

Real Time Contingency Planning: Initial Experiences from AICRPDA



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National Initiative on Climate Resilient Agriculture
All India Coordinated Research Project for Dryland Agriculture
Central Research Institute for Dryland Agriculture

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Front Cover

Clockwise : (1) Sowing with Roto till dirll (S.K. Nagar, Gujarat); (2) Better Pigeonpea crop with mid season correction (Faizabad Dist. U.P.); (3) Saving horticulture plants through *Pitcher* system (Biswanath Chariali, Assam); (4) Supplemental irrigation from in farm pond through drip system to Sweet corn (Indore, M.P.)

Back Cover

Clockwise : (1) Agro advisory service through message on blackboard in NICRA village and SMS in mobile phones (Jamnagar Dist. Gujarat); (2) Mulching with groundnut shells in Cotton (Rajkot, Gujarat); (3) Compartment bunding for *in situ* moisture conservation in NICRA village (Solapur Dist. Maharashtra); (4) VCRMC Meeting in progress in NICRA village (Lakhimpur Dist. Assam);

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FOREWORD

The Government of India has accorded high priority to R&D for coping with climate change in agriculture sector. The Prime Minister's National Action Plan on Climate Change has identified agriculture as one of the eight National Missions. During 2010-11, the ICAR has launched a major Project entitled, **National Initiative on Climate Resilient Agriculture (NICRA)** in order to enhance the resilience of Indian agriculture by covering crops, livestock and fisheries to climate change through development and application of improved production and risk management technologies, and demonstration of site specific technology packages in farmers' fields. The overall expected outcome is enhanced resilience of agricultural production to climate variability in vulnerable regions. The project has four components viz., (i) Strategic research on adaptation and mitigation; (ii) Technology demonstration on farmers' fields to cope up with current climate variability; (iii) Sponsored and competitive research grants to fill critical research gaps and (iv) Capacity building of different stake holders.

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was started in 1971 with 16 centers. At present, the project has a network of 22 centers located in 20 State Agricultural Universities and two other Universities. Out of 22 centers, 8 centers have Operational Research Project (ORP) for testing the research findings in farmers' fields and receive feedback for refinement of such technologies to enable up-scaling in the target domains. Under Technology Demonstration Component of NICRA at AICRPDA centres, the on-station and on-farm demonstrations were planned in five thematic areas viz., (i) Real Time Contingency Planning; (ii) Rainwater Management; (iii) Soil Health and Carbon Sequestration; (iv) Energy Management; and (v) Alternate Land Use System. The demonstrations under real time contingency planning are conducted under real time weather situations. Further, the interventions under rain water management (*in-situ* and *ex-situ*) and energy management were proven location specific rainfed technologies. The demonstrations under alternate land use are long-term adaptation strategies which are likely to attract the farmers for adoption and benefit with ecosystem services.

I compliment the efforts of Dr B.Venkateswarlu, Director, CRIDA, Dr Ch. Srinivasarao, Project Coordinator (Dryland Research), Dr G.Ravindra Chary, Dr G.R.Maruthi Sankar and Er. R.Nagarjuna Kumar, the Chief Scientists, Scientists and staff of AICRPDA and ORP Centers for compiling outputs of Real Time Contingency Plans implemented across the country both on-station and on-farm. I hope that this publication will help and guide the officials of State Agriculture Department in implementing crop contingency plans when a part of the state experiences drought or flood situation.



(A.K. SIKKA)

PREFACE

Agriculture is the source of livelihood for nearly two-thirds of the population in India. A major part of the agriculture is rainfed (~80 out of 142 million ha net cultivated area) and will remain so for at least for a foreseeable future. The impact of climate change and variability in the country on agricultural production is quite evident in the recent years. The weather aberrations like drought and floods extreme events like high intense excess rainfall, frost, hail storm, heat wave, cold wave etc are recurrent in most parts of the country in the crop growing seasons. The South-West monsoon accounts for nearly 75% of the natural precipitation received in the country and exerts a strong influence on the *kharif* food grain production and the economy in terms of agricultural output, farmers' income and price stability. The onset of South-West monsoon, the amount of rainfall and its distribution are crucial factors which influence the performance of agriculture. The probability of erratic monsoon rains is about 40% which implies that in 4 out of 10 years there would be an adverse impact on the crop production. There is a need to develop appropriate strategies to deal with such eventualities. Many contingency plans are available at various scales. However, any contingency intervention either technology related (land, water, soil, crop) or institutional and policy based, which is implemented on real time basis in any crop growing season, which is considered as *Real time Contingency Plan*, is the need of the hour to stabilize crop stands, production and income in rainfed regions.

