NABARD

National Bank for Agriculture and Rural Development
Climate Change Fund (CCF)

Study on

Adoption of Climate Resilient Technologies in Scarce Rainfall Zone of Andhra Pradesh

भाकृअनुप
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Abbreviations

AAS	Agro meteorological Advisory services
ATARI	Agriculture Technology Assessment and Research Institute
CRA	Climate Resilient Agriculture
CRIDA	Central Institute for Dry land Agriculture
CRT	Climate Resilient Technologies
CSA	Climate smart agriculture practices
GDP	Gross Domestic Product
ICAR	Indian Council of Agriculture research
IMD	Indian Meteorological Department
IPCC	Intergovernmental panel on climate change
KMS	Kisan Mobile Sandesh
KVK	Krishi Vigyan Kendra
Mo ES	Ministry of Earth Sciences
MRWF	Medium Range Weather Forecast
NCMRWF	National Centre for Medium Range Weather Forecast
NICRA	National initiative on Climate Resilient agriculture
NRM	Natural Resource Management
RCT	Resource conservation technologies
VCRMC	Village Climate Risk Management Committee
WMO	World Meteorology Organization

Details of Project Implementation

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ABSTRACT

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. The improved agricultural practices evolved for diverse agro-ecological regions in India have potential to enhance climate change adaptation. Adaptation is the most prudent tool to face the losses due to climate change. Resiliency is the ability of a system to absorb shocks and recover as quickly as possible to normal conditions. NICRA is an ICAR initiative launched in 151 climate vulnerable districts across the country. A number of climate resilient technologies were demonstrated and capacity building of farmers was done in the project. The present study made an attempt to investigate the perception of farmers on climate change and their adoption and their economic returns through adoption of the technologies and use of Agro Advisory Services using *ex-post facto* research design. Kurnool and Ananthapur districts of Andhra Pradesh were selected purposively as the locale of the study. Majority of the farmers are middle aged with high school education and are small farmers with good mass media exposure and medium extension contact. Majority of the farmers have high level of perception on climate change and its impact on agriculture in terms of increase in cost of cultivation, low yields due to dry spells and incidence of pest and diseases. Majority of the farmers are adopting climate resilient technologies. Eighty four per cent of the farmers in Kurnool district are adopting conservation furrows and 92 per cent are adopting drought tolerant varieties and intercropping of red gram and setaria. Calf registration and establishment of fodder banks are highly adopted by the farmers in livestock management. In Anantapur district 92 percent are adopting conservation furrows and 67 per cent of the farmers benefitted with check dams by providing life saving irrigation to their crops. Likewise 92 percent are adopting drought tolerant varieties followed by intercropping of red gram and groundnut. Majority of the farmers are maintaining small sheep units scientifically.

Independent variables are highly correlated to perception and adoption of the climate resilient technologies. The study also revealed that renovation of percolation tank helped in increasing the cropping intensity. Intercropping of setaria and red gram gave Rs 15,620/ha and Groundnut + red gram system gave Rs 20,200/ha additional net returns. Drought tolerant jowar variety N-15, groundnut variety Dharani, red gram variety PRG-176

and Bengal gram NBeG-3 gave additional net returns over farmers' practice. Calf mortality was reduced by 66 per cent and use of urea molasses and silage feeding to animal proved beneficial. Most of weather based agro advisory services given were pest and disease management followed by crop production, horticulture and livestock. Majority of the farmers felt that the services were utilized in selection of drought tolerant varieties and most of them strongly agreed that the messages were received in right time for control of pest and diseases. Fifty eight per cent strongly agreed crop management advisories helped to increase their crop yields and fifty three percent strongly agreed cost of supplementary irrigation was reduced followed by total cost of cultivation of the crop. Most of the farmers understood the message received. The study gave insight for the policy makers to emulate NICRA modules across the country and to redesign the already existing models with climate change perspective as it became a part of Indian farming.

CHAPTER I

Introduction

Earth Provides Enough for Every One's Need, Not for Their Greed

Mahatma Gandhi

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. The fact that climate affects development and development affects the climate has come to be known widely during recent times. The problem of human induced climate change first came into force and drew the attention of the scientists and policy makers when Inter Governmental Panel on Climate Change (IPCC) was established. The Inter governmental Panel on Climate Change (IPCC) defined climate in a narrow sense as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. For the past some decades, the gaseous Composition of earth's atmosphere is undergoing a significant change, largely through increased emissions from energy, industry and agriculture sectors, wide spread deforestation as well as fast changes in land use and land management practices. Left unmanaged, climate change will reverse development progress and compromise the well being of current and future generations. Impacts will be global, but much of the damage will be in developing countries, where, 11 per cent of arable land could be affected by climate change, including a reduction of about 16 per cent of agricultural GDP.

1.1 How Climate change impacts agriculture:

Climatic changes and increasing climatic variability are likely to aggravate the problems of future food security by exerting pressure on agriculture. Countries like India are more vulnerable in view of the high population depending on agriculture, excessive pressure on natural resources and poor coping mechanisms. In India, significant negative impacts have been implied with medium-term (2010-2039) climate change, predicted to reduce yields by 4.5 to 9 per cent, depending on the magnitude and distribution of warming. Since agriculture makes up roughly 16 percent of India's GDP, a 4.5 to 9% negative impact on production implies a cost of climate change

to be roughly up to 1.5 per cent of GDP per year (Venkateswarlu *et al*., 2013). The yield reduction likely brought out by many factors including pests, weeds and diseases, loss of biodiversity, rise in sea level, saline water intrusion in coastal belts, poor quality of irrigation water, decline in soil fertility, and irregularities in onset of monsoon, heat wave, cold wave, drought, flood and cyclone. Climate change can affect the yield positively as well as negatively. Through impacting agricultural inputs like water for irrigation and availability of solar radiation, the type of crops cultivated would be determined by climate variability. Agriculture, particularly in India with nearly 60% rainfed area, became a highly risky venture with vagaries of monsoon besides the interplay of other abiotic and biotic factors. It accelerates riskiness of agriculture with pronounced effect mainly due to two reasons; firstly rainfed agriculture is practiced on fragile, degraded and sloppy lands which are thirsty as well as hungry and prone to erosion. Secondly, the people dependent on rainfed agriculture are also lien in terms of financial, physical, human and social capital limiting their capacity to adapt to the changing climate. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which, much of the population depends.

Most of the studies projected that the decreased yield in rain fed and dry land wheat and rice and loss in farm net revenue between 9 to 25 per cent for a temperature increase of 2 to 3.5^{o}C. Sinha and Swaminathan (1991) showed that an increase of 2^{o}C temperature could decrease rice yield by about 0.75 tons/ha in the high yield areas, and a 0.5^{o}C increase in winter temperature would reduce wheat yield by 0.45 ton/ha. Saseendran *et al*. (2000) showed that for every one degree rise in temperature the decline in rice yield would be about 6 percent. Major impacts of climate change will be likely on rain fed crops (other than rice), which account for nearly 60 percent of cropland area. In India, poorest farmers often practice rain fed agriculture. For the temperature rise of 2 ^{0}C in mean temperature and a 7 per cent increase in the mean precipitation would create a 12 per cent reduction in net revenues for the country as a whole (Dinar *et al*., 1998).

1.2 Need for planned adaptation:

Enhancing agricultural productivity is critical for ensuring food and nutritional security for all, particularly the resource poor small and marginal farmers who would be affected most. In the absence of planned adaptation, the consequences of long term climate change could be severe on

the livelihood security of the poor. Therefore, it is of utmost important to enhance the resilience of Indian agriculture to climate change. *Resilience is the ability of a system to absorb shocks and recover as quickly as possible to normal conditions*. Planned adaptation is essential to increase the resilience of agricultural production to climate change. Management practices that increase agricultural production under adverse climatic conditions tend to support climate change adaptation because they increase resilience and reduce yield variability under variable climate and extreme events. The potential adaptation strategies are: developing cultivars tolerant to heat and salinity stress and resistant to flood and drought, modifying crop management practices, Improving water management, adopting new farm techniques such as resource conserving technologies (RCTs), crop diversification, improving pest management, better weather forecasting and crop insurance and harnessing the indigenous technical knowledge of farmers. The Government of India has accorded high priority on research and development to cope with climate change in agriculture sector.

The Prime Minister's National Action Plan on climate change has identified Agriculture as one of the eight national missions. With this background, The Indian Council of Agricultural Research (ICAR), New Delhi has launched a major network project entitled, ***National Initiative on Climate Resilient Agriculture*** (NICRA) during 2010-11, focusing on the process of developing district level contingency plans for all the rural districts of country with Central Research Institute for Dry land Agriculture (CRIDA), Hyderabad as the nodal agency with an outlay of Rs.350 crores for the XI Plan. The project was implemented by Krishi Vigyan Kendras (KVKs) at district level, regionally coordinated by the 11 ATARIs (Agriculture technology Application Research Institute) with overall planning, monitoring and coordination by CRIDA and was being implemented at large number of Research Institutes of ICAR, State Agricultural Universities and 100 KVKs (districts) in the beginning and now expanded to 151 KVKs (districts) across the country.

NICRA has the major objectives, to enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies; to demonstrate site specific technology packages on farmers' fields for adapting to current climate risks; and to enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application. Both short term and long terms outputs are expected from the project

in terms of new and improved varieties of crops, livestock breeds, management practices that help in adaptation and mitigation and inputs for policy making to mainstream climate resilient agriculture in the developmental planning. The overall expected outcome is enhanced resilience of agricultural production to climate variability in vulnerable regions.

1.2.1 Components of the Project:

- Strategic research on adaptation and mitigation
- Technology demonstration on farmers' fields to cope with current climate variability
- Sponsored and competitive research grants to fill critical research gaps
- Capacity building of different stake holders.

The technology demonstration component of NICRA identified climatic vulnerabilities of selected village in each of the 151 districts based on a scientific analysis of climate related problems, farmers' experiences and perceptions. Adaptation and mitigation strategies were implemented through intervention modules following a bottom-up approach. The focus of the programme is not only to demonstrate the climate resilient agriculture technologies but also to institutionalize mechanisms at the village level for continued adoption of such practice in sustainable manner. Under the technology demonstration component, interventions are generally undertaken in four modules in order to address the climatic vulnerabilities. While the specific interventions for each village would be based on the needs and requirements, and climatic vulnerability of that particular village. Availability of resources also plays a role in determining the interventions. The four modules of intervention are briefed below:

1.2.1.1 Natural resources:

This module consists of interventions related to in-situ moisture conservation, biomass mulching, residue incorporation instead of burning, brown and green manuring, water harvesting and recycling for supplemental irrigation, improved drainage in flood prone areas, conservation tillage, artificial ground water recharge, renovation of the water harvesting structures and water saving irrigation methods.

1.2.1.2 Crop Production:

This module consists of introducing drought/temperature tolerant varieties, crop diversification , introduction of new cropping sequence ,advancement of planting dates of *Rabi* crops in areas with terminal heat stress, water saving paddy cultivation methods (SRI, aerobic,

direct seeding), frost management in horticulture through fumigation, community nurseries in multiple dates for delayed monsoon, farm machinery custom hiring centers for timely completion of farm operations, location specific intercropping systems with high sustainable yield index.

1.2.1.3 Livestock and Fisheries:

Major activities of this module are use of community lands for fodder production during droughts/floods, augmentation of fodder production through improved planting material, improved fodder/ fodder banks and fodder storage methods like silage and haylage. Fodder enrichment, prophylaxis, improved shelters for reducing heat stress in livestock, management of fishponds/tanks during water scarcity and excess water and promotion of livestock as a climate change adaptation strategy.

1.2.1.4 Institutional Interventions:

This module consist of institutional interventions either by strengthening the existing ones or initiating new ones relating to community seed bank, fodder bank, commodity groups, custom hiring centre, collective marketing group, introduction of weather index based insurance and climate literacy through a village weather station will be part of this module. Creating awareness and Capacity building among farmers and other stake holders on resilient Agriculture.

1.3. Need for weather forecasting:

It is estimated that about eight percent of the total crop losses can be avoided through improved weather forecasts. Better understanding of weather and its variability on the overall effect of the different processes contributing to agricultural production is necessary to adopt appropriate cropping system, soil and water management practices. Weather forecasting is essential especially when farm management strategies provided mitigation techniques to crops/ livestock.

1.3.1 Attempts in scientific weather forecasting:

Weather forecasts in all temporal ranges are desirable for effective planning and management of agricultural practices. The development of response strategy helped farmers realize the potential benefits of using weather-based agro meteorological information in minimizing the losses due to adverse weather conditions, thereby improving yield, quantity and quality of agricultural productions. In fact, short and medium-range weather forecasts play a significant role in making short-term adjustments in daily agricultural operations.

Weather service for the farmers in India was started by the India meteorological department (IMD) in 1945. However, attempts in this direction were imitated in 1932. The Government of India established the National Centre for Medium Range Weather Forecasting (NCMRWF) under Department of Science and Technology in 1988 to develop suitable numerical weather prediction models for medium range forecast (3-10 days in advance).

The main objectives of NCMRWF are:

- Develop location specific medium range weather forecasts.
- Develop weather-based agro-based meteorological Advisory services (AAS) to the farming community.
- Promote and coordinate research in related areas of meteorology and agro-meteorology.
- Agro met Advisory Bulletins comprising of expert advice on the crop, soils and weather are made available to the farming community by AAS units in 83 zones in the country.

These units disseminate it in real time through TV, AIR and newspapers to the farmers. The AAS set up is multi-disciplinary and multi-institutional. Some of the early works that appeared in the late 1960s concentrated on effectiveness of agro meteorological information. Studies have also been carried out to determine the potential benefits in agricultural farm decisions from long-range weather predictions, particularly in areas where the El Niño/Southern Oscillation has marked impact on the regional climate. However, very little work has been done on the economic impact of medium-range weather forecasts on farm-level decisions. In general, it is difficult to assess the economic benefit of any advisory service given to take measures against catastrophes or life-threatening situations, but it is possible to assess the economic benefit of the agro meteorological services. This can be done if the scientific methods to be used for weather-based advisories which have a direct relationship with the traditional knowledge of the farmers.

From a farmer's perspective, the forecast value increases if the weather and climate forecasts are capable of influencing their decisions on key farm management operations. Thus, it becomes essential to relate with the requirements of farmers, understand their needs and give the forecast in appropriate spatial and temporal range. This ultimately helps in increasing the reliability of the forecast and thus in better adoption of the weather-based advisory.

The National Centre for Medium Range Weather Forecasting (NCMRWF) under the Ministry of Earth Sciences (MoES), Government of India in collaboration with India Meteorological

Department (IMD), Indian Council of Agricultural Research and State Agricultural Universities had been providing Agro meteorological Advisory Services (AAS) at the scale of agro climatic zone to the farming community based on location-specific medium-range weather forecast (MRWF). Since 2007, the entire framework of AAS, developed and successfully demonstrated by NCMRWF, has been relocated at IMD under Mo ES for extending the service (in operational mode) to districts under these agro-climatic zones. It is now called the Integrated Agro meteorological Advisory Service of Mo ES. Thus, the AAS set up exhibits a multi-institutional, multidisciplinary synergy to render an operational service for use of the farming community.

These weather-based agro-advisories have been helping the farming community to take advantage of prognosticated weather conditions and thereby form a response strategy. This was also reported by the AAS units about farm operations so that, the farmers utilize the information on crop management and reduce the crop damage (Rao, 2003).

All the four modules were implemented in the NICRA village. Selected technologies based on the need of the farming situation of the village were demonstrated.

1.4 Statement of the problem:

India is currently experiencing the severe impact of climate change. With unpredictable weather, farmers keep changing crop management practices by growing resistant varieties and are prepared for constant changes in the farming practices. Several global studies also depicted that India is particularly vulnerable to climate change as major portion of agriculture is rainfed. Practices imparting climate resilience in agriculture and livestock management are the best adaptation option available. Preparedness to the climate vagaries and better incorporation of people from various strata can propel adoption of these practices. NICRA had been implementing its interventions across the country. Technology demonstration component and capacity building component of NICRA had paved the way to climate resilience in 151 districts. Perception of Climate Change, Extent of Adoption of Climate Resilient Technologies and use of Agro Advisory Services in these areas are to be analyzed to find out the extent to which these technologies could induce resilience of stakeholders for sustainable agriculture production and development.

