCD) together with urea also is an effective technology for reducing N$_2$O and CH$_4$ paddy fields. Use of neem coated urea is another simple and cost effective technology and can be followed in entire south Asia by small farmers. Promotion of integrated farming system for small and marginal farmers will be a viable alternative in combating climate change. Multiple-enterprise agriculture wherein crop livestock, poultry, fish farming and tree in a single unit of land will minimize the risk.

Increasingly more blocks are being declared as ‘black” in regard to the ground water situation. In this context a large number of farmers will continue to depend on dry land agriculture where they suffer from depleted land and water resources, uncertain weather, low value crops and low productivity. There is a huge gap between the yield obtained and the potential yield of these crops in dry land conditions. There is also a vast scope for increasing supplementary enterprises, especially dairy and dryland horticulture. For this he suggested the needed action in terms of increasing investment in land improvement and water conservation, instituting proper price policy, establishing efficient marketing structures, ensuring adequate supply of credit and providing protection against risks. He stressed the need for effective governance and enabling people’s participation as they are the key elements in delivering the needed action to realize the full potential of rainfed agriculture (Vyas, VS., 2007).

The ecological foundation of agriculture is essential for sustainable advancement. Soil health, efficient use of water and mobilization of the farming community towards the management of natural resource are all vital issues. Now farming has become a high risk profession and the support from agricultural systems was reaching only to a small minority of farmers. Natural resource management should concentrate on common property resources (Yugandhar, BN., 2007).

The agriculture land had good water retention capacity and was rich in nutrients till the early 60s. The farmers were adopting organic ways of agriculture which they have been practicing since centuries. The region witnessed the penetration of Green Revolution in the mid 60s. Owing to the strong traditions of sustainable agriculture, the farming community did not accept.
the introduction of chemicals and pesticides initially. But, the farming community was lured to purchase chemicals. In return, they were offered cement bags. These bags were otherwise available only against permit. Then there were cases when the government officials used to spray Urea in the farmer’s fields free of cost during night time in order to prove its ‘benefits’. In short, one could say that the shift from organic ways of agriculture to chemical based farming was under compulsion and not by choice. (Anil Rana 2006).

Rice is grown by direct and transplanted conditions. Weed competition is more in direct seeded rice. Reduction in yield to the tune of 34% in transplanted rice, 45% in direct seeded low land rice and 67% in upland rice are reported. Weed competition in direct seeded rice is greatest during the first three weeks. The critical period for weed free condition for higher productivity is reported to be 30 – 35 days in transplanted rice where as direct seeded low land and upland condition the weed free period ranges from 40-60 days (ANGRAU).

Production for the far off markets necessitated use of external inputs like chemical fertilizers, hybrid seeds, pesticides, irrigation etc. Increased dependency on high cost external inputs in agriculture also made farmers to depend on external credit on a regular basis. Dependence on credit for agriculture, a matter of shame during 1960s, became an absolute necessity by 2000. Cultivation of cash crops like cotton and tobacco, also led to scarcity of fodder. This resulted in farmers giving up animal husbandry, thereby resulting in acute scarcity of farmyard manure and making the use of chemical fertilizers inevitable. Adoption of modern technologies in agriculture like tractors and pump sets have resulted in the neglect of draught animals. Even the livestock production has been totally changed into industrial type of production from backyard system.

Agriculture in India, was an integrated cultivation of crops, animals and trees to meet most of the family and community needs rather than market. Trees played an important role in providing green manure, fodder, fruits, fuel and timber besides conserving soil water and hosting beneficial insects and birds. We had more than 15 species of cereals which were drought and pest resistant and were more nutritious. It is necessary to revive the traditional knowledge on seed selection and preservation to bring back the self reliance and seed availability at the time of sowing.

With depletion of agricultural lands and lack of irrigation facilities, agriculture in arid and emiarid regions is becoming uneconomical. Agroforestry provides a viable solution for such problems. Promotion of afforestation should be based on well tested technical and economic data to guide the farmers and general public in the right direction ( Narayan G Hegde, 2011).
Planting trees on bunds and wastelands generates additional biomass, serving as a source for enriching soil-health. Chetna brought about a positive impact on the livelihoods of tribal farmers in Utnoor by promoting small shifts in the cropping systems integrating trees. Such interventions being low external-input have proved to be environmentally safe and economically viable (Ashok Kumar, 2011).

Tree cultivation in agroforestry system has the potential to take pressure off extractive harvesting from natural forests, contributing to in-situ conservation, limiting deforestation and fixing carbon in farmland. Agroforestry is therefore seen as an important means of ‘climate-smart’ development (Maikhuri RK and Vikram S Negi, 2011).

Tree based farming has proved successful in providing sustained incomes for the farmers in the rainfed areas. The model has helped in converting the unproductive waste lands of tribal families in parts of Maharashtra into productive mango and cashew growing lands (Sherkar and R C Kote, 2011).

Practitioners of agriculture who have paid close attention to the ways in which their crops grow under different conditions often have a good sense of the linkage between soil fertility and the living status of the soil. The very term “soil” does not reflect adequately the extent to which its fertility is a consequence of the life within it – the abundance, diversity and activity of soil organisms. It would be better to talk and think in terms of “soil systems”, as implied by the motto of organic farmers: “Don’t feed the plant – feed the soil, and the soil will feed the plant”.

Green manuring is the best way to improve soil health. Cover crops build balanced ecosystem and develop the right kind of micro climate for the plants. They also restrict direct sunlight on to the ground, thus, restricting the growth of weeds over 2-3 years time. Presence of weeds in a way is an index to soil fertility. All the weeds act as host plants for soil microbes, which build up the soil health. Instead of trying to eliminate weeds, it is better to raise cover crops, especially the leguminous ones, restricting the growth of weeds. Cover crops not only fix huge amounts of nitrogen in the soil but also help in managing the pests (Nandish, BN., 2006).

Soil degradation reduces soil productivity and is a serious problem on much of the land in semiarid regions. To avert continued degradation, the soil productivity balance must be shifted from degrading processes to conservation practices. Crop residue management and conservation tillage are on the positive side of the balance. When adequate residues are available and conservation tillage is used, soil erosion is greatly reduced and water conservation is enhanced. Water conservation is important for improving crop yields in semi-arid regions, especially where irrigation is not used. A major constraint to residue management in many
countries is low production and widespread use for other purposes. In such cases, clean tillage and appropriate support practices such as contouring, furrow diking, strip cropping and terracing may provide adequate soil and water conservation benefits. Where these are not adequate, alternative management practices should be implemented to ease the demand for residues, thus permitting more of them to be retained on the land for soil and water conservation purposes. Some alternative practices include limited or selective residue removal, substituting high quality foliages for residues as animal feed, alley cropping, using wasteland areas more effectively, improving the balance between feed supplies and animal populations, and using alternative fuel sources (Ungera et. al., 1991).

Small scale watershed development is a viable way to improve degraded ecosystems, create diverse livelihood opportunities for rural people and build stable ecosystems based on the pillars of water, soil and biodiversity. (Raghavendra Rao, K., 2010)

Animals provide manure, food and income and are used for cultivation and transport economically. Different animals can be fed on farm wastes efficiently which provide financial security at the time of distress. In Indian culture, cattle are treated as an integral part of the family. After undergoing the huge loses from adapting crossbred cows like Holstein, Frisien and Jersey, farmers are fast changing towards indigenous cattle, since their maintenance is cheaper and the male calves can be used for cultivation and transport (Narayana Reddy, L., 2006).

Livestock is moving out of agriculture. If we can take care of the bullocks for 3 months an year, they would be brought back into farming systems and this could be achieved with investments matching the subsidy on diesel consumed for land preparation and weeding. Bullocks in this sense might compete with mechanization. Streamlining of bullock power would help in timely sowing of crops by small and marginal farmers that in t self improves the productivity by about 20%. Similarly, supporting graziers, value addition of fodder etc. and easing critical small constraints will bring the livestock back into farming systems. Separating livestock systems from agriculture will cost the economy more as it increases demand on energy and nutrients. We need to protect such integration. Goats and sheep have an economic rate of return equal to IT sector and have very high income generating potential for the poor(Ravindra, A., 2007).

Usually farmers who do not own any cattle are not in the practice of applying farm-yard manure. To overcome this problem, it is necessary to think of various ways by which farmers may have access to farm-yard manure, compost, etc. One possibility could be the promotion of composting as an enterprise that can be taken up by self help groups that dot the rural areas of Andhra Pradesh(Rukmani, R and Manjula, M., 2009).
There are strong evidences across the country, which show that regenerative and resource-conserving technologies and practices can bring both environmental and economical benefits for farmers and communities. It is also proved that Community Based Organizations (CBOs) can provide good platform for various innovations to take roots. There are different experiences in relation to Non Pesticidal Management, Farmers Field Schools, Community Seed Banks, Organic Farming, Decentralized Food Security, Social Regulation of Water etc. by various government and nongovernment agencies across the country. There are also other experiences like System of Rice Intensification, Diversity based Cropping Systems, Millet based Cropping Systems, Innovative use of Labor and Drought Adaptation Initiatives. In rainfed areas the innovation need not narrowly focus on productivity alone, but also on sustaining resources and reducing the costs and risks.

The farmer is the end user of resources, production technologies and development facilities, the need is to build capacities of small and marginal farmers (middle level) in handling natural resources and managing farming as an enterprise. We are in a situation where farming is externalized; even dryland farmers are now dependent on market for seeds. The issue is not only the cost but also reliability. Even in rainfed farming the elite farmers are enterprising, but the majority of the middle level farmers are starving for information. Farming from subsistence has moved on to market; now they have to generate the income.

Organic farming which was dismissed earlier as unproductive is now gaining popularity because of the market pull. Organic farming based on approaches to solve production problems is more sustainable rather than being market driven. On production front, the question is how we move from a plant-nutrient relationship to soil-productivity relationship and how to measure system’s productivity rather than yield per unit cropped area. He said that experiences show that rainfed agriculture benefits by organic farming (Ramanjaneyulu, GV., 2007).

Introduction of rice into the diet of rainfed areas not only caused anemia, but the crop requires high rainfall and flat lands which is quite unsuitable to rainfed areas. Thus, cultivation of paddy in dryland areas in fact increased the fallow land leading to further degradation. To grow one kilo of rice, 3000 liters of water is required and each acre of irrigated area takes 6 million litres of water. In economic terms, the cost of this water use would be 60,000 rupees per acre. (Satheesh, PV., 2007).

SRI yields in Purulia rainfed areas are promising. In Tripura, there is an effort in which SRI was taken up in 14,000 hectares of land within 2-3 years and this was done by the Agricultural Department in convergence with Panchayat Raj Department. These sort of experiences need to
be related to the context of rainfed farming. And for that there should be ‘learning alliances’, he concluded (Shambu Prasad, 2007).

The savings in power subsidy for the 4 irrigations that could be saved in SRI paddy, can pay for all weedings, which seems to be a bottleneck in its promotion. He felt that we are into an ‘irrigation’ paradigm. If we can shift to a ‘critical irrigation’ on a large scale paradigm we can achieve substantial increase in overall production. We have not invested on borewell irrigation other than power subsidy. If we can provide for developing infrastructure in distribution of borewell water it would enable provision of critical irrigation support to rainfed crops where the productivity gains are about 40 to 60%. (Ravindra, A., 2007).

Organic farming is intensively promoted in Cuba where change in focus of research from chemical to organic. In India there is a the need for revival of traditional cascade of tank systems. System of Rice Intensification as a concept which is now not limited to paddy but also extended to other crops like castor, sunflower in Gujarat (Venkateswarlu, J., 2007).

Scientists promote pesticides because it is an easy option. They don’t have to do anything except recommend dosages. Andhra Pradesh has been reeling under high costs of cultivation, with deeply indebted farmers. When group action is required, government efforts don’t seem to work too well. Technologies that require group action don’t get pushed and IPM has failed to bring down the cost of plant protection. (Sanghi, NK., 2006).

A paradigm shift that should consider that the farmers need hand holding for better utilization of resources (less exploitative). This should also consider there defined role of enablers and the extension approaches (PTD and FFS in University curriculum) and that development is a shared responsibility; CSO can never provide the scale; but can provide the models. Two decades of experience in Andhra Pradesh on Non Pesticidal Management (NPM) shows that pest is a symptom of ecological disturbance rather than a cause and can be affectively managed by using local resources and timely action. The emerging new paradigm of sustainable agriculture shows that the new knowledge synthesized from traditional practices supplemented with modern science can bring in ecological and economic benefits to the farmers. The small success from few villages could be scaled up into more than 1.5 million ha in three years. The costs of cultivations could be brought down significantly without reduction in yield. The institutional base of Community Based Organizations like Federations of Women Self Help Groups provides a good platform for scaling up such ecological farming practices. This experience also shows how the grass root extension system when managed by the community can bring in change and help the farming community to come out of the crisis (Ramanjaneyulu, et al. 2009).
Community Managed Sustainable Agriculture in Andhra Pradesh is already in 1500 villages; Zero Budget farming is being practiced in more than 10 lakh acres in Maharashtra, Karnataka, Andhra Pradesh and Punjab. These experiences have amply demonstrated that Ecological Farming is possible on a scale provided essential support systems are built. It is also established that Community Managed Systems are essential for strong natural resource management systems.

The Non Pesticidal Management initiative by the Society for Elimination of Rural Poverty (SERP) through Mandal Mahila Samakhya (MMS) in collaboration with NGOs in the last three years shows that moving towards local resource based sustainable agriculture is the only way to sustain the livelihoods of small and marginal farmers. The women self help groups form an excellent institutional platform for scaling up such models. During kharif, 2007 the program covered 5 lakh acres across 18 districts of Andhra Pradesh covering all the farmers in about 1600 villages benefiting 2 lakh farmers. The program is also integrated with ongoing programs like NREGA on pilot scale to provide further employment opportunities to the agriculture workers. The last three years experiences have brought in big learnings in terms of sustaining agriculture based livelihoods. The costs of cultivation could be brought down ranging from Rs. 2000/acre in crops like redgram, groundnut, to Rs. 10,000/acre in chillies. The savings on other ecological and health costs is an added bonus. In Ramachandrapuram, a small village in Khammam District of Andhra Pradesh, all the 400 odd farmers could get back all their mortgaged lands back from the savings made in the last three years. There are more than 50 villages which have gone pesticide free during kharif, 2007. This program will be further strengthened with Additional Central Assistance under Rastriya Krishi Vikas Yojana to reach 5000 villages in next five years covering 25 lakh acres (10 % of state area) with an outlay of Rs. 182 crore (Raidu, D.V. and G.V.Ramanjaneyulu, 2008).

The idea of teaching farmers to cultivate without pesticides was first tested by the Centre for Sustainable Agriculture (CSA), an independent research institute. In scaling up process, the Society for Elimination of Rural Poverty (SERP), which implements the program on a broader base as community managed sustainable agriculture (CMSA) on behalf of the government, calls it India’s largest ecologically driven agricultural programme. It was begun in 2004 as an initiative to counter farmer suicides and implemented on 400 acres in a dozen villages. Now, it’s being practised by over 6 lakh farmers on 17 lakh acres. The programme has over the last six years reached 4,025 villages in 21 of the 23 districts of the state (Madhavi, T., 2010).

In recent years however, there has been a marked decline in the variety and diversity of cultivated crops such as rice and cereals. The Green Revolution emphasized the use of high yielding varieties which responded only to high doses of fertilizers and pesticides. Today, the genetic base has narrowed down considerably. Monoculture, using expensive inputs to
maximize production has become the order of the day. Genetic uniformity invites disaster by making the crop vulnerable to pest and disease attacks. During the 1970s, the Grassy-Stunt Virus devastated rice fields from India to Indonesia, endangering the world’s single most important food crop. After a four year search which screened over 17,000 cultivated and wild samples of rice, only one population of the species *Oryza nivara*, growing wild near Gonda in Uttar Pradesh, was found to have a single gene for resisting Grassy-Stunt Virus Strain 1. Today, resistant rice hybrids containing the wild Indian gene are grown across 1,100,000 sq. km. of Asian rice fields. The rate at which indigenous Rice varieties are getting depleted is extremely alarming. It is becoming increasingly clear that to maintain biodiversity in farmers’ fields, an alternative system of seed production and distribution has to be created. Efforts at community level will help in restoring back the lost biodiversity (Vijayalakshmi et al., 2007).

The seed takes the major share (50%) in groundnut crop production cost. The seed systems in Andhra Pradesh, like the rest of the country, consist of public, private and civil sectors. The formal seed sector of groundnut is represented by the government owned Andhra Pradesh State Seed Development Corporation (APSSDC). Informal sector includes own-saved seed, borrowings from others and the local seed trade which contributes to about 60% of seed needs. In this context, the concept of ‘village based seed bank’, (VBSB) which advocates village self-sufficiency in production and distribution of quality seeds, is fast gaining ground (Ravinder Reddy Ch and S.P. Wani, 2007).

About 80 percent of the food crop varieties traditionally grown have become rare or even extinct in some places. New varieties are produced and sold by seed companies, and the cost of seeds is constantly increasing. In this context, the groundnut seed exchange system developed in this village is very effective for this particular crop. It ensures that groundnut seed, which cannot be stored for more than three months, is available locally, is of good quality and is affordable. Another important development during this process has been the change in mindset of the farmer who has irrigation facilities becoming actively involved in seed production and multiplication for his fellow villagers. The farmer-led seed exchange system is addressing the immediate needs of farmers in a very cost-effective manner (Suresh, K., 2007).

High-yielding varieties and chemical farming have lost their universal acceptability in Kolar, Karnataka. Community seed banks run by women’s collectives in the area, along with preserving indigenous seeds, given new options for them. Advantages of achieving food security and livelihood opportunities through natural resource management have facilitated farmers to go for low-input, nonchemical farming. Around 350 farmers are accessing the seed banks every year and the number of native ragi varieties in a village, Shettikal alone has increased from two in 2000 to nine in 2004 (Anitha, P., 2007).
With regard to seeds, there is enormous demand for them which is reflected in the agitations in some parts of the country. There are also incidents where the farmers are ‘fired upon’ for seeking quality seeds. In Anantapur in the rush for the seed 7 farmers were trampled to death. Why we are creating such a fuss when there is scope for creating community seed banks, he questioned. It was suggested that State Agricultural Universities(SAUs) can be encouraged to scout for location specific landraces/ varieties and improving them rather than withdrawing from the seed sector (Satheesh, PV., 2007).

A major source of seed supply for farmers in Anantapur district is the seeds retained over their previous harvest. The problem of seed storage is significant, as the seed rate of groundnut is quite high and it is also a bulky crop. Farmers face not only space constraints but also pest infestations on the stored groundnut seeds. Development of suitable community seed storage structures is necessary to enable farmers to retain a portion of their produce for seed purpose. (Rukmani, R and Manjula, M., 2009).

By growing diverse crops on their farms, women have not only increased biodiversity, but have recovered over 80 traditional landraces and set up over 60 seed banks to distribute seeds within their communities. By re-establishing control over the seeds they grow and building their understanding of biodiversity, women have gained status within their communities as seed providers. The recovered seeds will be stored in the village to serve as an in situ community gene bank to help other farmers grow traditional crops. In Andhra Pradesh, the Deccan Development Society (DDS) has helped over 5,000 marginalised Dalit women organise themselves into sanghams, or village unions, to increase their control of food production, seeds, natural resources and markets (Satheesh, PV., 2010).

2.8.0. Policy issues

While concentrating on the four major policies he opined that Policy is not the beginning and the end of action: investment, technology and organisations are also important. He said that many of these policies are relevant for agriculture as such and some are specific to rainfed farming. Elaborating on the price policy, Prof emphasized on addressing the anomalies with regard to Input and Output price policy as the gap between them is widening. The situation is that where ever policy is directed to make inputs cheaper by overt or hidden subsidies, e.g. in water, power, or nitrogenous fertilizers, it led to imbalanced and inefficient use of inputs, leading to loss of productivity in the short as well as long term (Vyas, VS., 2007).
Rainfed areas are under-invested and then there are controversies in technology. There is visible promise in approaches like NPM and organic farming. But the crux of the problem in rainfed areas is improvement of productivity, surpluses and incomes. Increasing small farm incomes, making small farm diversify to yield surpluses is the real challenge. Thinking rainfed agriculture for subsistence, there is a chance that technology becoming the preserve of only the rich and those in irrigated (Yugandhar, BN., 2007).

Analysing the plan-expenditure under various heads for the state of Andhra Pradesh over 1990–91 to 2004–05, it is clear that there is an upward shift in the pattern of expenditure on agriculture and allied activities in the recent years. While this is a good sign and is absolutely essential to revive agriculture in the state, it is disturbing to find that within agriculture what is spent on research and education has declined to 2 percent in 2001–02 from 13 percent in 1995–96. After 2001–02 this percentage has further declined and is lower than 2 percent by 2004–05. This pattern needs to be reversed if we have to move towards a break through in dry land agricultural technology. (Rukmani, R and Manjula, M., 2009).

There is urgent need for scaling up of the proven innovations of research and extension: New knowledge on crop ecosystem, efficacy of locally evolved recipes and formulations, economics of ecological benefits, new protocols to validate, more participatory methods of knowledge and technology generation from linear top down models and NGOs as partners in knowledge and technology generation than as passive recipients are the needed elements in research area. Extension should be more knowledge centric than product centric. Emphasis should be on approaches like Farmer Field Schools.

Respecting farmer’s knowledge and using successful farmers as resource persons is critical. NGOs and farmers should be treated as equal partners in planning and designing rather than as delivery channels. The focus should be on community managed rather than community paid. As part of institutional approach, it is necessary to organize farmers for better decision making and practice; and it is also essential that the labor should be organized to deliver inputs and services like pest surveillance, pest management contracts etc. There is a need to extend public support for research on ecological farming, promoting newer partnerships in extension (which are community managed rather than community paid) and also for using, building and protecting local resources. (Ramanjaneyulu, GV., 2007)

The anomaly in economic prices of the inputs should be determined and publicized. Overt subsidy should be given, mainly, with the objective of improving productivity with the use of a given input. Credit should be made available for a crop cycle of two or three years rather than for one season. As dry land agriculture is diversified, credit should be against the total income.
portfolio rather than only against crops. Keeping in view the dryland farmers who get bulk of their income only in one season, consumption credit should also be made available. Depending on the severity and duration of a calamity, clear provisions for waivers (waiving interest, waiving part of principle, waiving full interest and principle) need to be designed. This policy should not be politically motivated. There is also a need to look at the ways of implementing the Credit Policy. Apart from the market induced risks, which are common for all agricultural producers, important problem faced by dry land farmers is the weather induced uncertainties. Farmers in the dryland areas are risk averse as they do not have anything to fall back upon. There are two important risk mitigation measures: MSP and agriculture insurance scheme. The later scheme is covering hardly 10 percent of the farmers. There is a vast scope to improve upon the existing risk mitigation. There is no need to replace the existing Crop Insurance Scheme but it can be further strengthened (Vyas. VS, 2007).

Recognising support for NRM, NPM, soil fertility improvement etc., as ecosystem improvements rather than production subsidies will improve our competitiveness in the world markets. Cost reduction must be taken as a primary agenda rather than productivity improvement alone. In addition there is a need to differentiate our agriculture policy into irrigated and rainfed agriculture policies, so that we can look beyond watersheds and build support systems required for rainfed areas rather than extending those available for irrigated agriculture unsustainably. This will also help in rainfed areas getting required investments and research backup (Ravindra, A., 2007).

