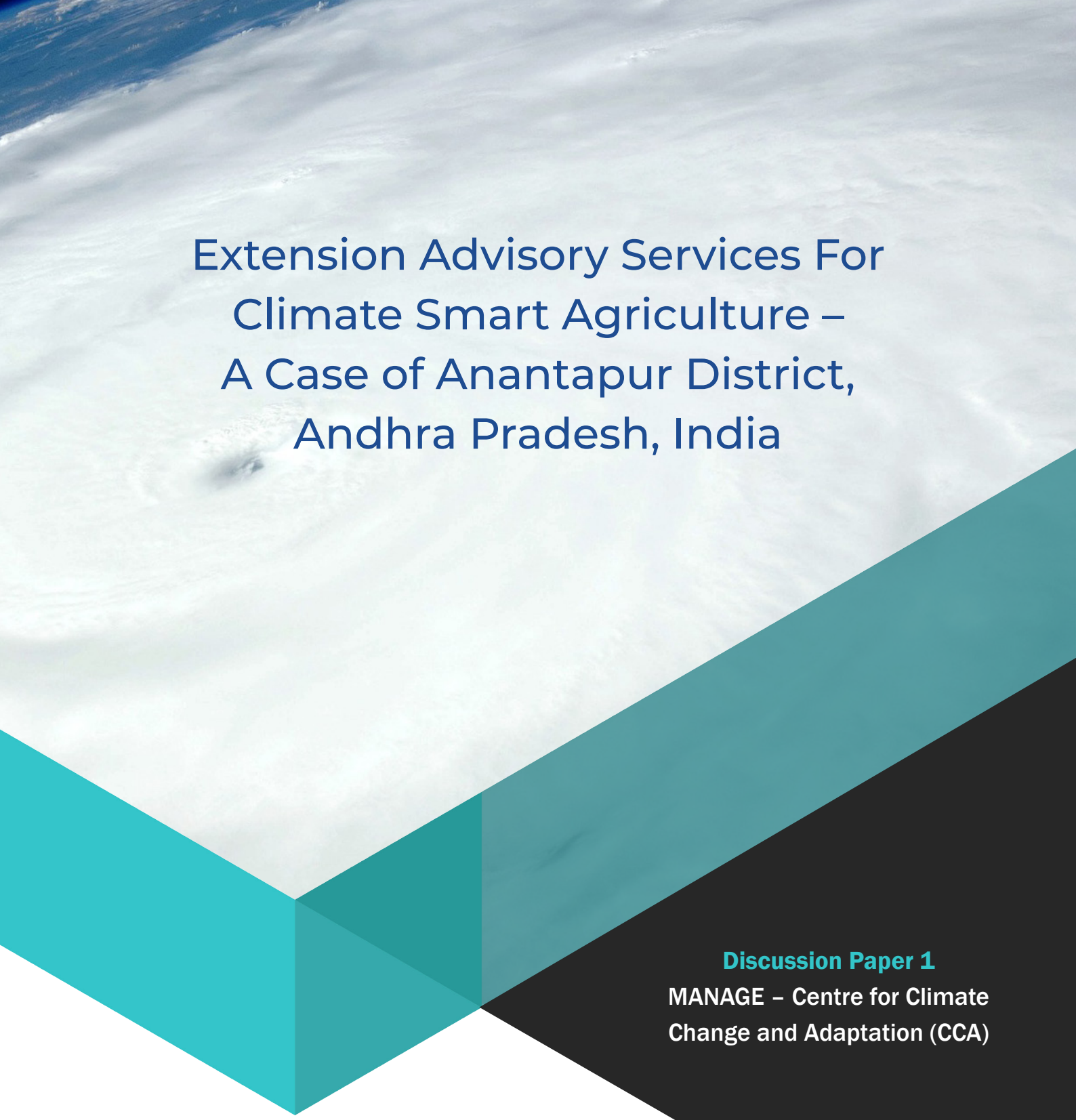

Extension Advisory Services For Climate Smart Agriculture – A Case of Anantapur District, Andhra Pradesh, India

Discussion Paper 1

MANAGE – Centre for Climate Change and Adaptation (CCA)

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About the Publication

The research report is based on the research conducted by Mr. A. Vincent, MANAGE Consultant under the Centre for Climate Change and Adaptation (CCA).

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Message from Director General

Smt. V. Usha Rani, IAS | Director General, MANAGE

The need for promotion of good agricultural practices against ever increasing weather aberrations and climate abnormalities has become the order of the day. In India, public extension system has long been involved in capacity building of farmers, transfer of improved technologies and agronomic practices in a phased and systematic manner, thereby enabling the farmers to maximise the farm output from minimum inputs. Moreover, in the recent past, the participation of private and NGOs have increasingly become significant for promoting climate resilient integrated practices. Most of the good agricultural practices and climate smart technologies/innovations/interventions popularised by these sectors helped the farmers to address the vulnerabilities of climate be it drought, flood and cyclone. Similarly, these stakeholders have developed and experimented various extension innovations and different climate advisory models to mitigate the impacts, adapt agriculture to climate change and enhance the natural resources within the agro ecosystem. Therefore, understanding the roles of public, private and NGOs, which are working towards climate smart agriculture is imperative.

I congratulate Mr. Vincent, A, Consultant, (MANAGE) for choosing an appropriate study entitled "**Extension Advisory Services For Climate Smart Agriculture – A case of Anantapur District, Andhra Pradesh, India**" to conduct research on climate smart agriculture in the drought-prone Anantapur district of Andhra Pradesh.

The discussion paper elucidates the various climate smart agriculture practices advocated by KVK-Reddy Palli, Department of Agriculture, Accion Fraterna Ecology Centre (AFEC) and Adarsha Rural Development and Training Society (ARDTS) in details and discusses the various factors and parameters that led to the success of the adoption of climate smart agriculture practices by the farming community. In the same way, the study has documented different extension interventions and models followed by the stakeholders and suggested the possibility of adopting these models for further upscaling of good agriculture practices across the climate vulnerable regions in the country in general and Anantapur district in particular. It would result in holistic sustainable agriculture.

Let me appreciate and congratulate Dr. N. Balasubramani, Director (CCA) for guiding the consultant for selecting the right research study with suitable methodologies, and collecting data, analysing and presenting. The study will serve as source material for the Centre for Climate Change and Adaptation (CCA) and will be helpful for the researchers, extension functionaries of different states and other stakeholders to take a lead from the paper and to replicate the study across the country in the coming days.

17.07.2019

(V. Usha Rani, IAS)

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Abbreviation

AFEC	Accion Fraterna Ecology Centre
AKPS	Annapurna Krishi Prasara Seva
ARDTS	Adarsha Rural Development Training Society
CA	Cluster Activist
CBO	Community Based Organisation
CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
CHC	Custom Hiring Centre
COP	Conference of Parties
CRP	Cluster Resource Person
CSR	Corporate Social Responsibility
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICS	Integrated Cropping System
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate change
KVK	Krishi Vigyan Kendras
MACS	Mutually Aided Cooperative society
MF	Master Farmer
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate change
NICE	Network for Information on Climate Exchange
NICRA	National Innovations on Climate Resilient Agriculture
NMSA	National Mission for Sustainable Agriculture
NGO	Non-Governmental organisation
RAWE	Rural Agriculture Work Experience
SAU	State Agricultural university
SHC	Soil Health Card
SMG	Sasya Mitra Group
STO	Socio Technical Organiser
UNFCCC	United Nations Framework Convention on Climate Change
ZBNF	Zero Budget Natural Farming

Abstract

This paper has analysed the extension advisory services of the KVK-Reddy Palli, Department of Agriculture, Accion Fraterna Ecology Centre (AFEC) and Adarsha Rural Development and Training Society (ARDTS), who are working in Anantapur district towards climate smart agriculture. To understand the extent of the participation of these stakeholders in climate smart agriculture, the ex post facto methodology was adopted. And, cluster sampling with critical case study method of purposive sampling was also used to study the impacts of the extension advisory services. Further, the primary data were collected from the stakeholders including the actual beneficiaries i.e farmers to triangulate the findings with the secondary data available, and also to analyse the perceived benefits of these climate smart agriculture practices by the beneficiary farmers against the risks and impacts of climate change.

The findings of the study show that the farmers in the study area (Anantapur district) have adopted the climate smart agriculture practices/technologies on account of two reasons. Firstly, “induced adoption” and secondly “wilful adoption”. The increased weather aberrations and uncertain climatic conditions such as irregular rainfall, failure of monsoon, frequent drought, non-availability of other livelihood options etc., have induced them to adopt any new practice or technology that could enhance the resilience of agriculture system over the present situations. Again, various extension strategies adopted by the stakeholders such as screening the climate vulnerability, sourcing suitable climate smart agriculture practices right from the seed selection to post-harvest management, demonstrating to the farmers with co-benefits, supporting them through farmers collectives and extension functionaries, providing contingency crop plans through ICTs and following up with the beneficiaries have led to the wilful adoption. These stakeholders have adopted cluster and project approach, however, these success stories/bright spots were happening in a small area due to the limitations such as funds, manpower, etc. Therefore, there is an imperative need for the scaling up of these proven climate smart practices/ technologies across the country with suitable extension interventions/strategies.

Executive summary

The threats of climate change have become reality in the recent past and the brunt of climate change is conspicuous in the agricultural sector as it is inextricably linked to the weather. Changes in climate affect food production adversely and thereby challenging the food and nutritional security of the billions of populations across the globe. It has been estimated that a total of 800 million population would become prone to vulnerabilities of climate change in South Asia. In India also, the changes in climate are likely to affect the crop productivity and income of the farm families. Indian farmers might have to incur near about 3 % net income loss if the temperature rises by 20C and +7 % change in average precipitation as the present agriculture systems are vulnerable to the changes in weather parameters. Further, the increase in the price of the essential food commodities would push 42 million population additionally into a vicious cycle of poverty. In view of this, transforming Indian agriculture from climate vulnerable to climate smart is the need of the hour. Several public, private and NGOs are working to address the challenges of climate change across the globe. The global initiatives such as the United Nations Framework Convention on Climate Change (UNFCCC), the Conference of Parties (CoP), Inter Governmental Panel on Climate Change (IPCC) have urged every country to plan, process and execute the programmes to mitigate the impacts/risks of climate change and to enhance the adaptability of agriculture.

In India, numerous climate smart initiatives have been framed and formulated by various stakeholders right from public sectors to NGOs including private organisations. India's National Action Plan on Climate change was one of the well-conceived policies of the government of India, which provides directions to the central and state governments to frame and adopt climate smart schemes, projects and programmes as a part of climate mitigation and adaptation. In agriculture, the National Innovations on Climate Resilient Agriculture (NICRA) and National Mission for Sustainable Agriculture (NMSA) have been initiated and are implemented effectively in the grassroots level by involving KVKs and Line Departments. Through these initiatives, the field level extension functionaries at various levels are involved in screening and introducing various climate smart practices/technologies to encounter the challenges of climate change and to address the risks/uncertainties.

In Anantapur, a number of public and private sectors/NGOs are involved in promoting climate smart agriculture practices. Out of which, KVK-Reddy Palli, the Department of Agriculture, Accion Fraterna Ecology Centre (AFEC) and Adarsha Rural Development and Training Society were selected purposively for the study, because of their active participation in the promotion of climate smart agriculture.

Today, most of the farmers in the project areas have adopted various climate smart agriculture practices/technologies such as seed treatment against drought, adoption of climate smart varieties (e.g. groundnut-K-9, LRG – 41, Red gram - PRG – 151 etc), diversified cropping pattern (e.g. Groundnut + Red gram), diversified cropping system (e.g. Mango + annual crops such as tomato/chilli), adapted to zero budget natural farming, applied the fertiliser based on the soil test, involved in the production of vermicompost, adopted mobile led irrigation, established watersheds, check dams and farm ponds, provided protective irrigation, adopted Indigenous Technical Knowledge (ITK), stored seeds in three layered bags, followed seed banks, community seed systems, clean development mechanism (e.g. Biogas) etc.