For the last four decades, across All India Coordinated Research Project for Dryland Agriculture (AICRPDA) network centres, efforts are being made to develop doable rainfed technologies for drought proofing in major rainfed production systems across diverse rainfed agroecologies. Since 2010-11, under National Initiative on Climate Resilient Agriculture (NICRA), the thrust area has been on the demonstration of land, crop, soil and water management practices as contingency measures on real time basis during weather aberrations like delayed onset of monsoon, early, midseason and terminal droughts and extreme weather events like excess rainfall, hailstorm etc. The real time contingency interventions were implemented under both on-station and on-farm in 36 NICRA adopted villages by AICRPDA centres in 26 districts in 15 states. The real time contingency interventions included crops, varieties, rainwater conservation and efficient utilization along with various crop management practices. The first priority was to have a reasonable crop stand in the field and then manage it for getting better crop yield and income which otherwise would have been a total loss to the farmers. In this bulletin, the initial experiences of AICRPDA on the real time contingency interventions implemented in diverse rainfed agroecologies are highlighted. Further, the initial preparedness, role of village institutions, and strategies/options for implementation of real time contingency plans are discussed.

We sincerely acknowledge Chief Scientists, Scientists and other staff at AICRPDA centres for their efforts in implementation and popularization of real time contingency interventions in a participatory mode in the NICRA villages. Further, we are highly grateful to all the stakeholders, particularly the practicing farmers, Village level Climate Risk Management Committees, Custom Hiring Management Committees for farm implements, farmers/farmer groups managing the seed banks in the NICRA villages, who have been a part of successful implementation of the real time contingency plans. We sincerely hope that in future, the implementation of real time contingency measures would likely to give stability to agricultural production and income in rainfed regions with appropriate institutional and policy back up.

Authors

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1. Background

Rainfed agriculture occupies a prominent place in Indian economy and rural livelihoods. It is spread over 55% of net cultivated area, contributing over 40% to the national agricultural production. Rainfed areas support 40% of India's population of over a billion, and play a vital role in food security. Over 87% of coarse cereals and pulses, 55% of upland rice, 77% of oilseeds and 65% of cotton are cultivated under rainfed farming. Resource poor farmers, the backbone of rainfed agriculture, were largely bypassed by green revolution whose benefits were mostly reaped by the already resourceful farmers holding irrigated lands. It is estimated that even after achieving the full irrigation potential, barring for successful completion of river linking project, nearly 45 to 50% of the total cultivated area will remain dependent on rain. Undoubtedly, the rainfed agriculture would continue to occupy a prominent place in Indian agriculture for a long time to come (Venkateswarlu *et al.*, 2011). Despite the progress made so far, rainfed agriculture in India encounters multiple risks and constraints relating to biophysical and socio-economic issues. Agricultural productivity in rainfed areas continues to remain low and unstable due to weather aberrations, nutrient disorder and poor socio-economic status of farmers. Recurrent droughts undermine the food, fodder and livelihood security of the rural mass and force them to migrate in search of work. Rainfed agriculture, which suffers from moisture shortages, frequent dry spells or drought like situations, should imbibe the technologies that conserve the soil and moisture effectively. Climatic variability is likely to affect the spatial and temporal scenario of agricultural production systems. Strategic and anticipated research to understand the significant role of climate variability on rainfed agriculture is being pursued at a greater depth. There is an immediate need to demonstrate appropriate technologies to make rainfed agriculture economically viable and environmentally sustainable.