1.5 Supporting literature across the globe:

Literature review is very crucial for any research study. The major objectives of literature review are to find out both theoretical and empirical work that has been done before, assist in delineation of the problem area, provides insight in to methods and procedures, provide a basis for theoretical framework, suggest operational definitions of major concepts and provide a basis for interpretation of findings. This research work is strictly a new one and it omitted any duplication, however the study has been enriched by various related investigations conducted in the area.

Anley *et al*., (2007) stated that improved education and disseminating knowledge is an important policy measure for stimulating awareness and local participation in various development and national resource management initiatives.

David (2007) indicated that, by using Heckman's sample selectivity probit model reveals that although experienced farmers are more likely to perceive climate change, it is educated farmers who are more likely to respond by making at least one adaptation. In terms of policy implications, it appears that improved farmers education would hasten adaptation. The provision of free extension advice may also play a role in promoting adaptation and improved transport links would improve adaptation. Farmers who have enjoyed free extension advice and who are situated close to the market are also more likely to adapt to climate change.

Nhemachena and Hassan (2007) reported that, farmers with access to free extension services, credit and markets significantly increase the probability of taking up adaptation options except moving from farming to non-farming. Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options.

Nhemachena and Hassan (2007) also suggested that, mixed crop and livestock farmers are associated with positive and significant adaptation to changes in climatic conditions compared to specialized crop and or livestock farmers. The mixed farming systems are better, able to cope with changes to climatic conditions by taking up various changes in management practices.

In Ethiopia, Deressa, Hassan, Ringler, Alemu, and Yesuf (2008) analyzed the determinants of farmers' choice of adaptation methods in the Nile Basin. Using cross-sectional data from a survey of farmers to illicit information on adaptation methods, the study found that the adaptation methods currently in place in the study area are; changing planting dates, using different crop varieties, planting tree crops, irrigation and soil conservation. The farmers reported that the use of different crop varieties was the most common adaptation method, while irrigation was the least common. They also reported that the reasons for not adapting are lack of information on climate change impacts and adaptation technologies, lack of financial resources, labour constraints and land shortages. The level of education, age, sex and household size of farmers were found to be significant determinants of adaptation to climate change in the study area. Also farmers in different agro ecological settings employ different adaptation methods.

Anil *et al*., (2010) observed that 51.25 per cent, 35.00 per cent and 13.75 per cent of the respondents had medium, high and low extent of adoption of cultural practices for water and soil conservation respectively. With regard to mechanical practices, majority (46.25%) of the respondents had medium, 36.25 per cent high and 17.50 per cent had low extent of adoption of mechanical practices for water and soil conservation. In case of horticultural practices, 38.75 per cent respondents showed high level of adoption, while 36.25 and 25.00 per cent respondents had medium and low level of adoption of these practices. In case of vegetative practices, majority of the respondents i.e. 48.75 per cent had medium extent of adoption of vegetative practices for water and soil conservation. Thus, there was a considerable variation in the extent of adoption of various watershed development practices. The extent of adoption of vegetative practices by the respondents was low followed by mechanical practices as compared to rest of the selected practices.

Acquah-de Graft and Onumah (2011) analyzed information collected from 185 farmers from western Ghana about their perceptions on, and adaptations to climate change in the region. While the majority of the farmers perceived increase in temperature and decreased precipitation as the climate change variables in that region, only 18per cent of the respondents did not perceive any changes in the two climatic variables. While about 60per cent of the respondents reported the use of one or more adaptation methods, 40per cent did not adopt any adaptation measures. The main adaptation measures adopted by farmers include changing planting dates, using different

crop varieties, planting tree crops, practicing irrigation, soil conservation and water harvesting. The farmers identified lack of information on climate change impacts and adaptation options, lack of access to credit, access to water, high cost of adaptation, insecure property rights and lack of access to sufficient farm inputs as the main barriers to the adoption of any adaptation measure. The probit analysis indicated that the significant determinants of adaptation to climate change are age, gender, education, farming experience, own farm land and other income generating activities.

Latha *et al*., (2012) concluded that the small and medium rainfed farmers were highly vulnerable to climate change and to a larger extent the small and medium rainfed farmers adopted coping mechanisms for climate change compared to large farmers.

Pathak (2012) identified ten adaptation options having the highest priority in mitigating climate vulnerability following experts ranking. These options were climate-ready crop varieties, water saving techniques, changing planting dates, integrated farming system, growing different crops, integrated pest management, crop insurance, conservation agriculture, improved weather based agro-advisory and improved nutrient management.

Ananta Vashisth *et al*., (2013) studied the adaption of Agro met advisory bulletin and economic impact of Agro met advisory services for wheat and rice in Rural Delhi and concluded that farmers are able to reduce the cost of inputs who followed Agro met services. It was also observed that net profit of AAS farmers was due to crop management done by them according to the farm advice given in the bulletin. It was also confirmed that the farmers, who followed the Agro met advisories, are able to minimize the input cost and increase the net profit as compared to the non AAS farmers in wheat, carrot and rice. This gain was due to the crop management done by the farmers according to Agro met advisory bulletins. Thus, the application of Agro met advisory bulletin, based on weather forecast is a useful tool for enhancing the production and income.

Hussain *et al*., (2013) concluded that Crop adaptation strategies viz., changes from long to short duration varieties (75%), changes in planting dates (85%), changes in quantity of seeds, fertilizer application, number of irrigation and spacing was adopted by majority (73%) of the farmers.

Venkatesh *et al*.,(2013) found that the utility of weather forecast information was more for spraying in grape gardens to eight per cent for inter-cultivation activities in field crops. Thus, by

adopting the weather forecasts for important agricultural operations, the farmers are coping up with the adverse effects of climate change.

Jasna (2015) stated that the data on average cropping intensity from both districts (Gumla and Thumkur) had shown that average cropping intensity of NICRA farmers was higher than that of non-NICRA farmers. The difference was tested using t-test to know statistical significance .The cropping intensity in NICRA village was 124.75 per cent where as in non-NICRA villages the cropping intensity was recorded as 66.22 percent ,and the difference was statistically significant at less than five per cent level of significance. The difference may be as a result of positive response of farmers to NICRA interventions.

Rani Saxena *et al*., (2015) reported that under use of agromet advisory services (AAS), the input cost is lessened and the net profit rose as compared to the non AAS in all the crops. This economic benefit was attributed to timely management of scarce resources in crops according to weather forecast based agromet advisory. Therefore it was concluded that the application of weather forecast based agromet advisory bulletin was useful tool for sustaining the production and overall farm income.

Madan *et al*., (2015) studied the M KRISHI^{R} (m= mobile; Krishi+ agriculture) platform, developed by Tata Consultancy services in Nashik in Maharashtra and Kanchipuram in Tamilnaadu and concluded that perception of the farmers on timeliness of farm advisories was high with regard to agronomic information (85%) followed by soil and water conservation information (83.3 %), pest and disease management (81.7), credit (76.7%) varietal information (72 %) and post harvest technology information. Regarding the quality of information more than 89 percent farmers perceived quality of information regarding crop protection was good followed by weather advisory. Seventy percent of the farmers opined that utility of information is highly relevant to the farming situation and they also opined that the information was suitable to big and small farmers 68.3 %). Eighty percent of the farmers felt that the information provided was cost effective and the language of the text message was clear and understandable (81.7%). The overall effectiveness of mKRISHI^{R} was highly effective (46.66%).

Arun *et al*., (2016) stated that about 60 per cent of survey households in the study sites implemented at least one CSA practice/technology in their farm. Majority of the CSA adopters

prefer to use improved crop varieties (80%), laser land levelling (42%), crop rotations (23%) and zero tillage practice (11%). The improved crop varieties which are tolerant to severe floods, droughts and pest/diseases, use nutrients and water efficiently and can adjust to climate change and variability. These varieties can be sown in different planting dates in a cropping season to adjust with changing monsoon time and temperatures. Laser land levelling and zero tillage could be water saving technologies for water deficient areas. For example, laser land levelling, by making the field well levelled, enhances water use efficiency compared to unlevelled fileds. Similarly, zero tillage with residue retention conserves soil moisture; reducing evaporative loss of moisture thus requiring less water than conventionally tilled fields.

According to Srinivasa Rao *et al*., (2017) adoption of farm ponds led to visible change in cropping pattern and area under rabi crops. Highest yield increase was noticed in green gram followed by Tomato. Crops like groundnut, sorghum soybean recorded significant yields after adoption of farm pond technology in Adilabad district of Telangana. In Ananthapur district ground nut yield increased from 12 .2 to 15.6 q/ha due to irrigation. In Chithoor district of Andhra Pradesh farm pond water was used to irrigate ground nut, fruits and vegetables. Increase in yield was more than 25 per cent for all the crops.

According to the Studies conducted in Jabalpur district of Madhya Pradesh by Sonal Agrawal *et al*., (2019) medium level of adoption of recommended practices (61 %) was observed in Kisan Mobile Sandesh beneficiaries. Majority of the young age group (57.26%) utilized KMS with high school education, medium size land holdings, and medium annual income. Economic motivation is high with higher information seeking behavior. KMS approach in addition to old approach gave confidence and trust between extension field functionaries and farmers. And also useful in obtaining feedback from the farming community, which helps in proper transfer of technology.

1.6 Need for the study:

Long term data for India indicates that rainfed areas witness 3-4drought years in every 10 year period. To overcome the drought, farmers have to be ready to adopt climate resilient agriculture technologies. Several improved agricultural practices evolved for diverse agro-ecological regions in India have potential to enhance climate resilience, if followed effectively. The study will help to portrait the status of farmers' perception and adoption of climate resilient technologies and use of agro advisory services for enhancing their income and yields. It provides a reasonable understanding on level of perception and adoption of climate resilient technologies among farming community, and to isolate factors promoting adoption and those hinder. The study will be of immense help in drawing a roadmap for taking up institutional interventions and extension strategies for adoption of the resilient technologies by the farmers. The study helps to delineate the economical resilient technologies also. It also helps in stream lining the different agro advisories given to farmers. Incorporating critical points from these, some potential suggestion are put forward in this study. The study is expected to be very relevant for the National level Organizations, , Planners, Policy makers, SAU and Researchers to identify points of success and failures, thus to reshape further step of their action. Relevance of the study has been enriched by some proposals for up scaling these technologies to more compatible, convenient but advanced levels. Further, the study offers few recommendations to facilitate replication of CRA technologies in other parts of the country as the Indian agriculture especially rainfed agriculture should go through the filter of climate change for more net returns and saving of resources especially soil water, air and plantation.

This study in turn helps in up scaling the technologies for improvement of farm production. It is high time to adopt climate resilient technologies; otherwise the future generations will surely be affected. The cultivation aspects should be probed deeply, as the cultivation aspects of the farmers are very much related to the behavior of the farmers in terms of knowledge level, perception, adoption and their socio-economic characteristics.

The literature on perception and adoption of climate resilient technologies in rain fed agriculture are scanty. Economic gains of the farmers by adoption of climate resilient technologies are not yet studied in detail. It is therefore felt necessary to study these aspects to get first-hand information from the practicing farmers and their suggestions for improvising the project model.

Keeping these factors in view, the present field investigation entitled **Study of adoption pattern of climate resilient technologies in agriculture in Scarce rainfall zone of Andhra Pradesh** has been undertaken with the overall objective of analysing the climate resilient technologies in rainfed agriculture under NICRA project in scarce rainfall zone of Andhra Pradesh covering Kurnool and Anantapur districts. The specific objectives of the study are as follows:

1.7 Objectives of the Study:

- To study the perception of farmers on climate change in agriculture.
- To know the adoption pattern of climate resilient technologies by the farmers.
- To study the impact of adopting climate resilient technologies on costs and returns.
- To study the impact of weather-based agro advisory services and extent of adoption by the farmers.

1.8 Hypotheses of the Study:

- The perception levels of the farmers on climate change are low.
- There is no adoption of climate resilient technologies among the farmers.
- There adoption pattern of climate resilient technologies has no impact on costs and returns among the farmers.
- There is no association between weather-based agro advisory services and the adoption pattern of climate resilient technologies among the farmers.

1.9 Operational definitions:

1.9.1 Climate Change:

Climate change refers to any change in climatic parameters (rainfall, temperature) over time, due to natural variability or as a result of human activity.

Climate Change refers to the climate of a place or region is changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean state or variability of the climate for that place or region. (UN/ISDR, 2004).

Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. (en.wikipedia.org/wiki/Climate change 2010)

1.9.2 Perception:

Perception is understanding and elucidation of changes in climate (rainfall, temperature) by farmers based on their past experience.

According to Kaste and Rosenzwing (1982) perception is basic to understanding behaviors because it is the means by which stimuli affect an organization or individual.

1.9.3 Adaptation:

Adaptations are the adjustments or alternations introduced by farmers in their farming system in order to manage the losses or to take advantage of changes in climate (rainfall and temperature).

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC TAR, 2001).

Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events is enhanced, developed, and implemented (UNDP, 2005).

1.10 Research Methodology:

Methodological and technical aspects embarked for accomplishing the research investigation are debuted in this chapter. Various aspects implemented in this study are had been organized under the following rubrics

1.10.1 Design:

Since the variables selected for the study had already occurred and are established facts, Ex-post-Facto research design has been followed for the conduct of the study and testing of the hypotheses.

1.10.2 Locale of the study:

The study was conducted in Kurnool and Anantapur districts of ***Scarce Rainfall*** Zone of Andhra Pradesh. The research locale was selected purposively, as the NICRA was being implemented in these districts since its inception. Kurnool and Anantapur districts represent dry

land and rainfed agro ecosystem and are mostly affected by drought and poor soil health. The study area is vulnerable to climatic variability.

1.10.3 Selection of Villages and Respondents:

The Kurnool and Ananthapur districts from the state of Andhra Pradesh are selected for the study as the NICRA project was being implemented since 2010-11. From each district, three villages were selected on the basis of random sampling method. Three villages, i.e., Yagantipalle, Meerapuram and Cherlokothuru were selected from Kurnool district and Chelamanuru, Chakaraipeta and Peravali villages of Ananthapur district are selected because the project was implemented in these villages. From each village, 30 farmers were selected for the study on the basis of random sampling method, covering a total of 180 farmers.

1.10.4 Tools of data collection:

Based on the objectives of the study, a semi-structured interview schedule was developed for the study. The data was personally collected by interviewing the respondents. The farmers were contacted at their residence or field.

1.10.5 Source of Secondary data:

Secondary data was collected from the annual reports of the NICRA project from Anantapur and Kurnool KVKs, ATARI zone 10 website, NICRA website, ICAR website various journals in agriculture sciences, social sciences, books, magazines, and other published articles in leading newspapers and relevant unpublished material.

1.10.6. Sampling Frame work:

District	Revenue division	Mandal	Village	No. of samples
Kurnool	Nandyal	Banaganapalle	Yagantipalle	30
Kurnool	Nandyal	Banaganapalle	Meerapuram	30
Kurnool	Nandyal	Banaganapalle	Cherlokothur	30
Anantapur	Anantapur	Singanamalla	Chamalur	30
Anantapur	Anantapur	Singanamalla	Chankaraipet	30
Anantapur	Anantapur	Narpala	Peravali	30

1.10.7 Tools of Analysis:

The data collected from the respondents was scored, tabulated and analyzed using statistical tools and techniques such as mean, standard deviation, chi-square test, correlation, ANOVA and multiple regression with the help of a computer using SPSS (statistical package for social sciences).

1.11 Limitations of the study:

Being undertaken by three members, and confined to NICRA project villages, the study suffers from the following usual limitations.

- The study was restricted to six villages from two districts, i.e., Kurnool and Anantapur from Andhra Pradesh.
- The study is limited to a sample of 180 respondents in view of time and resource constraints.
- As the study used Ex-post-facto design all the disadvantages and shortcomings associated with the design set the limitations for the study. The oral response bias could be one of the limitations of the study.
- The results of the study are applicable only to the farmers of the study villages and to similar situations prevailing elsewhere.

In spite of the above limitations, it is hoped that this study would provide better insight into the use of climate resilient technologies and their impact on costs and returns of the farmers. It may also help in formulating better strategies for up scaling the climate smart technologies for rain fed farmers.