The gain in knowledge and awareness of the farmers about these climate smart agriculture practices and technologies and the highest rate of adoption were the results of the plough to plate extension approaches followed by these stakeholders. Mostly the extension interventions and strategies such as assessment of climate vulnerability, identification of technology cum knowledge gaps, sourcing appropriate technologies/innovations, Indigenous Technical Knowledge (ITK), networking with suitable partners, enabling ICT based contingency information, hand-holding by extension functionaries with one to one communication, harnessing climate funds, mobilising communities, adopting project and cluster approaches (end to end approach), establishing convergence with the schemes and programmes of central and state governments, creating innovation platforms, developing suitable institutional mechanism, establishing appropriate market linkages, all the more, Involving end users (farmers) through participatory approaches have led to the fullest adoption.

As a result, farmers in the project areas of Anantapur district are now able to perceive the changes in weather; diversify the cropping pattern through contingency crop plan; reduce the cost of cultivation through appropriate crop production practices/technologies/farm machinery; market the produce and get remunerative income, etc.

However, only the beneficiary farmers of the project area have adopted the climate smart agriculture practices because of the cluster approaches of the stakeholders due to their own limitations. Therefore, this end to end extension approaches, coupled with climate smart agriculture practices/technologies advocated by these stakeholders need to be amalgamated based on the need and climate vulnerability of every cluster for a holistic development of climate smart agriculture to drought-proof the Anantapur district, which would result in adapting agriculture to climate vagaries, enhancing the resilience, sustaining the agroecosystem, increasing the productivity and stabilising the income of farmers.

Introduction

Climate change is explicitly accepted as real and become a serious global problem. The brunt of climate change is conspicuous on the primary, secondary and tertiary sectors. Of the three sectors, the primary sector is more vulnerable to climate change owing to its dependence on climate. Climate change alters the production systems, thereby threatens the food and nutritional security of the billions of population across the globe. The changes in climate, affect agriculture in all its dimensions such as shift in climatic and agricultural zones, effect on organic matter/soil fertility, soil erosion, reduced soil water availability, soil chemical composition (alkalisation, salinization), affects pests and disease dynamics, and affect the overall productivity of crops (Khan et al, 2009). The conditions of livelihood will even get worse in the regions like Asia & Pacific and Africa as about 40-50 and 67 % of the total population of these regions are directly working in agriculture. The increase in global temperature is the root cause of climate change and it is caused by the two major factors namely natural factors and anthropogenic activities (human interventions). The mean global temperature (combined land and ocean surface) increased to 0.850C between 1880 and 2012 (Pachauri et al-IPCC, 2014). In total, about 800 million people in South Asia would be prone to climate change scenario including India. The climate change induced yield loss was estimated to be 4.5 to 9 % in India, which will lead to a loss of 1.5 % of GDP on an annual basis (Vijayan and Viswanathan, 2018).

Need for climate smart agriculture?

In India, the loss of productivity and increase in food price are the two extremities of climate change, which would push about 42 million population additionally into the poverty trap and cause 0.4 % loss in overall consumption rates. India is likely to face around 10 % rise in cereal price and 3-4 % more poverty after 30 years than the present times due to rise in temperature and other weather parameters (Jacoby et al, 2011). Indian farmers might have to incur near about 3 % net income loss if the temperature rises by 20C and +7 % change in average precipitation (Kumar, 2011). It is clear that the present agricultural systems are vulnerable to the ever increasing climate change in India. Therefore, for transforming the Indian agriculture from climate sensitive to climate smart needs an invigorated extension advisory services. In this context, a number of public, private and NGOs are involved in sensitising the farmers for promoting climate smart agriculture. The extension advisory services of these sectors would enable the farmers to be aware of the adaptation measures, access information and adopt climate resilient agricultural practices. A number of studies and research have been undertaken to understand the impacts of climate change on agriculture and associated threats to food and nutritional security. However, this study was undertaken in Anantapur district, Andhra Pradesh to comprehend the extension advisory services of public and private sectors including NGOs in ensuring climate smart agriculture as well as the study discusses the climate smart agricultural practices promoted by these sectors, with the following objectives,

1. To study the various stakeholders involved in climate Smart agriculture
2. To document the extension advisory services provided by the stakeholders towards climate smart agriculture
3. To analyse the extent of adoption of climate smart technologies/practices and intesrventions
4. To document the case/success stories of farmers who have adopted climate smart practices.

Review of Literature

Worldwide scenario of extension advisory services of public, private and NGOs sectors in promotion of climate smart agriculture

The public extension plays a major role in extension advisory services. However, the roles of private and NGOs have become highly significant in carrying out the extension activities in the recent past, (Kénou, 2016). The extension advisory services of the public, private and NGOs in climate-smart agriculture includes provision of timely information about the weather forecast, promotion of crop and livestock diversification, better crops production technologies (i.e. quality seeds, improved varieties, efficient water management practices, suitable soil management practices, post-harvest management practices and efficient marketing. The farmers organisation/collectives, government, CGIAR (CIMMYT/IITA) and private sector have been popularising conservation agriculture, Systems of Rice Intensification (SRI), Drought Tolerant Maize in Africa (DTMA) and Index-based weather insurance (ACRE) in Zambia (Africa), Vietnam/ Asia, Sub-Saharan Africa, East Africa (Kenya, Rwanda, Tanzania) respectively as a way of making agriculture climate-smart in the recent past (FAO, 2018).

Extension advisory services, coupled with the climate smart policies have become pivotal since the inception of the convention on the United Nations Framework Convention on Climate Change (UNFCCC). It came into being in 1992 with the aims reducing the risks of Climate change and adapting agriculture to future uncertainties. The Conference of the Parties (COP) is a major decision making body of the United Nations Framework Convention on Climate Change (UNFCCC). The first ever COP meeting was held in Berlin, Germany in March 1995. The COP held in 1997 in Kyoto was one of the important milestones in addressing climate change. Kyoto Protocol-11th December 1997, Kyoto, Japan- legal binding established for industrialized Nations to reduce the emission of six GHG's (CO2, CH4, NO2, Sulphur hexafluoride, hydrofluorocarbons and Perfluorocarbons) 5.2 per cent during 2008-2012 from 1990 emissions. In this timeline, the 21st session of the COP was held in Paris in 2015. The Paris Agreement has formally acknowledged the urgent need to scale up our global response to climate change, which draws even greater ambition from governments. Further, the Paris agreement aimed to keep the rise of global temperature of 21st century well below 2 degrees Celsius from pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Since 1995, a total of 24 COP sessions have been held till 2018. Globally, various institutes/organisations are involved in addressing the issues concerning climate change, in particular agricultural organisations such as the Intergovernmental Panel on Climate change (IPCC), Food and Agriculture Organisation (FAO), the Consultative Group on International Agricultural Research (CGIAR), International Food Policy and Research Institute (IFPRI), USAID etc.

Several NGOs such as Bangladesh Rural Advancement Committee (BRAC), VI Agroforestry in Africa, CARE International, etc. For example, NGO-VI Agroforestry has made awareness among the local community groups/about the adoption of the Sustainable Agriculture land management through the Western Kenya Carbon Project. They also involved in capacity building of the extension functionaries and farmers. It has covered about 45 thousand hectares of lands and 0.6 lakh farmers since 2009 (VI Agroforestry, 2012). Similarly, CARE International has organised the Farmers Field Schools (FFS) about the Hillside Conservation Agriculture under Mitigation of Climate Change in Agriculture (MICCA-FAO) among smallholders in the Uluguru Mountains in eastern Tanzania during 2011-14. The MICC has reached about 1148 through FFS (Likhi, 2017)

Interventions of India on mitigation and adaptation to climate change

India's National Action Plan on Climate change (NAPCC) was implemented in 2008 with the eight sub schemes viz., (i) "Jawaharlal Nehru National Solar Mission" (JNNSM), (ii) National Mission for Enhanced Energy Efficiency, (iii), National Mission for Sustainable Habitat, (iv) National Water Mission (v) National Mission for Strategic Knowledge on Climate Change (vi) National Mission for Sustainable Agriculture (vi) National Mission for Green India and (viii) National Mission for Sustaining the Himalayan Ecosystem to mitigate and adapt to climate change.

Initiatives have been taken to make agriculture more adaptive and resilient to climate variability and to reduce carbon emission. Important initiatives in this regard include crop diversification programme under Rashtriya Krishi Vikas Yojana (RKVY), National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI). Other supporting programmes viz. Soil Health Card (SHC), Paramparagat Krishi Vikas Yojana (PKVY), Mission Organic for Value Chain Development for North East (MOVCD), Rainfed Area Development (RAD), Sub-Mission on Agroforestry (SMAF) and National Bamboo Mission (NBM) are also being implemented under the National Mission for Sustainable Agriculture (NMSA), which is one of the eight Missions of NAPCC.

Government of India gives more emphasis to Rainfed Area Development (RAD), which was evident from the large scale activities undertaken by RAD such as 12,000 ha of Integrated Cropping System , 28,000 ha of livestock based farming system, 46,000 of water harvesting and management structure (tanks, community water harvesting ponds and so on), etc during 2018-19. Similarly, 1,751 training and 456 demonstrations were organised under RAD of NMSA during the said period. The line departments have also played a crucial role in creating awareness about these schemes to the farmers. The field level extension functionaries of these departments have been involved in assessing the impact of weather changes at farm level, screening and introducing various climate smart practices envisaged in the NMSA.

The initiative like the National Innovations on Climate Resilient Agriculture (NICRA) - A network project of ICAR (http://www.nicra-icar.in/nicrarevised/) gives emphasis on strategic research, technology demonstration, capacity building and sponsored / competitive funds to build resilience to climate change. As part of the NICRA project, the vulnerability assessment was carried out and major climate vulnerable regions were identified, which have frequently been affected by climate change. Accordingly, a district level contingency plan was prepared with suitable mitigations and adaptation strategies to address the various vulnerabilities by involving stakeholders. Further, a total of 121 villages, one representative village/cluster of villages in each district have been selected across the country and demonstrations are conducted about resilient practices/technologies on four components of NICRA namely;

1. Natural Resource Management
2. Crop production
3. Livestock management and
4. Institutional innovation.

On crop productions component of NICRA, the interventions such as integrated cropping system modules, diversification of crops, biotic and abiotic stress tolerant varieties, zero till drill, direct seeded rice, mulching, laser land levelling, happy seeder, micro irrigation, dry converted wet rice, conservation bench terrace, conservation furrows, rolling stem application, in situ incorporation of biomass and crops

residues, community nursery, climate smart landscaping, water and soil management etc. are being undertaken (Prasad et al, 2016). For Example, as a part of crop production component, the introduction of TS-3R (Red Gram) variety by KVK-Hulkoti (Karnataka state) as an intercrop in Maize cultivation; CR 1009 Sub 1 (Paddy) tolerance to flood by KVK-Needamangalam, Tiruvarur (Tamil Nadu state); Short duration variety of Red gram, BDN – 711 by KVK-Jalna (Maharashtra state) etc. have contributed to climate smart agriculture. Notably, the NICRA's activities on the management of natural resources through the creation of watershed, check dams, community/individual ponds, reclamation of wastelands etc., have significantly sustained the agro-ecosystem and the production. Similarly, the promotion of livestock management practices such as Breed, feed, shelter management and health management in livestock, has played a major role in adapting "agriculture as a whole" to climate change. In addition to this, institutional innovations and other support services such as Custom Hiring Centre, seed and fodder banks have ensured the availability of farm inputs and implements at an affordable price to the farmers, thereby helping the end users to undertake agricultural operations timely.