Climate Variability and Agriculture Impacts

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the high population depending on agriculture and excessive pressure on natural resources. The warming trend in India over the past 100 years (1901 to 2007) was observed to be 0.51°C with accelerated warming of 0.21°C per every 10 years since 1970 (Krishna Kumar, 2009). The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. Climate change impacts are likely to vary in different parts of the country. Parts of western Rajasthan, Southern Gujarat, Madhya Pradesh, Maharashtra, Northern Karnataka, Northern Andhra Pradesh, and Southern Bihar are likely to be more vulnerable in terms of extreme events. The rainfall analysis of India showed that

significant negative trends of rainfall were observed in the eastern parts of Madhya Pradesh, Chhattisgarh and parts of Jharkhand, U.P., and northeast India. Lal *et.al.* (2001) reported that annual mean area-averaged surface warming over the Indian sub-continent is to likely to range between 3.5 and 5.5 °C by 2080s. These projections showed more warming in winter season over summer. The spatial distribution of surface warming suggests a mean annual rise in surface temperatures in North India by 3 °C or more by 2050. The study also indicated that during winter, the surface mean air temperature could rise by 3 °C in Northern and Central parts, while it would rise by 2 °C in Southern parts by the same period. In case of rainfall, a marginal increase of 7 to 10% in annual rainfall is projected over the sub-continent by 2080.

Rainfall is the key variable influencing crop productivity in rainfed farming. Intermittent and prolonged droughts are a major cause of yield reduction in most crops. Long term data for India indicates that rainfed areas witness 3-4 drought years in every 10-year period. However, no definite trend is seen on the frequency of droughts as a result of climate change so far. For any R&D and policy initiatives, it is important to know the spatial distribution of drought events in the country. A long term analysis by CRIDA of rainfall trends in India (1901 to 2004) using Mann Kendall test of significance indicate significant increase in rainfall trends in West Bengal, central India, coastal regions, south western Andhra Pradesh and central Tamil Nadu. Significant decreasing trend was observed in central part of Jammu Kashmir, northern MP, central and western part of UP, northern and central part of Chattisgarh. Analysis of number of rainy days based on the IMD grid data from 1957 to 2007 showed declining trends in Chattisgarh, Madhya Pradesh, and Jammu Kashmir. In Chattisgarh and eastern Madhya Pradesh, both rainfall and number of rainy days are declining which is a cause for concern as this is a rainfed rice production system supporting large tribal population who have poor coping capabilities (Rao, 2013).

Since the beginning of 21st Century, India has experienced droughts in quick succession, of which the 2009 was the most recent one that significantly affected *kharif* crop production. It was the second largest all India monsoon rainfall deficit since 1972 (23% below normal). Incidentally, 2009 also achieved the distinction of being the warmest year in past several centuries across the world. However, after 2009, 2010 proved to be the warmest year on record since 1850. 2011 is now the 11th warmest year on record since 1850. Apart from that, 1998 was one of the warmest years; 2003 experienced unprecedented heat and cold waves across the globe; occurrence of high temperature in March 2004 adversely affected crops like wheat, apple, potato etc. across northern India; 2005 witnessed destructive hurricanes/cyclones across the globe and again, 2007 was as warm as 1998 in the entire northern hemisphere and unusual summer rains and floods were experienced in many parts of India. Besides that, the amount and distribution of rainfall is becoming more and more erratic which is causing greater incidences of droughts and floods globally. The increase in frequency of heavy rainfall events in last 50 years over Central India points towards a significant change in climate pattern in India

(Goswami, 2006). The data clearly indicates increase in heavy (>10 cm) and very heavy (>15cm) rainfall events and decrease in light to moderate rainfall events.

Weather Variability and Impacts on Agriculture

- Rainfall drives water availability and determines sowing time (rainfed crops)
- Temperature drives crop growth and duration
- Temperature and Relative Humidity influence pest and diseases incidence on crops
- Radiation influences the photosynthetic productivity
- Wet and dry spells cause significant impact on standing crops, physiology, loss of economic products (eg. fruit drop)
- Extreme events (eg. high rainfall/floods/heat wave/cold wave/cyclone /hail/frost) cause enormous losses of standing crops

Agriculture is the source of livelihood for nearly two-thirds of the population in India. The sector currently accounts for 14.2% of the GDP and employs 55% of country's total workforce. The sharp fluctuations in agricultural growth are mainly attributed to the vagaries of monsoon. Some part of the country or the other experiences monsoon failure almost every year but most states encounter drought once in 2 to 4 years. The south west monsoon accounts for nearly 75% of the natural precipitation received in the country and therefore exert a strong influence on *kharif* food grain production and the economy in terms of agricultural output, farmers' income and price stability. Both the amount of rainfall and its distribution are crucial factors influencing performance of agriculture. The probability of monsoon rains being erratic is 40% of the time which implies that in 4 out of 10 years there would be an adverse impact on crop production in the absence of appropriate strategy to deal with such eventualities.