Dryland farmers in general, millet growers in particular should be honoured as water conservers. Farmers should be compensated with water bonus, conservation bonus and climate change bonus. Minimum Support Price for millets should be enhanced. Millets are 6 times nutritious than rice and he argued that they should be introduced into PDS, FFW, ICDS, midday meal, social welfare hostels, etc. A grape farmer gets more than one lakh rupees Bank finance whereas a sorghum farmer gets Rs. 1600 only. Developing farmer led extension systems and farmer-led research at all SAUs and research stations is need of the hour. There is also a need to develop long term strategy for each agroclimatic zone based on the specific situations and create new non corporate organic markets controlled by small farmers. Community supported farming need to be promoted where there will be dynamic interface between farmers and consumers (Satheesh PV, 2007).

Traditionally, food grains dominated the cropping pattern of the Anantpur district has also undergone vast changes over the decades. district with more than two-thirds of the gross cropped area under food grains. With the adoption of the bunch variety of groundnut in
Anantapur, since late 1970s, groundnut became the major crop. However, groundnut crop is marked by low yield levels that exhibit a declining trend (Rukmani, R and Manjula, M., 2009)

As Indian agriculture gets more and more impacted by changing weather patterns, which has become more acute in the last few years because of climate change, the ministry of agriculture through the Indian Council for Agricultural Research (ICAR) and state agricultural universities are working on district-specific contingency plan for the agriculture and allied sectors, which includes fisheries, animal husbandry and dairy farming. Since its start in March 2010 under the Rashtriya Krishi Vikas Yojana, the draft manual for 89, out of the total 600 odd districts, in the country have been prepared and submitted for validation by experts. The comprehensive district-specific document would give details on the crops and cultivation practices to be adopted in case of deficient or delay in monsoon, unseasonal rains, frosts or unusually high temperature excessive rains etc. “Each district would have a scientific document at the disposal of district collector for adaptation in case of eventualities,” B Venkateswarlu, director, Central Research Institute for Dryland Agriculture (CRIDA), a Hyderabad based body affiliated to ICAR, told FE (Sandip Das, 2010).

Most of the farm support is couched into the physical inputs. Ironically, ‘convenience and administrability’ have become the guiding factors of providing subsidies rather than the desirability of a particular process. Subsidising Urea rather than nitrogen is one such example and this leaves farmers ‘no choices’ but to use those inputs. We have to innovate upon process related support for agriculture rather than input driven technology. Investing on pest surveillance mechanisms is another example of investing on the processes that will reduce pest load by about 20 to 30 per cent (Ravindra, A., 2007).

India still does not have a well-defined drought policy, although it began considering an ‘anticipatory drought management approach’ in 1966 when the country was hit by a severe drought-induced food crisis. The task of drought forecasting is entrusted to the India Meteorological Department (IMD) which, over the years, has fine-tuned a methodology for forecasting the intensity of the southwest monsoon on a regional basis. (source: www.empowerpoor.org)

The performance of the state in terms of agricultural extension services was found to be relatively poor when compared with other states. For instance, an agricultural extension officer in Andhra Pradesh has to cover more than 10 villages or 3700 farm families whereas in states like Maharashtra and West Bengal it was only 2 or 4 villages (AP HD Report, 2007).
The current status of agricultural technology delivery system in Anantapur leaves much to be desired. The Training and Extension wing of the Department of Agriculture, operates with a bare minimum of field-level extension officers. A large number of sanctioned posts remains vacant, resulting in overburdening of available field-level staff. While the Department of Agriculture has sanctioned staff strength of 551 posts, in January 2009 we found 57 percent of these posts remaining vacant. However, during February 2009, recruitment of staff had taken place and the vacant posts of Mandal Agricultural Officers were filled up. However, the posts of Agricultural Extension Officers (AEO), those who have the mandate to visit villages and provide technical guidance to farmers, have not yet been filled. Out of 139 sanctioned posts, only 38 have been filled. That is, 73 percent of Agricultural Extension Officers posts remain vacant as on March 2009. This is a huge backlog, considering that even if all the 139 sanctioned posts of Agricultural Extension Officers are filled up it would be far from adequate to meet the ideal norm of 1,000 farm families per Agricultural Extension Officer. In fact, with the present allotment of officers, the number of farm families assigned per officer would be almost 3,915, which is much higher than the stipulated 1,000 farm families per officer.

The posts of adarsha ryuthus, Farmer’s Friend, were created in year 2005. Adarsha Ryuthus serve as interface between the farmers and the Department of Agriculture. According to the guidelines there has to be one adarsha ryuthu per 250 farm families. Adarsha Ryuthus are supposed to serve as facilitators at the village level for generating more awareness among farmers on various aspects of agriculture. The huge backlog in filling up sanctioned posts affects the quantity as well as quality of extension activities in the district. This comes out very clearly from the wide disparity, in terms of awareness and access to information, between farmers in different parts of the district. The adarsha ryuthus should only complement the public extension system and should not be looked upon as a substitute for field-level Extension Officers. (Rukmani, R and Manjula, M., 2009).
3.0.0. Current agricultural practices in select hydrological units in AP.

The study was carried out in 9 hydrological units spanning seven districts of Andhra Pradesh with the help and cooperation of partner NGOs in selection of villages and arrangement of logistic facilities like organizing farmers meetings with focused group discussions. The details of the mandals and partner NGOs is given below (Table 4). The discussions were focused on the major crops cultivated by the farmers, available natural resources like village tanks, awareness of various schemes by the department in harnessing limited resources, various programs implemented by state departments like drought relief, contingency crop plans and prevailing agronomic practices.

Table 4. Pilot hydrological units and partners for SPACC project by BIRDS

<table>
<thead>
<tr>
<th>Partner NGO</th>
<th>District</th>
<th>Mandal</th>
<th>Representative HU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BIRD</td>
<td>Kurnool</td>
<td>Allagadda</td>
<td>Chinneru</td>
</tr>
<tr>
<td>2 PARTNER</td>
<td>Kadapa</td>
<td>Kasinayana</td>
<td>Bokkineruvagu</td>
</tr>
<tr>
<td>3 SYA</td>
<td>Anantapur</td>
<td>Guthi</td>
<td>Upparavanka</td>
</tr>
<tr>
<td>4 GVS</td>
<td>Chittoor</td>
<td>Ramasamudram</td>
<td>Kadirinayanicheruvu</td>
</tr>
<tr>
<td>5 CARVE</td>
<td>Prakasam</td>
<td>Markapur</td>
<td>Yadalavagu</td>
</tr>
<tr>
<td>6 DIPA</td>
<td>Prakasam</td>
<td>Giddalur</td>
<td>Narsireddypallivagu</td>
</tr>
<tr>
<td>7 SAFE</td>
<td>Prakasam</td>
<td>Cumbum</td>
<td>Narsireddypallivagu</td>
</tr>
<tr>
<td>8 CARE</td>
<td>MB Nagar</td>
<td>Uppunuthala</td>
<td>Mallappavagu</td>
</tr>
<tr>
<td>9 SAID</td>
<td>Nalgonda</td>
<td>Thipparthi</td>
<td>Nathiganicheruvu</td>
</tr>
</tbody>
</table>

Current season the rainfall was scanty which begun as timely and normal season, ended up with poor distribution and early cessation of rains, resulted in drought spell in the crucial maturity phase of several crops. There is overall deficit rainfall and crops faced receding moisture condition in soils. The district level rainfall figures are presented below. (Table 5).

Table 5. Rainfall received in select dry farming districts of AP during the kharif 2011.

<table>
<thead>
<tr>
<th>District</th>
<th>Normal RF</th>
<th>Actual RF</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Prakasam</td>
<td>532.4</td>
<td>333.2</td>
<td>-37</td>
</tr>
<tr>
<td>2 Kurnool</td>
<td>555.1</td>
<td>425.1</td>
<td>-23</td>
</tr>
<tr>
<td>3 Anantapur</td>
<td>415.5</td>
<td>317.8</td>
<td>-24</td>
</tr>
<tr>
<td>4 Kadapa</td>
<td>482.4</td>
<td>424.9</td>
<td>-12</td>
</tr>
<tr>
<td>5 Chittoor</td>
<td>536.1</td>
<td>517.2</td>
<td>-4</td>
</tr>
<tr>
<td>6 Mahbubnagar</td>
<td>529.6</td>
<td>420.0</td>
<td>-21</td>
</tr>
<tr>
<td>7 Nalgonda</td>
<td>644.2</td>
<td>416.7</td>
<td>-35</td>
</tr>
</tbody>
</table>
3.1.0. Dryland agricultural practices in select hydrological units

3.1.1. General observations from the study

A. Seed source and storage

i. About 20% farmers produces most of his seed requirement (Rice, Red gram, Green gram, Black gram, Bengal gram.

Table. Popular Seed varieties in drylands AP, their source and storage

<table>
<thead>
<tr>
<th>Crop</th>
<th>Popular Seed varieties</th>
<th>Seed source</th>
<th>Storage structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>Tella hamsa, IR-4, BPT-5204</td>
<td>Local market and self preserved</td>
<td>Gunny bags , straw based or earthen pots</td>
</tr>
<tr>
<td>Bengal gram</td>
<td>Kranthi, Swetha, Annegiri, ICCV-10, Jyothi</td>
<td>Local Market self preserved</td>
<td>Cloth bags / Earthen containers in soil</td>
</tr>
<tr>
<td>Cotton</td>
<td>Tulasi, Mallika, Bunny, Brahma Munagari,</td>
<td>Local Market.</td>
<td>Cloth bags at farmer level for arboreums and polythene bags</td>
</tr>
<tr>
<td>Ground nut</td>
<td>TMV-2, Kadiri-3, JCG-88, Tirupathi-1</td>
<td>Local market / state dept.</td>
<td>Gunny bags</td>
</tr>
<tr>
<td>Jowar</td>
<td>CSH-9, CSH-5, Kavery, Haritha</td>
<td>Local market and self preserved</td>
<td>Cloth bags / Earthen containers</td>
</tr>
<tr>
<td>Sun flower</td>
<td>Mordan, APSH-11, NDSH-1,</td>
<td>Local market</td>
<td>Cloth bags / Earthen containers</td>
</tr>
<tr>
<td>Tomato</td>
<td>Pusa early dwarf, Pusa ruby, Roma</td>
<td>Local market</td>
<td>-</td>
</tr>
<tr>
<td>Red gram</td>
<td>LRG-30, Maruthi, Asha, ICPL-85063</td>
<td>Local Market, self preserved</td>
<td>Gunny bags / Earthen containers</td>
</tr>
<tr>
<td>Sesamum</td>
<td>Gauri, Madhavi, YLM-11, YLM-17, chandana</td>
<td>Local market and self preserved</td>
<td>Cloth bags / Earthen containers</td>
</tr>
<tr>
<td>Castor</td>
<td>Kranthi, Haritha, Kiran, Jyothi, DCH-32</td>
<td>Local Market, self preserved</td>
<td>Cloth bags / Earthen containers</td>
</tr>
<tr>
<td>Maize</td>
<td>DHM-103, madhuri kavery, haritha,</td>
<td>Local market</td>
<td>Cloth bags / Earthen containers</td>
</tr>
<tr>
<td>Sweet orange</td>
<td>Sathgudi, mosambi</td>
<td>Nursery</td>
<td>-</td>
</tr>
</tbody>
</table>
ii. About 80% farmers purchase in the local market produced by private companies. In case of drought or crop failure State Department of Agriculture, supplies the seeds to farmers. Some farmers store seeds for extended periods (Paddy, Red gram, Black gram, Green gram, Bengal gram, Groundnut, Chilli) in traditional methods/structures.

B. Soil fertility management
- Majority of the farmers above 80% are aware of the ill effects of the chemical fertilizers.
- The nutrient requirement of the soil is mainly supplied in the form of chemical fertilizers. Application of farm yard manure (FYM) is on a limited scale and showing the dwindling cattle population as a plausible reason.

C. Soil erosion management
- Majority of the farmers are not aware of the soil erosion and loss of fertile layer of soil. Learning from various media sources, few farmers are aware of ploughing across the slope and contour bunding, but in practice are not implemented for lack of financial resources.
- Many of the farmers are not aware of the crops that accelerate/prevent erosion. There is a need to train farmers on land utility based cropping system.

D. Crop residue management
- The crop residue from paddy, sorghum, maize, ground nut is used as fodder for cattle.
- Left out stubbles after harvesting as crop residue from cotton and redgram are used for fencing or covering roofs. In some places crop residues from tomato, chilli or other vegetables are left out in field and at the time of planning next crop, it is burnt out or rarely composted.

E. Major marketing channel

The dry land farmers are resource poor at large, and 90 % of them dependent on local market usually through the money lenders who lend them for input expenses and consumption loans. Farmers in such condition are found to be forced to sell at a lower price to his input dealer. In case of cotton and dry chilli, accessibility to the market yards and the local buyers play a major role. For green chilli, and other crops including vegetables local market in nearby town and weekly village fairs are major channel for
marketing. Dry chilli farmers Prakasam district store their stocks in cold storage structures till they get good price in market as it has a spice value.

The discussion is presented with a perspective of cost of cultivation of major crops from different hydrological units and various practices followed. The statistical data presented here under are for the year of 2011 kharif, sourced from website of Department of Economics and Statistics, Hyderabad (website: http://www.apdes.ap.gov.in/).

3.1.2. CHINNERU HYDROLOGICAL UNIT

In Kurnool district, the Chinneru hydrological unit lies across Rudravaram and Allagadda mandals which has dryfarming areas, owing to irrigation facility available from KC canal, large areas of paddy is being cultivated. The major crops in Rudravaram mandal in kharif are paddy followed by redgram. In rabi, chickpea is the major crop followed by jowar. In this section, we discuss practices followed and cost of cultivation in paddy in this region followed by chickpea.

A. PADDY

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>3075</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>203</td>
</tr>
<tr>
<td>Redgram</td>
<td>1756</td>
</tr>
<tr>
<td>Black gram</td>
<td>107</td>
</tr>
<tr>
<td>Green gram</td>
<td>117</td>
</tr>
<tr>
<td>Groundnut</td>
<td>97</td>
</tr>
<tr>
<td>Cotton</td>
<td>372</td>
</tr>
<tr>
<td>Castor</td>
<td>64</td>
</tr>
<tr>
<td>Jowar</td>
<td>248</td>
</tr>
<tr>
<td>Bajra</td>
<td>281</td>
</tr>
<tr>
<td>Maize</td>
<td>115</td>
</tr>
<tr>
<td>Chilli</td>
<td>373</td>
</tr>
<tr>
<td>Sunflower</td>
<td>21</td>
</tr>
<tr>
<td>Others</td>
<td>358</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>7187</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Crop</strong></th>
<th><strong>Area in ha</strong></th>
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<tr>
<td>Black gram</td>
<td>107</td>
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</tr>
<tr>
<td>Groundnut</td>
<td>97</td>
</tr>
<tr>
<td>Cotton</td>
<td>372</td>
</tr>
<tr>
<td>Castor</td>
<td>64</td>
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<td>Jowar</td>
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<td>281</td>
</tr>
<tr>
<td>Maize</td>
<td>115</td>
</tr>
<tr>
<td>Chilli</td>
<td>373</td>
</tr>
<tr>
<td>Sunflower</td>
<td>21</td>
</tr>
<tr>
<td>Others</td>
<td>358</td>
</tr>
</tbody>
</table>

**Table.6. Cost of cultivation data on Paddy cultivation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughings : 3 Guntakas: 1</td>
<td>3000</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>20 – 30 kg /acre</td>
<td>2000</td>
</tr>
</tbody>
</table>
### Cultivation practices in paddy

1. Paddy is cultivated under canal or borewell irrigation, wherever available as it is the staple crop and is grown under standing water conditions.

2. Seed rate is usually 25-30 kg in broadcasting practiced in some upland conditions. For 30-35 kg for sowing behind a harrow (gorru). In majority of cases a nursery bed of area 0.05 acre (for one acre main field) is prepared with 400-500 kg FYM and good quality soil, overnight soaked 16 – 20 kg seed is broadcasted on the bed. Farmers usually apply chemical fertilizers to a tune of 2kg urea and 6 kg single super phosphate to the nursery bed and apply 800 g carbofuran 4G granules against pests within 10 days after sowing.

3. Farmers prepare land to fine tilth, leveled, irrigated and puddle till the field reaches consistency of slurry. Intensively cared seedlings from 21 day old nursery are transplanted in main field @3-4 / hill. Farmers dip rice seedlings in 0.02% chlorpyriphos solution before sowing in the main field.

4. Farmers slowly departed from the practice of applying oil cakes, tanksilt, green manuring and green leaf manuring for various reasons and increased the application of chemical fertilizers. Each acre is applied with 1 bag of DAP as basal dose, followed by 1 bag of potash and 2 bags of urea.

5. Weeding is manual in majority of cases and of late weedicides are being used because weed competition is more in direct seeded rice/upland rice. Reduction in yield to the tune of 34% in transplanted rice, 45% in direct seeded low land rice and 67% in upland rice are reported. Weedicides butachlor @ 800 ml or anilophos 400 ml or 2,4-DEE granules @ 5 kg/acre are mixed with sand and broadcasted one week after transplantation. A social factor behind this trend is unavailability of labor and increased cultivation costs.

6. Pesticide sprays for crop protection range between 3-5 depending on incidence of major pests like BPH (acephate @1.5g/L or imidachloprid @ 0.25ml/L), gall midge (carbofuran@10kg or Phorate@5kg /acre) and stem borer (monocrotophos @1.6ml/L)
or acephate @1.5g/L) or diseases like blast (tricyclozole 0.6g/L) and sheath blight (propiconazole@1ml/L).

7. Once the crop is harvested, small heaps are allowed to dry in the field. Threshing is carried out manually by cattle or using tractor. Recently combined harvesters are being used for harvesting as well as segregating grain and straw simultaneously.

8. In upland (dryland/rainfed) paddy, land is prepared to fine tilth and seed is sown directly by seed drill or behind the plough. Input cost on fertilizer and pesticides is low. Crop is totally rainfed and no standing water is maintained. In such conditions the expected average yield is about 10 quintals per acre only.

**B. CHICKPEA**

It is a rabi pulse crop and requires cool humid weather and mainly suited for moderate rainfall areas of 400-700mm. Water-logging results into wilt diseases (when grown with Redgram). Optimum temperature regime for chick pea is 24-30°C. Chick pea is a long day plant and requires sufficient bright sunshine. The period of cool temperature decides the duration of the crop, as the winter is warm in South India the duration is about 90-110 days. There are 2 important varietal types available in India, Kabuli /Desi type of which desi type is mostly cultivated.

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land prep</td>
<td>Soil type: Black Ploughing and harrowing with Guntakas</td>
<td>3400</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>20 -26 kg /acre</td>
<td>2200</td>
</tr>
<tr>
<td>3 Fertilizers</td>
<td>FYM 4 tons, DAP: 2 bags and Complex 2 bags</td>
<td>5530</td>
</tr>
<tr>
<td>4 Weeding</td>
<td>3 x Rs. 100</td>
<td>300</td>
</tr>
<tr>
<td>5 Plant protection</td>
<td>4-5 sprays of pesticides</td>
<td>2000</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>1 time@800(equipment and labour)</td>
<td>800</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Yield:1000kg</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Market Rate (Grain) Rs35/kg=35000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fodder 2 tons value</td>
<td>2000</td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income: Rs.</td>
<td>37500</td>
</tr>
<tr>
<td></td>
<td>Total cost: Rs.</td>
<td>15230</td>
</tr>
<tr>
<td></td>
<td>Net income: Rs</td>
<td>22270</td>
</tr>
</tbody>
</table>
Cultivation practices in chickpea

1. Land is ploughed deeply in kharif and left out fallow for moisture retention. During rabi the land is brought to fine tilth before sowing.
2. Seed is sown directly using manual laborers or using dibbler on residual moisture. Seed treatment with Rhizobium culture @ 1kg /10 L water to coat on seed.
3. FYM is applied as per local availability and fertilizers are given usually in form of a basal dose of 2 bags DAP, followed by 2 bags of complex per acre usually, which happens to be almost double the recommendation, NPK in 8:20:16.
4. Depending on the availability 1-2 irrigations are given after sowing, as it would help in increasing yields. Weeding is carried out manually but fluchloralin @ one litre / acre as pre sowing herbicide, pre emergence herbicide pendimethalin @2 liters/acre are used recently.
5. Pest control is achieved through 4-5 sprays of various chemicals (acphate1 g/l + quinalphos 2ml/litre), and in some large farms it is carried out using tractor mounted multi nozzle sprays.
6. Crop is harvested at maturity, after threshing the seed is separated and crop residue bhusa is used as fodder/compost material/fuel.

3.1.3. BOKKINERUVAGU HYDROLOGICAL UNIT

In Kadapa district the Bokkineru vagu hydrological unit lies in the Kasinayana mandal where cotton is major crop followed by paddy and redgram. Here under we will discuss the cost of cultivation of cotton and general cultivation practices followed in the hydrological unit.

A. COTTON

This crop is regarded as white gold as it is grown as a commercial crop under irrigated and rainfed conditions. It is traditonaly grown in heavy black soils, but now grown in all types of soils. The crop is sensitive to stagnation of water. Most of cotton grown in india are hirsutum species and called as american cottons. This crop consumes more than 50% of the pesticides consumed in indian market. Apart from lint, the seed oil (oil content 15-25 %) is used for blending with other edible vegetable oils and oil cake as animal feed/organic manure.

Table.8. Cost of cultivation in cotton

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Soil type-Redy sandy loam</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>Ploughing followed by harrowings</td>
<td></td>
</tr>
</tbody>
</table>
2 Seed & sowing  450 gm / acre  |  3000
3 Fertiliser  FYM 4 tons, Dap: 1 bag, Urea:1. Bag and Complex 1. bag  |  4100
4 Weeding  20 x Rs. 100  |  2000
5 Sprays  Fungicides&Pesticides  |  1400
6 Irrigation  Water conservation: Ridges and furrows  |  800
7 Harvesting  Picking cost  |  6000
     Yield :700kg @ Rs.4000/q  |  28000
8 Cost benefit  |  Total income: Rs. 28000
     |  Total cost: Rs. 20300
     |  Net income: Rs 7700

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>711</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>78</td>
</tr>
<tr>
<td>Redgram</td>
<td>692</td>
</tr>
<tr>
<td>Green gram</td>
<td>14</td>
</tr>
<tr>
<td>Groundnut</td>
<td>13</td>
</tr>
<tr>
<td>Cotton</td>
<td>1740</td>
</tr>
<tr>
<td>Jowar</td>
<td>12</td>
</tr>
<tr>
<td>Bajra</td>
<td>103</td>
</tr>
<tr>
<td>Maize</td>
<td>71</td>
</tr>
<tr>
<td>Chilli</td>
<td>436</td>
</tr>
<tr>
<td>sunflower</td>
<td>98</td>
</tr>
<tr>
<td>Turmeric</td>
<td>46</td>
</tr>
<tr>
<td>Others</td>
<td>3568</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>4233</strong></td>
</tr>
</tbody>
</table>

Cultivation practices in cotton

1. Land preparation will start with the receipt of first monsoon showers, a ploughing is followed by repeated harrowing till fine tilth is achieved.

2. Once the land is prepared and trash and weeds are removed, a marker is drawn based on the spacing depending on the variety (60x30 cm) / hybrid (90 x 90 cm or above), and seed is sown manually at the cross section of the marker drawn in length and breadth of the plot. Seed preference is for hybrid seeds with Bt, based on seed available commercially with various seed companies. The seed available in market is pretreated with imidachloprid, claims to protect crop for one month against sucking pests.
3. FYM to a level of 2-4 tons/acre is applied based on the availability. Basal dose of fertilizer, usually DAP/complex is applied either along with the seed or as along the rows. Then top dressing with urea is done along the rows or as pocket placement i.e., application of fertilizer close to the base of the plant into a small pit made with a stick.