For example, NICRA activities in Shekta village of Ganapur taluk, Aurangabad district of Maharashtra show that the climate smart initiatives and extension advisories have led to the increase in income and productivity from low to medium level. Further, NICRA has improved the social participation, expenditure pattern, occupation, material possession, annual income, land possession etc (Pise et al, 2018).

A number of initiatives on ICT have been experimented by India as a part of climate smart agriculture. Examples, ICT hubs of ICRISAT, farmer portal, Kisan Suvidha, Bhuvan Hailstorm mobile App of GoI, Indian-weather (IMD), Micro Level Agromet Advisory Services (MAAS), SKYMET, NICE (Network for Information on Climate Exchange)-CCKN (German development cooperation (GIZ). For example, Agromet Advisories of CRIDA was one of the novel initiatives that helped to encounter the challenges of climate change. Under this initiative, the weather bulletins were prepared and suitable contingency crop plans were disseminated to the farmers. The bulletins consisted of the weather events for the past, present and future (at least 5 days ahead), crop state information and related farm activities or production practices to be taken up to mitigate the impacts of future weather changes (V.U.M.Rao, CRIDA).

In most of the states, the major policy interventions like the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA, 2005) has helped in undertaking the climate resilient activities in agriculture such as the creation of mini watershed areas, water conservation, excavation/renovation of reservoirs/ ponds, other rainwater harvesting structures, tree plantation and maintenance, etc. Thus, the scheme like this could enhance the resilience of agriculture and allied sectors during severe droughts and other climatic risks (Udmale et al, 2014). The farmers in Saddapalli and Gundlaplli villages, Chikkaballapur district in Karnataka state have joined in MGNREGA after the crop loss resulted from the vagaries climatic conditions. It was reported that 82 of the households in these villages have gained employment opportunities from MGNREGA and most of them were employed during the winter season. Thus, the scheme has provided a substantial income to the farmers in these villages, which compensated the income loss from agriculture due to climate change (kattumuri et al, 2017).

The role of state government is also indispensable in adapting agriculture to climate change. Every state and union governments through their line departments are implementing subsidised micro irrigation schemes, crop insurance schemes, smart input management through organic or natural farming, smart marketing through collectives or through value addition/e-marketing (e-NAM) etc. For example, Government of Andhra Pradesh is promoting the Zero Budget Natural Farming (ZBNF) as a saviour to the climate change and about 1.4 lakh farmers in Andhra Pradesh have adopted ZBNF, which accounted

for nearly 0.6 million hectares of farmlands (The news mint, 2018). The government of Maharashtra has signed the Maharashtra Project for Climate Resilient Agriculture agreement with the World Bank and was facilitated by the government of India. An amount of 420 million US dollar will be given by the International Bank for Reconstruction and Development (IBRD) to implement the project, the project will benefit about 25 million small and marginal farmers in the areas of Marathwada and Vidarbha regions of Maharashtra. Also, it encompasses serious activities, which include on the farm and off-farm watershed development programmes, dissemination of climate resilient technologies such as micro-irrigation systems, expansion of surface water storage system, facilitation of aquifer recharge, popularisation of climate resilient seed varieties (e.g. drought, salt, heat-tolerant varieties). Likewise, the emphasis is given to enhance the capacity of farmers' organisation such as local farming institutions, Farmers Producers Organisations, agri-enterprises, thereby ensuring the timely agro advisories and extension services to overcome the climate risks (PIB, 2019).

In addition to these public sectors, the number of private and NGOs are involved in participatory climate smart agriculture and are providing climate advisory services to the farmers to mitigate the impacts and adapt to climate change. The private sectors such as TATA Trust, JSW, Dr. Reddy's Foundation, , Reliance Foundation, DCM Shriram Limited, India, Hindustan coca-cola beverages private limited, India Big basket, Sattva, JK Tyre and Indus Ltd, Ambuja Cement Foundation, The Goat Trust to name but a few through its Corporate Social Responsible funds and other external funds/climate funds. For example, DCM Shriram Limited - India *has introduced climate-smart sugarcane agronomy package of practices (PoP) named the 'Meetha Sona' program*, as a way of training the farmers about the better package of practices for increasing the yield of Sugarcane. Besides, a variety of extension services were offered to enhance the capacity of both extension workers and farmers, which include establishing demonstration farms for climate-smart sugarcane cultivation practices, such as new climate-resilient, high-yielding varieties; soil health improvement; water-use efficient practices and technologies such as mulching, furrow irrigation, land levelling, and drip irrigation systems; and an integrated pest management programme. The extension services have led to the improvement of its 0.8 lakh farmers' livelihood (including 15 000 women farmers) through the adoption of climate-smart practice like inter-cropping, optimum use of irrigation water, reduced stubble burning and mulching etc. (World Bank, n.d.)

There are several NGOs are working in the field of agriculture and conducting several extension programmes in the country. The NGOs such as Sahayog Sansthan – A non-profit society, Rajasthan, Watershed Organisation Trust, Pune, Dhan Foundation-Madurai, Tamil Nadu, M. S. Swaminathan Research Foundation, Chennai, Tamil Nadu, Cecoedecon, Rajasthan, Navdanya (NGO), Uttarakhand to name but a few are also making their efforts in addressing the climate vulnerability. For example, the NGO, Cecoedecon (Centre for Community Economics and Development Consultants Society-Rajasthan state, India) organises farmers into a community/groups in the Bhipur village, Rajasthan for the *wide-scale adoption of community-based climate-smart practices* such as the construction of bunds and gully Plugs around the field, digging of feeder channel and deepening wells. These group approaches led to the year-round availability of water for farming, drinking, keeping fishes and cattle and growing Chestnut (Sustainet, 2014).

Methodology

The district has about 4.3 million population with 70 % of them living in rural areas. About 9 m ha of 11 million ha of the farm's land is rain-fed agriculture. More than 90 % of the farmers are marginal and small farmers and most of them are belonging to the SCs, STs and Other Backward Class (Accion Fraterna Ecology Centre, 2016-17-Annual Report).

Box 1. Birds eye view of Anantapur district

Anantapur is located in the south of Andhra Pradesh state and shares its border with Karnataka in the south and west, and shares its border with Chittoor on the southwest, Kurnool on the north and YSR Kadapa on the southeast. The district Anantapur has about 949 villages spreading across 63 mandals/Tehsils. The 63 mandals are grouped under three division namely Anantapur (20 mandals), Dharmavaram (17 mandals) and Penukonda divisions (26 mandals).
Census of India, 2011

Fig 1. Dry land is being ploughed expecting a seasonal rainfall (22.09.18), Anantapur

With the 552 mm of average annual rainfall, the district Anantapur marks the second driest district in the country next only to Jaisalmer (Rajasthan state). Of the total 63 mandals, only 10-15 mandals have received a minimum rainfall in the year 2018, which is not sufficient for more than 50 % of the standing crop. This situation of scanty rainfall and increased droughts have been prevailing for the past 10 years. The increased climate-related risks and challenges have forced the marginal and small farmers to desert their farmlands and migrate to the cities such as Bombay, Bangalore, Tirupati etc., The medium and big farmers have become small farmers owing the reduced water availability, desertification of the farmlands due to failure of monsoon etc., in many cases marginal and small farmers have become agricultural labourers to the big farmers owing to the inability to cope with the climate change.

In addition to various other problems faced by the farmers, they also indebted to money lenders and other credit institutes like banks and credit cooperative society due to climate induced crop failure. As a result, farmers were forced to commit suicide (Mr. Anandhagri, personal discussion, 2018).

Fig 2. Current Fallow Lands in Anantapur district

The department of agriculture and allied sectors, KVK-Reddy Palli and NGOs such as Accion Fraterna Ecology Centre and Adarsha Rural Development and Training Society working in Anantapur district were selected purposively, because of their active involvement in the promotion of climate smart agriculture.

According to the survey and assessment of NICRA-ICAR, a total of 121 districts are climate vulnerable districts in the country. Of which, five districts namely, Anantapur, Chittoor, Kurnool, Srikakulam and West Godavari are located in Andhra Pradesh. In this context, the present study has been taken up in drought-prone - Anantapur district. It has received not more than 381 mm annual rainfall on an average in the past five years, which is next only to Jaisalmer district in Rajasthan state (The new mint, 2018). However, Anantapur is unlike the district of Jaisalmer, most of the rural population (70 %) depends on agriculture. For example, the district has about 4.13 lakhs cultivators 8.79 lakhs agricultural labourers, whereas the district Jaisalmer's cultivator population and agricultural labourers are about 1.32 lakhs and 0.43 lakhs respectively (Census of India, 2011), thus, making the district most vulnerable to climate change variability. The district is categorised under the scarce rainfall zone among the ten agro-climatic zones in the state of Andhra Pradesh as well.

Fig 3. Rain fed red gram, Anantapur

The ex-post facto research design was adopted. The secondary data analysis coupled with the historical analysis were followed to study the climate smart activities promoted by the NGOs such

as Accion Fraterna Ecology Centre, Adarsha Rural Development and Training Society, KVK- NICRA and the Department of Agriculture, as these organisations are actively involved in promoting climate smart technologies in Anantapur district. The primary data was collected from the stakeholders using the checklist prepared for the study. The data was collected using the key informant interview method, focus group discussion and case study with the stakeholders of climate smart agriculture and farmers.

The cluster sampling was used to study the climate smart activities of different stakeholders, followed by a critical case sampling cum expert/informant sampling was used under purposive sampling. The emphasis was given to elucidate the qualitative information from the stakeholders with the case analysis.

Results and discussion

The outcomes of the study indicate that the stakeholders have participated in the entire gamut of the supply chain for identifying and promoting climate resilient innervations and to ensure the adaptation. The results and discussion of this section are elucidated under the various head and subheads, which include crop management, seed management, climate smart varieties, cropping pattern, crop diversification, Integrated Cropping System; inputs management; water management; knowledge management and Clean Development Mechanism. Further, the perception and the extent of adoption were also documented and presented in this section.

Box 2. RAWE as an extension method towards climate smart village

Farmers expressed that the demonstration of seed treatment with Pseudomonas firmis – a drought resilient climate smart seed treatment practice by the students of RAWE programme – Acharya N. G. Ranga Agricultural University (ANGRAU), Kurnool enabled them to save their crops against the severe drought situations occurred in 2018. In this context, if the SAUs adopt RAWE model as reaching the farmers effectively, it would complement the extension services of public and private sectors in adapting agriculture to climate change and improving the wider penetration of climate smart technologies.

Climate smart seed management

The awareness about the treatment of seeds with the Pseudomonas firmis among the farmers in the village of Peravali has been increasing due to the demonstration made by the students of Rural Agriculture Work Experience (RAWE) programme – Acharya N. G. Ranga Agricultural University (ANGRAU), Kurnool. The treatment of seeds with the Pseudomonas firmis mitigates impacts of droughts and provides resilience against root grubs in groundnut. About seven farmers in Peravali have adopted technology in the year 2018. The farmers in Peravali village felt that treating the groundnut, pulses (Red gram, green gram) and other field crops seeds with Pseudomonas firmis helps in withstanding drought up to 10-15 days. It was observed that until the demonstration of seed treatment with Pseudomonas firmis by the students of RAWE, the farmers in the village of Peravali had a little knowledge on seed treatment and its associated benefits to climate change.

In addition to this, the farmers associated with the NICRA project have expressed that 60 % of the beneficiary farmers of NICRA have adopted the seed treatment. They also perceived that the seed treatment has reduced the application of fertiliser, number of sprays (from 5 to 2 to 3), reduced cost of inputs, application time, saved no of labour, and labour cost in groundnut, pulses, etc., and thereby saving an amount of Rs 1500 – 2000 per acre of land.