Monsoon failures result in drought which has serious implications for small and marginal farmers and livelihoods of the rural poor. The impact of climate change on agriculture will be one of the major deciding factors influencing future food security of the world including India. A major part of the agriculture in India is rainfed (~80 million ha out of 142 million ha net cultivated area and will remain so for at least for a foreseeable future. The crop losses due to climate variability will vary from region to region depending on regional climate, crop and cropping systems, soils and management practices. Rainfed crops are likely to be worst hit by climate change because of the limited options for coping with variability of rainfall and temperature. The major crops like wheat and rice are expected to undergo all the weather aberrations and their sustainability will be determined by crop's capacity of natural adaptability as well as appropriate mitigation measures adopted.

Assessment of climate change impact over Indian agriculture (Aggarwal, 2009)

so far has indicated that a marginal 1°C increase in atmospheric temperature along with increase in CO_2 concentration would cause very minimal reduction in wheat production of India if simple adaptation strategies like adjustment of planting date, increased fertilizer use, irrigation water availability and varieties are adopted uniformly. But in the absence of any adaptive mechanism, the yield loss in wheat may cross 4-5 million tons. As far as Indian agriculture is concerned, temperature rise during *rabi* is of more significance. For minimum temperatures, most of the locations in India are showing an increasing trend. This is a cause of concern for agriculture as increased night temperatures accelerate respiration, hasten crop maturity and reduce yields. The increasing trend is more evident in central and eastern zones where rainfall is also showing a declining trend which makes this area more vulnerable and requiring high attention for adaptation research.

Extreme Weather Events and Impact on Agriculture

Extreme weather events like heat wave, cold wave, untimely and high intensity rainfall, hailstorm and frost are increasingly being experienced in different parts of the country.

Heat wave: During the period March–July, spells of hot weather occasionally occur over certain parts of India. These spells are often seen to move from one region to another. Hence, this phenomenon is termed as a heat wave. Several deaths are reported when the heat waves become severe.

Severe heat wave	Departure of maximum temperature by 5°C for regions where normal temperature is above 40°C $+7^{\circ}\text{C}$ for regions where normal maximum is less than 40°C
Heat Wave	Departure of maximum temperature by 3 to 4°C or more for regions above 40°C

Continuous higher temperatures during critical growth stages of *rabi* crops reduces the crop yields considerably

Cold wave: Cold waves are incursion of dry cold winds coming from north direction and are associated with passing western disturbances. Departure of minimum temperature by -3 to -4°C from normal where normal minimum temperature is less than 10°C is called as a cold wave. The maximum frequency of cold wave over the last 100 years occurred in Jammu & Kashmir followed by Rajasthan and Uttar Pradesh. Lowest temperature -33.9 recorded on 22 March 1911 at Dras in J & K.

Floods: Heavy rains due to depression in the Bay of Bengal and low pressure from the Arabian Sea from September 29 to October 2 in 2009 have caused flash floods in north Karnataka and the Rayalaseema region of Andhra Pradesh, affecting nearly two million people and claiming 210 lives. In Karnataka, 15 districts were affected and 161 people perished. In Andhra Pradesh, five districts were hit by the flash flood and 49 people lost

their lives. Of the two million, 1.4 million people affected are from Andhra Pradesh. Agriculture land affected 205,584 (in ha)

The heat wave during February-March in north India caused an estimated loss of 6 million tonnes of wheat in 2002-2003. A decline in production of 60% in rapeseed and 50% in linseed was observed in Himachal Pradesh due to heat wave in March 2004. Cold wave conditions in 2002-03 caused an estimated loss of 10-100% in different crops. In Rajasthan about 20-30% damage in tomato and in Haryana 15-25% damage in mustard were recorded. Other extreme events like heavy rains accompanied by hailstorm during March 2007 damaged wheat, sugarcane and oilseed crops in thousands of hectares in Punjab and Haryana. In Madhya Pradesh, entire pigeonpea crop in an area of 7000 hectares in Punjab and Haryana was damaged due to frost and extreme cold condition. In 2009, heavy rainfall in Raichur districts of Karnataka, Kurnool and Mahabubnagar districts of A.P damaged standing crops in lakhs of hectares due to floods and sand casting on river banks of Krishna and Tungabhadra rivers. During the same year, the areas affected by drought initially were also affected by floods later in the season resulting into contingency measures being taken up by respective district authorities. It is to be noted that the maximum expected flood limit in 100 years for Krishna river was exceeded during the same year due to very intense rainfall events of more than 250 mm per day in the catchment.