CHAPTER II

Results and Discussion

This chapter is the heart of the project study; it is a blend of the results and findings based on data collected from the field and from other sources. The results are based on analysis of the data with regard to perception about climate resiliency, adoption pattern of climate resilient technologies and -economic impact of these technologies and use of agro-advisory services by the farmers. The results are presented, discussed and interpreted under the following heads:

1. Profile characteristics of the respondents.
2. Perception of farmers on climate change.
3. Adoption pattern of climate resilient technologies by NICRA farmers.
4. Economic impact of climate resilient technologies.
5. Utility of weather based agro advisory services.

2.1. Profile characteristics of the respondents:

2. 1. 1. Age:

Majority of the farmers from Table 1 (65 %) belongs to middle age group followed by young age group (25 %). Only ten per cent of the sample belongs to old age group.

It was evident from the table 1 that the majority of the farmers who are in middle and old age are stuck with agriculture and the youth are leaving to towns and cities for better options other than agriculture**.** The findings are in agreement with Ramesh I Chadachal (2017) and kaliyan babu (2019).

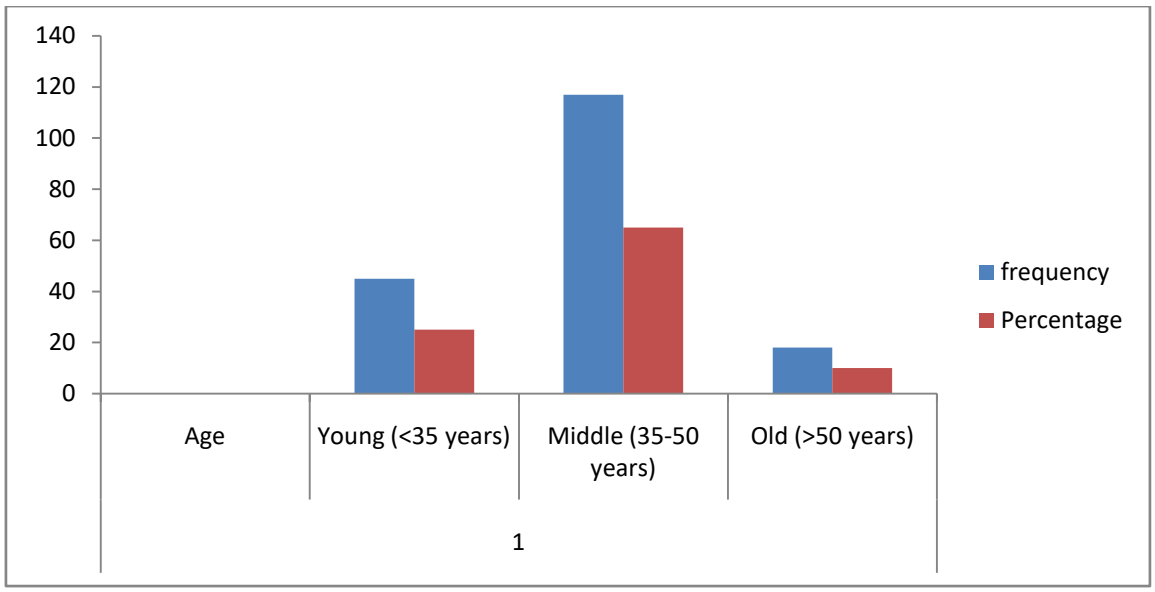


Figure 1. Distribution of respondents according to Age

2.1.2. Education:

From the table 1 it was found that the majority of the farmers completed high school education (58.88%) followed by intermediate education (13.89%), and graduation (10%), primary and middle school. However 3.33 percent of the farmers are still illiterate.

It can be concluded that majority of the farmers are literate they can read write and understand any information regarding climate and agriculture. Old aged farmers have not attended school, it may be due to lack of awareness about education.

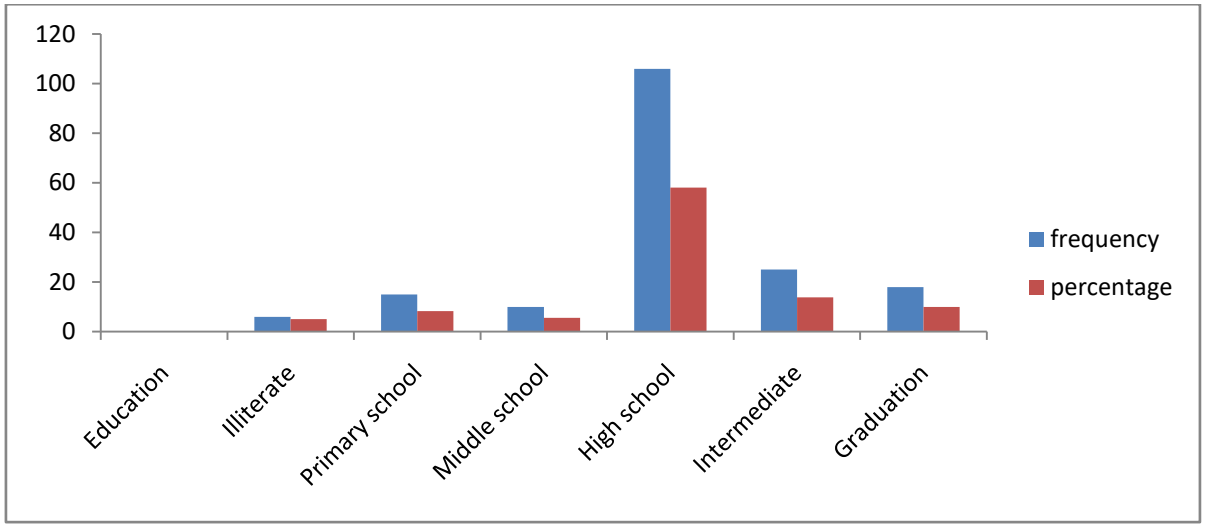


Figure 2. Distribution of respondents according to education

2.1.3. Land Holding:

From the table 1 it was evident that the majority of the farmers (53.4%) possess land holding of 2.5 to 5 acres. acres, followed by farmers with more than five acres (27.22 %) and the rest are marginal farmers with less than 2.5 acres of land. It can be concluded that majority of the land holdings belong to small and marginal category followed by medium category land holdings.

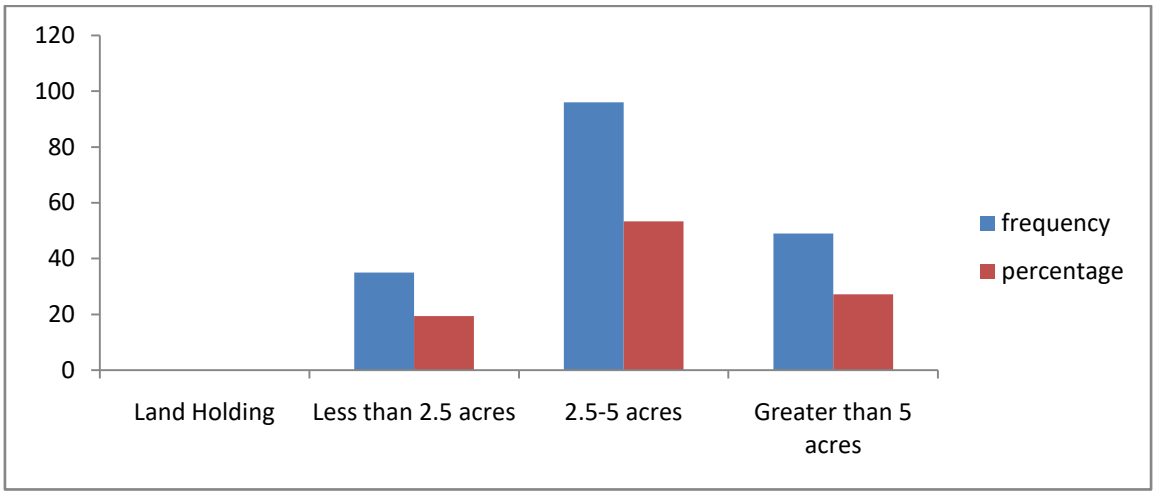


Figure 3. Distribution of respondents according to Land Holding

2.1.4. Farming Experience:

Majority of the farmers from table1 (47.22) had 10-20 years of experience, followed by 20 years experience (32.23) and 20.55 per cent of the respondent have experience less than 10 years. It can be concluded that the middle and old aged farmers were in to agriculture and youth are not interested in agriculture.

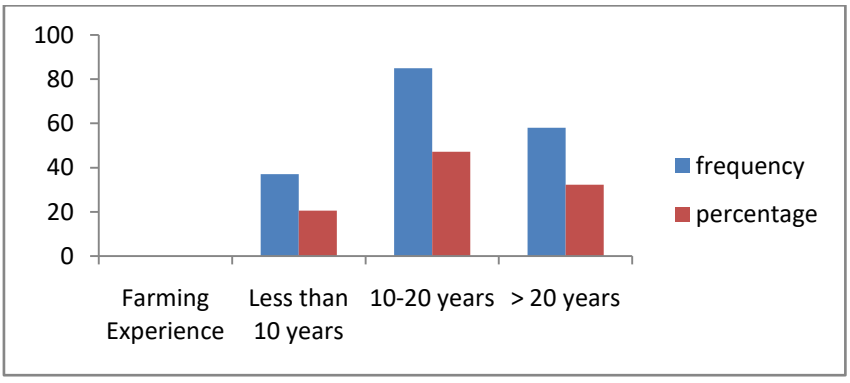


Figure 4.Distribution of respondents according to Farming Experience

Table 1: Profile characteristics of the respondents

S. No.	Variables	NICRA farmers (n=180)	
		Frequency	Percentage
1.	**Age**		
	Young (<35 years)	45	25.00
	Middle (35-50 years)	117	65.00
	Old (>50 years)	18	10.00
2.	**Education**		
	Illiterate	6	5.00
	Primary school	15	8.3
	Middle school	10	5.5
	High school	106	58.08
	Intermediate	25	13.8
	Graduation	18	10.00
3.	**Land Holding**		
	Less than 2.5 acres	35	19.4
	2.5-5 acres	96	53.3
	Greater than 5 acres	49	27.2
4.	**Farming Experience**		
	Less than 10 years	37	20.55
	10-20 years	85	47.22
	> 20 years	58	32.23

2.1.5 Mass media exposure:

From the table 2 it was indicated that majority of the respondents (45%) have high exposure to mass media followed by medium exposure(38.33) and low exposure to mass media (16.67%) to mass media.

It can be concluded that majority of the respondent have exposure to mass media, this can be attributed to the mass media such as TV and mobiles. Only few farmers with high exposure to mass media can be attributed to their personal interest on agriculture and availability of mass media.

Table 2: Distribution of respondents according to their mass media exposure

S. No.	Category	Frequency	Percentage
1	Low (<9.66)	30	16.6
2	Medium (9.66 – 13.03)	69	38.3
3	High (>13.03)	81	45.00
Mean: 11.35 SD: 3.36			

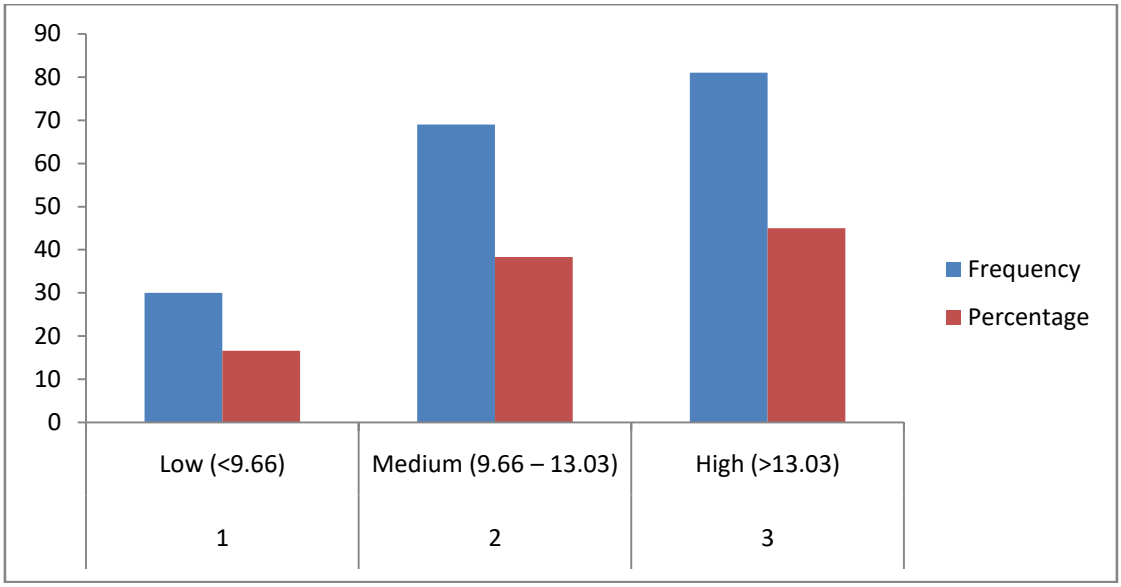


Figure 5. Distribution of respondents according to their mass media exposure

2.1.6 Extension Contact:

From the table 3 it was found that distribution of respondents to extension contact was medium (51.11%) followed by high (25%) and low (23.89%) levels of extension contacts.It can be concluded that the extension contacts are fairly maintained by the respondents.

Table 3: Distribution of respondents according to their extension contact

S. No.	Category	Frequency	Percentage
1	Low (<14.27)	43	23.8
2	Medium (14.27 – 17.52)	92	51.11
3	High (>17.52)	45	25
Mean: 15.90 SD: 3.25			

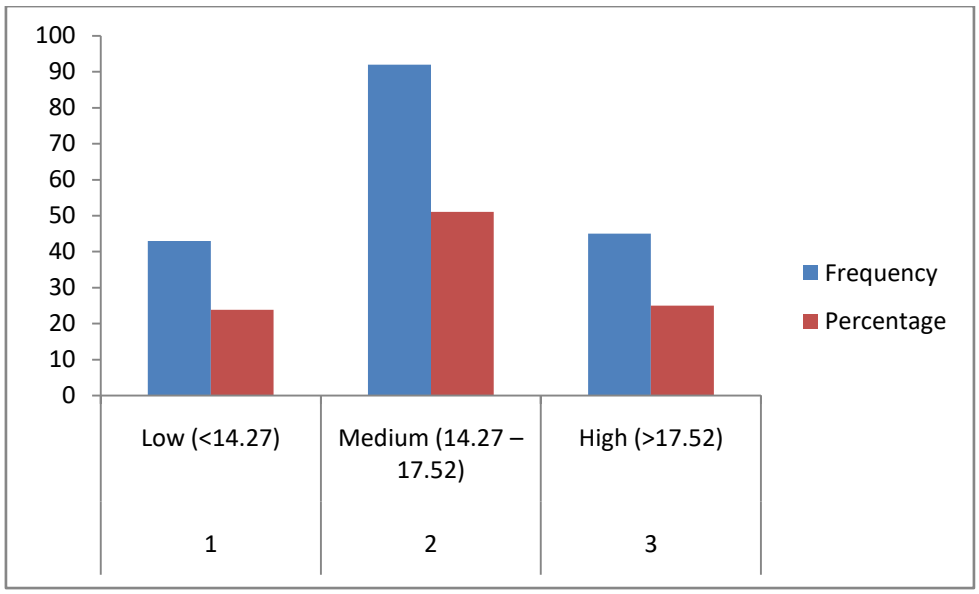


Figure 6 .Extent of contact with extension functionaries

2.2. Perception about climate change:

2.2.1 Perception level on climate change

From the table 4 it was evident that the majority of the respondents have high level of perception (61.11%) on impact of climate change in agriculture, followed by medium level of perception .It is clearly evident that only five per cent of the farmers are under low level of perception about climate change.

It can be concluded that more than sixty per cent of the respondents have good perception on climate resiliency. The reason behind their perception levels on climate resiliency is attributed for their participation in the different activities such as taking up demonstrations on climate resiliency and capacity building programmes under NICRA project**.** The results are in line with Maddison (2006), Nhemachena and Hassan (2007) and Shankara M. H 2010.