From the above two observations, the rate of adoption technologies can be hastened with suitable extension methods (e.g. RAWE) and programme interventions (e.g. NICRA). In India, there are about 64 State Agricultural Universities (SAUs) with a number of sub campuses and each of these Universities has a pool of climate smart technologies coupled with RAWE as one of the extension programmes for the final year students of B.Sc. (Agriculture). Therefore, there is an ample opportunity to disseminate such climate

smart practices/technologies based on the identified climate vulnerabilities in different agro ecological systems in their jurisdiction.

Climate smart varieties

The increased temperature, frequent occurrence of droughts and delayed rainfall and failure of the monsoon are the recurring phenomena in many parts of Anantapur. The occurrence of these extreme events resulted in reduced crop output and increased the cost of cultivation. This highest degree of risks associated with droughts due to climate change has necessitated the NGOs like Accion Fraterna Ecology Centre (AFEC), KVK-Reddy Palli to promote and popularise the drought tolerant varieties of both field and horticultural crops that can mitigate the impacts of delayed monsoon, the imbalanced distribution of precipitation and ever increasing droughts.

Fig 4. K – 6 groundnut variety, Agricultural Research Station, Kadiri

Table 1. Climate smart varieties and their impact

S. No.	Stakeholder	Varieties	Climate resilient traits	Extent of adoption and impact
1.	KVK	K – 6 (Groundnut)	Drought tolerant with sound maturity.	About 90 % of the farmers have adopted K – 6 variety in the Peravali village as it is able to perform better under the extreme weather conditions like increasing temperature, droughts and reduced moisture conditions due to delayed monsoon even in the month of September.
2.	KVK	K – 9 (Groundnut)	Resistant to droughts and has high oil content (53 %) and high yielding (1600 – 1800/ha).	The demonstrated of K – 9 groundnut variety by KVK through NICRA made a successful impact in Peravali village. A total of 8 farmers have adopted the variety since 2013.

3.	KVK	Dharani (groundnut)	Tolerant to drought and resistant to groundnut leaf spot disease and it has been promoted to replace K-6.	A total of 12 farmers have adopted Dharani variety in Peravali village. With the higher yield of 525 kg per ha over the yield of K-6 (478 kg/ ha), it generates Rs. 6567 as a net income when compared to the net income of K-6 (Rs. 3774/ha).
4.	KVK	LRG – 41 and PRG - 151 (Red gram)	Drought tolerant varieties with high resistant to pod borer and high yielding.	About 125 farmers have adopted the variety of LRG – 41 covering about 52 ha of lands and around 40 farmers have adopted PRG – 158 with the coverage of 30 ha in the NICRA villages. The B: C ratio (3:0) of PRG – 151 is more than that of LRG – 41.v
5.	KVK	PCH-111 Castor	PCH – 111 is resistant to wilt and tolerant to drought. The hybrid castor has been promoted as an alternative to farmers' local practice as the cost of cultivation of PCH -111 is lesser (Rs. 16250) than local variety (18000).	About 6 farmers have cultivated PCH -111 in Peravali village. The net income of PCH -111 is about Rs. 16421, which is 2.5 times more than the local castor variety (Rs. 6375).
6.	AFEC	Benishan (Mango)	Drought resistant and possesses high market value due to its taste.	The mango variety Benishan demonstrated by AFEC has been adopted by a majority of farmers in Anantapur district, which helped farmers to overcome water stress and drought. A farmer gets as much as 1000 Kgs or 100 baskets of mangoes per season and fetches an income about Rs. 15, 000 on an average per acre @ Rs. 15 Kg per Kg even with the reduced rainfall. Besides, farmers informed that the Benishan variety could fetch a maximum of Rs.30/Kg depending on the demand.

5.	AFEC	Ujwala/ PRG 176 (Red Gram)	Resistant to terminal drought and is suitable for light chalka soils (light red soils with low water retention).	The year 2018 has recorded a longest (90 days) dry spells in many parts of Anantapur. Hence, the drought-resistant variety (PRG 176) was demonstrated in the 230 villages of Accion Fraterna project areas. During the study period, the crop was not yet harvested. However, farmers felt that this variety is withstanding the terminal droughts. Therefore, AFEC is planning to upscale the variety for the wider adoption based on the result of the demonstration plots in the ensuing season.

It was learnt from the stakeholders involved in the implementation of above interventions (Table 1) that the success of addressing the risks of drought by the implementing agencies such as KVK and AFEC is attributed to various factors such as assessment of vulnerability of the project areas in advance, screening of suitable varieties for the identified vulnerabilities, creation of awareness and stocking the required quantity of drought resistant varieties of various crops, demonstration of resistant varieties in the project areas and technical hand holding during the demonstration period. These extension activities undertaken by the stakeholders in tandem have influenced the adoption behviour of farmers. It was also understood that AFEC has adequate grassroots level extension functionaries (80 Nos) i.e. Socio Technical Organisers (STOs), each of them covers about 2-4 project villages. Each of these STOs of AFEC visits the project fields on a regular basis and suggests the improved practices from time to time. These one to one communication and transfer of real time climate information have helped the farmers to develop a trust in AFEC as well as motivated them to adopt the technologies at a faster rate. Although the productivity of crops mainly groundnut, pulses (e.g. Redgram) have improved over a period of time due to the adoption of climate smart varieties. Still, there is a huge scope for upscaling the varieties to a larger extent as the productivity of groundnut has reduced gradually in Anantapur district. According to the kharif-2018 survey of groundnut crop by APEDA, the yield of groundnut in Anantapur district was relatively lower when compared to the groundnut yield (883 Kg/ha) of the state (Andhra Pradesh) and of the country (1336 Kg/ha). Whereas, the highest yield of groundnut (2051 kg/ha) was recorded in the state of Rajasthan (kharif-2018 survey of groundnut crop of APEDA). In this context, still, there is a huge scope for the introduction of high yielding varieties and technologies of groundnut. ICRISAT is one of the technical partners of AFEC and AFEC has a collaboration with the Research Institutes of groundnut Kadiri (Acharya N.G. Ranga Agricultural University, Anantapur, Andhra Pradesh). Therefore, the research, extension organisation and NGOs working in Anantapur district can leverage the existing networks/collaboration to harness the synergy to develop and disseminate the drought resistant groundnut varieties, which is still a major crop in the district.

Furthermore, KVK and AFEC have demonstrated different drought resistant varieties on a limited scale in their project/adopted villages. As the demonstrations have shown that the drought resistant varieties have significantly reduced the adverse effects of droughts. Hence, the frontline extension systems of the

department of agriculture may take forward these proven varieties to a larger area for the benefit of the farming community.

During the interaction, it was also understood that the one to one communication of the STOs (AFEC) has facilitated the adoption rates. Hence, ATMA (Agricultural Technology Management Agency) can make use of the existing Farmer Friend effectively by imparting training to them on climate resilient technologies.

Climate smart cropping pattern

Monocropping is a cause of concern in addition to the adverse impacts of climate change. Monocropping system of groundnut had been cultivated by about 90 % of the farmers in Anantapur district until the year 2000 be it rainfed farmers or irrigated farmers (Personal Interaction, Dr.Y.V. Malla Reddy, Director, AFEC). The introduction of the green revolution led to the wider adoption of groundnut as a mono crop by the farmers in Anantapur owing to the increased demand for oil. The public extension system has introduced the high yielding groundnut crop (e.g. TMV 2) in the district of Anantapur in the 1970s. The introduction of high yielding groundnut variety TMV 2 led to the reduction of area under pulses and minor millers in Anantapur in the late 1900s and 2000s. The increased area under groundnut might be because of the subsidies, incentives and continuous persuasion of public extension system during 1970s-2000, thus, motivating farmers to adopt groundnut in large scale (Table 1).

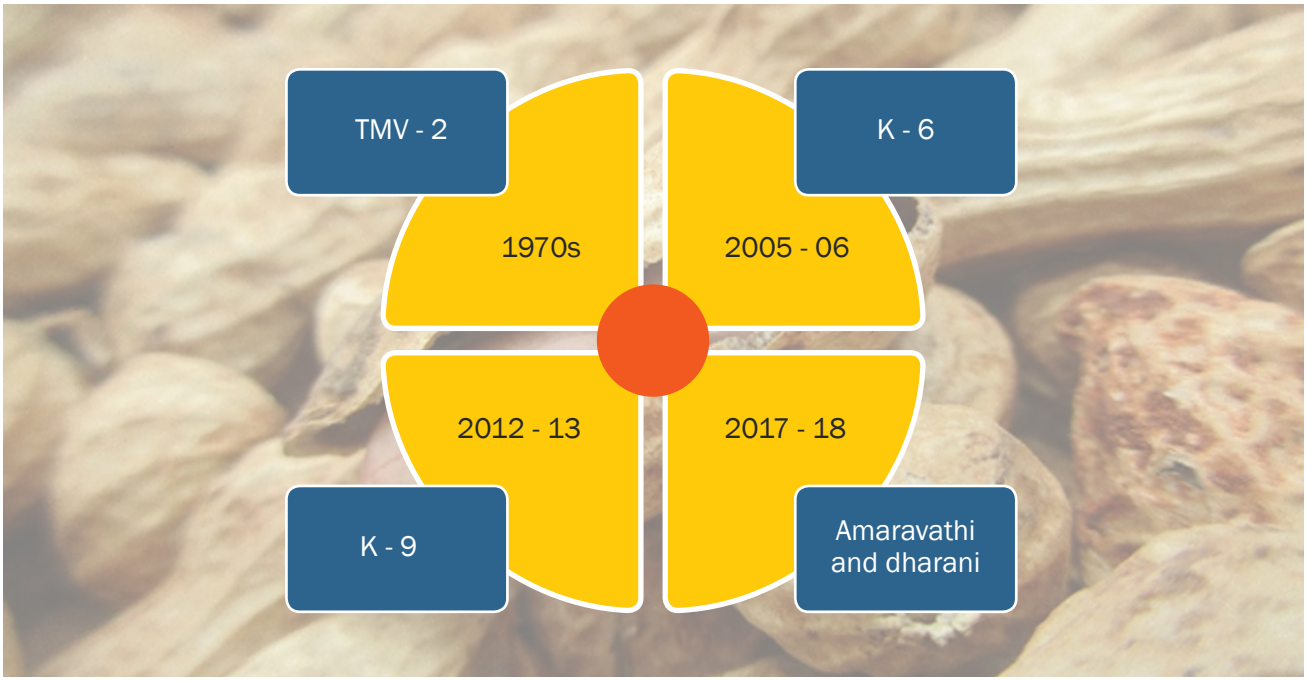

Fig 5. Time period of the adoption of climate smart groundnut varieties by the farmers in Anantapur district. Source: Dr. K. Sampath Kumar, Agricultural Research Station, Kadiri.

According to the study conducted by the MSSRF during the year 2009, the area under groundnut was only about 18.4 % (1.94 lakh ha) during 1960-61, however, it increased to 74.18% (8.11 lakh ha) in the year 2005 - 06. On the other hand, the area under millet was 52.37 % (5.54 lakh ha) in 1960-61 and was reduced to 3.41 % (0.37 lakh ha) in 2005-06. However, farmers are gradually diversifying their cropping pattern again into climate smart cropping pattern with millets and pulses. Until 2016-17, the area under diversification was extended up to 30 % (Annual Reports of AFEC, 2016-17). Furthermore, the increased awareness / knowledge of the farmers about the changing weather parameters in their

locality and the availability of alternative cropping systems to tackle the extreme events resulted in the adoption of intercropping (groundnut/pulses), mixed cropping (Mango/Tomato/chilli), crop diversification (Groundnut to millets/pulses) etc. (Table 2).

Fig 6. Intercropping of red gram in mango orchard, Pampanur, Anantapur.