National Initiative on Climate Resilient Agriculture

National Initiative on Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The project was formally launched by the Hon'ble Union Minister for Agriculture & Food Processing Industries Shri Sharad Pawarji on 2nd February 2011 (Fig.1).



Fig.1 Hon'ble Union Minister for Agriculture and Food Processing Industries Shri Sharad Pawar launched NICRA on 2nd February, 2011

NICRA Project : The Objectives

- To enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.
- To demonstrate site specific technology packages on farmers' fields for adapting to current climate risks.
- To enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

The project consists of four components viz. a) Strategic Research, b) Technology Demonstration, c) Capacity Building and d) Sponsored/Competitive Grants.

NICRA - Technology Demonstration

The technology demonstration component consists of the following partners:

1. KVKs in eight zones -100
2. Network Centres of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) - 23
3. Technology Transfer Divisions of Core Institutes – 7

NICRA - AICRPDA Programme Initiative

The technology demonstration component of NICRA across network centres of All India Coordinated Research project for Dryland Agriculture (AICRPDA) envisages identifying climatic vulnerabilities of agriculture in the selected village in each of the 28 districts based on historical weather data from the nearest weather station, farmers' experiences and perceptions, preparing and implementing adaptation and mitigation strategies following a bottom-up approach. The focus of the program is not only to demonstrate the climate resilient agriculture technologies but also to institutionalize mechanisms at the village level for implementation of successful adaptation strategies on a sustainable basis. One village or a cluster of villages from each of the 28 selected districts were selected for technology demonstration. The technology demonstration component in the selected districts is being piloted by the respective AICRPDA centers. The details of NICRA adopted villages are given in Annexure - I.

Climatic characterization of the village: Climate vulnerability, in general, of the village was analysed based on time series climatic/ weather data pertaining to the selected village or from the nearby weather station in order to understand the extent of vulnerability of the village's agriculture to climatic variability. The information was collected and analyzed related to : a) *Rainfall-annual as well as during kharif season* (Normal; trend in past 10 years (if any) increase/decrease), b) *Number of rainy days (seasonal as well as annual)* (Overall average, decadal average (1971-80, 1981-90, 1991-2000, 2001-09), c) *Intensive rain-spells (above 60 mm per day)* (Decadal average (1971-

80, 1981-90, 1991-2000, 2001-09), d) *Number of dry-spells in past 10 years* (Exceeding 15 days, exceeding 10 days in the *kharif* season as well as in the whole year), e) *Length of growing season* and f) *Changes during past one decade Number of floods severely/ completely damaging crops and livestock* (Decade-wise number for the past three decades)

The information on damage (number. of events decade-wise for the past 3 decades) due to other weather extremities such as frost, heat and cold waves, hail storm, sea inundation of agricultural fields and consequent problems, information if any, on soil degradation due to extreme weather events.

Participatory appraisal of the village: To understand the farming systems, resource situation, constraints and climatic vulnerabilities and to identify opportunities of climate change adaptation and mitigation in the selected village participatory rural appraisal was done. The information was collected on land use pattern, area, production and productivity of different agricultural and horticultural crops, livestock composition and production, fishery production, awareness level of farmers about climate change, ground water level and its use, income from agriculture and allied activities, level of risk of crop loss due to climatic variability in the past one decade. This information was collected from the farmers and village key informants. During participatory appraisal was undertaken as follows:

Assessment of natural resource status: In the village to understand why the agriculture remains vulnerable to climatic change, it was planned to assess the status of natural resources, socio-economic, institutional and infrastructural status and major farming systems. The status of natural resources cover soil type, quality, organic matter status and depth of soil and its suitability for different crops, access and level of use of manure (FYM & green) and fertilizers, scope for improving organic matter in soil, access to water-rainwater (if harvested), ground water (open wells and bore wells and whether level is declining) and canal water (timely availability and access); account of major changes in flora and fauna during past one decade and its causes. Such assessment was useful for NRM related interventions.