4. Topping i.e., Nipping terminal shoot is a common practice with farmers, around 90 days after sowing (DAS), that prevents vegetative growth and induces more fruit/boll bearing sympodial branches.

5. Farmers spray various chemicals depending on the pest infestation. Since 8 years, the bollworm occurrence has not been devastating and most of the plant protection sprays are targeted against sucking pests (aphids, jassids, whitefly, mites and mealybugs). Pesticide like methyl demeton @2ml/L or imidachloprid SL @0.4 ml/ L or acetamiprid@ 0.2g/L are usually sprayed for these pests.

6. Picking of cotton is carried for 3-5 times depending on duration of crop. Early cessation of rainfall like it happened in the current season 2011-12 results in fewer pickings and even lesser yields also.

7. Cotton is marketed through the trader usually happens to be the seed / fertilizer / pesticide dealer, who supplies the inputs to farmer on credit, this situation results in farmer having limited choice on price and whom to sell. This added with increased input costs, interest on debts, over ambitious tenant farming, getting in to compounding effects like resulting in farmer resorting to extreme steps like suicide.

3.1.4. UPPARAVANKA HYDROLOGICAL UNIT

In Anantpur district Upparavanka Hydrological unit lies in the Guthymandal and the major crop happens to be groundnut followed by jowar. Here we discuss the area, cost of cultivation and practices followed by farmers on these two important crops.

A. GROUNDNUT

This crop is cultivated under very low rainfall conditions with 500 mm above in a crop season. It is suitable to light to heavy soils, but actually grown in large area in sandy loams, with low nutrient contents and moisture holding capacity. Groundnut 90% area is cultivated in kharif, average yields are comparatively low due to erratic behaviour of monsoon i.e late onset of monsoon, dryspell during critical crop growth stages, heavy rains at later stages or early withdrawal of monsoon.
Table 9. **Cost of cultivation in groundnut**

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughings : 2 Guntakas : 2</td>
<td>2500</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>50 - 75 kg/acre</td>
<td>3750</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>FYM : 2 tons, DAP : 1 bag, Potash – 25 kg</td>
<td>3200</td>
</tr>
<tr>
<td>4 Weeding</td>
<td>12 x Rs.100</td>
<td>1200</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>Pesticides</td>
<td>1400</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>8x100</td>
<td>800</td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income:</td>
<td>17000</td>
</tr>
<tr>
<td></td>
<td>Total cost:</td>
<td>12850</td>
</tr>
<tr>
<td></td>
<td>Net income:</td>
<td>4150</td>
</tr>
</tbody>
</table>

Crop Area in ha

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>178</td>
</tr>
<tr>
<td>Redgram</td>
<td>1024</td>
</tr>
<tr>
<td>Groundnut</td>
<td>14701</td>
</tr>
<tr>
<td>Cotton</td>
<td>49</td>
</tr>
<tr>
<td>Castor</td>
<td>286</td>
</tr>
<tr>
<td>Jowar</td>
<td>1106</td>
</tr>
<tr>
<td>Bajra</td>
<td>24</td>
</tr>
<tr>
<td>Chilli</td>
<td>84</td>
</tr>
<tr>
<td>Sunflower</td>
<td>956</td>
</tr>
<tr>
<td>Others</td>
<td>402</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>18810</strong></td>
</tr>
</tbody>
</table>

**Cropping pattern in gooty mandal in Anantpur district**

**Cultivation practices in Groundnut**

1. Farmers prepare land for sowing soon after the onset of monsoon. One or two times ploughing is followed by 1-2 times harrowing. These are sufficient as groundnut is cultivated in loose sandy loams. The weeds and stubbles of previous crop will be removed to make the field clean.
2. The field is applied with FYM 1-2 tons/acre, well incorporated in to soil before sowing.
3. Seed is treated with fungicides and bio-fertiliser like Rhizobium. Treated seed is usually dried under shade before sowing. The sowing will be usually carried out manually or using dibbler.
4. Farmer applies 1 bag of potash and 1 bag of DAP per acre as basal application.
5. Farmers resort to 2-4 sprays of chemicals for controlling defoliator pests like Spodoptera/ hairy caterpillar and for diseases tikka leafspot or rust.
6. The crop will be harvested by uprooting by a harrow once it reaches to maturity, the pods will be harvested and dried for optimum moisture content.

B. Jowar / Sorghum

Sorghum is a sturdy crop and withstands any climatic hazards than any other crop. This is a poor man's crop which is mostly grown under low input conditions. This can be grown in black cotton soils to light soils and comes up well in any season kharif, rabi or summer.

Table.10. Cost of cultivation for Jowar

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Land preparation</td>
<td>Ploughing and harrowing</td>
<td>2500</td>
</tr>
<tr>
<td>2. Seed &amp; sowing</td>
<td>3 -4 kg/acre</td>
<td>1000</td>
</tr>
<tr>
<td>3. Fertiliser</td>
<td>Fym 2 tons, urea 2bags, Complex-1 bag</td>
<td>2530</td>
</tr>
<tr>
<td>4. Weeding</td>
<td>15 X Rs. 100</td>
<td>1500</td>
</tr>
<tr>
<td>5. Sprays</td>
<td>3 X Rs. 400</td>
<td>1200</td>
</tr>
<tr>
<td>6. Irrigation</td>
<td>18 x Rs.400</td>
<td>7200</td>
</tr>
<tr>
<td>7. Harvesting</td>
<td>Cost of harvesting</td>
<td>3500</td>
</tr>
<tr>
<td></td>
<td>Yield- 15 q/acre</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market rate: Rs. 1800/q</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fodder value</td>
<td>2000</td>
</tr>
<tr>
<td>8. Cost benefit</td>
<td>Total income:</td>
<td>29000</td>
</tr>
<tr>
<td></td>
<td>Total cost:</td>
<td>19430</td>
</tr>
<tr>
<td></td>
<td>Net income:</td>
<td>10430</td>
</tr>
</tbody>
</table>

Cultivation practices in Jowar

1. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowing till fine tilth is achieved.
2. Sorghum is broad casted (higher seed rate 5-7 kg/acre) or drilled by local seed drill (3-4kg/acre) or dibbling (2.5 kg/acre). The transplanting method is mostly used for hybrid sorghum in chittor district, the seed growers follow the transplanting method of sowing.
This method is developed by them for obtaining perfect synchronisation of male and female lines of sorghum hybrid CSH-5.

3. Seed treatment done usually for control of grain smut with sulphur @5g/kg seed.

4. FYM to a level of 2-4 tons/acre is applied based on the availability. Basal dose of fertilizer, usually DAP/ complex is applied either along with the seed or as along the rows. Then top dressing with urea is done.

5. Farmers spray various chemicals depending on the pest infestation like shoot fly and shoot borer carbofuran granules @4kg/acre , and for ergot of sorghum, with sticky sugary secretion, farmers give 1-2 sprays of mancozeb@2g/L at flowering.

6. Harvesting is manual and threshing using cattle/mechanically. All crop waste is used as dry fodder for cattle.

C. SUNFLOWER

Sunflower is a short duration (90-100 days) Drought and saline tolerant: suitable for the best component crop in dry land farming as it fits well in multiple and intercropping systems. Photo insensitivity of crop enables its cultivation in all seasons i.e kharif, rabi and summer. Due to its wider adaptability, it comes well up in any type of soils. High productivity per unit area per unit time with respect to yield of oil (oil content 48-53%).

Table.11. Cost of cultivation for Sunflower

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughings</td>
<td>2400</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>2 kg/acre</td>
<td>2100</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>Fym 3 tons, urea, complex one bag each</td>
<td>3100</td>
</tr>
<tr>
<td>4 Weeding</td>
<td>10 x Rs.100</td>
<td>1000</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>Pesticides</td>
<td>700</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>2-3 times</td>
<td>800</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Cost of harvesting</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td>Yield :700kg; Market rate:Rs. 3500/q</td>
<td></td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income: Rs.</td>
<td>24500</td>
</tr>
<tr>
<td></td>
<td>Total cost: Rs.</td>
<td>11600</td>
</tr>
<tr>
<td></td>
<td>Net income: Rs</td>
<td>12900</td>
</tr>
</tbody>
</table>
Cultivation practices in Sunflower

1. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowings till fine tilth is achieved.
2. Farm yard manure to a level of 2-4 tons/acre is applied based on the availability. Line sowing using seed drill or behind plough is followed. Basal dose of fertilizer, usually complex fertiliser applied either along with the seed or as along the rows. Then top dressing with urea is done in 2 split doses.
3. During flowering time farmers follow a practice of rubbing the flower heads with a soft cloth to enhance the seed setting and yield.
4. Farmers spray chlorpyriphos @2ml/L or fenvalerate @1ml/L against head borer or defoliator pests. Farmers make sounds using various methods like drumming of using crackers to frighten birds, one of the major pests.
5. The heads are ripe when back of the head turns yellowish brown and lower leaves become brown to dark brown. Harvesting is manually done with sickle cutting the heads and threshing done by mechanically using sticks or shellers.

3.1.5. KADIRINAYANI CHERUVU HYDROLOGICAL UNIT

In Chittor district Kadirinayanicheruvu hydrological unit lies in the mandal Ramasamudram, the cropping pattern in kharif is presented below. Apart from Ground nut, vegetables are widely cultivated and single crop tomato is cultivated in 15,184 ha (State Horticulture Dept data 2007-08) in Chittor district with a production of 1,82,208 tonnes. There are hundreds of hectares under tomato in this mandal. The cost of cultivation and practices are presented here under.

A. TOMATO

Tomato is a warm season vegetable, though grown round the year in all types of soils ie., heavy to light soils. There are determinate (erect plant), indeterminate (creeping) and semi determinate types in tomato. Tomato is sensitive to irrigation ie., dry spells or water stagnation both are detrimental for the yields.

Table.12. Cost of cultivation for tomato

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughing</td>
<td>3000</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>200 g/acre</td>
<td>4000</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>FYM 4 tons Dap: 1 bag Urea:1 bag Complex .1 bag</td>
<td>4100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4</td>
<td>Weedings</td>
<td>20 X Rs. 100</td>
</tr>
<tr>
<td>5</td>
<td>Sprays</td>
<td>Fungicides &amp; Pesticides</td>
</tr>
<tr>
<td>6</td>
<td>Irrigation</td>
<td>Water conservation: Ridges and furrow</td>
</tr>
</tbody>
</table>
| 7 | Harvesting | Yield: 8000kg  
|   |   | Market Rate: Rs. 4/kg |
| 8 | Cost benefit | Total income: Rs. |
|   |   | Total cost: Rs. |
|   | Net income: Rs | 10500 |

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>521</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>248</td>
</tr>
<tr>
<td>Groundnut</td>
<td>2487</td>
</tr>
<tr>
<td>Cotton</td>
<td>24</td>
</tr>
<tr>
<td>Tomato &amp; others</td>
<td>2396</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>5652</strong></td>
</tr>
</tbody>
</table>

Cultivation practices in tomato

1. Farmers prepare land for sowing with first onset of monsoon. For vegetables the soil is prepared to fine tilth. The weeds and stubbles of previous crop will be removed to make the field clean.
2. The field is applied with 1-2 tons farm yard manure / acre, well incorporated in to soil before sowing.
3. Seeds sown on raised nursery beds 1m X 4m carefully prepared with adding decomposed FYM and before sowing is treated with fungicide like Copper oxy chloride@3g/L. The seedlings with 26-30 day age will be transplanted on main field on side of the ridges, after treating seedlings with seedling root dip with solution of Rogor 2ml + Bavistin 1g/L in 10 litres of water.
4. Generally available varieties/hybrids fall under determinate, indeterminate or semi determinate type, where in indeterminate/ semi determinate varieties are supported with sticks and/ ropes.

5. To prevent cracking of fruits farmers apply borax @ 8-12 kg/ acre. Farmer applies 1 bag of complex/DAP per acre as basal application. Top dressing will be done with urea in 2-3 split doses.

6. Farmer will resort to 4-6 sprays of chemicals (chlorpyriphos or Quinalphos @2ml/L) for controlling borer pests like Helicoverpa/Spodoptera, sucking pests like whitefly (acephate@1g/L) which is a vector for leaf curl and serpentine leaf miner. farmers spray dithane M45@2g/L for early/ late blight, a major disease.

7. The crop will be harvested by picking fruits throughout the crop season starting from end of 2nd month onwards till 4-6 months, subjected to market price and demand. The stage of harvested fruit (green/ripe) depends on the distance of the market.

3.1.6. YADALAVAGU, NARSIREDDYPALLIVAGU AND JAMPALERUVAGU HYDROLOGICAL UNITS

In Prakasam district three hydrological units Yadalavagu, Narsireddypallivagu and Jampaleruvagu are surveyed for cropping patterns, with the help of three partner NGOs working in the region. The cropping patterns and the practices followed in major crops are presented below. In Giddaluru Madal Red gram and sesame are major crops followed by cotton and paddy. Here under we discuss the cost of cultivation and package of practices for redgram and sesame.

A. Red gram

This is very important part of Indian diet. It is a quantitative short day flowering response plant i.e. the onset of flowering is hastened as day length shortens. It tolerates heat and drought. It prefers moist and warm climate during vegetative period and cool and dry period during reproductive stage. The ability of pigeonpea to produce economic yields under soil moisture deficit makes it an important crop of dry land agriculture. The husk of pods after threshing is also used as cattle feed.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>787</td>
</tr>
<tr>
<td>Redgram</td>
<td>2499</td>
</tr>
<tr>
<td>Black gram</td>
<td>24</td>
</tr>
<tr>
<td>Green gram</td>
<td>454</td>
</tr>
<tr>
<td>Cotton</td>
<td>1175</td>
</tr>
<tr>
<td>Castor</td>
<td>250</td>
</tr>
<tr>
<td>Sesamum</td>
<td>1675</td>
</tr>
<tr>
<td>Maize</td>
<td>44</td>
</tr>
<tr>
<td>Chilli</td>
<td>472</td>
</tr>
<tr>
<td>Vegetables</td>
<td>869</td>
</tr>
<tr>
<td>Orchards</td>
<td>289</td>
</tr>
<tr>
<td>Others</td>
<td>1105</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>8856</strong></td>
</tr>
</tbody>
</table>

Table 14. Cost of cultivation for Red gram

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land preparation</td>
<td>Ploughing : One, Guntaka : One, Harrowings - One</td>
</tr>
<tr>
<td>2</td>
<td>Seed &amp; sowing</td>
<td>3-8 kg /acre</td>
</tr>
<tr>
<td>3</td>
<td>Fertiliser</td>
<td>Complex: 2 Bags</td>
</tr>
<tr>
<td>4</td>
<td>Weedings</td>
<td>12 x 100</td>
</tr>
<tr>
<td>5</td>
<td>Sprays</td>
<td>3 – 4 sprays of pesticides</td>
</tr>
<tr>
<td>6</td>
<td>Irrigation</td>
<td>Cuttling cost</td>
</tr>
<tr>
<td>7</td>
<td>Harvesting</td>
<td>Yield: 400kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market Rate: 2800/q</td>
</tr>
<tr>
<td>8</td>
<td>Cost benefit</td>
<td>Total income:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total cost:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net income:</td>
</tr>
</tbody>
</table>

Cultivation practices in Red gram

1. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowings till fine tilth is achieved.

2. Farmers give seed treatment with fungicides like Bavistin 1g/kg seed captan or Thiram @ 2.5 g/kg before sowing to control fungal diseases like wilt and reduce incidence of other seed and soil borne fungi.
3. Basal dose of fertilizer, usually DAP/complex is applied either along with the seed or as along the rows. Farmers spray fenvalerate or profenophos @2ml/L against podborer/webber, and basal drenching for diseases like wilt with dithane M45@2g/L.

4. Harvesting is manually done when pods are dry with sickels and threshing is mechanical.

5. Leaf and threshed pods is used as dry fodder for cattle and stems for fuel/fencing/roofs.

6. The Redgram is said to be indeterminate in growth habit where the flowering goes on continuously over the months on the same plant. Flowering, unripened pods & already, developed pods at the same time. The whole plants are cut when most of the pods are dried. Then the plants are bundled and staked for one week for the purpose of post harvest ripening of unripened pods after that the dried pods are beaten with sticks and then the seed is separated.

B. SESAMUM

Sesame is the oldest oil seed crop of the world. The seed has high food value because of the higher contents of good quality edible oil (oil content 48-55%) and nutritious protein. Sesame requires fairly hot conditions during growth for optimum yield and is capable of with standing a higher degree of water stress. The crop can be grown entirely on stored soil moisture, but highly sensitive to water logging. Very sandy, saline and alkaline soils are not suitable.

Table.15. Cost of cultivation for Sesamum

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughing and harrowing</td>
<td>2500</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>3 kg/acre</td>
<td>750</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>Complex-1.5 bags</td>
<td>1200</td>
</tr>
<tr>
<td>4 Weeding</td>
<td>10 X Rs. 100</td>
<td>1000</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>3 pesticide sprays</td>
<td>300</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Cost of harvesting</td>
<td>1500</td>
</tr>
</tbody>
</table>

Yield- 4 q/acre
Market rate- Rs. 4000/q

8 Cost benefit
Total income: 16000
Total cost: 7250
Net income: 8750

Cultivation practices in Sesamum

1. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowing till fine tilth is achieved.
2. Basal dose of fertilizer, usually complex, is applied either along with the seed or as along the rows. Seed is mixed with three times quantity of sand and sown in rows with traditional seed drill/gorru.

3. Farmers spray monocrotophos @1.6ml/L or chlorpyriphos@2.5 ml/L against podborer/webber, and for wilt disease dithaneM45 @2g/L and for powdery mildew sulfur@3g/L. plants affected by phyllody turn to witches brooms, are removed and burnt to destroy them.

4. The crop is harvested when the leaves, stems and capsules begin to turn yellow and the lower leaves start shedding. To prevent shedding of seed, the crop harvested before it is dead ripe in the field. When leaves turn 75% yellow, the plants are cut at the ground level carried to threshing yard, stacked for a week in the sun with the cut ends upwards. plantstied in bundles, dried under sun and threshing done by beating with sticks.

5. Leaf and pod waste is used as dry fodder for cattle and stems for fuel/fencing/roofs.

In Markapurm mandal redgram is major crop followed by paddy, chilli and castor. Here under we discuss the cost of cultivation and practices followed in castor.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>427</td>
</tr>
<tr>
<td>Redgram</td>
<td>1564</td>
</tr>
<tr>
<td>Green gram</td>
<td>68</td>
</tr>
<tr>
<td>Cotton</td>
<td>788</td>
</tr>
<tr>
<td>Castor</td>
<td>323</td>
</tr>
<tr>
<td>Bajra</td>
<td>225</td>
</tr>
<tr>
<td>Maize</td>
<td>11</td>
</tr>
<tr>
<td>Chilli</td>
<td>995</td>
</tr>
<tr>
<td>Vegetables</td>
<td>30</td>
</tr>
<tr>
<td>Orchard crops</td>
<td>1557</td>
</tr>
<tr>
<td>Others</td>
<td>281</td>
</tr>
<tr>
<td><strong>Net sown area</strong></td>
<td><strong>6269</strong></td>
</tr>
</tbody>
</table>

A. CASTOR

Castor is one of the ancient important non-edible oil seed (oil content 40-55%) crop, which has industrial and medicinal value. Globally, India ranks first both in area and production. It grows well in warm climates with light sandy loams. The seed cake is used as concentrated organic manure.
Table 16. **Cost of cultivation for castor**

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land preparation</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ploughing and harrowing</td>
<td>2500</td>
</tr>
<tr>
<td>3</td>
<td>Seed &amp; sowing</td>
<td>700</td>
</tr>
<tr>
<td>4</td>
<td>Fertiliser</td>
<td>2000</td>
</tr>
<tr>
<td>5</td>
<td>Complex-2 bags</td>
<td>2000</td>
</tr>
<tr>
<td>6</td>
<td>Weedings</td>
<td>1200</td>
</tr>
<tr>
<td>7</td>
<td>Sprays</td>
<td>1200</td>
</tr>
<tr>
<td>8</td>
<td>Irrigation</td>
<td>250</td>
</tr>
<tr>
<td>9</td>
<td>Harvesting</td>
<td>1500</td>
</tr>
<tr>
<td>10</td>
<td>Cost of harvesting</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Yield - 5 q/acre</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Market rate: Rs. 3500/q</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Total income</td>
<td>17500</td>
</tr>
<tr>
<td>14</td>
<td>Total cost</td>
<td>8150</td>
</tr>
<tr>
<td>15</td>
<td>Net income</td>
<td>9350</td>
</tr>
</tbody>
</table>

**Cultivation practices in castor**

1. Castor is cultivated in poor soils in dry land condition resulting in low productivity though the oil has medicinal/industrial use and having high export value. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowing till fine tilth is achieved.

2. Most of the hybrids and varieties from public and private sectors are tolerant to pest and diseases. Seed treatment with thiram / captan @3g/kg seed is done before sowing.

3. Seed is drilled along with the fertilizer, basal dose of fertilizer, usually DAP/complex is applied either along with the seed or as along the rows. Then top dressing with urea is done 2-3 splits.

4. Farmers spray carbaryl @3g/l or monocrotophos 1.6ml/L against semilooper, Hairy caterpillars and *Spodoptera*. For fruit and shoot borer, dimethoate or metasystox @ 2 ml/L is sprayed. Major disease is grey rot /botrytis, which has devastating effect on crop under high humid and cloudy conditions, late sown crops are found more susceptible.

5. Capsules harvested when they turn yellow and starts drying. Harvested spikes are usually placed in heaps around one week and then sun dried for a couple of days. Threshing is done by beating with the sticks or trampling under the cattle feet or tractor or power operated threshers.
In Cumbum mandal major crop is paddy, followed by redgram, sesameum, cotton and chilli. Here under we discuss the cost of cultivation and package of practices in chilli.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>809</td>
</tr>
<tr>
<td>Redgram</td>
<td>529</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>21</td>
</tr>
<tr>
<td>Green gram</td>
<td>147</td>
</tr>
<tr>
<td>Cotton</td>
<td>242</td>
</tr>
<tr>
<td>Castor</td>
<td>16</td>
</tr>
<tr>
<td>Sesamum</td>
<td>247</td>
</tr>
<tr>
<td>Chilli</td>
<td>241</td>
</tr>
<tr>
<td>Vegetables</td>
<td>95</td>
</tr>
<tr>
<td>Others</td>
<td>544</td>
</tr>
<tr>
<td>Net sown area</td>
<td>2891</td>
</tr>
</tbody>
</table>

A. CHILLI

This is important cash crop in AP, grown in well drained black and sandy loamy soils. The crop prefers warm and dry climate for its growth.

Table 17. Cost of cultivation for Chilli

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost / acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land prep</td>
<td>Ploughings and Guntakas</td>
<td>2000</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>Nursery - 650 g/acre; direct sowing 2.5 kg/acre</td>
<td>2500</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>FYM 2 tons Dap: 2 bags; Urea: 1 bag Complex: 1 bag</td>
<td>4100</td>
</tr>
<tr>
<td>4 Weedings</td>
<td></td>
<td>3000</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>Fungicides and pesticides</td>
<td>3000</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>Water conservation: intercultivation 6 times</td>
<td>1200</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Yield: 1500 kg (Drypod)</td>
<td>12000</td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income: Rs.</td>
<td>75000</td>
</tr>
<tr>
<td></td>
<td>Total cost: Rs.</td>
<td>30100</td>
</tr>
<tr>
<td></td>
<td>Net income: Rs</td>
<td>44900</td>
</tr>
</tbody>
</table>
Cultivation practices in Chilli

1. Farmers prepare land for sowing with first onset of monsoon. The weeds and stubbles of previous crop will be removed to make the field clean. The field is applied with farm yard manure 2-3 tons/acre, well incorporated in to soil before sowing. Chilli needs very fine tilth since size of seed is small.