The main strategies adopted by AFEC to promote climate smart agricultural practices include (i) mobilisation of community (856 nos) for drawing water from local reservoirs to provide protective irrigation (A total of 3206 farmers in 30 villages within area of 3950 acres were benefited from the community led protective irrigation), (ii) partnering for financial support with the Department of Rural Development (GoI), Department of Agriculture (GoAP), Department of Rural Development (GoAP), Fair Climate Network (Bagepalli), Indigo Airlines (New Delhi), Suzlon foundation, Bread for the world, ICCO-Cooperation, NABARD (National Bank for Agriculture and Rural Development), Environmental Defence Fund, etc for promoting the climate smart activities and (iii) leveraging partnership with technical/ knowledge organisations such as the Acharya N. G. Ranga Agricultural University, Andhra Pradesh, International Crop Research Institutes for Semi-Arid and Tropics (ICRISAT) and other local NGOs and (iv) Sustaining the trustworthiness and credibility among the 30000 small and marginal farm families of their project villages with whom AFEC has been working for about 34 years. These strategies have helped the farmers to sustain the diversified cropping pattern against the backdrop of growing water scarcity, increasing dry spells and frequent occurrence of droughts.

Further, AFEC has the partnership with its farmers' collectives (SMGs) in implementing various climate smart programmes, projects, climate smart crop production practices, etc. Until 2018, AFEC has covered about 8 mandals (Sub – Divison) of 63 in Anantapur district. However, being an NGO, AFEC has not been able to cover larger areas due to lack of funds, inadequate manpower etc.

In view of this, to upscale the climate resilient practices, Government may identify the potential knowledge partners, NGOs and other private organisations. These identified stakeholders may be involved in mobilising the farmers, disseminating the knowledge of climate information and persuading them to adopt the climate smart cropping pattern in a convergence mode. This consortium approach would help to harness the strength of each partner to meet the large scale demand of dryland farmers in terms of fund requirement, technical manpower and to provide customised climate smart advisory services to the farming community.

The public institute like KVK - Reddy Palli was also successful in creating awareness and behavioural change among farmers towards climate smart agriculture in their adopted villages. KVK is working on the basis of a contingency plan prepared as part of NICRA. The plan indicates that the district has about 2.71 % (51900 ha) of cultivable wastelands. This wasteland can be converted into cultivable / pasture lands/Agro-forestry through a Public and Private Partnership. Further, the government may improve the convergence among grassroots level organisations/bodies (e.g. Panchayat) and NGOs. This could improve the vegetation, minimise desertification, enhance soil fertility and carbon sequestration. Although the contingency plan is an effective initiative, it needs further decentralisation. Therefore, the extension system may think of developing a block/mandal level contingency plan, which will have more relevance and accuracy. This could improve the extension advisory services and ensure the sustainable agroecosystem against drought hit Anantapur district.

Fig 7. Community led protective irrigation

Table 2. Climate smart cropping pattern and its impact

S. No.	Stakeholder	Climate smart cropping pattern	Extension advisory service	Extent of adoption and impact
a.	Climate smart Intercropping			
1.	AFEC	Groundnut + castor, Groundnut + Red Gram (7:1), Foxtail millet + Red Gram (7:1), Jowar + Red Gram, Pearl Millet + Red Gram, Ragi + Red Gram, Castor + Red Gram (11:1), Bengal Gram/ Green gram + Red Gram, Green Gram + Jowar	Farm Field school, training, meeting and demonstration to the farmers coupled with field days	About 6 000 farmers (mostly rainfed farmers) from 230 villages spreading across 8 mandals of Anantapur district namely Atmakuru, Kudair, Raptadu, Dharmavaram, Kalyandurgam, Beluguppa, Settur and Kundurpi (Tehsils) have adopted in the past 10 years, which covered about 5852 acres until 2018. The farmers have adopted any one of the cropping pattern, which is suitable for their field situation and on and off farm resources. The intercropping has curtailed the monocropping of groundnut from 90 % to 70 % till 2016 in Anantapur district (AF, 2015 -16).
2.	KVK	Groundnut (K – 6) + red gram	Demonstration, training and awareness programmes	The farmers get about Rs 7 100 / ha as a net income with the adoption of the intercropping of groundnut + red gram. However, the growing of any one of the crops as mono crop be it groundnut or redgram gives only Rs 4000/ha. (NICRA-KVK, Reddy Palli, 2012-2017). About 18 farmers have adopted the technology, which covers an area of 28.02 ha in Peravali village
3.	KVK	Korra (suryanadhai)+ red gram	Demonstration, training and awareness programmes	About 43 farmers have adopted this cropping pattern with the area coverage of 43 ha in the village of Peravali, which is one of the NICRA adopted villages in Anantapur. With the maximum yield from both the Korra (Foxtail millet) and red gram, the farmers gain a reasonable income. The average seed yield of Foxtail millet (Suryandhi variety) is about 1250 Kg per ha in addition to the straw yield of 3200 kg per ha. The farmer can realise about Rs 27557 per ha of land from Korra (Suryanadi variety) as a net income.

b.	Climate smart crop diversification			
1.	AFEC	Horticulture + agriculture: Horticultural Crops (Mango, Tamarind, Gooseberry, sapota etc.,) + annual crops (Pulses, millets, groundnut, Bajra, Jowar, Foxtail millet or vegetables etc.,)	Farm Field School, demonstration and field days followed by exposure visits	About 1520 farm families have adopted growing of tree crops with annual crops either field crops or vegetables, which covers about 5775 acres of land. Farmers' net profit from groundnut was not more than Rs 3,000 in the past due to the poor yield of groundnut (Avg. 100 Kgs/acre) resulted from irregular rainfall during the critical growing period of the crop. However, the shift to horticulture cum tree crops and adoption of intercropping of vegetables in the mango orchard supported with micro irrigation led to the increased income. The farmers could get the net profit of about Rs 15, 000 – 20, 000 per acre from the vegetables alone. Besides, the Benishan variety of mango gives about the net profit of about 15 000 per acre. Thus, making the farmers financially more secure even with the increasing temperature/droughts and reduced rainfall. The farmers perceived that the high income would enable them to adopt high value technologies (Anantha planter, Aqua seed drill etc.,) for crop production in the coming days.
2.	ARDTS	Millets such as kora (Foxtail millet), samu (little millet), sajja (Pearl Millet) and boragullu)	Training and capacity building of farmers towards millets. About 10 -15 training organized by Adarsha Rural Development Training Society every year	About 4000 farmers have changed their cropping pattern from groundnut to millets and integrated dairy, sheep and goats in the production of millets in the past 8 years till 2018. It covered about an area of 3 000 – 4 000 acres in the mandals of Kadiri and Hindupur. Presently, growing of millets gives about Rs 30 000 per acre as net income due to the contract farming established with millet marketers (e.g. Timbaktu), which was facilitated by ARDTS. Whereas, the net income from groundnut was not more than 3 000 per acre in the past years.
3.	KVK	PCH – 111, SiA-3085 (Castor) Foxtail millet (Suryanandi)	Demonstration	The climate adaptive traits of PCH – 111 (Castor) helped the farmers to overcome the droughts in the village. Similarly, Foxtail Millet (Var. Suryanandi) makes Peravali village to become resilient to the increased temperature and droughts. About 4 and 12 farmers have diversified their cropping pattern towards PCH – 111 and SiA-3085 (Castor).

c.	Contingency cropping			
	KVK	Yellow Jowar (AJ-140) and Horse gram	Awareness creation and demonstration	About 26 farmers adopted the contingency crop plan Yellow Jowar (AJ-140) in 2013 owing to the drought, which covered about the area of 27.2 ha and the yield was recorded to be 900 kg per ha on an average. Likewise, 14 farmers have adopted the contingency cropping pattern of horse gram. However, the Horse Gram was not able to withstand the severe drought situations in the same year (2013)

sources: Annual Reports, 2015-16, 2016-17 of AFEC and NICRA report (2012-17), KVK, Reddy Palli

Box 3. A Case study of Mr Vanurappa – Rewriting the script of the supply chain

"Farming might have extinct in Pampanur (Atmakur mandal, Anantapur district) without the interventions of the government of Andhra Pradesh and Accion Fraterna (NGO) namely subsidised drip irrigation system and introduction of drought tolerant mango variety respectively as expressed by the small dry land farmer - Mr Vanurappa, Pumpanur village. The shift in cropping pattern towards mango (Baneshan) has enabled Mr Vanurappa to become more adaptive to the risks of climate change such as increased drought and uncertain rainfall in the recent past, especially, the longest dry spells occurred from July to September, 2018 for a period of 80 - 90 days. In the same way, intercropping of tomato (1/2 acre) and chilli (1/2 acre) in the mango orchard sustains the income of Mr Vanurappa throughout the year. The need for the labourers is met from his own family, whereby he saves labour cost of about Rs. 10, 000 for 2 acres. As his farm is located nearer to the Subramanya Swami temple, which is famous in Pampanur, he sells his produce on the road side every day. The people visiting the temple and the passerby procure the Chilli and Tomato directly from him, thereby avoiding the intermediaries and fetching a better farm gate price up to Rs 30 or 40 per kg. Hence, Mr Vanurappa gets an additional income of Rs 20,000 from the intercropped areas (Chilli and Tomato) of one acre. The farmers could get a reasonable farm income and mitigate the adverse climate effect to considerable extent, mainly because of the interventions like subsidised bore wells coupled with drip irrigation, introduction of drought tolerant perennial crops like Mango (Benishan), introduction of intercrops/ cash crops (Tomato and Chilli), supplemented with the localised innovative market support, in addition to the continuous technical backstopping during the entire supply chain. The entire supply chain of production system is possible because of the dedicated NGO (AEFC), who is involved in networking with the various programmes/schemes of the public and private sectors. This model works well on a project approach rather than the individual departments working on a compartmentalised approach.

Climate adaptive Integrated Cropping System - A case study of AFEC

Integrated Cropping System (ICS) has increasingly been adopted by the farmers as a way of overcoming climate uncertainties and ensuring remunerative income. However, the Climate adaptive

Integrated Cropping System in the rainfed is altogether a different connotation. AFEC has done several demonstrations on climate adaptive Integrated Cropping System for the past 10 years, which includes integration of tree crops like mango, jamun, custard apple, guava, gooseberry, biomass tree and sheep or goat/cattle with annual crops such as millets + pulses or groundnut, Fodder trees with annual crops etc. Initially, the adoption rate was less on account of two reasons, firstly the farmers were unwilling to take up any new cultivation practice other than groundnut. Secondly, the distribution of rainfall was also fairly normal until 2008-09 as opined by Mr. Y.V. Malla Reddy, AFEC). However, uneven rainfall, prolonged dry spells and the increased droughts have forced the farmers to adopt Climate Adaptive Integrated Cropping System. By and large, about 8 000 – 10000 farmers have adopted the Climate Adaptive Integrated Cropping System in Anantapur district. However, farmers have adopted the cropping system with little modification in a way that the farming system suits their farmland, water availability and on-farm resources. Most of the farmers have adopted the ICS due to the continuous demonstration of AFEC and it was also observed that AFEC has made a convergence with the state government of Andhra Pradesh and the central government for optimising the extension and input services. For example, AFEC has created awareness among its farmers about the Andhra Pradesh Micro Irrigation Project (APMIP), because of which, most of the farmers have adopted the subsidised micro irrigation, which led to the diversification of cropping pattern from groundnut to tree and horticulture based cropping system. The free seedlings/ saplings of horticulture department were the incentives to most of the farmers in shifting their cropping pattern towards horticultural crops. For example, the collaboration of AFEC with the Mahatma Gandhi National Rural Employment Act (MGNREA) helped the farmers to get the Benishan mango saplings at free of cost. On the other hand, AFEC has identified the right buyers for the marketing of the produces from the field itself. Thus, the convergence of various stakeholders was the most significant extension approach followed by AFEC in bringing the desirable changes in climate smart cropping system. However, the reach is limited to the farmers of the 230 project villages.