Table 4: Distribution of respondents according to their perception level on Climate change

S. No.	Category	Frequency	Percentage
1	Low (<15.79)	9	5.00
2	Medium (15.79 – 19.30)	61	33.89
3	High (>19.30)	110	61.11
Mean: 17.55 SD: 3.50			

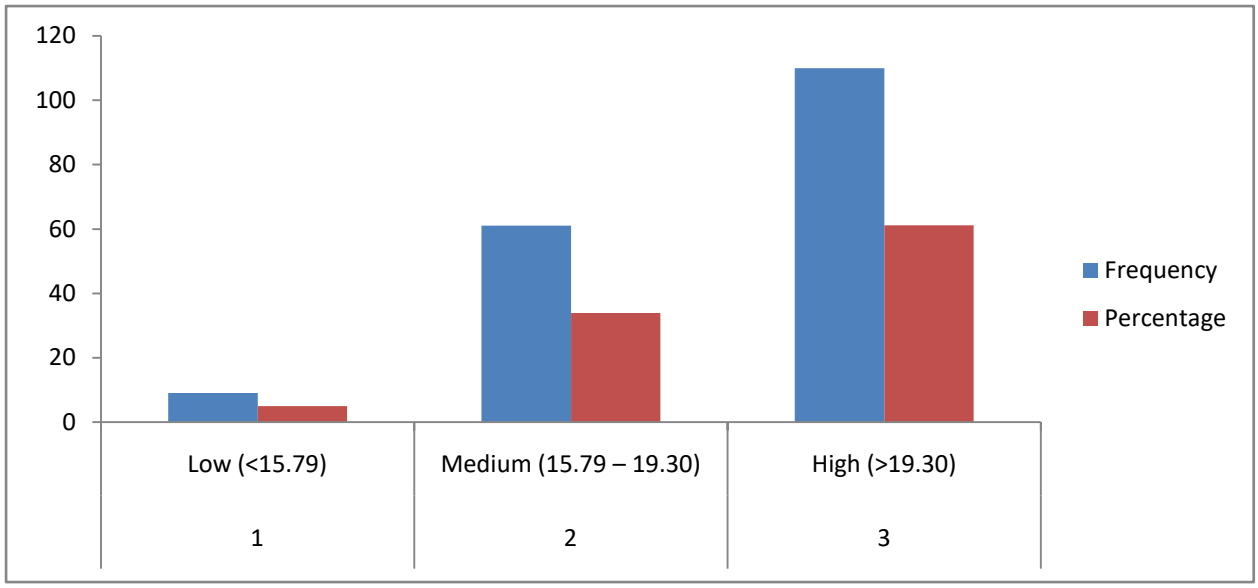


Figure 7 .Perception level of farmers on Impact of Climate Change in Agriculture

2.2.2. Perception of farmers on impact of Climate Change on Agriculture:

Table 5 depicts that farmers in the study area had good perception on climate change impact on agriculture as rainfall and temperature play an important role in production of crops. But direct impact of temperature on crop performance and incidence of pest and diseases is a hidden factor. But farmers are able to judge impact in terms of evapotranspiration, incidence of pest and diseases. The farmers in the study area agreed that Rainfall distribution was uneven and cost of cultivation increased due to climate change. Ninety five per cent of the farmers perceived that the dry spells in the critical stages of the crop growth period. Ninety three per cent of the farmers felt that incidence of pest and diseases increased due to climate change and 86.67 per cent of the farmers perceived that crop yields were reduced. Almost seventy nine per cent of the farmers opined that the onset of the monsoon is delayed / changed. Seventy percent of the farmers perceived that crops cultivated were being changed in view of climate change while 30 per cent of the farmers have no idea. Sixty eight per cent of the farmers perceived that more loss of nutrients from the soil due to heat while 32 per cent of them were unable to perceive. These results are in conformity with studies of Vernon (1994) Sinha *et al*., (1998).The results are also in line with Shankara M. H 2010 and Latha *et al* 2012

Table 5: Perception of farmers about impact of Climate change on agriculture

S.No	Statement	Response					
		Agree		Cannot say		Disagree	
		F	%	F	%	F	%
1	Change in the onset of monsoon	142	78.89	38	21.11	-	-
2	Rainfall distribution is uneven	180	100	-	-	-	-
3	Cost of cultivation increased due to climate change.	180	100	-	-	-	-
4	More loss of nutrients from soil due to heat	123	68.33	57	31.67	-	-
5	Incidence of pest and diseases increased due to climate change	167	92.77	23	12.78	-	-
6	Crop yields were decreased	156	86.67	24	13.33	-	-
7	There is change in crops sown due to climate change	126	70	54	30	-	-
8	Experienced dry spells in critical stages of crop	171	95	9	5		

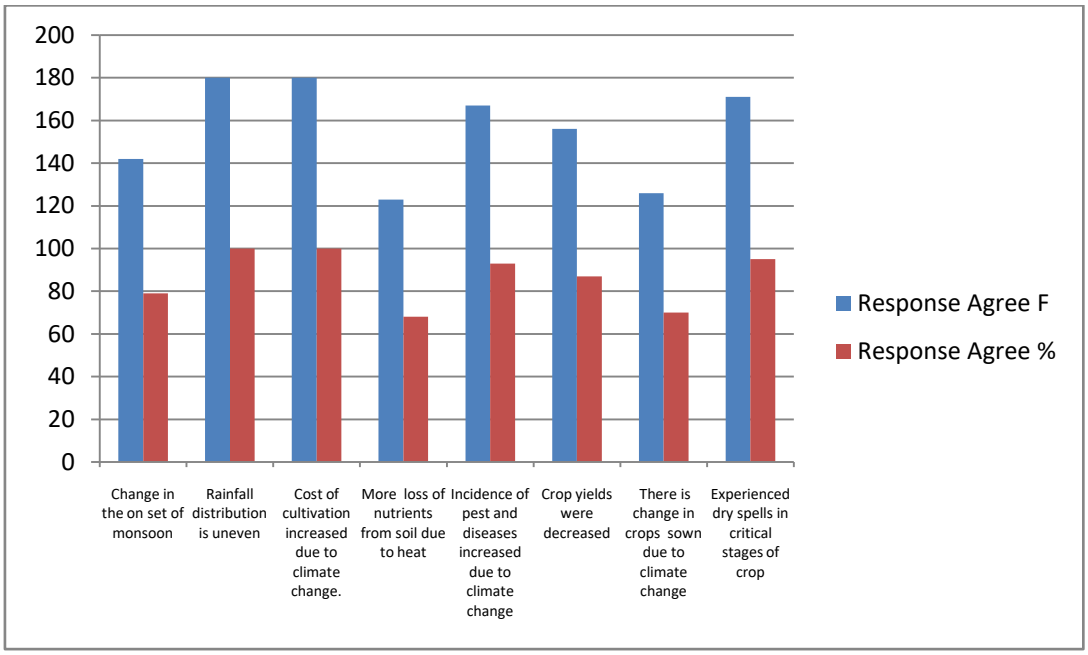


Figure 8. Perception of farmers on climate change

2.3 Adaptation of climate resilient technologies

2.3.1 Adaptation level of climate resilient technologies:

It was recorded (Table 6) that majority of the respondents (62.22%) were adopting climate resilient technologies in their farms in high range followed by medium and low range.

It can be concluded that majority of the farmers were adopting climate resilient technologies due to their increased levels of knowledge and availability and feasibility of the resilient technologies. The findings are line with Anil etal., (2010), Latha et al .,(2012), Pathak (2012), Hassan et al., (2013), Jasna (2014) and Arun et al .,(2016).

Table 6: Distribution of respondents according to their Adoption of Climate Resilient Practices

S. No.	Category	Frequency	Percentage
1	Low (< 4.81)	9	5.00
2	Medium (4.81 – 9.81)	59	32.78
3	High (>9.81)	112	62.22
Mean: 7.00 SD: 4.36			

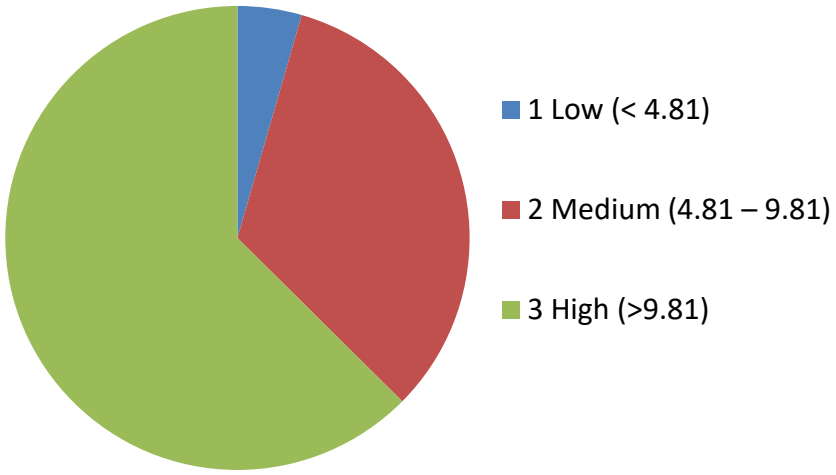


Figure 9. Adoption level of Climate Resilient Technologies

2.3.2 Adoption pattern of different Climate Resilient Technologies by farmers in Kurnool district:

From the table 7 it was found that under Natural resource management majority of the farmers (84%) are adopting the practice of ridges and furrows to conserve moisture at 30 to 35 DAS (Days after sowing)in all rainfed crops like Red gram, Bengal gram, Jowar etc. Thirty seven per cent of the farmers have adopted drip irrigation method to irrigate their fields. Thirty per cent of the farmer's reclamated their saline soils with the application of recommended dose of gypsum. The findings are in line with the findings of Pathak (2012), Yadav(2012), Tagore (2012) and Qurshi (2015).

It can be concluded that the importance of conserving moisture in rainfed crops was well taken by the farmers of the Project village. Drip irrigation method was practiced by the horticulture farmers.

The adoption farm pond technology was meager because the technology was adoptoed by only big farmers and the small farmers have not adopted this technology due to fear f losing the cultivable land.

Reclamation of soils was taken up by the farmers whose soils are saline in nature. Traditional compost pits were existing in the village for every farmer. The farmers who had opted for modernized compost pits are young educated and economically better.

In crop production majority of the farmers (92%) are adopting drought tolerant varieties of rainfed crops like Red gram, Setaria, Yellow jowar and Bengal gram. Seventy two per cent of the farmers are going for alternate crops like Setaria in place of cotton and maize. Likewise intercropping system with Setaria and Red gram (68%) was also being widely practiced by the farmers.

It can be concluded that, practicing of sowing drought tolerant varieties can be attributed to the availability of seed at KVK, seed bank of the village and the increased capacities of the farmers on Climate Resilient Agriculture. Alternate crops taken up farmers can be attributed for their past experience (failure of long duration crops like cotton and maize) and increased knowledge level through project. Intercropping of Red gram and Setaria was widely accepted because of the several demonstrations organized in the village and visualization of the economic benefits of bimodal distribution of rainfall. The findings are in line with the findings of Deressa,

Hassan, Ringler, Alemu, and Yesuf (2008) Pathak (2012), Yadav (2012), Tagore (2012) and Qurshi (2015), Debahash et al., (2019) and saddam et al., (2019).

Regarding live stock majority of the farmers (81.11%) are going for calf registration followed by establishment of green fodder units with hybrid napier varieties (68.99%) and use of RSMM (Regional Specific Mineral Mixture).

It can be concluded that the majority of the farmers realized the importance of calf health and its period of conversion to heifer. It was observed that the calf mortality was completely stopped and the farmers had economical advantage in short period. As the importance of live stock was well under stood by the rainfed farmers, they sought livestock as an important livelihood opportunity and prioritized to establish green fodder in their farms or went for leasing in the land with water facility for fodder cultivation.

Table 7: Adoption pattern of climate resilient technologies by NICRA farmers In Kurnool district (n=90)

S. No	Technology		Adoption	
			F	%
1	NRM	Farm Ponds	10	11.11
		Compost pits	9	10.00
		Insitu moisture conservation measures like Formation of ridges furrow between crop rows at 30-35 DAS	75	83.33
		Resource conservation measures like introduction of drip irrigation	34	37.78
		Reclamation of sodic soils with gypsum as per pH	27	30.00
2	Crop production	Alternate cropping pattern like fox tail millet - Suryanandi and SIA-3085	65	72.22
		Drought tolerant varieties of red gram Seteira, & Bengal gram	83	92.22
		Intercropping systems like Setaria+Redgram (5:1)	61	67.78
3	Live stock	Calf registration	73	81.11
		Use of RSMM	54	60
		Establishment of foggers to protect livestock from extreme weather conditions	3	3.33
		Green fodder	62	68.99

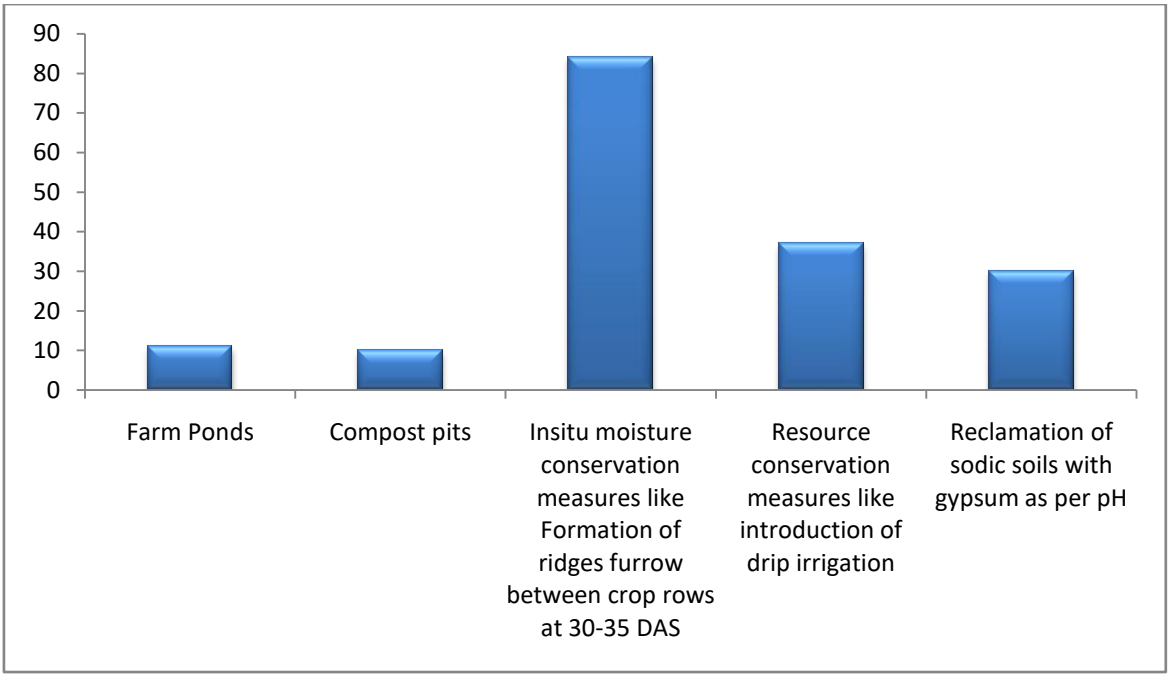


Figure 10. Adoption of NRM technologies in Kurnool district

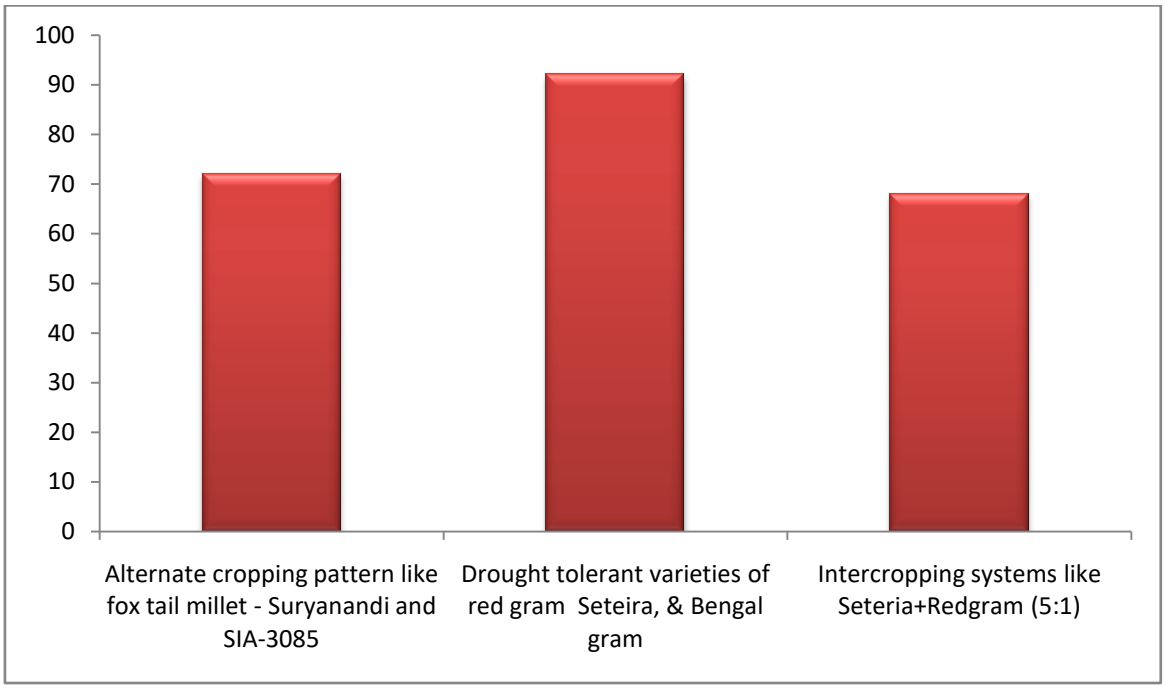


Figure 11 Adoption of Climate resilient Crop Production technologies in Kurnool district