2. Seeds sown on raised nursery beds to a size of 6 m x 1 m width carefully prepared with adding decomposed FYM and before sowing. Commercially available seed is pre treated with fungicides and pesticides like imidachloprid. Bed is sprayed with granules of fipronyl @ 80g/0.05 acre to avoid leaf curl. To suppress wilt farmers spray copper oxy chloride @3g/L to nursery bed.

3. The seedlings with 6 weeks age will be transplanted on main field after treating seedlings with fungicides and pesticides. Farmer applies two bags of complex/DAP per acre as basal application. Top dressing will be done with urea in 2-3 split doses.

4. Farmer will resort to 4-6 sprays of chemicals for controlling borer pests like Helicoverpa/Spodoptera, sucking pests like whitefly, mites and thrips. For borer pests farmers spray monocrotophos @ 1.6ml/L or quinalphos@ 2ml/L; farmers even prepare poison baits with these chemicals for spodoptera. For upward leaf curl (thrips) farmers spray carbaryl @ 3g/L or phosalone @ 3ml/L and for downward leaf curl (mites), dicofol@3ml/L or sulphur @ 3g/L sprayed. Major diseases are powdery mildew, fruit rot, blight and bacterial wilt.

5. The crop will be harvested in 3-4 pickings of fruits in kharif and under irrigation even 6-8 pickings. Fruits starts ripening about 3months after transplanting and picking may go on for 2 to 3 months. Green chillies are harvested for vegetable purpose depending on good market price, and mature fruits are harvested and dried for spice purpose as dry chillies. Farmers store dry chillies in cold storage godowns for months together until better price prevails in market.

3.1.7. MALLAPPAVAGU HYDROLOGICAL UNIT

In Mahaboobnagar district the hydrological unit Mallappavagu lies partly in Uppunuthala Mandal, here the cropping pattern is dominated by cotton and maize in kharif and in rabi season the cropping pattern is groundnut based. Here under we discuss the cost of cultivation and practices followed in maize.
A. MAIZE

Maize has highest yield/ha among the cereal crops. Though it is mainly used as a food crop in India by the rural population in the form of bread and gruel, it has vast industrial potentialities as well having many as 50 different uses. Green ears find a ready market in the urban areas. The grain is ground into flour for making bread. Maize is being used as a poultry and cattle feed. It is a short day plant with C4 type of photosynthesis, the crop has very efficient utilization of solar radiation and 600 mm rainfall with even distribution is sufficient for good cultivation.

Table 18. Cost of cultivation for Maize

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land prep</td>
<td>Ploughings: 2, Guntakas: 01</td>
<td>1500</td>
</tr>
<tr>
<td>2 Seed &amp; sowing</td>
<td>5 – 7 kg/acre</td>
<td>950</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>FYM: 3 tons, DAP: 1 bag, Urea: 1 bag</td>
<td>3120</td>
</tr>
<tr>
<td>4 Weeding</td>
<td>6 x Rs.100</td>
<td>600</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>2 sprays of pesticides</td>
<td>400</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Harvesting cost</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>Yield: 12 q</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market Rate: 1000/q</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fodder- 2 tons</td>
<td>2000</td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income</td>
<td>14000</td>
</tr>
<tr>
<td></td>
<td>Total cost</td>
<td>7470</td>
</tr>
<tr>
<td></td>
<td>Net income</td>
<td>6530</td>
</tr>
</tbody>
</table>
Cultivation practices in maize

1. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowings till fine tilth is achieved.
2. Seed are treated with mancozeb 3g/kg and imidachloprid @5g/kg dose, however commercial seed available pre treated. Farm yard manure to a level of 2-4 tons/acre is applied based on the availability. Basal dose of fertilizer, usually DAP/complex is applied either along with the seed or as along the rows. Then top dressing with urea is done.
3. Most of the hybrids are double crosses by private companies, farmers prefer yellow dent corn types. Green cobs are also sold to market depending on prevailing price.
4. For zinc deficiency ie, yellowing of leaf and white terminal bud, farmers apply zinc sulphate 20 kg / acre. Farmers spray endosulphan@3ml/L for shoot borer and mancozeb@3g/l for leaf blight.
5. Indicator for harvesting is when cob cover turns pale brown and the grains are too hard to be pressed in with finger nail. Harvesting is manual and threshing is done mechanically using sheller.
6. Enough time is given for drying and shelling. Generally, the plants are left in the field for one or 2 days after harvesting. The grains dry up during this period. Remove the husk and cobs are kept in sun for 2-3 days before shelling. After threshing stems and leaves used for dry fodder for cattle and threshed cobs used for fuel.

3.1.8. NATHIGANI CHERUVU HYDROLOGICAL UNIT

In Nalgonda district the hydrological unit Nathiganicheruvu lies partly in Thipparthy Mandal, here the cropping pattern dominated by cotton, Paddy and redgram in kharif and there are large areas under sweet orange cultivation.

A. Sweet orange

Citrus plants are grown in a wide range of soils ranging from sandy loam or alluvial soils, clay loam or deep clay loam or lateritic/acidic soils. Citrus orchards flourish well in light soils with good drainage properties. A rainfall above 750 mm is sufficient, but citrus species cant tolerate heavy winds. Apart from direct consumption as fruits/processed foods, there are several side products for food industry are obtained from these fruits like pectin and essential oils.
Crop Area in ha

- Paddy 1674
- Redgram 1056
- Green gram 559
- Groundnut 178
- Cotton 3653
- Castor 702
- Sweet orange/orchard crops 1951
- Net sown area 9773

Table 19. Cost of cultivation for Sweet orange

<table>
<thead>
<tr>
<th>Item</th>
<th>Practice</th>
<th>Cost Rs/ acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Land preparation</td>
<td>Ploughings: 1, Guntakas: 1</td>
<td>1000</td>
</tr>
<tr>
<td>2 Saplings @ planting</td>
<td>160/acre; spacing 5m x 5m</td>
<td>*(5000)</td>
</tr>
<tr>
<td>3 Fertiliser</td>
<td>FYM: 2 tons, neem cake 500 kg, 4 bags DAP, 400 kg vermicompost</td>
<td>8000</td>
</tr>
<tr>
<td>4 Weedings</td>
<td>12 x Rs.100</td>
<td>1200</td>
</tr>
<tr>
<td>5 Sprays</td>
<td>Plant protection</td>
<td>3000</td>
</tr>
<tr>
<td>6 Irrigation</td>
<td>18 irrigations</td>
<td>5400</td>
</tr>
<tr>
<td>7 Harvesting</td>
<td>Picking</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td>Yield: 10 tons</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market Rate: 7000/ton</td>
<td></td>
</tr>
<tr>
<td>8 Cost benefit</td>
<td>Total income:</td>
<td>70000</td>
</tr>
<tr>
<td></td>
<td>Total cost:</td>
<td>22600</td>
</tr>
<tr>
<td></td>
<td>Net income:</td>
<td>47400</td>
</tr>
</tbody>
</table>

* This is calculated on the 4-8 year old standing crop of sweet orange orchard in which establishment and gestation period is not taken into consideration.

Cultivation practices in Sweet orange

1. During summer pruning and thinning is carried out to remove dead and decaying branches and also to give proper shape to the tree for efficient utilization of sunlight.
2. Land preparation will start with receipt of first monsoon showers, basins will be prepared around the trunks. Water conservation and proper drainage channels are prepared.
3. Farm yard manure to a level of 2-4 tons/acre, neem/castor cake @ 500 kg/acre and vermi compost @ 400 kg/acre is applied to base of the plant in a radius of 2-3 fit in the basin. Basal dose of fertilizer, usually DAP/ complex is applied along with manure.

4. Short duration inter crops, like pulses (ground nut, green/black gram, cowpea, sunhemp) are grown in between the trees.

5. Farmers spray monocrotophos@1.6ml/L or dimethoate@2ml/L for defoliators, fruit sucking moth; for scales dimethoate @2ml/L and for mites dicofol@3ml/L are sprayed.

6. To control gummosis farmers apply Bordeaux paste to the tree trunk, and for powdery mildew spray bavistin or sulphur 1 kg/200L of water.

7. Fruits are picked manually and transported to nearby market.
4.0.0. Recommendations for strategic adaptation to climate change

The recommendations derived out of this study are elaborated at length in medium / long term strategic approaches and in short term micro level interventions adaptable crop wise. These issues are specifically discussed keeping view of dryland farming systems in the hydrological units in Andhra Pradesh. For sustainable livelihoods in dryland regions, agriculture cannot be seen isolated from other farming occupations like animal husbandry, poultry and pisciculture etc., since all these form an inter dependent web in a rural setting. In restoring and balancing these systems, however it needs a paradigm shift in tools and systems that give overall profitability, sustained incomes and ecological balance. The approaches discussed here under would help hopefully in adapting to the effects of climate change and long run reversal of the negative impacts on agriculture.

Adaptation strategies to address the climate change impacts on agriculture are needed urgently through new research and proper interpretation of the accumulated research results from the decades of dryland research under different agro-climatic settings. Development of crop varieties capable of withstanding temperature increases and aberrations in temperature need a greater attention, whereas the understanding of crop growth regulators and soil water plant relationship under changed CO₂ levels in grain and biomass production of individual crops require research. Current research on improving the water use efficiency of crop plants, their drought and pest resistance and also agronomic practices need more emphasis. The following adaptation strategies are suggested on the basis of research carried out so far (Joshi, NL., Amal kar., 2009).

4.1.0. Long term approaches on adaptations to climate change

These approaches keeps in mind the natural resources availability, like soils, water bodies and animal and human populations and their dependencies on resources. This will consider the needs on the part of communities, opportunities available and policy and invest supports needed from academic and administrative bodies.

4.1.1. Farming system based approaches

a. Diversified farming
A shift from sole cropping to a diversified farming system is highly warranted. Horticulture and agro forestry need to be given more encouragement, whereas in the drier part of the arid lands greater emphasis is required on pasture or biomass development for the livestock, which becomes a major component of the individual farmers economy. Use of farm level land in the more vulnerable arid areas should be optimized to sustain production and manage risk, rather than to increase productivity. Utilizing the available natural resources equally, equitably and development of alternate livelihoods linked to agriculture and its allied occupations to sustain to sustain the village communities is the key approach to adapt for the climate change risks. In this regard CRIDA has developed over years a concept of farming systems approach that helps in understanding and utilizing resources in a sustainable way (Annexure-II).

b. Income diversification

Drought leads to farmer indebtedness. Coupling debt relief with micro-credit to start new businesses, or insurance to cover initial business risks, can encourage a change of occupation, limiting exposure to climate related risks. Imparting education and skills, building roads and developing markets are critical to building climate resilience in the long term.

Promoting cattle rearing as well as creating fodder banks: Cattle provide an essential part of livelihood and many necessary inputs for agriculture. Measure need to be taken to assure the existence of a sufficiently large cattle population. Subsidies for foreign cattle breeds supposed to increase milk production should be abandoned. The bigger breeds need more fodder and are not adapted to local weather conditions as prolonged heat periods. Farmers repeatedly mentioned the need for fodder banks in order to be able to get the cattle through prolonged drought periods.(Narayan Reddy, L., 2006; Ravindra, A., 2007)

4.1.2. Natural Resource conserving technologies:

Taking agriculture from green revolution to sustainable level needs a rethinking of approaches and processes. Sustainable agriculture uses naturally available inputs around farm to manage the crops and leads to organic farming. A further advanced approach is conservation agriculture which aims at continuous minimal mechanical soil disturbance, permanent organic soil cover, diversified crop rotations of annual crops and plant associations of perennial crops. Conservation agriculture is more than a zero-tillage-based cropping system. Farmers following this use low-cost tools and equipment and traditional crop varieties without pesticides, herbicides or herbicide-tolerant varieties. Conservation agriculture methods enhance natural
biological processes above and below the ground by reducing interventions such as mechanical soil tillage to an absolute minimum.

Use of resource conserving technologies like surface seeding or zero tillage not only restrict the release of soil carbon in atmosphere, but also sometimes help withstand partially the adverse climate, and provide better yield or stabilize it. For example surface seeding or zero tillage of upland crops after rice gives good yields similar to that when planted under normal conventional tillage over a diverse set of soil conditions. However, more research is needed for their applicability in arid lands.

**A. Drought amelioration on permanent basis**

Any production system as a technology has different components referred to as techniques. The system, by and large, would be an improvement over the existing traditional or indigenous system. In either case, the system would be basically subsistent in nature and the productivity must be improved. Apart from moisture stress to corps, mismanagement of rainwater also entails serious land degradation converting vast areas across the country into wastelands. It is a paradox that rainwater, the most vital resource for crop production in drylands, becomes a dominant factor (as runoff) of land degradation to the extent that productive lands are converted into uncultivable wastelands (Vyas, VS., 2007).

**B. Land capability based productive farming systems**

Planting of trees, especially nitrogen fixing tree species could be a viable option to address problems, as declining soil fertility as well as mitigate detrimental weather influences. Educating farmers in agri horticulture and starting projects in this area is highly recommendable. Hence, reforestation and forest protection initiatives are needed. Reestablishing the forest cover would help in many ways: For example by providing alternative source of income from non-timber forest products (NTF), by supplying fuel to villagers, as well as preserving soil moisture and limit erosion. In this regard CRIDA has carried out research work over years, to develop and establish the concepts (Annexure-III)

Tailored cropping systems that Agro Ecological zones should be followed to minimize adverse affects on the total land productivity. Contingency crop Plans should be available along with inputs and generated market. Optimum fertilizer use may help guard against drought by encouraging deep root system and utilizing soil water efficiently. Cropping system selection is based up on land capability, rainfall and soil.
Land capability and system based fertilizer management practices need to be followed for building soil resilience and quality. The steps in enhancing the crop productivity in rainfed areas are –

- Timely sowing of seed in rows in the moist zone
- Use of proper seed rate to achieve adequate plant stands
- Timely weeding creating soil mulch so that soil moisture is not lost through evaporation.
- Use of seed-cum-ferti-drills for good plant stand
- Row placing of moderate levels of fertilizer (basal as well as top dressing) not on blanket basis, but on a need base
- Use of complex fertilizers depending on the economic status of the farmer
- Intercropping in areas with >650 mm rainfall as a step towards risk distribution
- Use of a legume as a component in the cropping system, either in rotation, sequence, or intercropping

Alternate land use systems (Agroforestry, Silviculture and Pasture) are identified for drought prone regions based on rainfall, land capability and soil order. (Ashok Kumar, 2011; Maikhuri, R K and Vikram S Negi, 2011) Some steps in enhancing productivity are:

- The commons may be divided into small plots of 5-10 ha and provided on long lease of about 19 years to the user groups.
- Adopt any of the system, such as fruit trees, silvipastures, multipurpose trees, or even pastures, a combination.
- Maximum number of trees per hectare may be limited by quantum of annual rainfall (product of rainfall, m and area, m²) divided by volume of water one full grown tree transpires annually (a product of canopy area, surface area in m², and potential evapotranspiration in m per annum).
- Rejuvenation by social fencing of improved plant species. Improved variety or new plant species suitable for the ecosystem.
- In tree farming the general cleanliness of the area is lost thus encouraging new diseases and pests. Hence, it is important to carry out weeding and make basins for the trees and furrows for in situ rainwater harvesting in the case of shrubs, grasses, and fodder legumes.
- Encourage cultivation of medicinal and other industrial plants in the commons as new avenues for income generation.

C. Land capability based soil and water conservation measures
To address the growing stress on water resources, projects in the area of water management, conservation and storage are essential for any adaptation strategy in Anantapur: Promote sustainable water management practices that includes better water management, regulating the unrestrained competition for groundwater and need for aggressive pursuit of water conservation. Also providing support for drip and sprinkler irrigation systems. In case farmers are aware of existing subsidy schemes, they complained about not getting them directly. Most of the money goes to enterprises producing chemical fertilizer or selling hybrid seeds. This does not really help small-scale farmers who try to shift production to sustainable, low input practices.

Integrated watershed management is the key to conservation and efficient utilization of natural resources of soil and water, particularly in rainfed agriculture where water is the foremost limiting factor of crop productivity. The prioritized steps involved in resource conservation are –

- Use of practices based on the existing traditional systems
- Encourage farmers to adopt contour farming
- Adopt contour bunding in new areas being brought under plough and with large farm plots
- Strengthen the existing bunds across the slope and provide weirs
- In the case of drainage line treatment, start from the ridge line to the bottom
- The traditional loose boulder structures as well as grassing may be adopted
- Later, gully plugging and construction of small check dams on the drainage line are carried out
- After bunding and provision of waterway, grow dual-purpose plant species on the bunds
- Provide small cross section bunds with a small furrow on the upper side, preferably with a heavy country plough or mould board plough
- The watercourse is covered with vegetation, preferably before other treatments are superimposed

Conservation is incomplete without smooth disposal of surplus water and development of inter-terraced area. Hence, the present emphasis is on replacing large section bunds with small section bunds to achieve uniform distribution of moisture. The principle behind the recommendation is to reduce the runoff by increasing the opportunity time through modifying land configuration and improving soil properties (Fig. 10). The red and black soils, two major soil types of the rainfed areas, have distinctly different characteristics and hence, differ in their needs of moisture conservation methods. The red soils (light soils) have higher infiltration rate but low moisture-holding capacity
while, the black soils (heavy soils) have low organic matter and suffer from infiltration rate because of higher expansion on wetting. Climate and soil are the two dominant factors in deciding whether or not runoff farming/water harvesting system will be possible and sensible. The hyper arid zone (P/PET < 0.03, where P is precipitation and PET is potential evapo-transpiration) is too dry for viable runoff farming, while sub humid zone (P/PET 0.5-0.75) will be too wet. The runoff-farming zone is primarily situated in the arid to semi-arid zones. A significant quantity of rainwater, 160 mha-m as surface flow is available for harvesting, which through small interventions, could be efficiently used for combating drought-related crop failures. Estimates reveal that areas receiving up to 1000 mm annual precipitation hold a potential to add 6.3 mha-m water equivalent through runoff. The steps involved in rainwater harvesting are –

- Use of traditional systems of rainwater harvesting (eg. Tanks, Talabs, Ahars, Zabo system). Construct suitable conduits.
- Other rainwater harvesting systems meant for recession cropping should also receive equal attention (eg. Khadin, Ad-band, Bandh).
- Non-functional systems should be repaired immediately. Refinements of indigenous water harvesting system may be attempted (Annexure-III).
- Silted tanks could be converted into percolation tanks, particularly in light soils.
- Rainwater harvesting for recession cropping is unique and has some location specificities including socio economic considerations. These must be considered first before going in for their imposition in new areas.
- The bandh system (otherwise known as Haveli system) can be transformed wherever possible to two cropping system instead of rabi (post rainy season) cropping only.
- Ponds or embankments should be constructed. A pond of 250 m3/ha catchment is recommended.
- Ponds are essential primarily for horticulture and multipurpose trees in Class V and above lands.
- Even small ponds can be dug and each plastered as a cistern (50 m3). Water can be harvested or transported into them in the arid eco system. Such water should be treated as of immense value for sustaining tree vegetation during the post rainy periods.
- The large embankments are costly and need full participation by the Government agencies.
- Structures such as percolation tanks meant for ground water recharge are expensive and should be constructed only when there is enough funds left after the normal treatment of the watershed. All the resource conservation measures
and other water harvesting systems enhance groundwater recharge. When these structures are built, there will be more water available in the region. This will trigger more wells including bore wells.

- Consider the wells existing in the area and then calculate the potential water supply as well as the increased supply through the various field and drainage line treatments.
- Follow strict water budgeting for sustainable use of the harvested rainwater.
- Allow only low duty crops. Avoid sugarcane, rice, and wheat. Encourage pulses and oilseeds.
- Introduce horticulture in class V and above lands. Provide irrigation cover for the first two years. Do not irrigate the fruit trees without providing suitable basins.

4.1.3. Policy level interventions tools for resource management on sustainable basis:

Enabling Policies on crop insurance (especially to withstand the impact of flood and drought) subsidies and pricing related to water and energy uses need to be strengthened at the earliest. Policies that would encourage enrichment of organic matter in soil and improve the soil health need emphasis like financial compensation or incentive for green manuring.

A sound policy framework should address the issues of redesigning social sector with focus on vulnerable areas/populations, introduction of new credit instruments with deferred repayment, liabilities during extreme weather conditions and weather insurance as major vehicle to transfer risk. Governmental initiatives should be undertaken to identify and priorities adaptation options in key sectors, viz., storm warning systems, water storage and diversion, health planning and infrastructure needs. Focus on integrating national development policies into a sustainable development framework that compliments adaptation. Besides the role of local institutions in strengthening capacities eg., SHGs, banks and agricultural credit societies should be promoted and role of private sector in relation to agriculture should be a matter of policy concern. There should be political will to implement economic diversification in spreading diverse livelihood strategies, mitigations and financial mechanisms (Schneider et al., 2007). Some of the key policy initiatives to be considered are

1. Mainstreaming adaptations by considering impacts in all major development initiatives.
2. Facilitate greater adaptation of scientific and economic pricing policies, especially for water, land energy and other natural resources.
3. Consider financial incentives and package for improved land management and explore clean development mechanism CDM benefits for mitigation strategies.
4. Establish Green Research Fund for strengthening research on adaptation mitigation and impact assessment.

• **Improving Extension Services**

Extension services are very important to us to address specific problems we face in our village. There are too few officers to cater for a large area. The best services are provided by NGO’s but they cannot be everywhere. There is a need for better extension services, wherein several research institutes in the area conduct research on better-adapted and high yielding crop varieties. However, the farmers most of the times do not get to know the results. Mostly, they are not informed on existing government initiatives either. Projects aiming at getting useful information out of the research institutes and government agencies into the fields would help farmers to better adapt to existing and upcoming challenges.

Link research to farmers improved communication between research- and government agencies and farmer communities would ensure research that is efficiently addressing farmer’s needs. However, such communication is largely missing in the study area and conducted research does often not suit the needs of small scale farmers. In addition to this strengthening the manpower in extension system and empowering them with trainings would be needed. (Rukmani, R and Manjula, M., 2009).

**B. Improved risk management through early warning and crop insurance:** it is necessary to develop a robust early warning system of spatial temporal changes in weather and other environmental parameters. The current medium range weather forecasting system needs to be more refined and applicable at a finer spatial resolution and the system of information dissemination needs to be more systematic. Modern tools of information technology could greatly facilitate this.

The provision of an effective crop insurance against weather-induced risks could improve the livelihood of small-scale farmers considerably. farmers need such insurance, and are willing to pay, within their means, for such services when they are effectively serving their needs. Existing insurance schemes are covering only certain cash crops. Additionally, insurance is not provided to individual farmers but only to a village as a whole. Designing and putting into practice economically viable crop insurance schemes could improve the situation of many farmer families.(Poonam Pande and Kaspar Akermann, 2011).
C. **Smart Subsidies**: Lobby government agencies to use smart subsidies to encourage a shift to more environmentally suited crops: Current subsidies and incentives implicitly encourage farmers to cultivate water-intensive crops - such as sugarcane or paddy - in dry regions. Smart subsidies can encourage a shift to dry land crops that are more suited to local conditions and less environmentally degrading.(Ravindra, A., 2007; Satheesh, PV., 2007).