Fig 8. Tomato intercropped in mango orchard, Mr. Venurappa, Pampanur, Anantapur

Zero Budget Natural Farming – Towards resilient agriculture

The Government of Andhra Pradesh introduced Zero Budget Natural Farming (ZBNF) in 2015-16 to address the risks of climate change. ZBNF serves as an alternative to the chemical-intensive conventional farming. The objective of ZBNF is to ensure the farmers' welfare, consumer welfare and sustainable agroecosystem.

The Department of Agriculture creates awareness among the farmers about the ZBNF and imparts the knowledge about the 4 cycle model of input management throughout the state of Andhra Pradesh with the help of NGOs and SHGs. The services of Master Farmers (MF)/Cluster Resource Person (CRP)/ Cluster Activist (CA) who are practising natural farming are utilized to disseminate the technology of ZBNF. They are also involved in building the capacity of the fellow farmers in the preparation of climate smart inputs needed for natural farming (Fig). These MF/CRP/CA are assisted by the Natural Farming Fellows (the graduates and postgraduates of agriculture and allied sectors) at the field level. The cluster approach is followed to mobilise the farmers and to enhance the capacity. There are about 1000 CRPs/ CAs functioning as the master trainers across the state of Andhra Pradesh. The planning of extension advisory services and implementation of the natural farming activities are undertaken by the District Project Management Unit of the Department of Agriculture. Most of the farmers have been adopting natural farming on small portions of their land to compare the perceived benefits of natural farming against conventional farming.

The success of ZBNF might be attributed to the identification of right community resource persons for demonstrating natural farming to the beneficiaries. Moreover, several Farm Field Schools (FFS) have been conducted on natural farming ever since the introduction of ZBNF, coupled with the funds available for the promotion of natural farming is promising. Above all, the line departments have also established convergence with NGOs for a wider popularisation of natural farming as a way of reducing the chemical fertiliser and increasing the adaptability of agriculture to the changing climate.

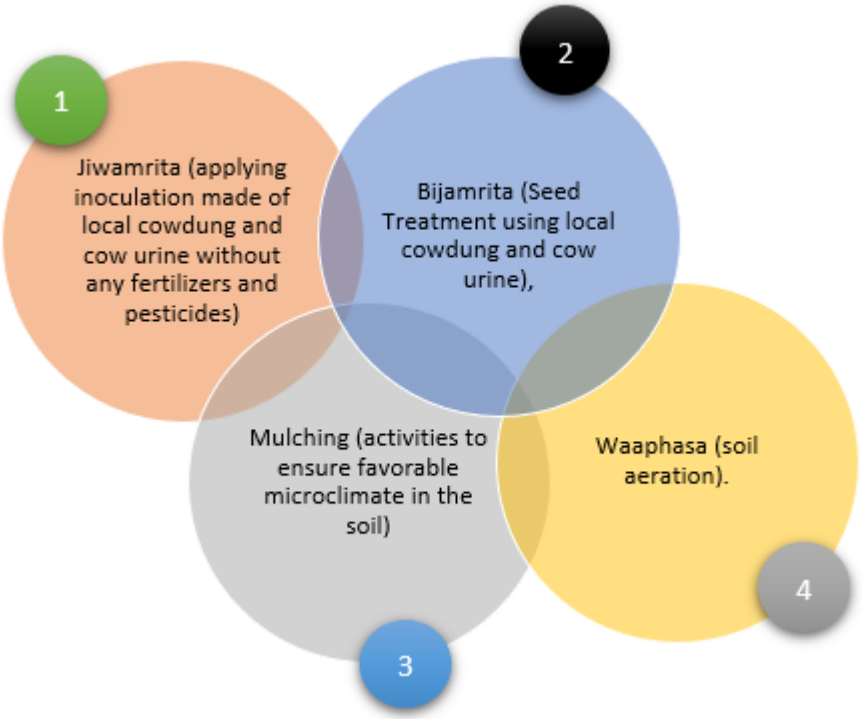

Fig 9. 4 Cycle model of Climate Smart Input Management under natural farming

Climate smart fertiliser management – A case of KVK

The farmers were literally competing with each other to apply more quantity of fertiliser in Peravali village because of their misconception that if they apply more quantity of fertiliser and they would get more yield says P. Venkataiah, a beneficiary farmer of NICRA from Peravali village. Further, he narrated that, If a farmer applies 2 bags of fertiliser (for example DAP and Urea) and the neighbouring farmers would apply 3 bags of fertiliser due to lack of knowledge on input management. However, there has been a significant change among farmers aftermath of the introduction of the NICRA programme by KVK-Reddy Palli. The introduction of Soil Health Card (SHC) and capacity building helped the farmers to adopt SHC based fertilizer application. About 60 % (39 Nos) of the farmers have adopted the soil test based application of fertiliser in the NICRA adopted villages since 2015, which resulted in saving of cost of cultivation (KVK-NICRA-5 years report 2011-2016).

Fig 10. Mr. Ramu, a farmer in Peravali village with his Soil Health Card of 2018

Box 4. Knowledge on soil test card based fertiliser application

Mr Ramu was not aware of the fact that his field had a huge amount of Potassium (K) even then he applied maximum quantity of (2 bags/acre) DAP for increasing the productivity due to lack of knowledge on soil testing and application of fertiliser based on the Soil Health Card. The knowledge camps and meetings of NICRA on Soil Health Card helped him to know about the testing of soil and methods for soil testing along with the application of fertiliser based on the reports of Soil Health Card. At present, he applies a specified quantity of urea, DAP and other minerals based on the reports of the soil fertility status/Soil Health Card.

Adapting to climate change through vermicompost – A case of ARDTS

The extension advisory services and training of Adarsha Rural Development and Training Society (ARDTS), Kodikonda have improved the knowledge among farmers about preparing vermicompost as a mitigating option to climate change. The increased awareness and capacity of the farmers may help in adopting appropriate farm practices, thereby negating the impacts of climate change and improving soil fertility. ARDTS has trained the farmers by engaging expertise from Low External Input for Sustainable Agriculture (LEISA) INDIA about the climate smart agriculture practices including vermicompost preparation. Furthermore, the agency has arranged a tie-up with input companies to procure vermicompost from about 4000 farmers (the majority of them are rainfed farmers) in the Kadiri and Hindupur mandals (Anantapur district). The similar model of convergence may be replicated and efforts may be taken to upscale the model.

Climate smart water management

As a part of Natural Resource Management components of NICRA project, KVK has given importance to the water conservation/water saving technologies. The KVK has demonstrated the farm ponds, drip irrigation, sprinkler irrigation and agronomic practices to conserve the water. A total of seven farm ponds and three Check dams have been created with the funds of NICRA in the adopted village and these structures are functional, which led to the increase in the groundwater table and increased the supplementary irrigation to an area of around 25 ha in 2014 (NICRA-KVK, Peravali, 5 Years Report). The fullest capacity of each farm pond is about 2 lakh litres of water. This water can be used to give 2 to 3 protective irrigation for groundnut, in case of Red Gram even 3 to 4 irrigation can be given. These Check dams and farm ponds have helped in the recharge of groundwater table and benefited about 23 bore wells belonging to 14 farmers in the village.

Table 3. Check dams in Peravali village

S. No.	Year of construction	No of check dam
1.	2015	1
2.	2017	1
3.	2018	1
	TOTAL	3

According to a farmer Sri K.C. Naidu, even 1/4th filling of the check dams with rainwater helps in the recharge of the groundnut water table for about 15- 20 inches in the surrounding area. He happily expressed that, 90 % of the farmers in his village have adopted drip irrigation as a way of overcoming the depleting groundwater. The maximum adoption of drip irrigation might be due to the highest subsidy provided through Andhra Pradesh Micro Irrigation Project (APMIP) for installing micro irrigation.

Similarly, the watershed programme of Accion Fraterna Ecology Centre has played a major role in drought proofing of Anantapur district. The watersheds namely Muttala, B.M. Palli, Kuder, Battuvanipalli, Garudapuram and Mallipalli were developed by AFEC from 2010 to 2017. These watersheds have enhanced both farm and non-farm activities (dairy farming, goat and sheep rearing, tailoring, basket weaving, garment making, engine repairs etc,) of 1770 farming community who have benefited from these watersheds (AFEC, annual report- 2016-17). It is understood that the funds were the critical factor to both KVK and AFEC for establishing watersheds in the identified areas. AFEC has received the grants/funds from District Water Management Authority (DWMA), Department of Rural Development under Integrated Wasteland Management Programme (watershed programme) and NABARD to develop watersheds in the region. Importantly, 18 Watershed Development Committee and seven Rainfed Farmers Cooperatives of AFEC are involved in the maintenance of these watersheds and are reaping the benefits of watershed activities. However, the net irrigated area in the district is 1.08 lakh ha. Similarly, a larger area of 8.1 lakh ha is under rainfed and 1.42 lakh ha is under fallow (NICRA-Contingency Plan, 2011). On the whole, the rise of fallow lands has been showing an upward trend. Therefore, still, there is a scope to develop the fallow land into cultivable land. This could be done by creating a large no. of water conservation structures in the rainfed area with a huge investment. In this context, the government needs to strengthen its collaboration with the private partners, reputed NGOs and may also mobilise CSR funds. These initiatives may enhance the resilience and act as natural insurance against extreme events of climate.

Fig 11. Farmers in Peravali village visit the NICRA watershed after rain fall on 15th September, 2018

Protective irrigation – A way to resilient agriculture

AFEC has created Knowledge and awareness of farmers about mobile drip/sprinkler irrigation system as a protective irrigation system through Climate Farm School, demonstration and climate training in the 230 project villages in eight mandals of Anantapur district. The water requirement for protective irrigation is either met from the farm ponds or shared on a community basis wherein about 3-5 farmers carry the water from the nearby available water source (ponds/lakes/water pool) using tractor mounted water tanker. In addition to this, financial incentive of AFEC has motivated about 250 rainfed farmers to adopt cement lined farm ponds in the dryland agriculture. The tractor-mounted water tankers and cement lined farm ponds have benefited 5026 farmers through protective irrigation covering 6035 acres. The community involvement was the major factor that led to the success of the programme. Moreover, AFEC has promoted 856 Community Based Organisations (CBOs) in 230 project villages and these CBOs are trained by the experts or STOs functioning at the grassroots on various protective irrigation techniques. These interventions have helped the farmers to save their crops from the vulnerability of climate change and to get a fair income from the crops.

Box 5. Understanding Protective irrigation

When there is a dry spell, a minimum amount of water is provided at least in the critical of crop to protect it from droughts.

The community led mobile water has created a major impact in sustaining the cropping systems. Therefore, Government can incentivise the local potential NGOs/ Entrepreneurs and appropriate funds can be allocated to Panchayat to implement such community led initiative in every village and to

upscale the technology to a similar agroecosystem. The government may mobilise the community at the grassroots and provide them with the revolving funds to purchase Tractor Drawn Water Tanker. Such an initiative may be helpful in bringing the fallow land into cultivable land and crop in the cultivable land can be saved from drought and drought-like conditions.

Fig 12. Tractor drawn water tanker

Cement lined farm pond

AFEC creates awareness about the farm pond through wall painting in all the project villages and provides a demonstration to the farmers about the preparation of cement lined farm ponds and encourage the farmers to make use of the stored water directly for the irrigation. Whereas, farmers having bore wells are encouraged to adopt non-cement farm ponds to facilitate seepage and infiltration of water for recharging groundwater. About 250 farmers in 230 project villages in the eight mandals have adopted cement lined farm ponds until 2018. The cement lined farm ponds can store the water for at least 45 days than that of non-cement lined farm ponds and help the farmers to apply 2 - 3 protective irrigations in pulses and 1 - 2 irrigation in groundnut even with the consecutive delay in rainfall.