Socio-economic status and Institutional arrangements: Information on land holding structure, level of income, literacy and education of farmers, asset base of farmers, participation in social networks, proportion below poverty line, access to critical inputs to agriculture and marketing opportunity for farm output, access to market information and technical knowledge, level of awareness and skills of farmers, access to different government schemes, existing institutional arrangements like SHGs, commodity groups, user groups and their effectiveness, etc. Based on the social dynamics in the village, different institutional arrangements were planned to implement the project activities.

Major farming systems: The information was collected on land use pattern, extent of irrigation, type of crops and varieties grown, yield levels, level of input use (fertilizer,

manure, pesticides, weedicide, etc), seed replacement rate in major crops, level of mechanization for different farm activities, system of irrigation (flood, drip, sprinkler), access to farm machines (owned/ custom hiring), access to improved seed, livestock species reared and their yields, incidence of various diseases in the livestock and consequent mortality and changes in cropping/ fanning systems during the past one decade. This analysis helped in planning appropriate climatic resilient technological interventions for individual as well as group of farmers.

Constraint Analysis: The multidisciplinary team analyzed the constraints related to climatic variability based on secondary weather data, resource situation, farming systems and agricultural yields in the past few years. The major constraints resulting from climatic variability includes; water scarcity, recurrent droughts (early, mid season, terminal), cold wave, heat wave, flood, pest and diseases of crop and livestock, fodder scarcity, poor access to appropriate seeds/planting material and critical inputs and farm machinery (timeliness and cost of access). The constraints were supposed to be analyzed by the multidisciplinary team in a manner so that the actual causes of constraints and points to intervention are identified.

Climate Resilient Technology Demonstrations at AICRPDA centers

Each center identified technological and institutional interventions for enhancing the resilience of farming systems to the climatic variability by involving the major stakeholders such as farmers, researchers, NGOs, officers of the line departments and extension specialists. Based on the detailed analysis of farming systems, resources, constraints, needs of the village, the climatic vulnerability (drought/floods/heat wave/frost/cyclone) and the available technology options from the concerned AICRPDA centre, Regional /Zonal Agricultural Research Stations of the SAU and ICAR institutes and time tested climate resilient farm practices adopted by innovative farmers identified specific interventions related to each of the four sub-projects (i) Real time contingency plan implementation in a participatory mode (ii) Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use (iii) Efficient energy use and management (iv) Alternate land use. It was planned to saturate the whole village with the identified interventions in order to demonstrate a discernable effect and document the constraints and lessons. Further the preference was given to the interventions targeted/ focused on the following:

- Interventions benefiting larger and resource poor group
- Interventions which give long-term and sustainable benefits
- Interventions that address resource conservation
- Interventions that promote/strengthen village level institutions

NICRA - AICRPDA Programme Implementation

Eventually, the whole village was to be saturated with the climate resilient technologies; however, in the beginning the number of interventions of different types was decided as per the budget available, vulnerability status and cooperation of the farmers. The interventions which require high investment like farm pond were planned

for few suitable locations in the village. The *in situ* moisture conservation and improved agronomic practices, inter-cropping and new varieties were taken by large number of farmers in the village. In selection of beneficiaries, the farmers' most vulnerable to climatic variability and small holders were given priority. It was also ensured that the village has control farm/plot/animals for all the implemented interventions in order to assess the impact of interventions in a short period. Every centre prepared action plan. The demonstration component of NICRA have been finalized in these centers in a participatory mode. The villages in districts and domain districts of the centers are given in and location of the NICRA adopted villages by AICRPDA centres is shown in Fig. 2.



Fig. 2 Location of NICRA villages adopted by AICRPDA centres

The major interventions were implemented both under on-farm and on-station situations, broadly under four theme areas:

I. Real time contingency crop plan implementation both on station and on farm in a participatory mode

- To demonstrate contingency related to crop, variety, any crop management practice during weather aberrations on a real time basis

II. Rain water harvesting (in-situ and ex-situ) and efficient use

- Demonstration on efficient *in situ* moisture conservation practices to conserve more moisture as an adaptation strategy; efficient and multiple use of harvested water or enhancing water use efficiency (life saving irrigation, sprinkler irrigation) as adaptation and mitigation strategies; groundwater recharging through bore well and open well, defunct well as drought proofing strategy

III. Efficient energy use and management

- Introduction of modern machines and implements to create awareness in the farming community about their use for different crops (establishing custom hiring centre and ensuring services in the village) and timely sowing of rainfed crops is considered as the major adaptation strategy.