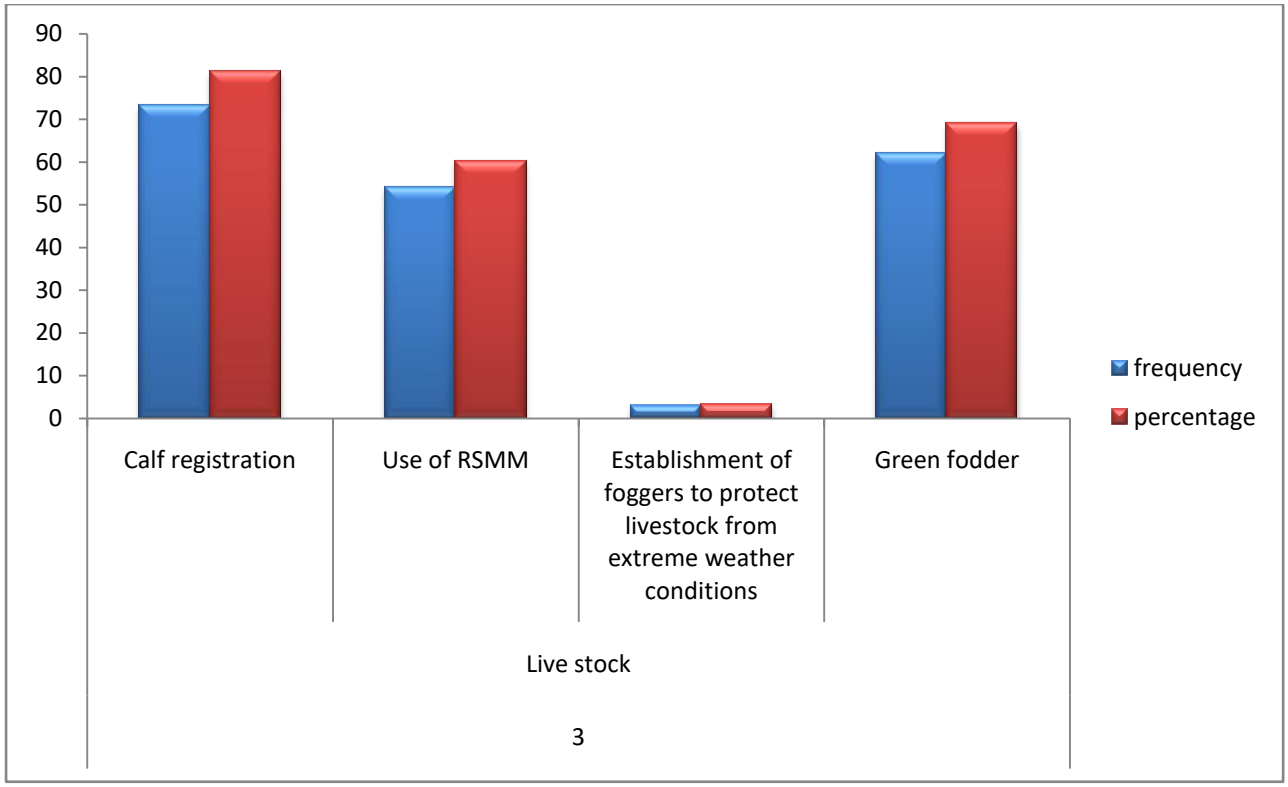


Figure12. Adoption of Climate Resilient Livestock management technologies in Kurnool district

Plate no 1 . Farm Ponds In Kurnool district under NICRA Project





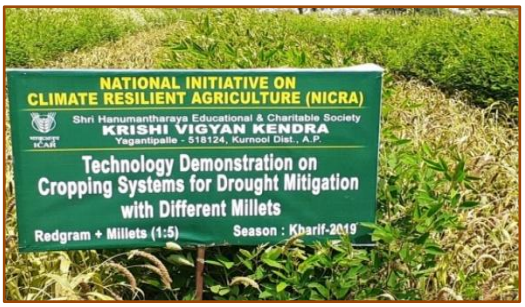

Plate no 2 . Percolation tank Desilting activity in Kurnool district








Plat no 3 Soil conservation through conservation furrows In Kurnool district



Intercropping of setaria and red gram in 1:5 ratio


Drought tolerent yellow jowar N-15

Mediuim duration red gram PRG-176

Drought tolerent variety o of bengal gran NBeG-3


Drought tolerent variety of Setaria Suryanandhi

Plate no 4 Climate resilient crop varieties cultivated in Kurnool disrict

Calf Registration Programme







Fodder Bank

Plate no 5 Livestock activities in Kurnool district

Check dam (Before)

Check dam (After)

Check dam with water

Checkdam (Before)

Check dam (After)

Check dam with water

Drainage channel (Before)

Drainage channel (After)

Open well before (After)

Plate no 6. NRM activities in Anantapur district under NICRA Project

Sub-Soiling with chisel plough in rainfed red soils

Demonstration of conservation furrows in groundnut

Plate no 7. Sub soiling for Moisture conservation activities in Anantapur district

2.3.3. Adoption pattern of climate resilient technologies by farmers in Ananthapur district:

From the table 8 it was found that under Natural resource management majority of the farmers (92%) are adopting the practice of ridges and furrows to conserve moisture at 30 to 35 DAS in all rainfed crops like red gram, groundnut, castor, etc. It was evident that the check dam water storage helped them in cultivating more crops by 67 per cent of the farmers. Forty one per cent of the farmers used either drip or sprinkler for irrigating their crops Thirty nine percent of the famers used farm pond water for giving critical irrigation to crops like groundnut and vegetables.

It can be concluded that the importance of conserving moisture in rainfed crops was well taken by the farmers of the Project villages. With the renovation of check dam more area was brought into cultivation .Drip irrigation method was practiced by the horticulture farmers. The results are in line with Yesuf, Di Falco, Deressa, Ringler, and Kohlin (2008).

The adoption of farm pond technology was meager because the technology was adopted by only big farmers. The results Srinivasa Rao et al., (2017) are contrary to it. The reason for low adoption of the technology is that as most of the farmers are small and marginal, fear of losing land prevented them from adopting the technology.

In crop production majority of the farmers (91%) are adopting drought tolerant varieties of rainfed crops like Groundnut, Red gram, Castor, Setaria etc. Sixty eight per cent of the farmers are going for alternate crops like Castor, Setaria in place of groundnut. Likewise intercropping system of groundnut and red gram with medium duration varieties of Redgram (68%) was also being widely practiced by the farmers. The findings are in line with Anil (2010) Latha *et al* (2012) Pathak *et al* (2012) and Jasna (2014).

It can be concluded that the majority of the farmers practicing sowing drought tolerant varieties can be attributed to the availability of seed at KVK, Seed bank of the village and the increased capacities of the farmers on Climate Resilient Agriculture. Alternate crop taken up by farmers can be attributed for their past experience (failure of long duration crops like Cotton and Maize) and increased knowledge level through project. Intercropping of Red gram and Groundnut was widely accepted because of the several demonstrations organized in the village and visualization of the economic benefits of bimodal distribution of rainfall.

Regarding live stock majority of the farmers (57%) are managing sheep in scientist manner, followed by use of mineral mixture for livestock. Back yard poultry with drought tolerant breeds

like Rajashri was taken by 39 per cent of the farmers. The results are in contrary to Debahahash et al (2019).

As the importance of live stock was well under stood by the rainfed farmers, they sought small sheep units as an important livelihood opportunity as ground nut haulms are available. Sheep with groundnut was found as predominant farming system. Back yard poultry was also well adopted by the farm families with climate resilient breeds.

Table 8: Adoption pattern of climate resilient technologies by farmers in Ananthapur district (n= 90)

S. No	Technology		Adoption	
			F	%
1	NRM	Check dam usage	60	66.67
		Insitu moisture conservation measures like Formation of ridges furrow between crop rows at 30-35 DAS	83	92.22
		Resource conservation measures like introduction of drip irrigation	33	36.67
		Farm pond for life saving irrigation	35	38.89
		Drip/ Sprinkler irrigation	37	41.11
2	Crop production	Alternate cropping pattern like castor millet - Suryanandi and SIA-3085	61	67.78
		Drought tolerant varieties of groundnut and red gram	82	91.11
		Intercropping systems like Groundnut+Redgram (5:1)	61	67.78
3	Live stock	Green fodder	37	41.11
		Mineral mixture	40	44.44
		Sheep unit management	51	56.67
		Back yard poultry with resilient breeds	35	38.89

Demo Dharani variety

Check K-6 variety

Castor as alternate crop to Groundnut

19:19:19 and urea for foliar application

Plate no 8. Crop Production Activities in Ananthapur district

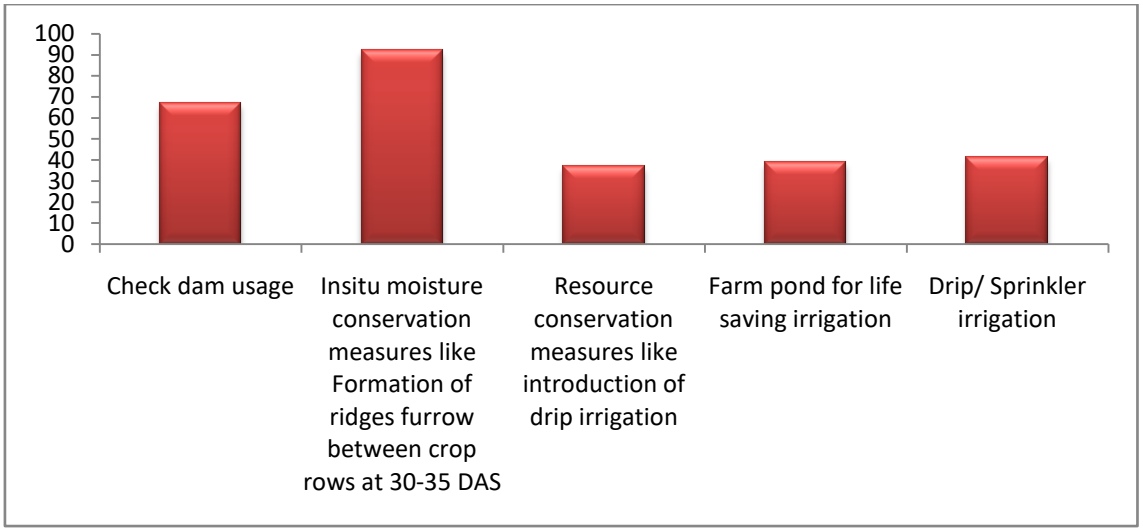


Figure 13.Adoption of NRM activities in Ananthapur district

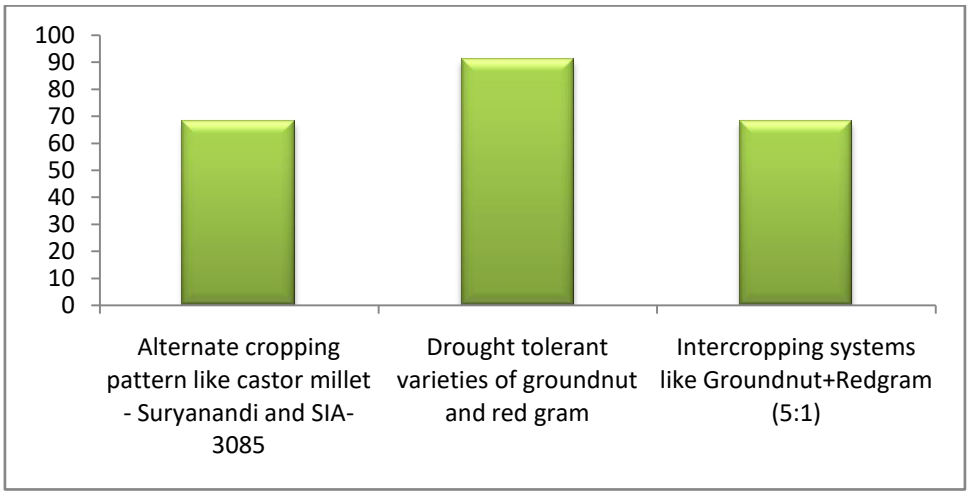


Figure14. Adoption of climate resilient crop production technologies in Ananthapur district

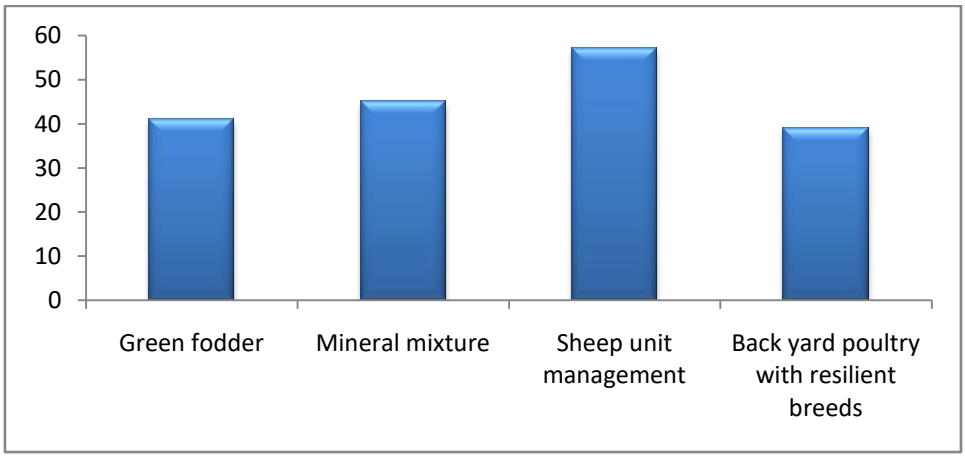


Figure 15.Adoption of climate resilient livestock technologies in Anantapur district

2.3.4. Relationship between independent variables with perception:

From the table nine it was analyzed that all the independent variables like Age, education, land holding, Farm experience, Mass media exposure and extension contact are highly correlated with the perception of farmers on climate resiliency at 5 per cent level of significance**.** The findings are in line with Abdullah and Samah (2013) and Saddam (2019).

Table 9: Relationship between independent variables with Perception

S. No.	Independent variables	Correlation Coefficients ('r'value)
1	Age	0.60**
2	Education	0.90**
3	Land holding	0.51**
4	Farming experience	0.58**
5	Mass media exposure	0.76**
6	Extension contact	0.36**

2.3.5. Relationship between independent variables with Adoption:

From the table (10) it was analyzed that the independent variables like Age, Education, Farming experience and Mass media exposure are highly correlated at 5 per cent level of significance. Whereas land holding and Extension contact are significant at 1 per cent level of significance. The findings are in line with those of Waman *et al.* (1998), Soni *et al.* (2000) Rahman and Yamao (2006), Kiranmayi (2013) and Sujatha *et al.* ,(2015) and kalyan babu (2019).