Fig 13. Cement lined farm pond, Mr. Kollana, Pampanur, Anantapur

Keeping the traditional knowledge with a modern mix of extension services – A case of Mr. Kollana

Pitcher irrigation using mud pot was adopted as climate smart irrigation method to mitigate drought by Mr Kollana a beneficiary farmer of AFEC. The required water is drawn from cement lined farm pond of his field with the help of oil engine. Oil Engine is hired at a nominal cost from the Sasya Mitra Group established by the AFEC. In the absence of water in the farm ponds, Mr Kollana hires tractor drawn irrigator to irrigate the field. In such a way that the mango orchard is not only under protective irrigation but also capable of producing a fair yield of 1000 kgs /acre with an income of Rs 15, 000 – 20, 000 / acre. However, this model is not followed by other farmers due to lack of awareness, knowledge about this method of irrigation and financial status of the farmers. As the crop is saved from the adverse effect of climate change and ensures minimum income, the government may incentivise other stakeholders to promote similar innovative irrigation methods. The adopted farmers have felt that various components of water conservation methods such as Cement lined farm ponds, mobile led tractor drawn irrigation, pitcher irrigation etc. may be included into the micro irrigation scheme of the Government of Andhra Pradesh.

Climate smart post-harvest management

AFEC has collaborated with ICRISAT in the development of three-layered bags for post-harvest management of field crops in general and pulses in particular. It has been promoted in all the 230 villages by AFEC. The three layered bags have the capacity to save the seeds up to 1 year as against 3 months when it is stored in gunny bags or polythene bags. About 2995 farmers have been benefited from the distribution of 9598 bags at subsidised cost until 2018. One of the major factors responsible for wider adoption of three layered bags by the farmers might be attributed to the training and awareness programmes conducted by the Sasya Mitra Groups (SMG) of AFEC over a period of time.

Box 6. Benefits of three layered bags

According to Ms. Ramalaxmi, one of beneficiary of AFEC the three layered bags are very useful in storage of red gram, green gram and ground nut and preserve them for about one and half years. As a result, farmers in the project villages of AFEC started adopting three layered bags, which led to the preservation of farmers' own seeds for next season, and thereby reducing the input cost of about Rs.1000/- each.

In addition to this, Adarsha Rural Development and Training Society has promoted marketing tie up with the Timbaktu (NGO) for procurement of millets. The assured market has encouraged about 4000 farmers of Atmakuru and Kadiri Mandals to switch over from groundnut to millets cultivation. The assured market also ensured the maximum profit to the millet growers.

In addition, the seasonal shift of rainfall has necessitated the farmers to adopt a better post-harvest management practice to tackle the brunt of climate change. In the same way, direct field to plate approach adopted by the Adarsha Rural Development and Training Society has helped most of the farmers to switch over their cropping pattern from groundnut to millets.

Table 4. Three layered bags

S.No.	Size of the bag Contingency cropping	Subsidised price (INR)
1.	Small	10
2.	Medium	20
3.	Big	30

Fig 15. Big size three-layer bag

Climate smart institutional approach

Seed bank

The farmer's awareness of seed banks has been increasing owing to the continuous training and capacity building of farmers by the public and private sectors. The KVK has been promoting the seed bank as a way to ensure the availability of climate smart varieties to meet the climate adversities mainly drought in Anantapur district. KVK has supplied foundation seeds of K-6 (Groundnut) and PRG-158 (Red Gram) which are capable of withstanding dry spells.

Table 5. Seed banks in the NICRA villages

S. No.	Crop	Variety	Impact
1.	Groundnut	K-6	32 quintals of seeds of K–6 have been produced until 2017 which benefited about 128 farmers altogether
2.	Red gram	PRG-158	2.5 quintals of seeds produced during 2016-17 and benefitted about 30 farmers in the succeeding year (2017-18) due to droughts

Own seed management system – A case of NICRA (Mr Ravi Kumar Reddy)

Supply of quality seed along with the knowledge and skill about the package of seed production an effective intervention taken by KVK- Reddy Palli under NICRA. The own seed management system helps the farmers to meet not only their own seeds but also reduce the cost of cultivation. Mr Ravi Kumar Reddy is one of the beneficiaries of own seed management system and he was supplied with 25 Kgs of groundnut kernel under own seed management concept of NICRA from KVK in 2012 since then Mr Ravi Kumar Reddy seldom purchases seed for groundnut and it helps him to save about Rs 300 per season (Rabi and Kharif) i.e. Rs 600 per year. This approach was found to have benefited the farmers largely. Therefore, efforts may be taken by both public and private sectors to popularise own seed bank to the other parts of Anantapur district. Initially, the seed requirement for the production and multiplication of seeds which are resilient to the emerging climate variability may be sourced from the National Seed Corporation, State Seed Corporations, Research Stations of ICAR/ SAU, thus, ensuring the self-sufficiency in the production of seeds within their locality.

Box 7. Economic benefits of own seed production

The cost of 25 kgs of ground nut kernel is about Rs 2400-2500 in the open market. However, the cost of own seed by the farmers is much less than the open market i.e. Rs 2100.

Custom Hiring Centre – Mechanizing farms towards drought proofing

The farmers in the NICRA villages have largely been benefited from the establishment of the two Custom Hiring Centres (CHC) at KVK Reddy Palli. The farmers have hired Anantha Seed drill, groundnut Thresher and Taiwan sprayer. The CHCs of NICRA have purchased a variety of farm implement and machinery to

benefit the farmers on a large scale. The farm machinery of these CHCs includes 8- row spring tyne double box-Seed cum fertilizer drill), Tractor mounted boom sprayer, Chisel plough, Power Weeder (Kisan Kraft Crop), Fertilizer/ Pesticide dispenser spot shot etc (NICRA, summary of reports – KVK, Reddy Palli-2016-17). The Anantha seed drill, Groundnut thresher (an implement that separated the pods from the crop) and Taiwan sprayer have been the three major farm implements used by the farmers on a rental basis. It might be that the groundnut is the major crop in the NICRA adopted villages and requires a significant amount of labour during sowing, input management and harvesting. Similarly, increasing labour shortage and labour wages were also one of the reasons for the wider usage of CHC by the farmers in the NICRA adopted villages. Moreover, an amount of 9.87 lakh have been spent by the KVK under NICRA on the purchase of these farm machinery and implements, therefore it is evident that a reasonable amount is required for establishing CHC and its maintenance. In this context, in order to benefit the farmers of the non-adopted NICRA villages in the drought-prone district, Anantapur, the government need to allocate more funds for establishing Custom Hiring Centre on a cluster basis and may create awareness about the farm implements. Similarly, the government may strengthen its convergence with local organisations such as Panchayat, farmers' collectives, Self Help Groups, etc. In addition, CSR funds may be tapped for establishing, maintaining and training the farmers, which would help the government to further upscale farm mechanisation in the district.

Fig 16. Groundnut thresher

Table 6. Custom hiring centre and its impact

S. No.	Farm machinery	Reach since 2011	Impact since 2011
1.	Anantha Seed drill	60 farmers have benefited from the CHCs of NICRA with the coverage of 252.2 ha of area in the three NICRA adopted villages.	The hiring of the Anantha Seed drill helped NICRA to generate about Rs 31 480 until 2017. The use of Anantha Seed drill not only helps in reducing the cost of production of crops but also helps the farmers to face the problem of labour shortage and undertake timely farm operations.
2.	Groundnut Thresher	81 farmers have benefited from Groundnut Thresher till 2017 and covered an area of 224.5 ha in the NICRA villages.	Rs 45,725 has been generated until 2017 owing to the hiring of groundnut Thresher by the farmers.
3.	Taiwan sprayer (since 2013)	83 farmers have benefited from Taiwan sprayer and covered an area of 140.5 ha.	Taiwan sprayer has generated about Rs 2800 till 2017.

The CHC is certainly a boon to the farmers in the villages (e.g. Peravali) of NICRA as the role of CHC is imperative in offsetting the farm labour shortage and in reducing the production cost. A Groundnut thresher with the capacity of 1000-1500 Kgs/hr costs a minimum of Rs. 50, 000. The resource deprived rainfed farmers may not be able to purchase the groundnut thresher by paying huge money individually.

Thus, the initiative like CHCs will help to a greater extent in undertaking agricultural operations efficiently and timely in the uncertain weather conditions.

Innovative platform - A case of Sasya Mitra Group (SMG)

The development of Community Based Organisations (CBO) or farmers groups increases the responses of the farm families towards climate change and to mitigate the adverse effects of climate change. In view of this, AFEC has developed about 800 SMGs with the membership of 1800 belonging to all categories of the farm families i.e. backward class, scheduled caste, landless agricultural labourers, small and marginal farmers. About four SMGs are developed in each of the 230 project villages (Fig 17). Five representatives are selected from each SMG. The selected representatives from four SMGs form a Grama Sasya Mitra Group (GSMG), which consists of 20 members and GSMG is responsible for the management of planning and monitoring of the activities of Sasya Mitra Group such as the management of inputs like sprayers, oil engines, sprinklers, water pumps etc. in the same way, two leaders from each of the Grama Sasya Mitra Group (GSMG) forms Mandal Sasya Mitra Group (MSMG) and there are about 8 Mandal Sasya Mitra Group (MSMG), which monitors the activities of AFEC. And they are also facilitated by the Area Team Leaders and Agriculture Extension Officers. These Sasya Mitra Groups at all levels are monitored and guided by the Apex Sasya Mitra Group (ASMG). The Apex Sasya Mitra Group consists of 40 members i.e. five leaders from each of the Mandal Sasya Mitra Group. The fortnightly meeting of Apex Sasya Mitra Group (ASMG) plans for the activities and extension advisory services for the promotion of climate smart agricultural activities among the 230 project villages covering about 30 000 active farmers. The Sasya Mitra Group (SMG) is also involved in savings and thrift, apart from sharing of resources (Box 8).

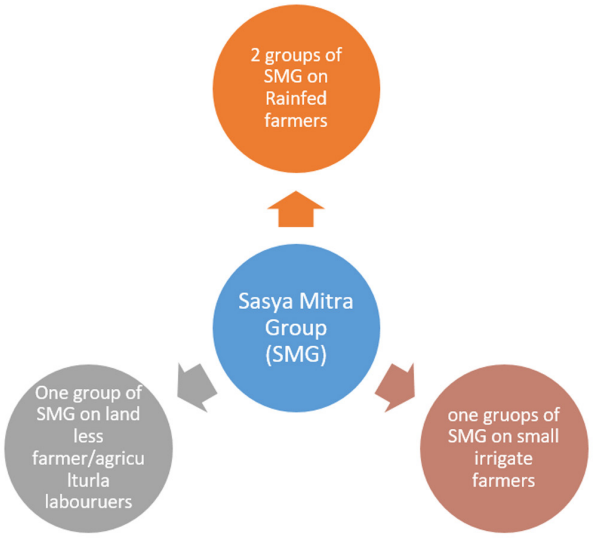

Fig 17. The general structure of formation of the four Sasya Mitra Group in a project village of AFEC

Box 8. Shared benefits of cooperatives

With the saving of Rs 50 -100 per member of SMG group every month, a total of Rs 1.81 crores was saved at the end of 2016-17. The savings are used as revolving funds and given as loans to the members. A total of 5000 families have availed loan as of 2017. Similarly, AP-MARKFED with the support of MACS, procured about 6902 quintals of red gram from the members of MACS at the Minimum Support Prices and thereby enabled them to sell red gram at higher price against the market price of Rs 3500.

As Anantapur district is mainly dependent on Rainfed and most of the farmers take a single crop, which has led to forced migration during the off-season for their livelihood. However, Mutually Aided Cooperative Societies (MACS) is supporting the people to take up off-seasonal livelihood activities.

NABARD has extended credit support of Rs. 224.62 lakhs for 1748 households of MACS to invest in alternative livelihoods such as garment making, auto driving, basket weaving, shopkeeping, etc., in the last five years. Therefore, promotion of societies would certainly pave a way to the farming community to involve in alternative livelihoods, and the income earned in the alternative livelihood may be useful to adopt climate resilient technology/practices in the cropping season.