D. **Increase investments in sustainable agricultural practices**
Public and private investments are needed for practices and technologies that sustain the natural resource base, enhance economic productivity and reduce the risks for poor farmers. This is particularly urgent in areas with wide spread degradation of soil resources. At the same time, policies and regulations that secure farmers’ rights to land over multiple seasons are needed as a precondition for farmers to invest in soil resources that may not yield returns for several years.(Yugandhar, BN., 2007)

E. **Enhance research, learning and knowledge sharing**
Research is needed to identify practices and technologies that adhere to the principles of sustainable agriculture and are affordable to small-scale farmers who have limited income and market access and cannot afford inputs. Research can provide insight into socio-economic issues, local knowledge-sharing networks and participatory learning approaches, such as farmer field schools, for dealing with agro-ecological issues such as pests, weeds, soil and organic matter(Rukmani, R and Manjula, M., 2009).

F. **Diversify agricultural mechanization and improve access to inputs**
Farmers need a regular supply of reduced-tillage equipment and seed stock for cover crops as mulches that reduce weed problem and need for repeated intercultivations. Thus, policy should encourage local private-sector entrepreneurs to manufacture and maintain improved equipment that reduces drudgery of the farmers and to identify and market multifunctional seed stock.

G. **Establish new market opportunities**
Sustainable /organic agriculture has potential to bring higher prices in emerging niche and “green” markets because of the quality and safety of its production and the environmental services generated by its production processes. Establishing GAP or organic certification processes or setting up carbon sequestration compensation
mechanisms encourages farmers to shift to organic / sustainable agriculture practices (Ramanjaneyulu, GV., 2007).

4.1.4. Contingency crop planning

Since kharif cropping is primary activity in the rainfed areas of arid lands, where monsoon variability plays a crucial role in production. Contingency crop planning will require a greater attention in these areas. Long term strategic approaches are also needed to efficiently conserve and utilize rain water on the one hand and in season tactical approaches to mitigate the adverse effects of weather aberrations on the other. District specific contingency plan for agriculture and allied sectors should be prepared and implemented by district authorities in collaboration with research institutions (Sandip Das, 2010).

Table . Suggested contingency cropping for different situations in AP. (ANGRAU).

<table>
<thead>
<tr>
<th>Time of onset of rains</th>
<th>Crop</th>
<th>Varieties</th>
<th>Regions/situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>Sesamum</td>
<td>Madhavi, Gowri</td>
<td>Medium black soils, medium and deep red soils</td>
</tr>
<tr>
<td>June</td>
<td>Sorghum</td>
<td>CSH-5, CSH-9, CSH-10, CSH-11, CSV-1.1, CSV-12, SPV-462, SPV-475</td>
<td>Red soils, light black soils.</td>
</tr>
<tr>
<td></td>
<td>Castor</td>
<td>Kranthi, Haritha</td>
<td>Telengana region</td>
</tr>
<tr>
<td>July</td>
<td>Groundnut</td>
<td>TMV-2, Tirupati-1, Vemana</td>
<td>Scarce rainfall zone of A.P.</td>
</tr>
<tr>
<td>August</td>
<td>Cotton</td>
<td>Mahanandi, NHH-4, Jayadhar, MCU-5</td>
<td>First fortnight of August, Arid Regions of Anantapur</td>
</tr>
<tr>
<td></td>
<td>Groundnut</td>
<td>TMV-2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pearl millet</td>
<td>ICTP 8203 WCC-75</td>
<td>Red soils.</td>
</tr>
<tr>
<td></td>
<td>Sunflower</td>
<td>MFSH-1, MFSH-8, MFSH-17, APSH-1L</td>
<td>Red soils and black soils</td>
</tr>
<tr>
<td></td>
<td>Setaria</td>
<td>Lepakshi, Prasad, Srilakshmi</td>
<td>Black soils, deep red soils</td>
</tr>
<tr>
<td>September</td>
<td>Sunflower</td>
<td>MFSH-1, MFSH-8, MFSH-17, APSH-1J, Adarsha</td>
<td>Black soils .</td>
</tr>
<tr>
<td></td>
<td>Redgram</td>
<td>LRG-30, LRG-41</td>
<td>Red soils in regions receiving North-East Monsoon rainfall</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>NTJ-1, NTJ-2, M-35-1, CSH-5</td>
<td>Red and Black soils</td>
</tr>
<tr>
<td>October</td>
<td>Sorghum</td>
<td>M-35-1, CSH-7R, CSH-6R,</td>
<td>Black soils</td>
</tr>
<tr>
<td>Crop</td>
<td>Hybrid/Variety</td>
<td>Soils</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>Any hybrid</td>
<td>Black soils</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>Rabi varieties</td>
<td>Black soils</td>
<td></td>
</tr>
<tr>
<td>Bengal gram</td>
<td>Annegiri, ICCV-2 (Swetha), ICCV-37(Kranthi), JG-11</td>
<td>Black soils</td>
<td></td>
</tr>
<tr>
<td>Safflower</td>
<td>Manjira, Sagar muthyalu</td>
<td>Black soils</td>
<td></td>
</tr>
</tbody>
</table>

**a. Availability of seed** (Source: [http://www.rainfedfarming.org/Seeds.html](http://www.rainfedfarming.org/Seeds.html))

Intensive agriculture development around high yielding varieties fuelled the green revolution. Systems for large-scale multiplication of HYV seeds, programs of seed replacement, seed villages etc., are the dominant support systems established for the purpose. Private companies and corporate firms came into picture with the advent of hybrid seeds. Unfortunately, the same systems are extended to rainfed areas and are expected to support agriculture growth. The requirement of seed systems in rainfed areas are however, strikingly different. The following factors define the contours of the seed system requirements:

- Local availability and access to diversified seed is the key to resilient farming systems.
- Diversity in crops/ varieties to adapt different soils, topography and rainfall pattern (early / late) is a major requirement in rainfed areas.
- Seeds for different crops (intercrops, green manure crops, contingency crops etc.) and different types of varieties are needed.
- Seed losses due to fluctuating rainfall is a common phenomenon, high cost of seeds in such situations impose higher risks.
- Timely availability of seeds, easy access, diversity in seed and redundancy in seed supply are critical parameters of rainfed seed systems.
- Genotype – environment interaction is higher in rainfed areas; more stable varieties are needed that can be multiplied locally.
- Many of these seeds may not be viable as commercial enterprises. Community control/ management over this complex seed system therefore, is pertinent.

Appropriate community managed seed systems like village seed banks are at the core of revival of rainfed areas. The present seed systems built around mono crops / few varieties or hybrids and gene-cropping would increase cost and risks. A separate vision/ perspective and an overhaul of the existing systems are much needed. Cluster (of villages) level seed
self sufficiency programs can be evolved in partnership with the farmers’ organizations. Infrastructure needs, revolving funds to maintain seed buffers, support for operational costs in maintaining seeds etc., can be supported by the government. A new paradigm needs to emerge for this to happen (Ravinder Reddy Ch and S.P. Wani, 2007).

b. Farmer participatory evaluation of crop varieties:
In the context of non availability of seeds in local varieties for commercial crops and choice of seed selection for farmers, grass root level organizations could plan evaluation of seed trials with participation of farmers. They may collaborate with research institutions with large genetic pool as well as with the organizations with gene banks managed at cooperative or village level. (Satheesh, PV, 2010; Suresh, K., 2007; Anitha, P, 2007; Rukmani, R and Manjula, M., 2009)

4. 2.0. Cropping system based technologies
Promoting the cultivation of crops and varieties that fit into new cropping systems and seasons, development of varieties with changed duration that can over winter the transient effects of change, release of varieties for high temperature, drought and submergence tolerance, evolving varieties which respond positively in growth and yield to high CO₂. Besides varieties with high fertilizer and radiation use efficiency and also novel crops and varieties that can tolerate coastal salinity and salt water inundation are needed. CRIDA has come out with a transformed Sorghum bicolor L. Mench cv. SPV462 with mtID gene from E. coli with an aim to enhance tolerance to water deficit and NaCl stresses. (Maheswari etal, 2006). Strategies for genetic enhancement of heat tolerant genotypes especially in pulses by identifying and validating markers for temperature tolerance coupled with yield potential, varieties with faster growth under high temperatures with early flowering and maturity. Crop varieties that are resistant to lodging may withstand strong winds during sensitive stages of crop growth.

Improved crop management through crop rotation and inter cropping, Integrated pest management, supplemented with agro-forestry, pasture improvement and afforestation schemes would be an important strategic adaptation in India. Grain legume intercrops have many potential benefits such as stable yields, better use of resources compared to sole cropping systems. Establishment of seed banks are crucial importance in highly variable and unpredictable environments. This facility will provide a practical means to re-establish crops obliterated by major disasters and extreme climate events. The promotion of scientific agro forestry buffers farmers against climate variability and sequester carbon, and produce a range of socio-economic and environmental benefits. In this regard based on soils, climate and land
capability scoring, principle crop grown by farmer, CRIDA has recommended cropping systems suitable to various regions (Annexure-iv).

**Efficient intercropping systems for different regions of Andhra Pradesh (ANGRAU)**

a) For Telagana region (Mahaboob nagar and Nalgonda):

- Pigeon pea + Blackgram - 1:2 ratio
- Groundnut + Castor - 5:1 ratio
- Sorghum + Pigeon pea - 2:1 ratio
- Castor + Cluster bean - 1:1 or 2:2 ratio
- Pigeon pea + Sunflower - 1:2 ratio

Among the different intercropping systems in Telagana region, sorghum + pigeon pea (2:1) is the most efficient system which result in maximum returns.
b) Rayalaseema region (Kurnool, Kadapa, Anantpur and Chittor):

- Groundnut + Blackgram - 7:1 ratio
- Groundnut + Castor - 5:1 or 7:1 ratio
- Groundnut + Pearl millet - 2:1 ratio
- Pearl millet + Pigeon pea - 1:1 or 2:2 ratio
- Pigeon pea + Sunflower - 1:2 ratio

Among the different intercropping systems in Rayalaseema region, groundnut + pigeon pea (7:1) or groundnut + castor (5:1 or 7:1) was found to be the most efficient system which result in maximum returns.

4.2.1. Researchable issues identified for future

- Breeding for improved crop varieties with specific reference to growth and flowering phenology, photo sensitivity/ insensitivity, stability in response to inputs viz., lodging resistance, optimum tillering, harvest index etc.
- Evolving efficient water and soil management practices in addition to identification of crops and varieties with high water use efficiency, dry matter conversion ratio, positive response to temperature extremes and elevated CO2 levels.
- Identifying new intercropping and novel farming system combinations including livestock and fisheries, which can withstand predicted climate change situations and can be economically viable.
- Identifying cost effective methods for reducing greenhouse gas emissions from rice paddies and also from cropping systems with livestock components.
- Promoting conservation agriculture practices especially in water harvesting, nutrient, pest and disease management.

4.3.0. Short term approaches on adaptations to climate change
4.3.1. Crop management strategies:

Crop management strategies to obtain high yields under rainfed conditions may vary depending on climate, available resources and farmer’s needs. However the basic idea is that maximum possible fraction of rainfall is used for crop growth and reducing the effects of other limitations to crop production, to obtain high rainfall use efficiencies. Looking at maintaining adequate plant stand, nutrient management, tillage and improvement in plant characteristics, and the control of weeds pests and diseases are priority issues. Recent studies highlighted the role of mulches and anti transpirants and reflectants in reducing the evapotranspiration losses. Aspects of water use efficiency in relation to crop production in arid and semi arid regions crop management practices like sowing of crop at optimum time, securing and maintenance of adequate and uniform plant stand is very essential for efficient use of rainwater and other inputs. Crop germination and seedling establishment are improved when seeds are planted in well prepared seed beds with suitable planting equipment.

Use of high quality seed ensures the uniformity of crop establishment. Improved cultivars from various crops are available for cultivars which are early and high harvest index and hence give higher yields than the local cultivars. Selection of cultivars resistant to pests and diseases and their timely control help in achieving high yield and water use efficiency. Similarly timely and efficient weed management is very essential. (Joshi and Singh 1994).

a. **Crop residue management**: When adequate residues are available and conservation tillage is used, soil erosion is greatly reduced and water conservation is enhanced. Water conservation is important for improving crop yields in semi-arid regions, especially where irrigation is not used. In majority of cases, clean tillage and appropriate support practices such as contouring, furrow diking, strip cropping and terracing may provide adequate soil and water conservation benefits. Where these are not adequate, alternative management practices should be implemented to ease the demand for residues, thus permitting more of them to be retained on the land for soil and water conservation purposes. Some alternative practices include limited or selective residue removal, substituting high quality foliages for residues as animal feed, alley cropping, using wasteland areas more effectively, improving the balance between feed supplies and animal populations, and using alternative fuel sources.

b. **Selection of crop variety**: it has been observed that the duration of traditional crops or varieties grown in dryland areas is often longer than that of effective growing season. These crops or varieties usually experience moisture stress, mostly during
the grain filing period. In slightly wetter regions inter cropping is the best choice. In such a case a short duration and a long duration crop may be inter cropped to make the best use of resources. In addition to efficient resource use inter cropping imparts stability to productivity and reduces the risk of crop failure (Vijayalaxmi, et al., 2007).

Table. Potential cropping systems based on rainfall and soil characters (ANGRAU)

<table>
<thead>
<tr>
<th>Rainfall (mm)</th>
<th>Soil type</th>
<th>Growing season (weeks)</th>
<th>Profile storage Capacity (mm)</th>
<th>Suggested cropping system</th>
</tr>
</thead>
<tbody>
<tr>
<td>350-600</td>
<td>Alfisols, shallow vertisols</td>
<td>20</td>
<td>100</td>
<td>Single rainy season cropping sorghum / maize / soybean</td>
</tr>
<tr>
<td>350-600</td>
<td>Deep aridisols, Entisols (alluvium)</td>
<td>20</td>
<td>100</td>
<td>Single cropping sorghum / maize / soybean in kharif / rabi</td>
</tr>
<tr>
<td>350-600</td>
<td>Deep vertisols</td>
<td>20</td>
<td>100</td>
<td>Single post rainy season cropping sorghum</td>
</tr>
<tr>
<td>600-750</td>
<td>Alfisols, vertisols, entisols</td>
<td>20-30</td>
<td>150</td>
<td>Intercropping Sorghum + Pigeon pea Cotton + Black gram</td>
</tr>
<tr>
<td>750-900</td>
<td>Entisols, deep vertisols, deep alfisols, inceptisols</td>
<td>30</td>
<td>200</td>
<td>Double cropping with monitoring Maize – safflower Soybean – chick pea Groundnut – horsegram</td>
</tr>
<tr>
<td>&gt; 900</td>
<td>As above</td>
<td>&gt; 30</td>
<td>&gt;200</td>
<td>Assured double cropping Maize – chick pea Soybean - safflower</td>
</tr>
</tbody>
</table>

c. **Choice of crops with changing sowing condition**: late onset of monsoon often leads to delayed planting and specific crop contingency plans have been developed for different agro-climatic zones to address the issue. For example in red soils of Telangana region, castor will give better yields than pigeon pea under late sown conditions.

d. **Crop row management**: when the crops depend on growing season rainfall, narrow row spacing may help in quick coverage of soil surface, thereby reducing evaporation losses from soils. High plant populations may use more soil water stress
during reproductive and grain filling stages. Consideration of depletion rate of soil water is more important when crops are sown primarily on stored soil water. Under such situations wide rows and low plant populations are highly desirable. Altering agronomy of crops by changing planting date and management of the plant spacing and input supply may help reduce the adverse impact of changes in some climate parameters. Alternative crops or cultivars more adapted to changed environment can further ease the pressure.

e. **Low input agricultural practices**

Strengthening of agricultural extension services by focusing on low input agricultural practices and locally adapted cropping patterns. While much research is conducted for rice, wheat and horticulture crops, farmers will need greater support with knowledge and policy assistance to make the transition to sustainable dry land farming on a large scale. They could also diversify into agro-forestry, which is more resilient, as well as livestock production. Encourage mix cropping at least partially to improve food security in case of crop failure, encourage short duration crop varieties during the monsoon season. Extension services need to inform farmers on most efficient crop combinations.

Promote further input reduction strategies as the use of traditional seeds, bio-fertilizer, and bio-pesticides on a large scale. Such practices reduce the vulnerability of small-scale farmers to weather induced risks considerably as they reduce financial losses in case of crop failure. Farmers named the cost for seeds and fertilizer as second and third highest expenses they have to pay for every season. Sometimes important yield losses occur because of the purchase of spurious seeds provided by the local seed dealers. The creation of village based seed banks could address this problem and reduce the financial burden for the farmers considerably. Extension services should train farmers in the production of bio-pesticides and bio-fertilizers that are produced out of locally available inputs. Promotion Nonpesticidal Management (NPM) and reintroduction of traditional pest-control measures like neem based pesticides, chilli-garlic extract, reduce pest attacks and therefore input cost as well (Ramanjaneyulu, GV., 2007).

f. **Water management:** efficient rain-water management acts as insurance for the crop during the rainfall – deficit periods. Management techniques that increase infiltration and soil-water storage and decrease the water losses by runoff, evaporation and evapo-transpiration from crop fields (eg. Inter row and inter plot
water harvesting, area or strip water harvesting) need encouragement. Farmers have also developed their own system of rainwater management which deserved to be studied and refined. For example if the onset of monsoon is late farmers switch over from long duration, high water requirement cereal corps to deep rooted legumes to cope with unpredictable midseason droughts. They have adapted water conservation practices like field bunding and dust mulching and when drought sets they reduce the plant populations. Researchers have refined several traditional management practices and have developed new ones to mitigate the drought effects to a certain extent. SRI method of cultivation of paddy has considerable levels of savings on water. (Shambu Prasad, 2007; Ravindra, A., 2007)

**Supplemental irrigation:** Giving an irrigation to stabilize and improve the yield of a crop which is otherwise dependent on rain water is termed as supplemental irrigation. Giving a supplemental irrigation during prolonged drought periods by using underground water even of poor quality can make all difference between crop failure and good yields. If the crop face drought at sensitive growth stages, application of supplemental irrigation is the best potential use of water supplies.

**g. Nutrient management:**

Crops in the arid and semi arid areas suffer not only from moisture stress but also from nutrient stress. Water conservation practices can become economically feasible on correction of nutrient deficiencies. Deeper root development for extracting stored moisture and nutrients at depth, but the response to applied fertilizer varies with the soil type, available water storage at seeding and seasonal rainfall during growing season. Availability of nutrients depends on moisture and chemical composition of soil, which are in turn favored by the amount of organic matter in soil. Now the shift should be towards enhancing the increasing organic matter and microbial activity through adding more biomass to soil, green manuring and composting should be our priorities. (Nandish, BN, 2006).

**4.3.2. In season drought management:** in-season drought is a potential stress for nearly all rainfed crops. Germination and crop establishment are the most sensitive periods, when moisture stress can have devastating effect on crop production. Moisture stress during crop growth stages of high leaf area indices will show the greater increase in yield. At high leaf indices, the rate of gases exchange is high as a result water is lost at
high rate. Reduction of leaf area indices by rationing or thinning out can partially mitigate the ill effects of drought. Timely weed control and use of mulches may also be useful in extending the period of moisture availability.

4.3.3. Drought Mitigating measures

The shortcomings of current drought policy of the government such as treatment of drought relief and proofing as two separate activities, procedural delays in declaring a region as drought hit, delay in initiating relief works, restrictions on execution of works, paucity of funds etc. (Hirway, 2001).

Important recommendations to mitigate the impact of drought such as drought support policies like self-reliance among farmers, self-employment oriented schemes during period of drought. Drought preparedness including sharing of expertise on climate forecasting, dissemination of information to the people, maintaining the stocks of food grains, seed, fodder etc. along with effective and efficient delivery mechanism and quick delivery of rural credit and reduction in the premium of insurance should receive high priority. However, the mitigating measures suggested form the present studies are classified under primary and secondary stakeholders (Singh et al., 2007).

4.3.4. Proactive measures for mitigating early season drought

1. Crop planning
   • growing short duration drought tolerant varieties /crops
   • intercropping with pulses
2. Repeated blade harrowing
3. Desilting of tanks
4. Growing crops for fodder alone
5. Re-sowing if drought occurs within three weeks after sowing
6. Seed treatment with drought inducing chemicals
7. Live stock rearing
8. Soil and water conservation measures
9. Ground water protection
10. Thinning
11. Transplanting seedling of millets
12. Mulching
13. Making tankers ready for supply of drinking water
14. Rain water harvesting

4.3.5. Proactive measures for mitigating mid season drought

1. Rainwater harvesting for life saving irrigation
2. Reducing the plant population by thinning
3. Use anti transparents
4. In situ moisture conservation practices in every village
5. Making provision for foliar spray of water
6. Soil mulch
7. Intercropping to minimize crop loss
8. Contingency crop planning
9. Defoliation of leaves at the bottom of the plant
10. Evolve alternate cropping pattern
11. Providing employment oriented activities

4.3.6. Proactive measures for mitigating late season drought

1. Harvesting rain water to give irrigation at critical stages of crop growth
2. Replacing paddy with less water requiring crops
3. Harvesting and recycling of runoff water from farm ponds
4. Inter cropping to minimize risks
5. Mulching at critical stages of crop growth
6. Rescheduling crop loans
7. Use of early harvesting and process
8. Use of anti transparent chemicals
9. Thinning
10. Defoliation of leaves at the bottom
11. Preserving feed and fodder for future
12. Off farm labor activities
13. Contour farming
14. Strip farming
15. Foliar irrigation
16. Deep ploughing
17. Regulation in release of available water
18. Discouraging of cultivation of water loving crops

4.4.0 Cropping system based specific recommendations
Dryland farming though majorly effected by dry spells and drought, the crops are cultivated in different rainfall, humidity and temperature ranges; and their distribution. The soils are found to be much varying in structure, texture and organic matter content, which makes them suitable for particular crops and particular variety of a crop. The recommendations mentioned here under are based on publications from Acharya NG Ranga Agricultural University, Agricultural Research stations and farmers experiences over years.