IV. Alternate land use for carbon sequestration and eco-system services

- To develop alternate land use system / farming system for carbon sequestration and ecosystem services

Overall, the package included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, crop management practices, foliar sprays, timely operations through custom hiring centre and alternate land use and ecosystem services.

Real Time Contingency Planning

Contingency crop planning refers to implementing a plan for making alternate crop or cultivar choices in tune with the actual rainfall situation and soils in a given location. In rainfed areas, as a general rule early sowing of crops with the onset of monsoon is the best-bet practice that gives higher realizable yield. Major crops affected due to monsoon delays are those crops that have a narrow sowing window and therefore cannot be taken up if the delay is beyond this cut-off date. Crops with wider sowing windows can still be taken up till the cut-off date without major yield loss and only the change warranted could be the choice of short duration cultivars. Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon. Breaks in monsoon cause prolonged dry spells and are responsible for early, mid and terminal droughts. These aberrant situations often lead to poor crop performance and or total crop failures. While early season droughts have to be combated with operations like gap filling and re-sowing, mid and late season droughts have to be managed with appropriate contingency measures related to crop, soil nutrient management and moisture conservation measures. Drought also causes loss in livestock productivity due to shortage in fodder production. Appropriate location-specific fodder production strategies are essential for reducing the adverse impact on livestock which is the major source of livelihood in dryland areas.

"Any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern (including extreme events) in any crop growing season" is considered as **Real Time Contingency Planning (RTCP)**.

If done timely and effectively, RTCP contributes household and village food and fodder security (Srinivasarao *et al.*, 2010).

2. Real Time Contingency Planning Implementation: Experiences from AICRPDA Network

During 2011-12 and 2012-13, various weather aberrations in agro-ecological subregions of the country like delayed onset of monsoon, midseason drought, terminal drought and extreme events like untimely excess rainfall events, were experienced both at on-station and on-farm (NICRA villages). To overcome these situations and to reduce production losses, various real time contingency interventions were implemented which included crops and varieties, soil, rainwater conservation and utilization along with various crop management practices. The first priority was to have a reasonable crop stand in the field and then manage it for getting better yield and income which otherwise would have been a total loss to the farmer, if not responded to the situation appropriately. The salient achievements of real-time contingency measures are discussed in this chapter.

2.1 Drought (Late onset, Early / Mid season and Terminal Drought)

1. NICRA Village: Chikkamaranahalli, Bengaluru Rural district, Karnataka

a. Rainfall Situation and Type of Contingency (Mid season Drought) :

In 2011, the village received 692 mm which was deficit by 60 mm compared to normal (751.9 mm) (Fig.3). The onset of monsoon was normal. There was deficit rainfall in June, July and in September; as a result the *kharif* crops experienced dry spells during second fortnight of June, July, October and first fortnight of September coinciding with the vegetative and reproductive stages of pigeonpea, fingermillet and groundnut.

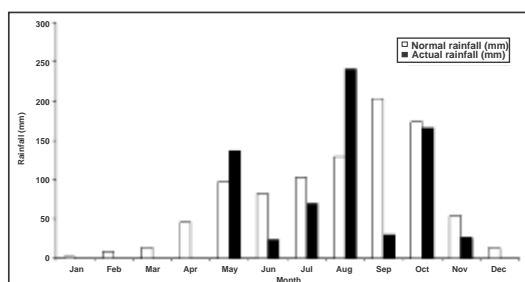


Fig. 3 Normal and actual monthly rainfall (2011) at Chikkamaranahalli village

Contingency Plan Implemented: A conservation furrow was opened between two rows of pigeonpea in pigeonpea + fingermillet (8:2) and groundnut + pigeonpea (8:2) intercropping systems.

Performance: Opening of conservation furrow (Fig. 4) enhanced *in-situ* moisture conservation, particularly due to better rainfall during August, thus overcoming dry spells during vegetative and or reproductive stages of pigeonpea and fingermillet resulting increased rainwater use efficiency (RWUE) by 2.25 kg/ha-mm, better performance of crops, additional fingermillet grain equivalent yield advantage of 1967 kg/ha, additional

net returns of Rs.19545, increase in BC ratio by 1.2 compared to farmers' practice of sole fingermillet in *Akkadi* system (Fig. 5) and no conservation furrow (Table 1).