Table 10: Relationship between independent variables with Adoption

S. No.	Independent variables	Correlation Coefficients ('r'value)
1	Age	0.70**
2	Education	0.69**
3	Land holding	0.23*
4	Farming experience	0.70**
5	Mass media exposure	0.76**
6	Extension contact	0.27*

2.4. Economic impact of Climate Resilient Technologies:

2.4.1. Economic impact of Percolation tank:

From the table 11 it was recorded that area under irrigation was increased by more than three folds and additional income obtained from the crops was 29.9 lakhs. It can be concluded that, with percolation tank desilting the ground water levels of the bore wells raised and helped to take up crops in rabi .

Table 11: Economic impact of percolation tank

Area irrigated (ha.)				Total area under irrigation		Additional area under irrigation	Crops cultivated				Crop yields (kg/ha)				Income (in lakhs)		Additional income	
Kharif		Rabi					Kharif		Rabi		Kharif		Rabi					
Before structue	After structure	Before	After	Before	After		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
30	80	-	56	30	136	106	Redgram Inter cropping Cotton	Redgram Cotton Paddy Maize	-	Jowar Maize Castor paddy	750 1250(S)+ 625® 1375	1625 1750(S)+ 1350® 2000	1500 4000 - --	3750 6500 4150 7555	12.5	42.5	-	29.9

2.4.2. Inter Cropping of Foxtail millet (*Setaria*) + Red gram (5:1):

It was evident from the table 12 that intercropping of red gram with Setaria (5:1 ratio) proved economical over the farmers practice. With the practice of intercropping there is additional net income of Rs 15,620/ha.

It can be concluded that intercropping system is more economical in scarce rainfall zone of Andhra Pradesh. The bimodal distribution of rainfall helped to give better economic returns in intercropping system with different crop durations. The results are in line with Latha *et al. (2012)*

Table 12: Economic impact of intercropping of Setaria and Red gram

Crop/Cropping System	Seed yield (kg/ha)	Fodder (kg/ha)	Cost of cultivation (ha/ac	Gross income (Rs/ac)	Net income (Rs/ac)	B:C ratio
Farmers' Practice Setaria (Sole)	1400	1588	14070	21000	6930	1.49
Demo Setaria + Redgram	919 (S) 394 (R)	1470	15228	38080	22852	2.50

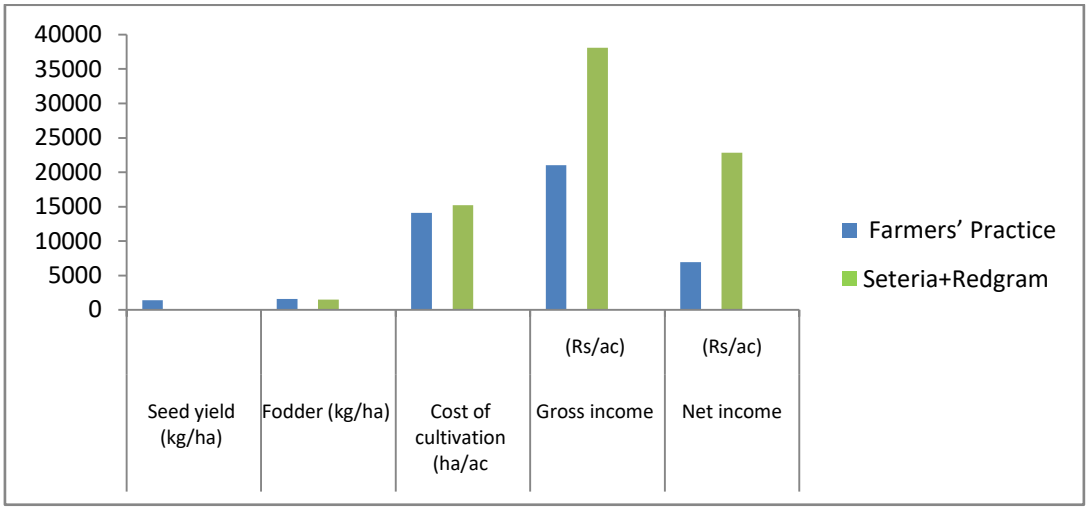


Figure 16. Yield and economics of Setaria and Redgram inter cropping

2.4.3. Inter Cropping of Groundnut + Red gram (7:1):

It was evident from the table 13 that intercropping of Red gram with Groundnut (7:1 ratio) proved economical over the farmers practice. With the practice of intercropping there is additional net income of Rs. 20,200/ha.

It can be concluded that intercropping system is more economical in scarce rainfall zone of Andhra Pradesh. The bimodal distribution of rainfall helped to give better economic returns in intercropping system with different crop durations. Farmer also opined that due to availability of red gram they were able to consume pulses regularly and beneficial to the soil by adding nitrogen and improving the biological properties of the soil. The findings are in line with Latha et.al (2012) and Jasna (2014)

Table 13: Economic Impact of Groundnut +Red gram intercropping system (7:1)

Crop/Cropping System	Seed yield (kg/ha)	Fodder (kg/ha)	Cost of cultivation (ha/ac)	Gross income (Rs/ac)	Net income (Rs/ac)	B:C ratio
Farmers' Practice Groundnut	1530	2500	46500	76500	30,000	1.6
Demo Groundnut + Redgram	1470 420	2400	48,500	98,700	50,200	2.03

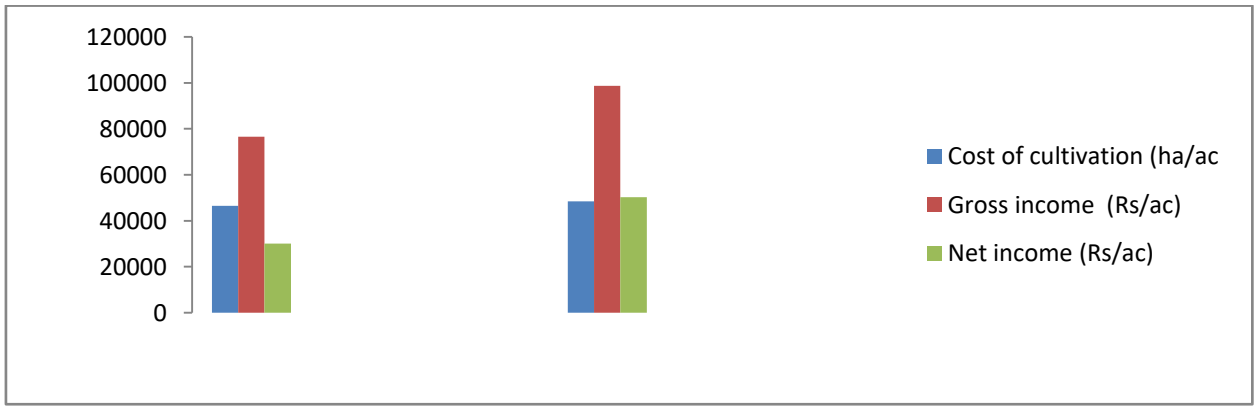


Figure 17. Economics of Groundnut + Red gram inter cropping

2.4.4. Cultivation of drought tolerant Jowar variety (N15):

It was evident from the table 14 that cultivating improved variety of Jowar proved economical over the farmers practice. With the practice of cultivating N15 variety of Jowar there is additional net income of Rs 15,600/ha/ac. It can be concluded that improved variety of Jowar with drought tolerance is more economical in scarce rainfall zone of Andhra Pradesh.The findings are in line with Latha *et al* (2012)

Table 14: Economic Impact of drought tolerant variety of Jowar

Crop/Cropping System	Seed yield (kg/ha)	Fodder (kg/ha)	Cost of cultivation Rs /ha	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmers' Practice Jowar (Sole)	1375	3700	28570	35750	7180	1.2
Demo N15	1975	6250	28570	51350	22780	1.7

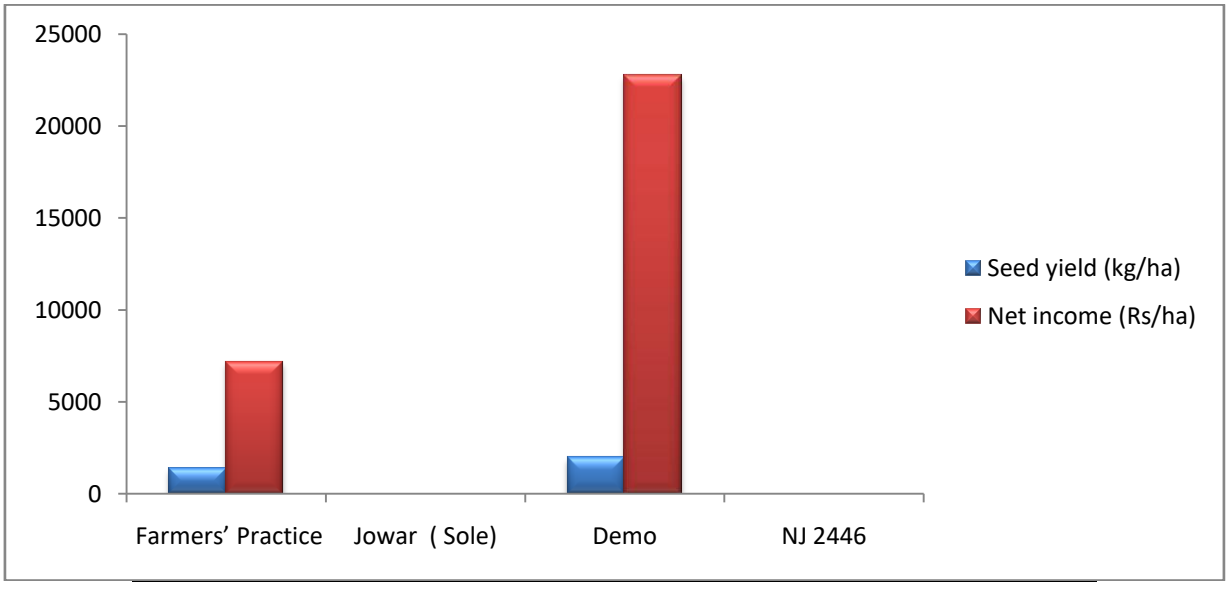


Figure No 18. Yield and Economics of Drought tolerant variety of Jowar N15

2.4.5. Cultivation of drought tolerant Groundnut Dharani (TCGS-1043):

It was evident from the table 15 that cultivating improved variety of Groundnut Dharani which is drought tolerant, having uniform maturity, with attractive pods and moderate stature yielded 1650 kg/ha with net income of Rs. 40,500/ha with additional net income of Rs. 33,500/ha. This variety is more suitable to this zone for its performance in extreme climatic conditions and demand in the market. The results are in line with YG Prasad et al., 2014and Jasna 2014

Table 15: Economic Impact of drought tolerant Groundnut variety

Crop/Cropping System	Seed yield (kg/ha)	Fodder (kg/ha)	Cost of cultivation ha/	Gross income(Rs/ha)	Net income(Rs/ha)	B:C ratio
Farmers' Practice Groundnut TMV2	910	1480	38,500	45,500	7,000	1.08
Demo Dharani	1650	2500	42,000	82,500	40,500	1.96

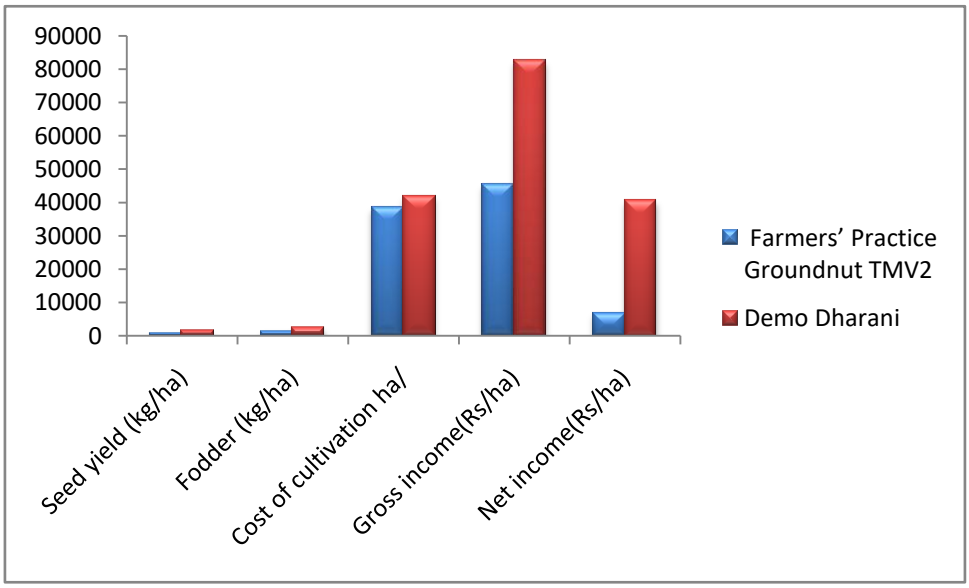


Figure No 19 Yield and Economics of Dharani variety Groundnut

2.4.6 Management of sucking pest in Bt. Cotton:

From the table 16 it was recorded that the farmers practicing improved climate smart technologies harvested more yield (1578 kg/ha) with more economic advantage compared to their traditional practice (1578kg/ha). The additional net income gained by adopting IPM strategies is Rs. 21,780/ha. It can be concluded that farmers are aware of the climate resilient technologies like foliar sprayings of nutrients, sucking pest management and IPM strategies. It can be concluded that by adopting climate smart technologies in Cotton production the yield and income of the farmers can be increased with environment safety.

Table 16: Economic impact of the sucking pest management

Treatments	yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmers practice	1390	64,500	83,400	18,900	1.29
Climate resilient practices	1578	54,000	94,680	40,680	1.75

.

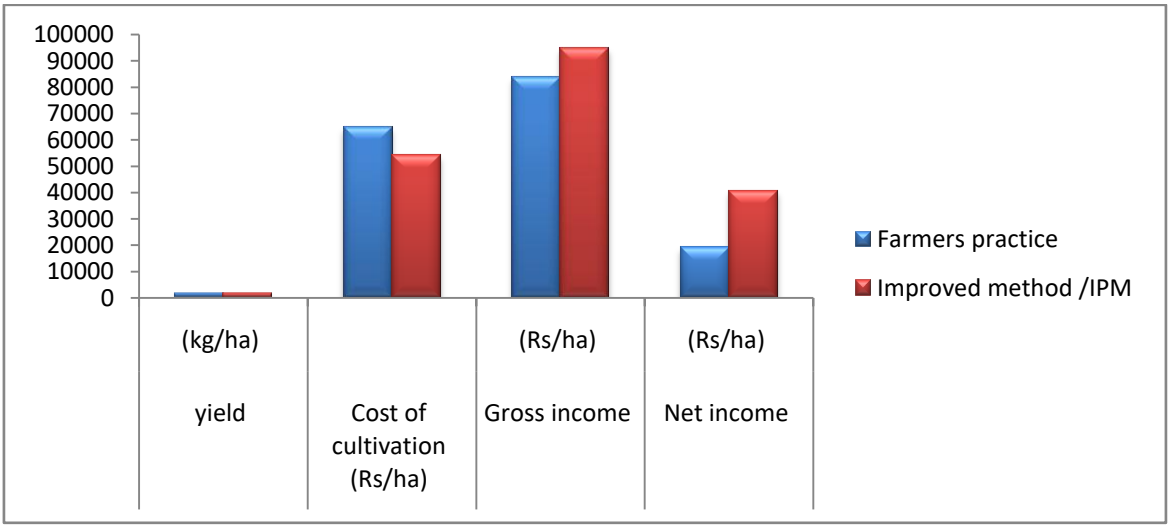


Figure 20. Yield and Economics of Climate resilient practices in Cotton

2.4.7 Performance of Medium duration variety Red gram (PRG-176):

From the table 17 it was recorded that the variety PRG-176 gave high returns compared to Asha by forty four percent. The cost of cultivation was higher in farmers practice. The net returns and yield was high in demonstration plot and the additional net returns obtained were Rs.16,719/ha.