A. Paddy

1. Select semi dwarf varieties with high grain potential for the specific situation.
2. Select a variety resistant to pest and disease in a particular locality, for example gall midge resistant varieties like pothana, kavya, Brown plant hopper tolerant varieties like where as varieties like MTU-1010 and Vajram are suitable in Mahaboobnagar district. Selection of the variety should also be based on sowing time, season and availability of water.
3. Encourage SRI method for more economic use of water, less quantity of seed, low input cost and high productivity.
4. Seed treatment: Prepare slurry of Azospirillum 600 g + Phosphobacteria 600 g with one litre rice gruel and mixed with 25 kg of rice seeds and ensure uniform seed coating. Bio fertilizers like blue green algae, Azolla, Azosporillum, PSB will help in sustaining soil fertility and can save on chemical fertilizers by minimum of 10-20%.
5. Ensure plant population and planting in optimum time. For Scare rainfall areas planting should not be beyond July –August in kharif.
6. Direct seedling would save establishment time for seedlings under late planting conditions and water deficit areas. Cost of raising nursery and transplanting can be saved due to direct seeding besides reduction in labor and water consumption.
7. Transplanting of healthy seedlings may be done at 4-5 leaf stage or when they are about 20-25 cm in height @ 2-3 seedlings not deeper than 2-4 cm.
8. Recommended dose of Nitrogen has to be applied in two splits instead of 3 split applications, P and K should be applied in a normal way.
9. Critical irrigation for upland rice are transplantation, tillering and panicle initiation.
10. Whenever zinc or Iron deficiency observed, respective controls measure applied by spraying ZnSo4 20 k g/ acre; in other case Ferrous sulphate (Annabedhi) @20 grams and 2 grams Lemon salt, diluted in 200 litre of water.
11. Perfect land leveling will ensure irrigation water throughout the field resulting in lesser weed growth.
12. Maintenance of optimum plant population @ 33 - 44 hills/square meter depending up on crop season and duration for attaining maximum yields.
B. Chickpea

1. Select short duration (90-100 days) and disease resistant varieties like ICCC-37, Annegiri. For early sowing ICCV-10 for late sowing extra short duration varieties such as ICCV-2 80-85days can be ideal.
2. Ideal Sowing time is October-November(Second fortnight of October) and seed rate is 30 kg/acre.
3. Seed treatment with Trichoderma@ 5 grams/kg or 200 grams of Rhizobium/kg seed.
4. Weeding within 35 days of sowing helps in optimum yields.
5. One critical irrigation at 35 days after sowing increases grain yield, but field should be well drained at flowering.
6. For organic production, 2-3 ton compost/acre, with 3-4 sprays of Jiwamrut/ Panchagavya as foliar sprays should be used. As per the recommendation of state agriculture department, 12kg Nitrogen: 24kg P₂O₅, 18 kg potash and 80 kg Gypsum/acre are adequate.
7. Podborer incidence can be lessened by inter cropping with Coriander at 6:1 or 6:2. Pest management options like pheromone traps, trap crops, border crops, bird perches, NPV virus etc should be effectively practiced to efficiently manage pests as well as cut down the costs.

C. Cotton

1. Selection of seed by farmer should be based on rainfall and soil type apart from its potential yield in ideal irrigated conditions. For rainfed situations short duration varieties with compact canopy which complete lifecycle before receding moisture situation are ideal. Closer spacing to a range of 60cm x 30cm could be adapted in rainfed conditions increasing the crop stand and compensate the growth and number of bolls/acre.
2. Treating seed with Trichoderma@ 5 grams/kg seed would help prevent the crop from wilting due to fungal infection.
3. Cropping systems approach is ideal for rainfed conditions, inter crops like pigeonpea, cowpea, black gram in rows would help for food security and soil improvement. Trap crops like castor, bhendi and marigold for pest control. To generate biomass for FYM, planting sunhemp, cassia sp., on bunds would help in supplementing the soil fertility.
4. Topping / Nipping at 90 days after sowing would stop indeterminate growth and increase sympodial (fruiting) branching.
5. Critical irrigations during flowering and bollformation would increase up to 30-50%.
6. Effective pest control is achieved with pulses as intercrops, followed by need based application of 5% NSKE and chilli garlic solution.

D. Groundnut

1. Selected varieties for dry areas in Kharif: Vemana, TMV-2, JL-24; Seed rate is 60kg kernels /acre
2. Seed treatment: Treating seed with DithaneM45 3g/ kg or Bavistan 1g /kg and mix thoroughly before sowing and seed treatment with chloropyriphos 6ml / kg seed to control white grub.
3. Spacing : 30x10cm (Rainfed)
4. Mulching: Mulching with groundnut shells 2 ton/acre after 30 days of sowing saves moisture and increase yield by 20%. Intercropping of groundnut with redgram or with mixed pulses in 11:1 ratio helps to conserving soil moisture and to prevent erosion.
5. Water harvesting and supplemental irrigation was found feasible and increase pod yield 20-40%. Supplemental irrigation with stored runoff water in farm ponds (desirable farm pond size is 10 mx10m and 2.5 m deep) may be applied through sprinklers system at moisture sensitive stages viz, pegging and pod development stage increase the pod yield.
6. Red hairy caterpillar controlled by summer ploughing and using light traps or setting of bonfires in the field 2 days after the rain in the evenings. Vegetative trapping of the larvae by using loppings of Ipomoea and Calatropis; sowing inter/border crops cowpea, green gram and castor; trenches along the borders of farm and applying ash in the furrows control the hairy caterpillars as they move from field to field.

E. Jowar

1. Selection of variety suitable to soil, season: for rain fed conditions of AP, suggested Hybrids:CSH-5,CSH-6 and varieties NTJ-1 and 2,PJ-890,N-13,N-14.
2. For Maghi season: Sep-Dec; Seed rate: 3-4kg/acre
3. Spacing ideal for rainfed condition is 45cm x 15cm and seed treatment with Trichoderma @5 grams /kg or Carbandizam @3 grams/kg for control smut seed born disease and thinning should be at 14-21 days after sowing.
4. Inter cropping with cow pea 2:2 ratio enhances the total fodder production without affecting grain yield of sorghum one inter cultivation with in 20-25 days should be carried out.
5. Spraying 5% Ammonium sulphate solution can destroy *Striga*. Care should be taken that the solution should not contact the jowar crop.
6. Moisture conservation: flat bed sowing followed by ridging 30 days after sowing.
7. Fertilizers recommended by department is 4 tons FYM and 24kg of N, 16kg P₂O₅, 12kg K₂O/acre. Apply FYM at the time of ploughing, P₂O₅ and Potash at the time of sowing. Nitrogen in two splits one at the time of sowing and other at knee height stage of the crop.
8. Moisture stress should not coincide at seedling stage, primordial initiation, Booting and flowering stages. One time irrigation for successful crop even under rainfed condition at 45 days after sowing is beneficial.
9. Timely early sowing, avoids shootfly, remove affected plants by thinning is ideal pest control option for shoot fly and for stem borer, apply 5% NSKE to 35 days crop.
10. Sugary disease will be controlled with mechanical removal of *Sclerotinia* from seeds by washing in 3% salt water followed by rinsing in water before sowing. Seed treatment with ash and cow urine are very effective. Spraying Dithane M-45 is effective at 50% flowering and then at weekly intervals.
11. Inter crop sorghum with Pigeon pea reduces the charcoal rot and irrigation at head emergence prevents the spread of the disease.

**F. Sunflower**

1. Seeds can be soaked in water for 12 hours to and shade dry before sowing hasten the field emergence. Seed rate 2kgs /ac and treat the seed with Thiram/captan @3grams/kg of seed
2. Adopt the spacing at 60cm x 30cm in heavy soils and 45 cm x 20cm for light and medium soils. Thinning should be done 10 – 15 days after sowing leaving only one plant per hill.
3. Farm Yard Manure at 4 ton/ac has to be incorporated during preparatory tillage. For rain fed crop52kg Urea:150kg Single Super Phosphate,19.2kg Murate of Potash 17kg Urea entire SSP and MOP has to applied as a basal and remaining urea has to applied in 2 equal splits at 25-30 and 50-55 days after sowing. Fertilizer application should be placement method.
4. Heads effected with necrosis should be removed and destroyed.
5. Hand pollination: Sunflower heads are gently rubbed with palm during flowering period from 8AM - 11 AM on alternative days for about 6 weeks. Cover the hand/palm with muslin cloth and gently rub the head with pollen of adjacent heads
6. Sulphur is essential for increasing oil yield; addition of elemental sulphur at 10 @ kg/acre is recommended to soil at last ploughing. Single super phosphate (SSP) is the best source for phosphorus as also supplies required sulphur.
7. In Zinc deficit soils, foliar spraying of ZnSO4 @ 1% is beneficial. Spraying Borax @ 0.2 % to flower head at ray floweret opening improves the seed filling and oil content.
8. The critical stages for moisture/irrigation are Bud initiation (30 DAS), flower opening at 45-50 DAS (most sensitive to moisture stress) and seed filling (60-75 DAS).
9. Ridges and furrow method is well suited for deep black and high rainfall areas for better growth of the crop. Adjust the sowing time such that reproductive stage donot coincide with heavy rains.
10. Shining metal ribbons tied in boundaries of field in north south directions to scare the birds away.

G. Tomato

1. Seed sowing only on raised nursery beds. Incorporate neem cake (400 grams per square metre) and farmyard manure (2kg per square metre) 15 days before sowing into the nursery bed to control soil borne diseases.
2. Treat seeds with \textit{Trichoderma} and \textit{Pseudomonas fluorescens} @ 5g/kg seed to control seed and soil borne diseases. Sow in rows at optimum depths (3-5 cm) and maintain proper moisture conditions.
3. Tomato is deep rooted crop and is highly sensitive to water stress both dryspell and stagnation, hence drip irrigation is ideal for higher yields.
4. Cover the nursery with 40 mesh nylon net to prevent entry of whiteflies prevents leaf curl virus also.
5. Keep the seedlings in \textit{Asafoetida} suspension before transplanting. Transplant seedlings when they are 26-30 days old ideal spacing is 60x60 cm (kharif), 50x50 cm (rabi), 60x45 cm (Summer).
6. Grow pearl millet or sorghum as a barrier crop around the tomato field.
7. Inter crop tomato with beans 8:1 ration to control bacterial wilt and serpentine leaf miner.
8. Grow marigold as a trap crop for fruit borer control in 8 :1 ratio.
9. Install yellow sticky traps 25 days after transplanting for control sucking pests like whitefly and jassids.

H. Redgram

1. Selection of disease resistant varieties like Maruti, Asha for wilt and sterility mosaic in endemic areas. Maruthi is suitable for light soils and low rainfall areas. Asha is suitable for heavy soils and high rainfall areas.
2. Follow optimum seed rate and spacing for increased yields.
3. Seed treatment with *Trichoderma* @ 5grams/kg and Rhizobium bio fertilizers 200 grams/kg.
4. Seed rate 3kg/ac and spacing 150 x 20cm (redsoils) and 180 x 20 cm in black soils.
5. Sow immediately after the onset of South-West monsoon (June-July15th).
6. Short duration varieties should be preferred during Kharif.
7. Monitoring of pest population during reproductive stage by erecting pheromone traps 4/ac and use of bio control agents such as NPV 200 LE/ac to control borer pest helicoverpa.

I. Sesamum

1. Selection of seed on the basis of local adoptability, sown in lines. Madhavi, Gouri and Rajeswari are good performing varieties.
2. Seed should be mixed with sand three times the quantity and sown with drill. Thinning should be done for optimum yields.
3. Uprooting plans effected by phyllody (viral disease) and should be destroyed.
4. Weeding in early stages reduces competition and achieves good yields.
5. Harvested plants should be dried upside down.

J. Castor

1. Selection of seed on the basis of local adoptability and resistant to diseases, sow with early monsoon showers, not later than August 15th.
2. Seed treatment with *Trichoderma* @ 5gm/kg seed help in reduction of diseases and its application along with FYM would be better.
3. Gypsum should be applied as basal dose@100kg/acre.
4. Nipping enhances branching and resultant high yields.
5. Defoliator like red hairy caterpillar (RHC) controlled by deep summer ploughing, bonfires, trenching and trap crops like *Ipomea* and *Calatropis*, branches to stop swarming caterpillars.
6. Neem based pesticides and NPV for major defoliator pests should be used.
7. Botrytis or grey rot can be prevented with precautionary antifungal sprays in cloudy, humid weather. On cyclone forecasting spray carbendizm@ 1gm/L atleast 6-8 hours before rains. After rains cease another spray should be done. Timely sowing and proper spacing would prevent the incidence of the disease.

K. Chilli

1. Varieties should selected based on suitability to low irrigation conditions, and notified varieties and hybrids, for example green chillies – Pusa Jwala and dry chilly - LCA-235.
2. About 500-650g of seed should be sown uniformly in 36 sq meter bed is required for planting one acre. Nursery should be grown on raised nursery beds.
3. Treat the seed with *Trichoderma* at the rate of 5 g/kg, phosphorus solubilising bacteria (PSB) 20 grams, 20 grams Aztobactor 20grms of seed before sowing. Apply 5kg of Neem cake 30 sq meters of nursery beds and sufficient quality of organic manures.
4. Drenching of nursery beds with *Trichoderma*@250gm/50L water at 12th and 19th day of sowing will prevent wilting of seedlings due to damping off. Transplant 35 to 40 days old seedlings, 2 seedlings per hill may be planted at 60 cm x 45 cm spacing.
5. A basal dose of 10 tonnes of farmyard manure per acre is to be applied in final ploughing. Sheep penning can be done if available. Apply neem cake at 100kg/acre, preferably mixing with fertilizers at the time of final ploughing. A balanced dose of NPK fertilizers is necessary to get a good crop. A basal dose of 24 kg P2O5 and 12 kg K2O is to be applied at the time of final ploughing. After 45 days of planting three split doses of 9kg N plus 4 kg K2O each at 15 days interval followed by irrigation. Foliar application of 1% urea along with insecticidal or fungicidal spray can be given and each time only 8-10 kg of urea may be required.
6. In the soils where zinc deficiency is noticed, application of 20 kg/acre of zinc sulphate or zinc sulphate spray at 2 g/lit of water using 500 grams of zinc sulphate /acre will rectify the deficiency.
7. Intercultivation is to be followed by hand weeding to check weed growth. Chilly can not with stand heavy moisture. Hence irrigation should be given as and when it is necessary.
8. For pest control, resorting to biopesticides like neem formulations and NPV are ideal as the dry chilli are exported as spice, needs to be low in pesticide residues.

L. Maize

1. Optimum plant population 26400/acre is a potential measure to realize maximum yield. Seed rate for hybrids is 7kg/acre, and ideal spacing in rainfed conditions is 75x20cm.
2. Optimum time for sowing in kharif season is mid June to mid July and for delayed Kharif is mid July to mid August.
3. Maize can be sown on ridge and furrow system and sowing is done through dibbling. The seed on one side of the ridge at 1/3 height from the top to facilitate better irrigation and drainage.
4. Fertilizers for rainfed crop: FYM 5 ton per acre, Nitrogen@36kg, P₂O₅@20Kg, K₂O - 16kg and Zinc sulphate@20kg per acre (in every 2-3 years). Balanced fertilizers on the basis of soil testing and Zinc should be applied in case of deficiency @20kg /acre.
5. Practice intercropping maize with red gram 2:1 ratio. Sequence crops Maize - Groundnut, Mize – Redgram to be preferred rather Maize to Maize as it is an exhaustive crop on soil.
6. Ensure moisture in the soil at critical stages during tasseling, silking and milking stages.

M. Sweet orange

1. Healthy orchard can be established with selection of disease free grafts from mosaic and tristeza. Disease resistant stocks like Rangapur lime should be preferred and varieties like balaji resistant to canker. While establishing orchards take care so that scion is at least 15 cm above soil.
2. Irrigation should be given though basin method and should be given to trees individually. Double ring method helps in preventing collar region diseases. Drip irrigation is best.
3. Shoots emerging from rootstock and water shoots should be removed promptly. Dry branches and branches in shadow should be pruned carefully and to the open ends Bordeaux paste should be applied.
4. Inter crops can be grown in standing orchard two months before fruiting, like groundnut, marigold, onion and watermelons. Don’t cultivate crops like chilli, tomato, brinjal and tobacco. Raising green manure crops like sunhemp or cowpea during early rains and incorporating in to soil would help in improving soil organic matter content.

5. Application of concentrated organic manures like castor / neem cake @ 15 kg per tree would reduce disease incidence and quality of fruits will improve. Application of *Trichoderma* 1kg and 10 kg of neem cake added to 90 kg FYM, cured for a week and applying to each tree @10 kg would be an ideal procedure.

6. Care should be taken not to damage root system while intercultivation or manipulating in the basins.
5.0.0. References


ANGRAU: Acharya NG Ranga Agricultural University, Publications:http://www.angrau.net/

Anil Rana 2006. From chemical intensive to sustainable agriculture practices. Leisa india 8(2):22.


Kensuken Kubo(2005), Cropping Pattern Changes in Andhra Pradesh during the 1990s: Implications for Micro-level Studies, Chapter:S; Joint Research Program Series, IDE-JETRO.


Sadhale n 1999, Krishi – parashara, Asian Agri history foundation, Hyderabad, pp94.


Annexure-I

Format used for collection of field data.

Dryland Agricultural practices in Andhra Pradesh – interview based questionnaire

District: ....................... Hydrological Unit: .......................  
Mandal: ............... Village: .......................  
Crop: ....................... Season: .......................  
Land owned by farmer ............ details (soil type/ slope ) ............ crops ............  
Leased Land ............ (soil type/ slope ) ............ crops ............  

1. Cost of cultivation

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<th>Own</th>
<th>Total Cost (Rs)</th>
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3. Changes in cropping pattern
   • Managing seed

   • Managing soil fertility

   • Managing moisture

   • Managing plant protection

4. Reasons behind changes

5. Adaptation of practices

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Annexure-II

Concept of Bio diverse Farming System Model Recommendations by CRIDA

Various components for integration are
• Parkland systems
• Trees on bunds
• Wind breaks
• Silvi-pasture system
• Agrohorticulture system
• Block plantations
• Economic shrubs
• Live fences
• Crops + green leaf manure species (mixed/intercrops)
• Integrated animal based systems- Fisheries, Dairy, Piggery, Small ruminants, Poultry, Apiary

For purposes of description and study, a farm can be divided by space and time factors into different enterprises, each having its own resource requirements and productivity pattern. This system includes all activities, either on or off the farm, that use farm resources. Most enterprises of the system are interrelated. The layout of the farm varies in response to many social factors (Grimble 1973, Ruthenberg 1971, National Research Council 1989 and Harwood 1974) and selection of models. Nutrient management efforts undertaken in isolation of the farmers’ livelihood strategies and coping mechanisms evolved over generations may not succeed. The narrow sectoral approaches to crop cultivation separating livestock should lead way for more integrated farmer centered approaches. Generating more options for the farmer to attach more to the land is the ultimate key required to ensure adequate production of biomass and integrated nutrient management. Several tools are available for this. Important among these is the farming systems approaches. For planners, policy makers and organizations concerned with integrated nutrient management, farming systems approach can be a real challenging option. A brief summary of the various components of farm enterprises may be useful in studying their interaction with the major cropping systems.

1.1 Live fence rows:
Fencerow areas are important in most uplands of small farm size in South-east Asian countries. They are usually planted to a species of legume (Leucaena leucocephala or Sesbania grandiflora) in wet areas and Zygiphus, Hibiscus, Glyricidia etc. species in dry areas (Korwar and Radder 1994). The former serve as a source of human food and animal feed, with leaf protein approaching 6 per cent. All are used for firewood and green manure. They are cut annually to a height of 1.5 meters, from which new shoots emerge each year. These species are ever present and an important part of small-farm agriculture. The fencerows may include other economic trees such as mango or kapok. Often they are planted to a grass species, such as Saccharum spontaneum, which is useful for fiber and for thatch. This species does not spread to cultivated fields.
Such fencerows are used in areas of seasonally high rainfall to control erosion as well as to separate fields. The diversity of plants in them and their effectiveness in controlling erosion are highly dependent on the animal systems. Uncontrolled grazing minimizes the effectiveness in controlling erosion are highly dependent on the animal systems.

In developed countries the existence of hedgerows are described as restricting mechanization and also in providing shelter for various insect pests as well as being a source of weeds. On small farms, however, mechanization is small-scale and not likely to be impeded (Banta 1973). The insect relationships of fencerow areas are open to question. Some workers feel that the increased diversity of insect species resulting from diversified cropping results in a more stable pest pattern and one that is more easily managed. Weeds in most well developed fencerows are excluded by the planting of desirable grass species and by controlled grazing. The fencerows have much to offer the small farmer as long as it does not interfere with small farm implements or water distribution.

1.2 Cropping Patterns
The attention in institute programs is focused on cropping patterns as the key aspect of farming systems. This is also reflected in the theme cropping systems of National and International Agricultural research Systems. This does not belittle the fact that cropping patterns interact closely with other farm enterprises, but indicates that attention is being focused on their improvement in the context of other farm enterprises.

Tree crops are common to most farming systems providing an element of stability to the system in areas of highly variable rainfall. Mangoes, and other drought-tolerant Bio-Diverse Farming System Models for Dryland Agriculture species characterize the low-rainfall areas. Long-duration annuals such as pigeonpea serve essentially the same purpose, but are higher in productivity. Most farming systems consist of a combination of these and other crops enterprises, which field-crop sequence patterns accounting for the bulk of farm productivity. Many aspects of crop management technology are closely related to the type of cropping pattern, making a systems approach essential to the successful development of new technology (Bantilan et al 1974 and IRRI 1974).

Most farmers, when designing their systems use a combination of enterprises having different resource requirements. Some may be of lower productivity but lend stability to the system. Others may be labor or cash-intensive and highly productivity, but unstable from the biological, management or economic standpoint. The net effect is to balance the farmer’s resources in meeting his needs for productivity and stability. As farm size increases, the labor constraint dictates a change in cropping pattern to less labor-intensive crops. Broadcasting in these cases may become handy.

1.3 Animal Systems
Animals on the farm interact with all other farm enterprises. They require considerable labour for tending as well as a year-round source of feed. Cropping patterns must be adjusted to meet these needs. Some of the interactions are quite precise, as the crop-animal interaction of a Philippine system. The cropping pattern is rice followed by maize in a 1500 mm, 6-month rainfall pattern. When the maize is harvested, the chicken population is markedly increased to use the available feed. The chickens are sold just after rice planting the next year in time to provide cash for nitrogen fertilizer, the major input for growing rice. Animals also, of course, supply power for farm operations. They also tend to add stability to the system, as their productivity generally does not fluctuate as widely in response to weather as does that of the crops.
1.4 Farmstead area
Diverse mixtures of annual and perennial crops characterize the farmstead area. Its function is both an aesthetic and economic. A well-developed homestead area provides a year-round flow of small income and a source of food and nutritional security. Its extent and productivity depend on the style of village commands, the number of small and large ruminants. Lowland areas of South-east Asia, have far smaller homestead areas than do the scattered dwellings common to upland areas. Untended grazing animals such as goats and cows greatly reduce the variability and productivity of these All India Coordinated Research Project for Dryland Agriculture (AICRPDA) areas. Since most of the plants are trees or shrubs, this area lends biological and management stability to the overall system (Grimble 1973).

1.5 Non-farm enterprises
These are enterprises conducted either on or off the farm but which do not utilize much of the agricultural land resource. These include activities, such as cottage industries, off-farm employment, contract tractor or animal work, or any activities, which use the farm’s human or physical resources and provide a return in the form of cash, kind or security. These activities influence other farm enterprises and thus become an important aspect of the system.

When agro-climatic conditions have been described, which determine specific types of farming systems, research can begin on complete systems within those environments. The institute is located in a representative site. Components of the systems, however, may be researched outside the area at a location where relevant conditions can be simulated. Water-use studied, for instances, may be conducted in simulated environments at research centers.

1.6 Description of model:
The model is On one hectare roughly 600-700 MPTs and one hundred fruit trees may be planted to serve enough fuel wood, fodder, compost material and cash income for a family of five. The objective of the model is to reduce the dependency on forest resources and wage labour. Depending on agroclimatic conditions the number of trees per hectare and the selection of fruit and forestry species may vary. Mango was by far the most popular fruit tree and forestry species with high growth rates or strong wood were preferred, for example Eucalyptus, Tectona grandis, Acacia auriculiformis, Casurina equisetifolia and Cassia siamea are some of the favoured species.