Community Seed Management System – A case of MACS

The community approach has increasingly been adopted by most of the stakeholders as a way to encounter climate change. Community Seed Management System (CSMS) was observed to be the most effective community approach of both AFEC and KVK-Reddy Palli. The approach has helped the farmers to minimise the cost of production as well as ensured the availability of quality seeds at the peak season despite the changing climate. It was observed that about 1,612 quintals of drought tolerant groundnut varieties such as K-6, K-9 and Haritha andhra were produced with the help of Mutually Aided Cooperative Society (MACS) members and the quality seeds were distributed to the needy farmers during 2017-18 through a community owned seed management system (Annual Report, 2017-Accion Fraterna Ecology Centre).

Farmer friend – Facilitating climate led extension

Adarsha Rythu (Model Farmer) scheme was introduced by the erstwhile Andhra Pradesh government in 2007, which aims to reduce the farmers' dependence on the extension functionaries for crop production advisories and solve the farm problems timely. These model farmers facilitate the reach of the public extension systems effectively. The significant roles of Adarsha Rythu have become an integral part of climate led extension. Knowing the importance of Adarsha Rythu, the NGO Adarsha Rural Development and Training Society has introduced the Adarsha Rythu led extension to tackle climate change and to adapt agriculture to the vagaries of climate. The Adarsha NGO has associated with the Government of Andhra Pradesh for the funds and manpower to create climate resilient agriculture. As of today, the Adarsha NGO makes use of the 25 Adarsha Rythus for the dissemination of climate information and climate resilient cropping pattern, technologies and good agriculture practices relating to minor millet production and value chain management. At present, these 25 Adarsha Rythus cover about 30 Panchayats in the Hindupur and Kadiri tehsils (Anantapur district) and serve as the point of contacts for the farmers in these two blocks.

Demo farmers for the entire value chain of farming – A case of ARDTS

In addition to the climate extension through the Adarsha Rythus, the Adarsha NGO has involved one or two potential farmers per village as the demo farmers for about 15 villages in the taluks of Kadiri and Hindupur. The demo farmers are working as climate knowledge disseminators. A continuous extension activity of these demo farmers has led the adoption of medicinal and aromatic plants by the farmers as an alternative to low yielding groundnut varieties. About 2000 acres of land have been brought under the cultivation of Ashwagandha from the mono crop of groundnut in the rain-fed area, benefiting about 800 farmers in the village of palasandaram and 5000 acres of land to the cultivation of Dhavanam aromatic plants in the irrigated areas. The institutional arrangement with the Mysore Agarbathi company and with an aromatic oil company, Bengaluru helped the farmers to get the required quantity of seeds and planting material (Ashwagandha and dhavanam) at free of cost and to market the produces back to them at better farm gate price. The buyback arrangement has helped the farmers to reduce the cost

of cultivation and increase the net profit as much as 20000 per acre. Therefore, there is a huge scope for the cultivation of medicinal plants and to enhance the income of the farmers whose livelihoods are threatened by the ever increasing temperature, increasing dry spells, the occurrence of droughts, decreasing water table etc. It is evident that the collaboration with these companies resulted in the availability of affordable seeds and other farm inputs in time, thereby motivated the farmers to shift their cropping pattern from groundnut to medicinal crops. Therefore, there is a need for structural change in government machinery and policies related to land use management and reproofing agriculture to climate change.

Climate smart Knowledge management

Knowledge management has become an essential part of climate smart agriculture. In order to create awareness among farmers about climate information, and to enable them to adapt to climate smart practices, timely information is indispensable. Most of the public and private sectors have invested in the development of various ICT platforms to provide real time climate related information and advisory services. In this way, KVK under the project of NICRA has used the virtual platform namely, Annapurna Krishi Prasara Seva (AKPS) for the dissemination of climate related crops management services/ contingency crop planning (Box 9) to its registered farmers in the three NICRA adopted villages. The programme coordinator, KVK has been entrusted to assess the weather parameter of the NICRA villages at a regular interval and to generate the content on the basis of the changing weather conditions with the suitable contingency crop pan, thereby enabling the farmers to adopt the required crop production practices/latest technologies to adapt agriculture to the climate change (Box 9).

Box 9. Augmented reality through Annapurna Krishi Prasara Seva

According to K. C. Naidu, the information sent through SMS services of Annapurna Krishi Prasara Seva (AKPS) on 14, September, 2018 concerning the cultivation of contingency crops such as castor, foxtail millet, jowar and red gram in the place of groundnut was adopted by most of the farmers in Peravali village as the onset of monsoon delayed for 14 days in September, which is not suitable for groundnut. It is therefore, Annapurna Krishi Prasara Seva has become an effective ICT tool in reaching out to the farmers in time.

The extension advisory services through mobile are new to the farmers in the villages of NICRA. The SMS services namely climate smart agricultural practices, pre and post weather warnings, and climate based contingency crop plans are sent to the farmers by KVK through AKPS on a weekly basis. About 100 farmers have registered to the AKPS in the village of Peravali. The messages are disseminated to the registered farmers in the local language (Telugu) hence, it helps the farmers to respond to climate information effectively and empowers them to make a timely decision

Fig 18. Mr Venkataiah shows the advisory services received through mobile on contingency crops amid failure of monsoon, Peravali, Anantapur

relating to farm operations. However, this practice was not widespread across the district. It was found that the ICT initiative i.e. Annapurna Krishi Prasara Seva of the Government of Andhra Pradesh has been a huge success, especially at a time when the climate change has become reality in influencing the season of crop production and productivity of crops. However, it is evident that the success of this initiative was dependent on the production of highly relevant, location specific content/message with mitigation/adaptation measures by KVK on the face of climate change and backstopping of relevant technologies to the farmers. Therefore, the government may focus on empowering the local public institutes to understand the influence of climate change on the production of crops and assess the need of each farm to deliver personalised advisories. Further, technical manpower may be created on a cluster basis to study the extent of impacts of climate change and to develop contingency crop planning. This would lead to timely dissemination of climate information along with the location specific mitigation options and adaptation measures, thereby ensuring the "knowledge led climate smart agriculture" in the entire drought-prone Anantapur district.

Integrated climate smart livestock services

Awareness programmes about the diseases of livestock, sheep and goat and control measures under NICRA have been useful to the farmers in Chekrayapeta, which resulted in the adoption of livestock maintenance system, pucca floor, mineral mixture for livestock production says Mr. Ravi Kumar Reddy, a beneficiary farmer of NICRA (Chekarayapeta village, Anantapur district).

Further, he stated that farmers of Chekarayapeta are mostly dependent on livestock for their livelihood. In the recent past, the incidence of diseases in animals and reduced availability of grass crops and pasture lands due to lack of rainfall as well as frequent occurrence of drought have added to the plight of Chekaraya peta. However, the training, meeting and extension advisory services of KVK through NICRA helped the farmers to aware of animal management aspects such as Mineral Mixture, shed maintenance, pucca floor, feed and fodder management, animal health management etc.

Farmers' awareness of mineral mixture has resulted in maximising the fat content of milk and fetched a high price in the market. Further, he explained that each of his buffaloes was yielding about 7 - 9 litres per day until 2012-13 with the fat content not exceeding more than 2.5 %. However, the adoption of Mineral Mixture along with other good livestock management practices led to the increased yield of milk about 10 - 11 litres per day with the fat content reaching up to 9.5 to 10 %. Today, the increased fat content in the milk helps Mr Ravi Kumar Reddy to fetch about Rs 60 per litre of milk which is otherwise sold at Rs 40 per litre of milk. Almost Rs 20 increase per litre of milk. However, it is certain that still most of the farmers in other villages are not aware of mineral mixture and its use as supplementary feed to the livestock says Mr. Reddy. Hence, a necessary measure may be taken to scale up the awareness camps/ knowledge programmes across the district with suitable extension methods.

Climate smart renewable energy

Climate smart renewable energy is one among numerous climate smart measures taken in CoP at Kyoto. According to the Kyoto Protocol (IPCC, 2007), the Clean Development Mechanism (CDM) is the way of reducing the emission of greenhouse gases and to mitigate the impacts of climate change. A slew of projects and programmes such as solar power, windmills, energy efficient boilers, etc., have been underway to achieve the Clean Development Mechanism across the globe. Among various clean development mechanisms in agriculture, biogas production is considered to be one of the efficient Clean

Development Mechanism (CDM). The public, private and NGOs are funding the clean development mechanisms in different sectors including agriculture. In Anantapur as well, AFEC has actively been involved in the promotion of biogas production plants among the households of its 230 project villages. The convergence of AFEC with UNFCC has promoted the farmers to adopt CDM - biogas units, the cost for the establishment of the units is borne by the forward funding from the Indigo airline. Around 2500 biogas units have been constructed in 15 mandals of Anantapur district as of 2018 since 2012-13. The Biogas units meet the energy requirement for cooking and water heating of the beneficiary families (mostly farmers), which would curtail the usage of fuel firewood by 3.8 tonnes per year/family. About 12500 units will be constructed in the coming days, which will certainly pave a way for climate smart renewable energy throughout Anantapur district. The size of each unit of biogas is about 2 cubic metre and each unit is estimated to generate about 3.77 carbon tonnes of CER (Carbon Emission Reductions) (Annual Reports, 2015-16 and 2016-17 of AFEC). However, with the limitation of funds and manpower, AFEC has not been able to cover the other mandals of the district. In order to upscale the biogas units across the district, there is an imperative need for the collaboration with the potential funding partners and local NGOs and grass root level organisations (e.g. Panchayat) by the government. Moreover, the government may identify the prospective Corporates who can provide their Corporate Social Responsibility funds towards the establishment of the Biogas units, thereby ensuring the climate smart energy and to contribute to the CDM of the Kyoto Protocol.

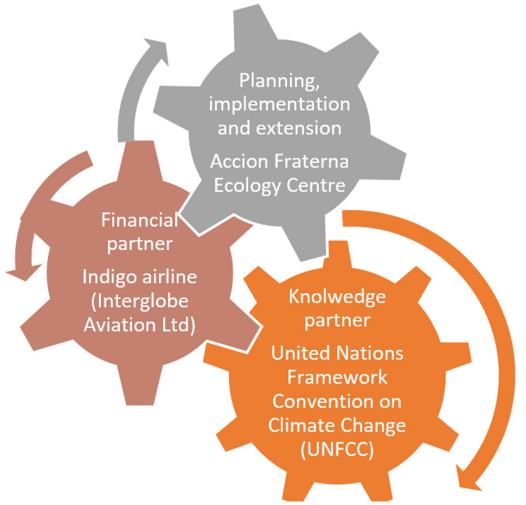

Fig 19. Public Private Partnership for climate smart renewable energy

Takeaways from the study

The findings of the study show that the success of the adoption of various climate smart agricultural technologies/practices by farmers is attributed to the cumulative and customised extension advisory services of the stakeholders. These extension strategies and intervention are assessment of climate vulnerability, identification of technology cum knowledge gaps, sourcing appropriate technologies/ innovations, Indigenous Technical Knowledge (ITK), networking with suitable partners, provision of ICT based contingency information, fostering extension functionaries for hand holding with one to one communication, harnessing climate funds, mobilising communities, adopting project and cluster approaches (end to end approach), establishing convergence with the schemes and programmes of central and state governments, creating innovation platforms, developing suitable institutional mechanism, creating appropriate market linkages, all the more, Involving end users (farmers) through participatory approaches. These interventions and extension advisory services are mostly restricted to the project area of the stakeholders due to their own limitations. Therefore, plough to plate extension approaches followed by these stakeholders may be brought together or to be converged in combination for the holistic development of climate smart agriculture of drought-prone Anantapur i.e. adapting agriculture to climate vagaries, enhancing the resilience, sustaining the agroecosystem, increasing the productivity and stabilising the income of farmers.

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