It can be concluded that the variety PRG176 is well suited to scarce rainfall districts, as the variety escaped haze at the time of flowering and terminal moisture stress the yields were better than the long duration variety and the variety was well suited to medium soils in Kurnool and Ananthapur districts. The findings are in line with Latha *et .al*. (2012)

Table 17: Performance of medium duration drought tolerant variety of Red gram

Comparison of Treatments	Seed yield (kg/ha)	cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Farmers practice Asha	864	24,530	46,656	22,126	1:1.90
Treatment / Demo PRG-176	1250	23,655	62,500	38,845	1:2.64

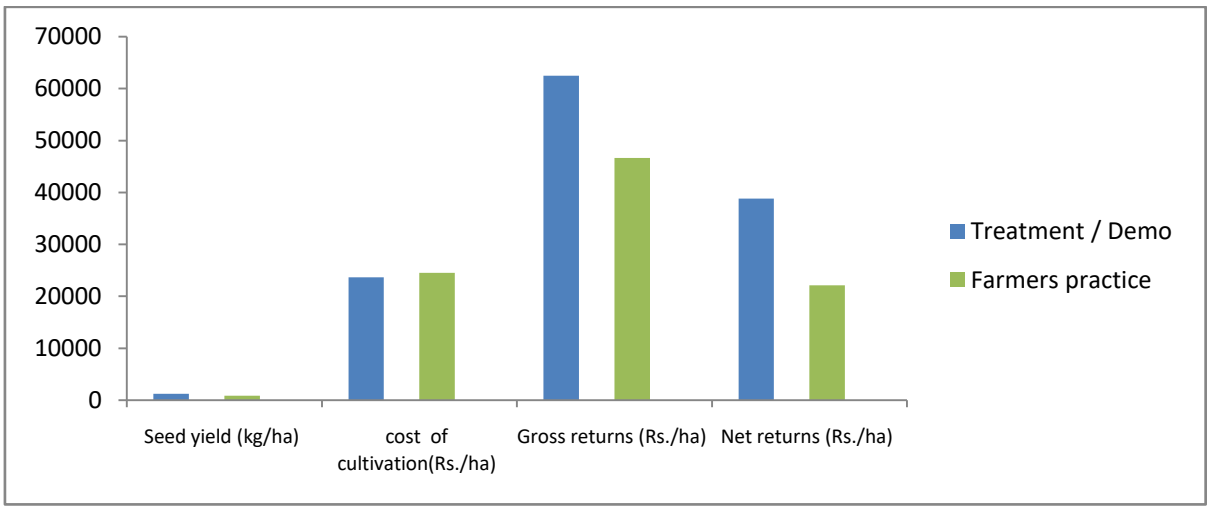


Figure 21. Yield and Economics PRG-176 Redgram variety

2.4.8 Performance of drought tolerant Bengal gram variety:

From the table 18 it was recorded that the variety NBeG-3 performed well with 22 per cent (1262 kg/ha) enhanced yield over the farmers practice. In terms of the income the variety gave Rs. 10.822/ha additional net returns than the farmers variety. It can be concluded that the variety NBeG-1 suited well to scarce rainfall zone. The additional yield obtained by this variety is due to its heavy rooting traits and tolerance to heat. The findings are in line with YG Prasad *et.al* (2014), & Jasna(20140

Table 18: Economic impact of drought tolerant Bengal gram variety

Treatments	Seed yield (kg/ha)	% Increase	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmers practiceJG11	1035	-	30,150	39,330	9,180	1:1.3
Improved variety (NBeG-3)	1262	22.0	27,954	47,956	20,002	1:1.7

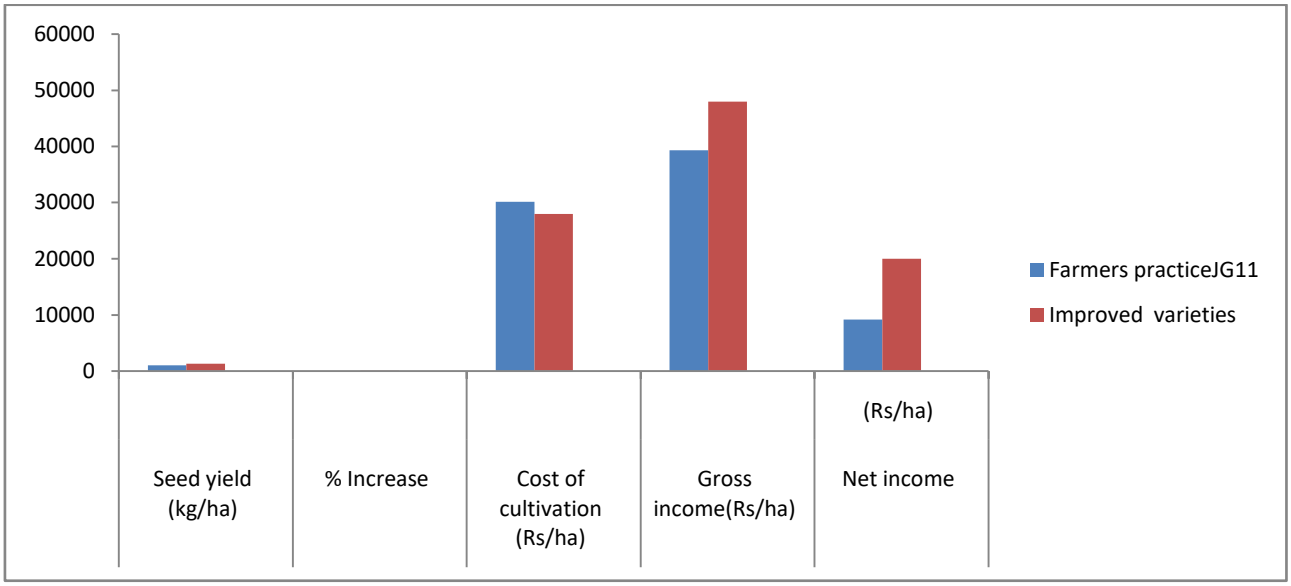


Figure. 22 Yield and Economics of drought tolerant variety of Bengalgram NBeG-3

2.4.9. Reduction of calf mortality through calf registration programme:

The table 19 reveals that the calf mortality was reduced by 66 per cent with increased body weight gain of 18.8 per cent. It was concluded that the mortality of calves can be reduced by proper health and nutrition care of the calf.

Table 19: Reduction of calf mortality through calf registration programme

Particulars	Farmers practice	Demonstration
Initial body weight (kg)	28.4	26.9
Final body weight (Kg)	76.7	84.3
Body weight gain (kg)	48.3	57.4
% increased in body Weight gain		18.84
Calf mortality	12%	4%

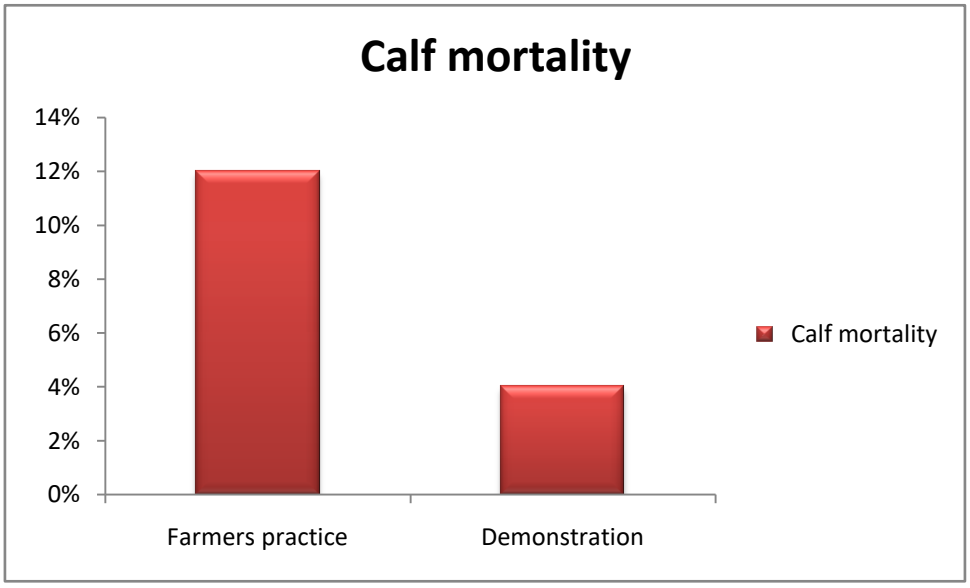


Figure 23 Calf mortality through Calf registration programme

2.4.10. Economic impact of Urea molasses usage in milk production of Desi Livestock:

From the table 20 it was clear that by feeding urea molasses there is 14.2 per cent increase in milk yield with net returns of Rs. 8,025 for sixty days of lactation period, which is having 33 per cent economical advantage. It is concluded that with inclusion of urea molasses farmers can earn higher income with minimum investment.

Table 20: Influence of Urea molasses in milk production of Desi Livestock

Treatments	Average milk yield/animal (L/day)	Total milk yield per animal (L/60days)	Percent increase	Cost of feeding (Rs/animal)	Gross Returns (Rs/animal)	Net returns (Rs/animal)
Farmers practice	3.47	208.2		1,395	6,770	5,375
FPF+ urea molasses	4.01	240.6	14.2	1,965	9,990	8,025

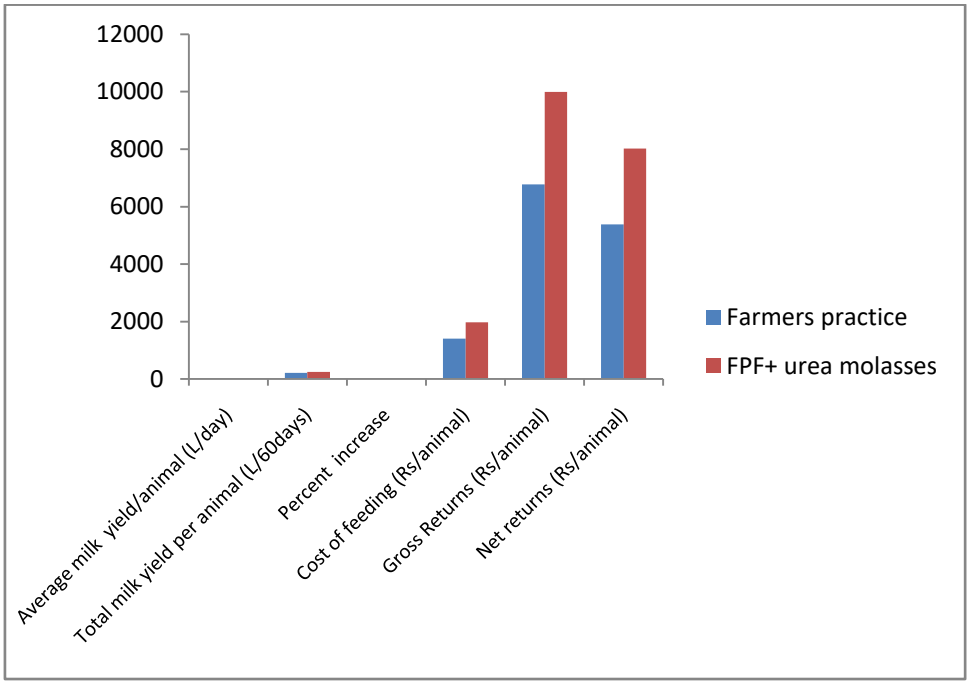


Figure 24 Economics Urea molasses feeding to livestock

2.4.11. Economic benefit of Silage feeding to milch buffaloes:

From the table 21 it was evident that by feeding of silage along with Jowar straw and feed there was increase of milk percentage by 15.5 with additional income of Rs. 2,368/ for 60 days. It can be concluded that the usage of silage is beneficial to the animal and the farmer. As it is beneficial government also recognized and providing to farmers in a big way through subsidies by department of animal husbandry.

Table 21: Economic impact of Silage feeding

Particulars	Milk yield in 60 days
Farmers practice (Jowar straw + Feed)	374.0
Silage + Jowar straw + Feed	432.0
% increase	15.5
Additional Income	2368.00
B:C ratio	1:3.0/1:4.67

2.5 Weather based Agro Advisory Services (AAS)

2.5.1 Type of Weather based agro advisory services received:

Kisan mobile advisory services were given to farmers for passing information to all the farmers in short time with less cost and more affectively in farmer's local language during the cropping season. From the table 22 it is evident that 49 messages were given to the selected farming during 2021-22 crop seasons on different subjects. Maximum number of messages was given in plant protection division followed by Crop production (26.5%), live stock and Horticulture. More number of messages were given in plant protection because it covers both agriculture and horticulture crops. The findings are in line with findings reported by M. R. Patel and *et al 2017.*

Table 22: Messages given to farmers discipline wise

S. No.	Subject	No	Percentage
1	Agronomy (crop production)	13	26.5
2	Horticulture	5	10.2
2	Plant protection	18	36.73
3	Weather information	5	10.2
4	Live stock information	6	12.24
5	Others	2	4.08
Total		**49**	**100**

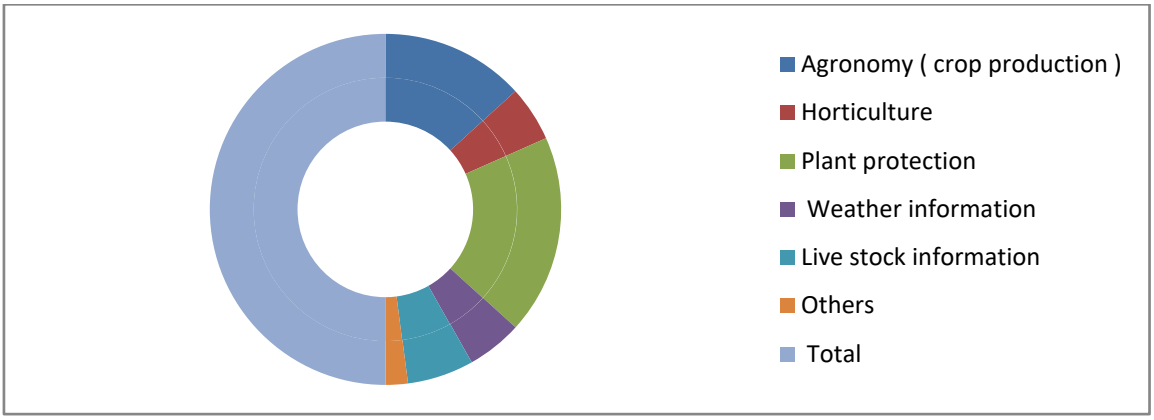


Figure 25 Messages given to farmers discipline wise

2.5.2. Utility of the Agro Advisory Services:

From the table 23 it is evident that in the five – point continuum of scale almost all the farmer agreed for the utility of kisan mobile advisory services in a positive way. Eighty per cent of the farmers strongly agreed for cultivation drought tolerant crops and seventy five percent famers strongly opined that messages were received in right time and thus helped to manage pest and disease affectively. More than sixty per cent of the farmers strongly agreed that the Advisories on livestock in managing the animals, while 31per cent of the farmers agreed that the messages are helpful and rest of the farmers could not come to opinion. Fifty eight percent of the farmers strongly agreed that the Crop management advisories helped to increase yield of horticulture crops while 37per cent of them agreed and rest of them are neutral about the benefit of the message. Fifty three percent of the farmers strongly agreed that cost of supplementary irrigation was saved by following the agro advisory services while 31per cent farmers agreed to it .More

than 52 per cent of the farmers strongly agreed that by following crop advisories the cost of cultivation was reduced compared to their counterparts while 45per cent farmers agreed in saving cost of cultivations and the rest of the farmers are neutral about the impact of the message, 7per cent of the farmers disagreed and the rest have no idea on reduction in cost of cultivation for irrigating the crops. Regarding the drought mitigating strategy messages 43 per cent of the farmers strongly agreed the benefit of the Agro advisory services while 25per cent agreed to it. But 23per cent of the farmers have no idea regarding the usefulness of the technology and the rest disagreed to it. The results are in concurrent to studies conducted by Vinay Nikam *et al*. (2020).