- c. Land preparation will start with receipt of first monsoon showers, a ploughing followed by repeated harrowings till fine tilth is achieved.
- d. Farm yard manure to a level of 2-4 tons/acre is applied based on the availability. Basal dose of fertilizer, usually DAP/complex is applied either along with the seed or as along the rows. Then top dressing with urea is done.
- e. Most of the hybrids are double crosses by private companies, farmers prefer yellow dent corn types. Green cobs are also sold to market depending on prevailing price.
- f. Farmers spray various chemicals depending on the pest infestation like shoot borers, aphids and diseases like wilt and blight.
- g. Harvesting is manual and threshing is done mechanically.
- h. After threshing stems and leaves used for dry fodder for cattle and threshed cobs used for fuel.
a. It is important to keep grazing animals and passers-by off the land. Hence the importance of creating thick live hedges, those can be pruned regularly and provide fodder for livestock or composting material.

b. Self-sufficiency of foodgrains is another objective of the model and the use of intercrops as well as high yielding varieties was promoted. To increase the soil fertility cost efficient technologies such as NADEPP and vermicomposting may be Bio-Diverse Farming System Models for Dryland Agriculture introduced. Use of PSB and Rock phosphate may require attention. (Various systems were developed and practiced worldwide on organic farming. Significant among them are - Howard system – Balfour Organic – UK; Biodynamic system – USA; Rusch Muller Organisch – Biological – Germany; Lemaire – Boucher/France; Regenerative – USA; Natural Farming – Japan; Permaculture – Australia.)

- The area would be systematically treated with field bunds across the slope. The trench cum bund created help to retain soil and moisture in situ. This also would promote good tree growth of various species planted on the bunds. Every field bund is covered with MPTs planted at a close spacing of 1 to 2 m in a row. The MPTs comprise of species such as teak, Subabul, Acacia, Gliricidia, Dalbergia, Casia, Casurina etc. Approximately 500 to 1000 plants per hectare are to be accommodated on boundaries and bunds. These plants are regularly pruned to avoid shading and to obtain biomass for mulching and fertilizing. The twigs pruned also provide enough fuel wood to meet the firewood requirement of the local community.
  - Fields are covered with live fencing using species such as Cassia siamea, Gliricidia, Euphorbia, Vitex nigundo, Pongamia etc. They provide manure and their decoction botanical pesticides. It may be noted that usually a farmer accepts a plant only when it has multiple utilities. These live fences in addition to providing protection to the plantations also help to increase bio-diversity in the area and produce substantial quantities of biomass. This biomass obtained by pruning the fencing regularly which helps in increasing soil moisture retention capacity and increased fertility.
  - The water harvesting should be both runon-runoff based. Farm ponds are opened at strategic locations to harvest excess runoff from the fields. These ponds help increase in percolation. The increased percolation leads to maintenance of better soil moisture regime, which in turn helps better tree growth. On the contrary farm ponds are sealed to integrate fish and poultry as per needs
  - Dryland horticulture species such as Mango, Tamarind and Cashew are promoted at a rate of 100 plants per hectare. The fruit species shall be a mix, both as varieties and species for enhanced availability of fruits during the year.
  - Livestock will be an integrated component. The form of livestock may vary from region to region. The number of animals is to be kept as low as possible meeting essentially home needs of the farmer and very little towards commercial activities. The browseable species is to be fed to the cattle by mostly stall feeding, except All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in pasture plots. Silaging will be the method for off-season needs. The nonbrowseable species will be converted into compost.
  - The farmyard manure and silt accumulated in the farm ponds will be recycled. Instead of spreading too thinly, a method will be designed in consultation with farmers as per the requirements to enrich different areas and covering the entire land in due course of time. The
above measures may result in congenial microclimate reducing aridity and crop losses due to moisture stress and result in increasing agricultural crop production due to –

- Better soil moisture regime
- Increased soil organic matter
- Windbreak effect due to live fences and tree plantation leading to better soil moisture retention and reduced transpiration
- The farmer occupied with land based activities for extended periods.
- Staying back on his land almost 12 months in a year and hence takes better care of land.
- Increased biomass availability helping in integration of livestock into the farming systems

- The horticultural trees providing sustained incomes even in bad rainy season thereby providing an insurance cover against fluctuations in crop production. The successful incorporation of tree component into farming systems in the program result in visibly improved protection to the watershed. This helped us to conceptualize a new approach to watershed treatment, with more thrust on permanent vegetation in agricultural fields.

Details of this process are given below.

1. Identification of rainfed cropping region Though the rainfed area distribution is wide spread, but a few districts contain most of the area. The area under districts for each of the production system was arranged in descending order according to the area covered. The production systems considered for the study are Rainfed rice, oil seeds, cotton, pulses, nutritious cereals. The districts covering 85% of the cropped area for a particular crop were selected and recognized as a cropping region. Thus, dominant districts for each of the production were identified. Dominant districts under each production system were classified based on soil degradation map of India (NBSSLUP, 1994) using the following criteria
   a. Water erosion with very high severity
   b. Water erosion with High severity
   c. Water erosion with Medium severity
   d. Physical deterioration waterlogged areas High severity
   e. Physical deterioration waterlogged areas Medium severity
   f. Chemical deterioration loss of nutrient – High severity Bio-Diverse Farming System Models for Dryland Agriculture
   g. Chemical deterioration salinization – High severity
   h. Chemical deterioration salinization– Medium severity

2. For each of the Production System, districts falling under the S.No. 1&2 were considered as high priority areas and the remaining districts under S.No. 4 - 8 are given lower priority. Priority districts thus identified for each of the production system have been merged together to identify the priority districts for the entire rainfed agro-eco sysyem as a whole.

3. Sustainable farming system models covering the priority districts and for each of the agro-eco sub region are developed. Information on the suitable farming system models for each of the agro-eco sub region and districts under each of the Agro-eco sub-regions (AESR) with priority status are described in Annexure-II. However, the interactions among these components when integrated into a farming system depends on many factors viz. rainfall, soils, management and the quantum of the components themselves.
Annexure-III

District level Bio-Diverse Farming system models for dryland agriculture

Model : I Silvi-horti pasture in Arid to semi-arid kharif alfisols in Chalka Region

Region: Karnataka Plateau (Rayalseema as inclusion), hot arid with deep loamy and clayey mixed red and black soils, low to medium AWC and LGP 60 – 90 days. (AESR 3.0).

Target Districts:
First Priority: Anantapur

Farming system model:

Crop Production System: Groundnut, Pigeon pea, Sorghum, Sunflower

Boundary Plantation: *Tamarindus indica*, Pongamia, *Eucalyptus camaldulensis*, *Prosopis juliflora*

Live fence

Outer Layer: Cactus, Lawsonia

Inner Layer: *Muraya coenigi*, *Carissa carundus*

Trees on crop lands

Fodder/green biomass: *Acacia nilotica*, *Ailanthus excelsa*, *Albizzia lebbeck*, *Hardwickia binata*, *Dalbergia sissoo*, *Azadirachta indica*

Fruit: Custard apple, Pomegranate, Tamarind, Fig, Jamun, Mango

Wood (Commercial/Farm Use/Fuel Wood): *Acacia nilotica*, *Acacia auriculiformis*, *Dalbergia sissoo*

Medicinal & Aromatic Plants: *Cassia angustifolia*, *Catharanthus roseus*, *Palma rosa*

Vegetables: Cluster bean, Pumpkin, Cow pea, Round melon, Drum stick

Livestock Production System: Female Cattle, Male Cattle, Female Buffaloes, Sheep, Goat, Poultry

Water harvesting techniques: Manage in <10 ha watersheds: Soil water balance studies: Runoff-erosion measurements: More emphasis on *in situ* water conservation: Increasing soil infiltration capacity and reducing soil crusting problem: Land shaping to store more water in the soil profile: Inter-plot water harvesting of 1:1 cropped to uncropped land: Dead furrows at 3.6 m intervals: Absorption/drainage type terraces: Vegetative barriers: Gully control.


Groundwater Exploration: Fluctuation of groundwater levels in low runoff area: Exploring ways of collecting more runoff to recharge soil profile.
Model:II Agri-horti-silvi culture in Arid to semi-arid kharif alfisols in Chalkas

**Region:** Deccan plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion: North Telangana plateau, hot moist semi arid with deep loamy and clayey mixed Red and Black soils, medium to very high AWC and LGP 120-150 days (AESR 7.2)

**Target districts:**
First Priority: Mahaboobnagar
Selected districts: Kurnool

**Farming system model:**

**Crop Production System:** Groundnut, Pigeon pea, Sorghum, Sunflower

**Boundary Plantation:** Glicicidia, *Dalbergia sissoo*, *Eucalyptus hybrid*

**Live fence**

**Outer Layer:** Cactus sps., Opuntia sps., *Lawsonia alba*

**Inner Layer:** Glicicidia, Leucaena, *Muraya coenigi.*

**Trees on crop lands**

**Fodder/green biomass:** *Leucaena leucocephala*, *Glicicidia*, *Azadirachta indica*, *Albizia lebbeck*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*

**Fruit:** Custard apple, Ber, Cherimoya, Mango, Tamarind, Jamun

**Wood (Commercial/Farm Use/Fuel Wood):** *A.nilotica, A. cupressiformis, H.binata, Dalbergia sissoo.*

**Medicinal & Aromatic Plants:** *Plantago ovata, Cassia angustifolia*, Palmarosa, *Vetiveria zyzanoides*

**Vegetables:** Cow pea, Clusterbean, Drumstick, Coccinia, Pumpkin, Round melon.

**Livestock Production System:** Female Cattle, Male Cattle, Female Buffaloes, Sheep, Goat, poultry

**Water harvesting techniques:** Manage in <10 ha watersheds: Soil water balance studies: Runoff-erosion measurements: More emphasis on in situ water conservation: Increasing soil infiltration capacity and reducing soil crusting problem: Land shaping to store more water in the soil profile: Inter-plot water harvesting of 1:1 cropped to uncropped land: Dead furrows at 3.6 m intervals: Absorption/drainage type terraces: Vegetative Barriers: Gully control.

**Soil and Water Conservation Practices:** Increasing catchment area: Designing catchment size for farm ponds under low runoff conditions: Water harvesting in lined dug-out ponds and use for life-saving irrigation: Efficient use of stored water: Groundwater Exploration: Fluctuation of groundwater levels in low runoff area: Exploring ways of collecting more runoff to recharge soil profile.
Model : III. Agri-horti-silvi culture in Arid to semi-arid khari kharif alfisols in Chalka Region

Region : North Telangana Plateau. Hot moist semi-arid ESR with deep loamy and clayey mixed red and black soils, medium to very high AWC and LGP: 120-150 days. (AESR 7.2)
Target Districts: Nalgonda, Medak
Farming system model:
Crop Production System: Castor, Groundnut, Sorghum, Pigeonpea, Greengram, Cotton
Boundary Plantation: Eucalyptus, A. nilotica, A. tortiles
Live fence
Outer Layer: Agave sisalana, Cactus
Inner Layer: Gliricidia, Sesbania, Leucaena, Custard apple, Guava. Muraya coenigi
Trees on crop lands
Fodder/green biomass: Albizzia lebbeck, D. sissoo, Leucaena, Azadiracta, Hardwickia binata, Acacia albida
Fruit: Custard apple, Tamarind, Jamun, Mango, Ber
Wood (Commercial/Farm Use/Fuel Wood): Dalbergia sissoo, A. auriculiformis, A. nilotica, Hardwickia binata
Medicinal & Aromatic Plants: Cassia angustifolia, Catharanthus roseus, Plantago ovata, Palmarosa, Vetiveria zyzanoides.
Vegetables: Cluster bean, Drum stick, Cucumber, Cow pea, Ridge gourd, Round melon, Okra, Water melon.
Livestock Production System: Sheep, Goat, Male & Female Cattle
Water harvesting techniques: Manage in <10 ha watersheds: Soil water balance studies: Runoff-erosion measurements: More emphasis on in situ water conservation: Increasing soil infiltration capacity and reducing soil crusting problem: Land shaping to store more water in the soil profile: Inter-plot water harvesting of 1:1 cropped to uncropped land: Dead furrows at 3.6 m intervals: Absorption/drainage type terraces: Vegetative barriers: Gully control.
Groundwater Exploration: Fluctuation of groundwater levels in low runoff area: Exploring ways of collecting more runoff to recharge soil profile.
Model : IV. Agri-horticulture in Arid to semi-arid kharif alfisols in Chalka Region

Region: Eastern ghats and Tamil Nadu uplands and Deccan (Karnataka) Plateau, hot semi-arid eco-region: Central Karnataka Plateau, hot moist semiarid Eco Sub Region with medium to deep red loamy soils, low AWC and LGP 120-150 days (AESR 8.2)

Target Districts: Chittoor

Farming system model:

Crop Production System: Finger millet, Horse gram, Sorghum, Fruit & Vegetables

Boundary Plantation: Tectona grandis, D. sissoo, Tamarindus indica

Live fence

Outer Layer: Cactus, Agave sisalana

Inner Layer: C.carundus, Leucaena, Gliricidia, Sesbania sesban

Trees on crop lands

Fodder/green biomass: L.leucocephala, Albizzia lebbeck, Dalbergia sissoo, A.indica, Pongamia, Cassia siamea

Fruit: Mango, Pomegranate, Sapota, Guava, Custard apple, Jamun

Wood (Commercial/Farm Use/Fuel Wood): A.nilotica, A.auriculiformis, Tectona grandis, Santalum album

Medicinal & Aromatic Plants: Catharanthus roseus, Cassia angustifolia, Solanum viarum, Dioscorea, Geranium, Pogostemon patchouli, Jasmine

Vegetables: Tomato, Chillies, Okra Water melon, Bitter gourd, Drum stick, Brinjal, Bitter gourd.

Livestock Production System: Female Cattle, Male Cattle, Female , Buffaloes, Sheep, Goat, Poultry

Water harvesting techniques: Manage in <10 ha watersheds, Soil water balance Studies: Runoff-erosion measurements: More emphasis on in situ water conservation: Increasing soil infiltration capacity and reducing soil crusting problem: Land shaping to store more water in the soil profile: Inter-plot water harvesting of 1:1 cropped to uncropped land: Dead furrows at 3.6 m intervals: Absorption/drainage type terraces: Vegetative barriers: Gully control.

Soil and Water Conservation Practices: Increasing catchment area: Designing catchment size for farm ponds under low runoff conditions: Water harvesting in lined dug-out ponds and use for life-saving irrigation: Efficient use of stored water:

Groundwater Exploration: Fluctuation of groundwater levels in low runoff area: Exploring ways of collecting more runoff to recharge soil profile.
Annexure - IV

Cropping system based recommendations from CRIDA

A. Groundnut based cropping system

Agroecological setting

- **Climate:** Hot moist semi arid
- **Physiography:** Rayalaseema region
- **Soils:** Deep red loamy soils (Alfisols 80%; Aridisols– 20%)
- **Annual rainfall:** 697 mm
- **Potential evapotranspiration:** 1556 mm
- **Moisture availability period:** 120-150 days

Soil and water conservation:
1. Contour bunding with a cross section of 0.63 m² and with horizontal spacing of 25 m to 125 m is recommended for red soils. The other soil conservation measures like compartment bunds of 15 m length and 10 m width or conservation furrow at 3.6 m interval or intercropping with mixed pulses like cowpea and horsegram can be adopted.
2. Integrated watershed management (manage in a < 10 ha watershed)
3. Water harvesting inlined with Cuddapah slabs to avoid seepage losses in dug out ponds
4. Increasing catchment area and design of pond size for catchment size
5. Interplot water harvesting of 1:1 cropped to uncropped area
6. Use of life saving irrigation
7. Indigenous water harvesting structures to be restored

Crop management

- **Varieties:** TMV-2, Vemana, TPT–4, TPT-2, TPT-1 and JL-24
  - For scarce rainfall in *kharif* – Vemana (K-134), Tirupati–2, TMV-2, JCG–88, Tirupati–1, Tirupati–4
  - For delayed onset of monsoon – Kadiri-4 (K-150)
- **Seed rate:** 100 kg/ha
- **Seed treatment:** Seed treatment with Mancozeb (3g)/ Carbendazim (2g) for one kg of kernals
- **Sowing time:** *kharif* – July
- **Planting pattern:** 30x10 cm
- **Nutrient management:** 20 kg N + 40 kg P2O5 + 40 kg K2O/ha. Reduce to 50% of recommendation if soil test value is medium
- In Zn deficient soils – apply ZnSO4 at 25 kg/ha once in three years

- **Pest management:**
  - Root grub: Apply Thimmet or Phorate granules at 10 kg/ha to soil before sowing or treat the seed with chlorpyriphos @ 6 ml/kg seed.
  - Aphids, leaf miner: Spray 0.05% Endosulfan or Dimethoate or Monocrotophos
  - Red hairy caterpillar:
    - Arrange bonfires 2 days after soaking rain from 8.00 PM to 10.00 PM
    - Make a furrow around the field, and apply Carbaryl dust in the furrow
- For second and third instar larvae spray dimethoate @ 2 ml/l or Monocrotophos @1.6 ml/l
- Poison bait with 10 kg rice bran + 1 kg jaggery + 500 ml Quinolphos can be applied for effective control.

**Weed management**

- Preplant application of Fluchloralin @3-3.5 l/ha
- Pre-emergence application of (within three days after sowing) Butachlor @4-5 l/ha or Pendimethalin @3.5-5 l/ha
- Mulching with groundnut shells @5 t/ha, 15-20 days after crop emergence.
- Application of antitranspirants like Kaoline or Lime water @ 50 g during drought conditions.
- To recover from drought effect spraying of urea @20 g/l of water

**Some other important practices**

- Deep ploughing once in three years, where soil depth is 20 cm or more.
- Preparatory cultivation with country plough or “Chekkala guntaka”, a traditional implement increases
- the yield of groundnut.
- Sand application @ 40 t/ha applied during summer increases the yield of groundnut
- Drought management practices like application of groundnut shells @ 5 t/ha at 10 days after sowing
- Drought tolerant varieties – Girnar -1
- Deep tillage is done for reducing soil borne pests
- Pearl millet act as a barrier for thrips and leaf miner
- Castor act as barrier for *Spodoptera litura*, *Achoea janata*
- Groundnut + soybean for trapping leaf miner and thrips
- Seed treatment: Carbendazim (Bavistin) 2 g/kg of seeds for seed borne fungi viz., collar rot and stem rot.

**Suitable cropping systems**

- Monocropping of groundnut: In 50% of the rainfed cultivated area
- Groundnut + pigeonpea (7: 1 or 11.1)
- Groundnut + castor (7:1 or 11:1)

**Farm implements/ tools:**

- Eenatigorru (bullock drawn, four row): Useful for sowing, seed and fertilizer placement. Suitable for those who have light draft animals (Rs.1500 per unit)
- Seed drill/planter (tractor drawn, nine row): It is a mechanical seed drill. More area can be covered in a day and intra row spacing is maintained (Rs.16000 per unit)
- Ashaguntaka (tractor drawn, seven row): Useful for harvesting of groundnut crop. More field capacity and labour saving (Rs.20000 per unit)
- Groundnut thresher cum decorticator: Useful for separating groundnut pods from haulms. It was found advantageous to thresh groundnut after 3-5 days after harvest. The cost of operation was Rs. 224/ha. It can also be used as decorticator with minor modifications. Perform timely operation and labour saving (Rs.45000 per unit)

**Alternate farming systems**

1. Crop + livestock (sheep @ 10/ha) system of farming will give 80% more income than crop system alone.
2. **Fodder/ green biomass**: *Dalbergia sissoo, Gliricidia, Albizia lebbeck, Cassia siamea, Azadirachta indica/stylo, Marvel-8 grass*

3. **Fruit**: Ber, Custard apple, Pomegranate, Amla + kharif spreading crops

4. **Medicinal and aromatic plants**: *Cassia angustifolia, Catharanthus roseus, Palma rosa, Vetiveria zizanoides, Rose, Geranium*

5. **Vegetables**: Onion, Brinjal, Chillies, Cowpea, Cucumber, Cluster bean, Drumstick.

**Contingent crop planning**

- **Early onset of monsoon** - Sorghum, greengram, pigeonpea, castor (May – June)
- **Normal onset of monsoon** - Groundnut, pigeonpea, groundnut + pigeonpea (July)
- **Late onset of monsoon** - Pearl millet, sorghum, greengram (after August 15th)
- **Very late onset of monsoon** - Pearl millet, cowpea, horsegram (early September)

**Agroecological setting**

**Anantapur**

- **Climate**: Hot arid
- **Physiography**: Rayalaseema region
- **Soils**: Deep loamy and clayey mixed red and black soils (Alfisols- 80%)
- **Annual rainfall**: 497 mm
- **Potential evapotranspiration**: 1858 mm
- **Moisture availability period**: 60-90 days

**Cuddapah**

- **Climate**: Hot dry semi arid
- **Physiography**: Rayalaseema
- **Soils**: Deep loamy, clayey mixed red and black soils (Alfisols - 60%, Vestic Inceptisols - 40%)
- **Annual rainfall**: 748 mm
- **Potential evapotranspiration**: 1835 mm
- **Moisture availability period**: 80-120 days

**Kurnool**

- **Climate**: Hot dry semi arid
- **Physiography**: Rayalaseema region
- **Soils**: Deep loamy, clayey mixed red and black soils (Alfisols - 60%; Vertic Inceptisols - 40%)
- **Annual rainfall**: 605 mm
- **Potential evapotranspiration**: 1828 mm
- **Moisture availability period**: 80-120 days

**Mahaboobnagar**

- **Climate**: Hot moist semi arid
- **Physiography**: North Telangana
- **Soils**: Deep loamy, clayey mixed red and black soils (Vertisols–40%; Vertic Inceptisols–20%; Alfisols–40%)
- **Annual rainfall**: 792 mm
- **Potential evapotranspiration**: 1678 mm
- **Moisture availability period**: 120-150 days
Nalgonda
- **Climate**: Hot moist semi arid
- **Physiography**: North Telangana
- **Soils**: Deep loamy, clayey mixed red and black soils (Alfisols 100%)
- **Annual rainfall**: 763 mm
- **Potential evapotranspiration**: 1761 mm
- **Moisture availability period**: 120-150 days

Anantapur, Cuddapah, Kurnool
- Contour bunds, graded bunds
- Contour bunding with a cross section of 0.63 m² and with horizontal spacing of 25 to 125 m is recommended for red soils. The other soil conservation measures like compartment bunds of 15 m length
- and 10 m width or conservation furrow at 3.6m interval or intercropping with mixed pulses like cowpea and horsegram can be adopted.
- Integrated watershed management (manage in a <10 ha watershed)
- Water harvesting inlined with cuddapah slabs to avoid seepage losses in dug out ponds
- Increasing catchment area and design of pond size for catchment size
- Interplot water harvesting of 1:1 cropped to uncropped area
- Use of life saving irrigation
- Indigenous water harvesting structures

Mahaboobnagar
- Inter-plot water harvesting of 1:1 cropped to uncropped land

Nalgonda
- Ridges and furrows

Crop management
- **Anantapur, Cuddapah, Kurnool**
  - **Varieties**: TMV-2, Vedanta, and TPT–4, TPT-2, TPT-1 and JL-24
  - For scarce rainfall in *kharif* – Vemana (K-134), Tirupati–2, TMV-2, JCG–88, Tirupati–1, Tirupati–4
  - For delayed onset of monsoon – Kadiri-4 (K-150)
  - **Seed rate**: 100 kg/ha
  - **Sowing time**: *kharif* – July
  - **Seed treatment**: Seed treatment with Mancozeb (3g)/ Carbendazim (2 g) for one kg of kernals
  - **Panting pattern**: 30x10 cm

- **Nutrient management**:
  - 20 kg N + 40 kg P2O5+ 40 kg K2O/ha. Reduce to 50% of recommendation if soil test value is medium
  - 20 kg N + 40 kg P2O5 + 50 kg K2O + 500 kg gypsum + 25 kg ZnSO4 (for Zn deficient soils) for every three years of groundnut crop + farm yard manure @ 10-12 t/ha. N, P and K as basal. Apply gypsum in rows near to base of the plants after weeding at first flowering. Gypsum application should be completed before 45 DAS / before second weeding.
  - In Zn deficient soils – apply ZnSO4 25 kg/ha once in three years
Weed control: Hand weeding at 20 and 40 days after sowing + pendimethalin at 50 days after sowing as post emergence @ 0.5 kg a.i/ha

Root grub: Apply Thimmet or Phorate granules at 10 kg/ha to soil before sowing or treat the seed with chlorpyriphos @ 6 ml/kg seed.