Table 23: Utility of the Mobile Advisory services

S. No.	Statement	Strongly Agree		Agree		Cannot say		DisAgree		Strongly Dis Agree	
		F	%	F	%	F	%	F	%	F	%
1	Soil testing information is suited to my farm.	45	25	68	37.7	39	21.6.	28	15	-	-
2	Crop management advisories decreased cost of cultivation	93	51.6	81	45	6	3.3	-		-	-
3	Crop management advisories helped to increase yield horticulture crop	104	57.7	67	37.2	9	5	-		-	-
4	Messages in right time reduced pest and disease incidence	135	75	34	18.8			11	6.11	-	-
5	Cultivated drought tolerant crop varieties.	145	80.55	34	18.88	-		1	0.5	-	-
6	Drought mitigating strategies helped to save the crop	78	43.33	45	25	42	23.33	15	8.33		
7	Advisories on livestock in managing the animal diseases was useful	109	60.55	56	31	15	8.33	-	-	-	-
8	Information provided reduced cost on supplementary irrigation to rainfed and ID crops.	95	52.7	56	31.1	7	3.8	12	6.6	-	-

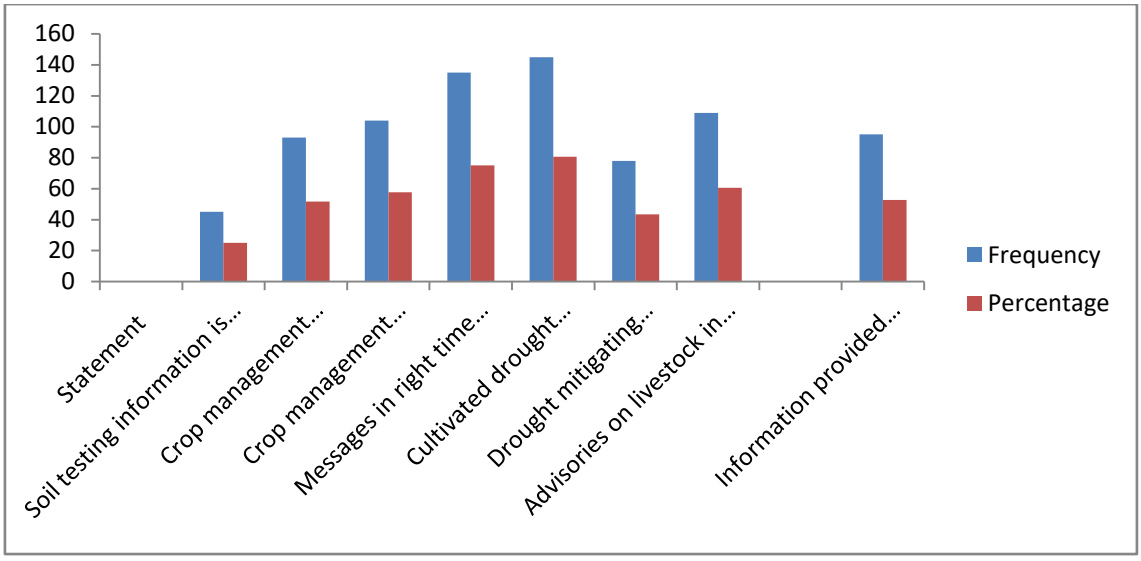


Figure 26 Utility of Mobile Advisory services

2.5.3. Understanding the Message:

From the table 24 it was evident that most of the farmers (81%) understood the message completely. However 16 per cent of the farmers understood the messages moderately and only 2.2per cent farmers did not understand the messages. The findings were in line with the findings of Omprakash and SK Shrivastava (2012) and Patel M.R et al (2017).

Table 24: Understanding of the messages by the farmers

Particulars	Frequency	Percentage
The message was completely understood	146	81
The message was moderately understood	29	16
The message was not understood	4	2.2

CHAPTER III

Summary and Conclusion

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. The improved agricultural practices evolved for diverse agro-ecological regions in India have potential to enhance climate change adaptation, if deployed prudently. Management practices that increase agricultural production under adverse climatic conditions also tend to support climate change adaptation because they increase resilience and reduce yield variability under variable climate and extreme events. *Resilience is the ability of a system to absorb shocks and recover as quickly as possible to normal conditions*. Planned adaptation is essential to increase the resilience of agricultural production to climate change. Management practices that increase agricultural production under adverse climatic conditions tend to support climate change adaptation because they increase resilience and reduce yield variability under variable climate and extreme events. Keeping this in view the present investigation entitled ***"Study of adoption pattern of Climate Resilient Technologies in Agriculture in Scarce Rainfall Zone of Andhra Pradesh"*** was undertaken with the following objectives.

3.1. Objectives of the study:

- To study the perception of farmers on climate change in agriculture.
- To know the adoption pattern of climate resilient technologies by the farmers
- To study the impact of adopting climate resilient technologies on costs and returns.
- To study the impact of weather-based agro advisory services and extent of adoption by the farmers.

1.2 Methodology:

Ex-post facto research design was adopted in the present investigation. Kurnool and Anantapur district from the Andhra Pradesh state were selected purposively, as they were covered under NICRA where the CRA technologies were being demonstrated. One mandal was purposively selected from Kurnool district and two mandals in Anathapur district and three villages were selected from each district. Thirty farmers from each village were selected at random to make a sample of 180 respondents from NICRA adopted villages.

3.3 Salient Findings:

3.3.1. Profile characteristics of respondents:

Majority of the farmers (65 %) belongs to middle age group followed by twenty five per cent belongs to young age group. Only ten per cent of the sample belongs to old age group.

Majority of the farmers completed high school education (58.88%) followed by intermediate education (13.89%), and graduation (10%), primary and middle school. However 5% of the farmers are still illiterate.

Majority of the farmers (53.34%) possess land holding of 2.5 to 5 acres, followed by farmers with more than five acres (27.22%) and the rest are marginal farmers with less than 2.5 acres of land. It can be concluded that majority of the land holdings belong to small and marginal category followed by medium category land holdings.

Majority of the farmers (47.22%) had 10-20 more years of experience, followed by farmers with more than twenty years of experience and 20.55 per cent of the respondents have experience less than 10 years.

3.3.2. Mass Media exposure:

Majority of the respondent have exposure to mass media, this can be attributed to the mass media such as TV and mobiles. Only few farmers with high exposure to mass media can be attributed to their personal interest on agriculture and availability of mass media.

3.3.3. Extension Contact:

Majority (51.11%) of respondents has medium level of extension contact followed by high (25.00%) and low (23.89%) levels of extension contact.

3.3.4. Perception on climate change:

The majority of the respondents have high level of perception (61.11%) on impact of climate change in agriculture, followed by medium level of perception .It is clearly evident that none of the farmers are under low level of perception.

3.3.5. Perception of farmers on impact of Climate Change in Agriculture:

All the farmers (100%) in the study area agreed that Rainfall distribution was uneven and cost of cultivation increased due to climate change. Ninety five per cent of the farmers perceived that there are dry spells in the critical stages of the crop growth period. Ninety three per cent of the farmers felt that incidence of pest and diseases increased due to climate change and 87per

cent of the farmers opined that crop yields were reduced. Seventy nine per cent of the farmers perceived that the onset of the monsoon is delayed / changed. Seventy percent of the farmers perceived that crops cultivated were being changed in view of climate change while 30 per cent of the farmers have no idea. Sixty eight per cent of the farmers perceived that more loss of nutrients from the soil due to heat while 32 per cent of them were unable to perceive the impact of climate change in agriculture.

3.3.6. Range of Adaptation of climate resilient technologies:

Majority of the respondents (62.22%) were adopting climate resilient technologies in their farms in medium range followed by low and high range.

3.3.7. Adoption pattern of Climate Resilient Technologies by NICRA farmers in Kurnool district:

It was found that under Natural resource management majority of the farmers (84%) are adopting the practice of ridges and furrows to conserve moisture at 30 to 35 DAS in all rainfed crops like Redgram, Bengalgram, Jowar etc. Thirty seven per cent of the farmers have adopted drip irrigation method to irrigate their fields. Thirty per cent of the farmer's reclamated their saline soils with the application of recommended dose of gypsum. The adoption farm pond technology was meager because the technology was adopted by only big farmers.

In crop production majority of the farmers (92%) are adopting drought tolerant varieties of rainfed crops like Redgram, Setaria, Yellow Jowar and Bengalgram. Seventy two per cent of the farmers are going for alternate crops like Setaria in place of cotton and maize. Likewise intercropping system with Setaria and Redgram (68%) was also being widely practiced by the farmers.

Regarding livestock majority of the farmers (81%) are going for calf registration followed by establishment of green fodder units with hybrid napier varieties (69%).

3.3.8. Adoption of Climate Resilient Technologies by NICRA farmers in Anantapur district:

Majority of the farmers (92%) are adopting the practice of ridges and furrows to conserve moisture at 30 to 35 DAS in all rainfed crops like Redgram, Groundnut, Castor etc. It was evident that the check dam water storage helped them in cultivating more crops by 67 per cent of the farmers. Forty one per cent of the farmers used either drip or sprinkler for irrigating their crops. Thirty nine percent of the famers used farm pond water for giving critical irrigation to crops like Groundnut and Vegetables.

In crop production majority of the farmers (91%) are adopting drought tolerant varieties of rainfed crops like, groundnut, red gram, castor, Setaria etc. Sixty eight per cent of the farmers are going for alternate crops like castor, Setaria in place of groundnut. Likewise intercropping system of groundnut and red gram with medium duration varieties of red gram (68%) was also being widely practiced by the farmers.

Majority of the farmers (57%) managed sheep units scientifically, followed by feeding of mineral mixture to livestock (45%) and green fodder (41 %) to milch animals. Thirty nine per cent of farmers possess backyard poultry with resilient breeds.

3.3.9. Relationship between independent variables with perception:

It was found that all the independent variables like Age, Education, Land Holding, Farm experience, Mass media exposure and Extension contact are highly correlated with the perception of farmers on Climate Resiliency at 5 per cent level of significance**.**

3.3.10. Relationship between independent variables with Adoption:

It was analyzed that the independent variables like Age, Education, Farming experience and Mass media exposure are highly correlated at 5 per cent level of significance with the adoption of Climate Resilient Technologies. Whereas land holding and Extension contact are significant at 1 per cent level of significance.

3.3.11 Economic impact of Percolation tank:

It was recorded that area under irrigation was increased by more than three folds and additional income obtained from the crops was 29.9 lakhs. It can be concluded that, with the desilting of percolation tank the ground water levels of the bore wells raised and helped to take up crops in rabi.

3.3. 12 Inter Cropping of Foxtail millet (*Setaria*) + Red gram (5:1):

It was evident that intercropping of red gram with Setaria (5:1 ratio) proved economical over the farmers practice. With the practice of intercropping there is additional net income of Rs. 15,620/ha.

3.3.13 Inter Cropping of Groundnut + Red gram (7:1):

It was found that intercropping of Red gram with Groundnut (7:1 ratio) proved economical over the farmers practice. With the practice of intercropping there is additional net income of Rs. 20,200/ha.

3.3.14 Cultivation of drought tolerant Jowar variety (N15):

Cultivating improved variety of Jowar proved economical over the farmers practice. With the practice of cultivating N15 variety of Jowar there is additional net income of Rs. 15,600/ha over the farmers' practice.

3.3.15 Cultivation of drought tolerant Groundnut Dharani (TCGS-1043):

Cultivating improved variety of Groundnut Dharani which is drought tolerant, having uniform maturity, with attractive pods and moderate stature yielded 1650kg/ ha with net income of Rs 40,500/ha, and additional net income of Rs 33,500/ha over the farmers' practice.

3.3.16 Management of sucking pest in Bt. Cotton:

It was recorded that the farmers practicing improved Climate Smart Technologies harvested more yield (1578kg/ha) with more economic advantage compared to their traditional practice (1578kg/ha). The additional net income gained by adopting IPM strategies is Rs. 21,780/ha. It can be concluded that farmers are aware of the Climate Resilient Technologies like foliar sprayings of nutrients, sucking pest management, and IPM strategies as per the climatic conditions.

It can be concluded that by adopting Climate Smart Technologies in Cotton production the yield and income of the farmers can be increased with environment safety.

3.3.17 Performance of medium duration variety of Red gram:

It was recorded that variety PRG-176 gave high returns (1250 kg/ha) compared to Asha (864 kg/ha) by forty four percent. The cost of cultivation was higher in farmers practice. The net returns and yield was high in demonstration plot and the additional net returns obtained were Rs. 16,719/ha.

3.3.18 Performance of drought tolerant Bengal gram variety:

It was recorded that the variety NBeG-3 performed well with 22 per cent (1262 kg/ha) enhanced yield over the farmers practice. In terms of the income the variety gave Rs. 10.822/ha additional net returns than the farmers variety.

3.3.19 Reduction of calf mortality through calf registration programme:

Calf mortality was reduced by 66 per cent with increased body weight gain of 18.8 per cent. It was concluded that the mortality of calves can be reduced by proper health and nutrition care of the calf during the initial period of its life.

3.3.20 Economic impact of Urea molasses mineral blocks on milk production:

By feeding urea molasses mineral blocks, there is 14.2 per cent increase in milk yield with net returns of Rs. 8,025 for sixty days of lactation period, which is having 33 percent economical advantage. It is concluded that with inclusion of urea molasses mineral blocks farmers can earn higher income with minimum investment.

3.3.21 Silage feeding to milch Buffaloes:

Feeding of silage along with Jowar straw and concentrate feed, there was increase of milk percentage by 15.5 with additional income of Rs. 2,368/ for 60 days. It can be concluded that the usage of silage is beneficial to the animal and the farmer.

3.3.22 Number of Weather based agro advisory services received:

It is evident that 49 messages were given to the selected farmers during the crop seasons on different subjects. Maximum number of messages wer given in plant protection division followed by Crop production (26.5%), live stock and Horticulture.

3.3.23 Utility of the Mobile Advisory services:

Eighty per cent of the farmers strongly agreed for cultivation of drought tolerant crops and seventy five percent famers strongly agreed that messages were received in right time and thus helped to manage pest and disease affectively. More than sixty Per cent of the farmers strongly agreed that the Advisories on livestock in managing the animals, while 31 per cent of the farmers agreed that the messages are helpful and rest of the farmers could not come to opinion.

Fifty eight percent of the farmers strongly agreed that the Crop management advisories helped to increase yield of horticulture crops while 37 per cent of them agreed and rest of them are neutral about the benefit of the message. Fifty three percent of the farmers strongly agreed that cost of supplementary irrigation was saved by following the agro advisory services while 31per cent agreed to it. More than 52 per cent of the farmers strongly agreed that by following crop advisories the cost of cultivation was reduced compared to their counterparts while 45 per cent farmers agreed in saving cost of cultivations and the rest of the farmers are neutral about the impact of the message while 7per cent of the farmers disagreed and the rest have no idea on reduction in cost of cultivation for irrigating the crops.

Regarding the drought mitigating strategy messages, 43 per cent of the farmers strongly agreed the benefit of the messages while 25 per cent agreed to it. But 23 per cent of the farmers have no idea regarding the usefulness of the technology and the rest disagreed to it.

3.3. 24 Understanding the Message:

Most of the farmers (81%) understood the message completely. However 16% of the farmers understood the messages moderately and the rest of the Farmers did not understand the messages.

3.4 Implications of the study:

The findings of the study will form a base to the organizations involved in promulgation of the climate resilient technologies. The study helps in redesigning the methodologies and interventions for better output and outcome.

- The study shows that majority of the farmers were middle aged high school educated, hence there is every need to attract youth by creating more avenues and enterprise based activities in agriculture.
- Majority of the farmers are small and marginal hence the CRTs should be developed to suit the needs and requirements of these farmers. The technologies should be cost effective and user friendly.
- Most of the farmers have medium level of extension contact which may lead to gap in adoption of the technologies. The extension contacts through several means have to be increased.
- The study identified and documented the impact of climate resilient technologies. These technologies can be up-scaled and out-scaled in the similar agro-ecosystem to address the climate variability, as it has become a part of agriculture decision system. Frame work is needed to the technologies that are not adopted by the farmers in spite of its utility .The strategy suggested for adoption and diffusion of technologies will help the researchers and policy makers in devising suitable policy framework.

3.5 Suggestions for future research:

- The present study was conducted only in two districts of Andhra Pradesh. Similar studies may be undertaken in other districts and in other agro-ecosystems to assess the impact of climate resilient technologies.

- The vulnerability of the farmers, farm women and other stakeholders as well as their resilience may be studied and documented for the benefit of the researchers and the policy makers to design appropriate strategies.

- Special focus is needed to study the women role in climate smart agriculture. Focus of climate resilient technologies should be on rainfed agriculture which are cost effective as 55 per cent of Indian agriculture is rainfed and 82 per cent of the farmers are small and marginal.

- There is also a need to study the institutional innovations in dissemination and promotion of climate resilient technologies and their role in community mobilization for higher adoption of such technologies.

- There is also a need to document and analyze the diffusion of these technologies and the factors associated in diffusion. It is also important to study whether the farmers further refined these technologies to suit to the specific problem situation.

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