Aphids, leaf miner: Spray 0.05% Endosulfan or Dimethoate or Monocrotophos

Red hairy caterpillar: Arrange bonfires 2 days after soaking rain from 8.00 PM to 10.00 PM

Make a furrow around the field, and apply Carbaryl dust in the furrow

For second and third instar larvae, spray dimethoate @ 2 ml/l or Monocrotophos @ 1.6 ml/l

Poison bait with 10 kg rice bran + 1 kg jaggery + 500 ml Quinolphos can be applied for effective control.

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Poison bait with 10 kg rice bran + 1 kg jaggery + 500 ml Quinolphos can be applied for effective control.

Weed management

Anantapur, Cuddapah, Kurnool

Preplant application of Fluchloralin @3-3.5 l/ha

Pre-emergence application of (within three days after sowing) Butachlor @4-5 l/ha or Pendimethalin @3.5-5 l/ha

Mulching with groundnut shells @5 t/ha, 15-20 days after crop emergence.

Application of antitranspirants like Kaoline or Lime water @ 50 g during drought conditions.

To recover from drought effect spraying of urea @20 g/l of water

Some other important practices

Deep ploughing once in three years, where soil depth is 40 cm or more.

Preparatory cultivation with country plough or “Chekkala guntaka”, a traditional implement increases

the yield of groundnut.

Sand application @ 40 t/ha applied during summer increases the yield of groundnut

In Alfisols – 100 % RDF (50% organic + 50% inorganic), 50% recommended N (40 kg/ha glyricidia as half basal + half top dressing)

In groundnut–castor rotation – 25% N (compost) + 75% N (inorganic)

LCC VI – custard apple (4.5x4.5 m), Ber (6x6 m), Soapnut (6x6 m), Tamarind (9x9 m)

For breaking seed dormancy treat with 0.05 % (5 ml/10l water) Etheryl (plant harmone). Soak kernal in Etheryl solution for 12 hrs and shade dry before sowing.

Crop substitution – groundnut substituted with pigeonpea, castor, pearl millet and sorghum

Crop rotation – kharif groundnut – greengram/ horsegram where Northeast monsoon is assured.

Drought tolerant varieties – Girnar-1

Deep tillage is done for reducing soil borne pest

Pearl millet acts as a barrier for thrips and leaf miner

Castor acts as a barrier for spodoptera litura, Achoea janata

Groundnut + soybean for trapping leaf miner, thrips

Seed treatment: Carbendazim (Bavistin) 2 kg of seeds for seed borne fungi viz., collar rot and stem rot.

Seed treatment with Mancozeb (3 g)/ Carbendazim (2 g) for 1 kg of kernels
• Cultural practices
  • Soil amendment with castor cake @ 500 kg/ha (preferably 15 days before sowing) for soil
    borne diseases like stem rot and collar rot.
  • Intercropping of groundnut with pigeonpea/ pearl millet/ sorghum (3:1) depending upon the
    locally recommended intercrops against foliar fungal diseases (early and late leaf spots, rust) and
    insect pests (leaf miner and thrips)
  • Use of trap crops such as cowpea/ soybean (leaf miner and leaf hoppers)/ castor
    (Spodoptera and leaf hoppers) as border crops for sucking/ defoliating insects.
  • One hand weeding at 30-35 days after sowing after the application of pre-emergence
    weedicde Fluchloralin @ 1.5 kg a.i./ha.

Mahaboobnagar, Nalgonda
  • Varieties: JL-24
  • Seed rate: 100 kg/ ha
  • Seed treatment: Seed treatment with Mancozeb (4 g)/ Carbanazim (2 g) for one kg of kernals
  • Planting pattern: 30x10 cm
  • Nutrient management: 20 kg N + 40 kg P2O5+ 40 kg K2O/ha.
  • In Zn deficient soils – apply ZnSO4 25 kg/ha once in three years
  • 50% recommended dose of fertilizer + Farm yard manure 5 t/ha in sequence crops

• Pest management:
  • Root grub: Apply Thimmet or Phorate granules at 10 kg/ha to soil before sowing or treat the
    seed with Chlopyriphos @ 6 ml/kg seed.
  • Aphids, leaf miner: Spray 0.05% Endosulfan or Dimethoate or monocrotophos
  • Red hairy caterpillar: Arrange bonfires 2 days after soaking rain from 8.00 PM to 10.00 PM,
    Make a furrow around the field, and apply carbaryl dust in the furrow
  • For second and third instar larvae, spray Dimethoate @ 2 ml/l or Monocrotophos @ 1.6 ml/l
    Poison bait with 10 kg rice bran + 1 kg jaggery + 500 ml Quinolphos can be applied for
    effective control.
  • Late leaf spot: Spray Mancozeb 2 g + Carbendazim 1 g/l or Hexaconazole @ 2 ml/l. Spraying
    can be taken up based on leaf wetness at 70 days after sowing. There is no need to spray for
    July sown crop.
  • Stem necrosis: Removal of weeds particularly Parthenium on the bunds and in the field

Weed management:
Mahaboobnagar, Nalgonda
  • Preplant application of Fluchloralin @3-3.5 l/ha
  • Pre-emergence application of (within three days after sowing) Butachlor @4-5 l/ha or
    Pendimethalin @3.5-5 l/ha
  • Mulching with groundnut shells @5 t/ha, 15-20 days after crop emergence.
  • Application of antitranspirants like Kaoline or Lime water @ 50 g during drought conditions.
  • To recover from drought effect spraying of urea @20 g/l of water
Some other important practices

- Drought tolerant varieties – Girnar–1
- Deep tillage is done for reducing soil borne pest
- Pearl millet acts as a barrier for thrips and leaf miner
- Castor acts as a barrier for Spodoptera litura, Achoea janata
- Groundnut + soybean for trapping leaf miner, thrips
- Seed treatment: Carbendazim (Bavistin) 2 g/kg of seeds for seed borne fungi viz., collar rot and stem rot.
- Seed treatment with Mancozeb (3 g)/ Carbendazim (2 g) for 1 kg of kernels

Suitable cropping systems

**Anantapur, Cuddapah, Kurnool**
- Monocropping of groundnut: In 50% of the area.
- Groundnut + pigeonpea (7:1 or 11:1)
- Groundnut + castor (7:1 or 11:1)
- Groundnut + pearlmillet (6:2)

**Mahaboobnagar, Nalgonda**
- Groundnut + pigeonpea (7:1)
- Groundnut + castor (7:1 or 11:1)

Farm implements/ tools:

**Anantapur, Cuddapah, Kurnool**
- Eenatigorru (bullock drawn, four row): Useful for sowing, seed and fertilizer placement. Suitable for those who have light draft animals: (Rs.1500 per unit)
- Seed drill/planter (tractor drawn, nine row): It is a mechanical seed drill. More area can covered in a day and intra row spacing is maintained (Rs.16000 per unit)
- Ashaguntaka (tractor drawn, seven row): Useful for harvesting of groundnut crop. More field capacity and labour saving (Rs.20000 per unit)
- Groundnut thresher cum decorticator: Useful for separating groundnut pods from haulms. It was found advantageous to thresh groundnut after 3-5 days after harvest. The cost of operation was Rs. 224/ha.
- It can also be used as decorticator with minor modifications. Perform timely operation and labour saving (Rs.45000 per unit)
- APAU groundnut seed cum fertilizer drill (three row – animal drawn)
- CRIDA seed cum fertilizer drill (four row – animal drawn)
- Groundnut thresher

**Mahaboobnagar, Nalgonda**
- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube
Alternate farming systems

Anantapur, Cuddapah, Kurnool

- **Fodder/green biomass**: Dalbergia sissoo, Gliricidia, Albizia lebbeck, Cassia siamea, Azadirachta indica/stylo, Marvel-8 grass
- **Fruit**: Ber, Custard apple, Pomegranate, Amla + kharif spreading crops
- **Medicinal and aromatic plants**: Cassia angustifolia, Catharanthus roseus, Palma rosa, Vetiveria zizanoides, Rose, Geranium
- **Vegetables**: Onion, Brinjal, Chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
- Crop + livestock (sheep @ 10/ha) system of farming will give 80% more income than crop system alone.

Mahaboobnagar, Nalgonda

- **Parkland systems**: Azadirachta indica, Acacia nilotica, Tamarindus indica
- **Trees on bunds**: Tectona grandis, Leucaena leucocephala, Borassus flabellifera, Cocos nucifera, Acacia nilotica var. cupressiformis
- **Silvipastoral system**: Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus ciliaris
- **Alley cropping**: Leucaena leucocephala + sorghum/pearlillet, Gliricidia sepium + sorghum/pearlillet
- **Agrohorti system**: Mango + short duration pulses
- **Fodder/green biomass**: Luecaena leucocephala, Azadirachta indica, Albizzia lebbeck, Bauhinia purpurea, A. procera, B. monosperma, A. amara, Dalbergia sissoo
- **Medicinal and aromatic plants**: Catharanthus roseus, Cassia angustifolia, Aloe barbadensis, Withia somnifera, Cymbopogon martini, Cymbopogon flexuosus, P rosalea, Palma rosa, Vetiveria zizanoides
- **Dye yielding plants**: Lawsonia inermis, Hibiscus sabdariffa, Tagetus errecta, Indigofera tinctoria, Annato
- **Other economic shrubs**: Curry leaf, Jatropha, Soapnut
- **Animal component**: Female cattle, Female buffaloes, Male cattle, Sheep and Goat
- **Other enterprises**: Sericulture, Poultry

Contingent crop planning

Anantapur, Cuddapah, Kurnool

- Early onset of monsoon (last week of May or June): Sorghum (CSH-5), greengram, pigeonpea (PDM-1), castor (Aruna, GAUCH–1), mesta (AMV–1)
- Normal onset of monsoon (July): Groundnut, pigeonpea (TMV–2, J-11), groundnut + pigeonpea, castor
- (Aruna, GAUCH–1), mesta (AMV–1), setaria, pearl Millet (MBH–110, MH–88), greengram
- Late onset of monsoon (August): Sorghum, greengram (after August 15th), pearl millet (MBH–110), setaria, groundnut (TMV–2)
- Very late onset of monsoon (September): Cowpea, horsegram (early September), pearl millet (MBH–110), horsegram (Anantapur local, BGM)
Mahaboobnagar, Nalgonda

• **June: Normal onset of monsoon**
  - **Sole crop:** Sorghum (CSH 5, CSH-6, CSH-9), pearl millet (MBH 110)
  - **Inter crop:**
    - Sorghum - pigeonpea (2:1)
    - Pearl millet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150-180 days may be used.

• **July: Late onset of monsoon**
  - Sow castor (Aruna, GAUCH-1)
  - **Sole crop:** Pearl millet (MBH-100), Bunch variety of groundnut (TMV-2, JL-24)
  - **Intercrop:** Maize (DHM-101, Ganga-5)
  - Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days

• **August: Very late onset of monsoon**
  - **Sole crop:** Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
  - Castor (Aruna, GAUCH–1) with increased seed rate (15 kg/ha)

B. Cotton Based cropping system

**Agro-ecological setting**

• **Climate:** Hot moist semi arid
• **Physiography:** North Western Telangana Plateau
• **Soils:** Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 50%; Alfisols – 50%)
• **Annual rainfall:** 992 mm
• **Potential evapotranspiration:** 1689 mm
• **Moisture availability period:** 120 – 150 days

**Soil and water conservation**

• More emphasis on *in situ* moisture conservation
• Increasing soil infiltration capacity and reducing soil crusting problem

**Crop management**

• **Varieties:** B 1007, LRA 5166, LPS 141, JKHY – 1, NHH 44, Savita
• **Seed rate:** 10-12 kg/ha – varieties; 2-3 kg/ha – Hybrids
• **Date of sowing:** 25th June to 8th July
• **Planting pattern:** Varieties - 75 x 30 cm; Hybrids - 90 – 120 x 60 cm
• **Nutrient management:**
  - Hilly areas
    - 60 kg N + 40 kg P2O5 for Varieties
    - 90 kg N + 45 kg P2O5 for Hybrids
  - Plains for varieties
    - 40 kg N + 20 kg P2O5 + 20 kg K2O/ha

**Pest management**

• Summer ploughing
• Avoid delayed sowings
• Use of certified seeds
• Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold
- Use of egg parasitoids *Trichogramma* sp. @ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinolphos @2 l/ha or Chloropyriphos @ 2 l/ha
- Weeding at 30 days after semi and of 60 days after sowing

**Some other important practices**
- Sowing in June/ July

**Suitable cropping systems**
- Cotton + pigeonpea
- Cotton + sorghum

**Farm implements/ tools**
- Ferti cum seed drill
- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube

**Alternate farming systems**
- Parkland systems: *Azadirachta indica, Acacia nilotica, Tamarindus indica*
- Trees on bunds: *Tectona grandis, Leucaena leucocephala, Borassus flabellifera, Cocos nucifera, Acacia nilotica var. cupressiformis*
- Silvipstoral system: *Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus ciliaris*
- Alley cropping: *Leucaena leucocephala + sorghum/ Pearl millet, Gliricidia sepium + sorghum/pearl millet*
- Agrohorti system: Mango + short duration pulses
- Fruit: Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- Fodder/green biomass: *Leucaena leucocephala, Azadiractha indica, Albizia lebbeck, Bauhinia purpurea, Acacia procera, Butea monosperma, Acacia samara, Dalbergia sissoo*
- Medicinal & Aromatic Plants: *Catharanthus roseus, Cassia angustifolia, Aloe barbadensis, Withia somnifera, Cymbopogan martini, Cymbopogan flexuosus, Vetiveria zizanoides, P.rosalea, Palma rosa.*
- Dye yielding plants: *Lawsonia inermis, Hibiscus sabdariffa, Tagetus erecta, Indigofera tinctoria, Annato*
- Other economic shrubs: Curry leaf, Jatropa, Soapnut
- Animal component: Female cattle, Female Buffaloes, Male Cattle, Sheep and Goat
- Other enterprises: Sericulture, Poultry

**Contingent planning**

**For Red soils:**
- **June:**
  - **Sole crop:**
    - Sorghum (CSH 5, CSH-6, CSH-9), Pearl millet (MBH 110)
  - **Intercrop:**
    - Sorghum- pigeonpea (2:1)
    - Pearl millet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150 – 180 days may be used.
July:
Sole crop:
- Fingermillet
- Sow castor (Kranti, GAUCH-1)
- Bunch variety of Groundnut (TMV-2, JL-24)
Intercrop:
- Maize (DHM-101.Ganga-5)
- Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days
August:
Sole crop:
- Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
- Castor (Kranti, Aruna, GAUCH –1) with increased seed rate (15 kg/ha)

For Black soils
First crop
June:
- Sorghum (CSH-5, CSH-6)
- Maize: (Ganga 5, DHM-101)
- Greengram (PS-16, HB-45, LRG –30)
July:
- Maize (Ganga 5, DHM-101)
- Greengram (PS-16, HB-45, LRG –30)
Second crop
September:
- Maghi sorghum (Moti, CSH-6)
- Safflower: (Manjira)
October:
- Safflower: (Manjira)
- Chickpea (Jyothi)

District Region
Guntur Low runoff and Medium yield
Prakasam gap

Agro-ecological setting
Guntur
- Climate: Hot moist semi arid/ dry sub humid
- Physiography: Eastern ghats
- Soils: Medium deep loamy, clayey mix red and black soils, deep clayey coastal and deltaic alluvium derived soils (Aridisols – 40%; Vertisols – 30%; Alfisols – 30%)
- Annual rainfall: 704 mm
- Potential evapotranspiration: 1777 mm
- Moisture availability period: 150 - 180 days
Prakasam
- Climate: Hot moist semi arid/ Dry sub humid
- Physiography: Eastern Ghats
- Soils: Medium deep loamy, clayey mixed red and black soils, deep clayey coastal and deltaic alluvium derived soils (Vertic Inceptisols – 70%; Orthids – 30%)
- Annual rainfall: 848 mm
- Potential evapotranspiration: 1951 mm
- Moisture availability period: 150 – 180 days
Soil and water conservation
Guntur, Prakasam
- More emphasis on in situ water conservation like mulching, deep tillage, conservation furrows
- Increasing soil infiltration capacity and reducing soil crusting problem
- Supplemental irrigation wherever feasible
- Field bunds for smaller areas may be encouraged for wider adoption

Crop management
Prakasam
- Cultivars:
  - L 389, MCH 5, LRA 5166, JKHY 1, Savita, LAM Hybrid 1
- Seed rate: 8-10 kg/ha
- Date of sowing: 15th July to 15th August
- Planting pattern: 90 x 45 cm; 105 x 45 cm; 90 x 60 cm; 105 x 60 cm
- Nutrient management
  - 90 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 45 kg P2O5 + 45 kg K2O + 10-15 t FYM/ha. Entire P and K at sowing
  - 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P2O5 + 50 kg K2O + 10-15 t FYM/ha. Entire P and K at sowing
- Pest management
  - Summer ploughing
  - Avoid delayed sowings
  - Use of certified seeds
  - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
  - Destruction of weeds
  - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
  - Trap cropping with Okra (1:10), castor, marigold
  - Use of egg parasitoids Trichogramma sp.@ 1.5 lakh/ha
  - Spray H-NPV @ 250 LE/ha
  - Use of Neem oil 5%
  - Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
  - Weeding at 30 days after semi and of 60 days after sowing
- Some other important practices
  - Sowing up to 15th July in red soils
  - Sowing up to 15th August in black soils
  - Sowing upto June second fortnight (Alfisols)
  - Sowing upto second fortnight of July (deep black soils)

Suitable cropping systems
Guntur, Prakasam
- Cotton + pigeonpea

Farm implements/ tools
Guntur, Prakasam
- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube.

Alternate Farming systems
Prakasam
- Fodder/ green biomass: Albizia lebbeck, Dalbergia sissoo, Leucaena, Azadirachta, Hardwickia binata,
Acacia albida
• Fruit: Custard apple, tamarind, jamun, mango, ber
• Medicinal/ Aromatic Plants: Cassia angustifolia, Catharanthus roseus, Plantago ovata, Palma rosa, Vettiveria zyzyanoides
• Vegetables: Cluster bean, drumstick, cucumber, cowpea, ridge gourd, round melon, okra, watermelon.

District Region
Kurnool Low runoff and High yield gap

Agro-ecological setting
• Climate: Hot dry semi arid
• Physiography: Rayalseema
• Soils: Deep loamy, clayey mixed red and black soils (Alfisols – 60%; Vertic Inceptisols – 40%)
• Annual rainfall: 605 mm
• Potential evapotranspiration: 1828 mm
• Moisture availability period: 80 – 120 days

Soil and water conservation
• Contour bunds, graded bunds
• Contour bunding with a cross section of 0.63m2 and with horizontal spacing of 25m to 125m is recommended for red soils. The other soil conservation measures like Compartment bunds of 15m length and 10m width or conservation furrow at 3.6m interval or intercropping with mixed pulses like cowpea and horsegram can be adopted.
• Integrated watershed management (manage in a < 10 ha watershed)
• Water harvesting in lined with cuddapah slabs to avoid seepage losses dug out ponds
• Increasing catchment area and design of pond size for catchment size
• Interplot water harvesting of 1:1 cropped to uncropped area
• Use of life saving irrigation
• Improvement of indigenous water harvesting structures

Crop management
• Varieties: Mahanandi, NA – 920
• Seed rate: 10-12 kg/ha; 3-3.5 kg/ha for Hybrids
• Planting pattern:
  • 60 – 68 x 22 cm for Desi cotton
  • 60 x 30 cm for American cotton

• Nutrient management
  • 90 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 45 kg P2O5 + 45 kg K2O + 10-15 t FYM/ ha. Entire P and K at sowing
  • 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P2O5 + 50 kg K2O + 10-15 t FYM/ ha. Entire P and K at sowing

• Pest management:
  • Summer ploughing
  • Avoid delayed sowings
  • Use of certified seeds
  • Seed treatment with Captan or Thiram @ 2-3 g/kg seed
  • Destruction of weeds
  • Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every
ten rows of cotton
• Trap cropping with Okra (1:10), castor, marigold
• Use of egg parasitoids Trichogramma sp. @ 1.5 lakh/ha
• Spray H-NPV @ 250 LE/ha
• Use of Neem oil 5%
• Spray of Quinolphos @2 l/ha or Chloropyriphos @ 2 l/ha
• Weeding at 30 days after semi and of 60 days after sowing
• Fluchloralin @ 1.0 kg a.i./ha or Pendamethalim @1.5 kg a.i./ha Preplanting application with one interculture 35 days after sowing

Some other important practices
• Mungani – Sowing in May last week and first week of June
• Hingari – Second fortnight of August onwards for Desi cottons
• August 15th to September 15th – American cotton
• Seed treatment of with Azospirillum or Azotobacter
• Mulching with crop residues
• Providing good internal and surface drainage
• Deep ploughing once in 2-3 years

Farm implements/ tools
• Eenatigorr (bullock drawn, four row): Useful for sowing, seed and fertilizer placement. Suitable for those who have light draft animals: (Rs.1500 per unit)
• Seed drill/planter (tractor drawn, nine row): It is a mechanical seed drill. More area can covered in a day and intra row spacing is maintained (Rs.16000 per unit)
• Ashaguntaka (tractor drawn, seven row): Useful for harvesting of groundnut crop. More field capacity and labour saving (Rs.20000 per unit)
• Groundnut thresher cum decorticator: Useful for separating groundnut pods from haulms. It was found advantageous to thresh groundnut after 3-5 days after harvest. The cost of operation was Rs. 224/ha. It can also be used as decorticator with minor modifications. Perform timely operation and labour saving (Rs.45000 per unit)
• APAU groundnut seed cum fertilizer drill (three row – animal drawn)
• CRIDA seed cum fertilizer drill (four row – animal drawn)
• Groundnut thresher

Alternate farming systems
• Fodder/ green biomass: Dalbergia sissoo, Gliricidia, Albizzia lebbeck, Cassia siamea, Azadirachta indica/ stylo, Marvel-8 grass
• Fruit: Ber, Custard apple, Pomegranate, Amla + in kharif spreading crops
• Medicinal and aromatic plants: Cassia angustifolia, Catharanthus roseus, Palma rosa, Vetiveria zizanoides, Rose, Geranium
• Vegetables: Onion, Brinjal, Chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
• Crop + livestock (sheep @ 10/ha) system of farming will give 80% more income than crop system alone.

Contingent crop planning
• Early onset of monsoon (last week of May or in June): Sorghum (CSH-5), greengram, pigeonpea (PDM-1), castor (Aruna, GAUCH –1), mesta (AMV –1)
- Normal onset of monsoon (July): Groundnut, pigeonpea (TMV –2,J-11), groundnut + pigeonpea, castor (Aruna, GAUCH –1), mesta (AMV –1), setaria, pearlmillet (MBH –110, MH-88), greengram
- Late onset of monsoon (August): Sorghum, greengram (after August 15th), pearlmillet (MBH –110), setaria, groundnut (TMV –2)
- Very late onset of monsoon (September): Pearlmillet, cowpea, horse gram (early September), pearlmillet(MBH –110), horsegram (Anantapur local, BGM).