Table 1. Managing midseason drought with conservation furrow in fingermillet + pigeonpea (8:2) intercropping system

Intervention	Rainfall (mm)	Yield (kg/ha)		FMGEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	BC ratio
		FM	PP				
Fingermillet + pigeonpea (8:2) with conservation furrow	621	2667	417	3861	6.22	31534	3.10
Farmers' practice (Sole fingermillet in <i>Akkadi</i> system and no conservation furrow)	477	1894	-	-	3.97	11989	1.90

FM - Finger millet, PP- Pigeonpea; FMGEY- Finger millet Grain Equivalent Yield



Fig. 4 Conservation furrow between rows of pigeonpea in Finger millet+ pigeonpea (8:2) systems



Fig. 5 Finger millet + *Akkadi* Crops and no conservation furrow

Similarly in groundnut + pigeonpea (8:2) intercropping system (Fig. 6), due to opening of conservation furrow between pigeonpea rows, there was enhanced RWUE of 3.59 kg/ha-mm, better performance of the intercropping system, increased pigeonpea equivalent yield (2072 kg/ha) and BC ratio (3.32) compared to the farmer's practice of sole groundnut and no conservation furrow (Table 2).



Fig. 6 Conservation furrow between pigeonpea rows in groundnut+ pigeonpea (8:2) intercropping system

Table 2. Improved productivity of groundnut + pigeonpea intercropping with conservation furrow

Intervention	Rain fall (mm)	Crop duration (days)	Yield		PEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	BC ratio
			GN	PP				
Groundnut + pigeonpea (8:2) with conservation furrow	577	188	792	913	2072	3.59	40506	3.32
Farmers' practice (Sole groundnut and no conservation furrow)	574	190	547	-	-	0.95	816	1.06

GN - Groundnut, PP – Pigeonpea; PEY - Pigeonpea Equivalent Yield

b. Rainfall Situation and Type of Contingency (Midseason drought): During 2012 in the village, the onset of monsoon was delayed by 17 days i.e. 23rd June and there was a deficit rainfall of about 45%, 73%, 74 and 53% during June, August, September and October, respectively (Fig. 7) and the crops experienced severe moisture stress at various stages. The *kharif* crops experienced midseason drought with four dry spells of more than >10days viz. during 1st June to 22nd June (22 days), 1st July to 15th July (15 days), 8th July to 30th July and 28th August to 27th September (31 days). Further, during north-east monsoon, there was deficit rainfall of about 159 mm compared to normal (241.1 mm).

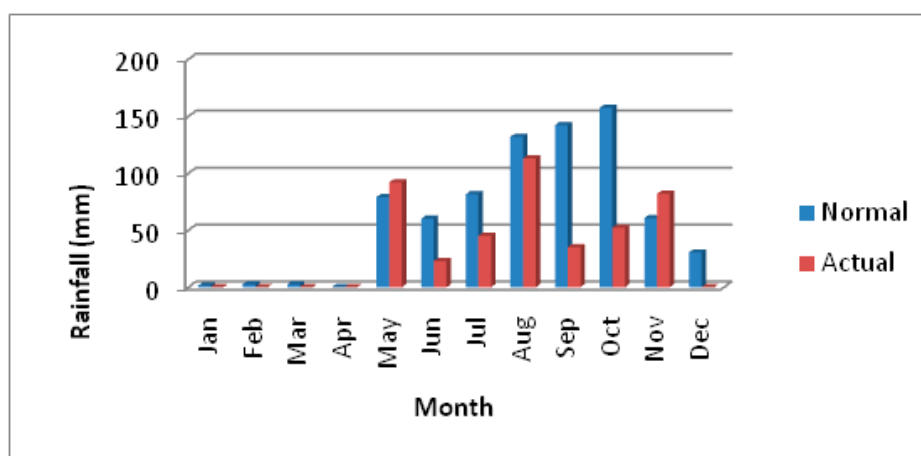


Fig. 7 Normal and actual (2012) monthly rainfall at Chikkamaranahalli village

Contingency Plan Implemented (crop management):

With the benefits accrued during 2011, the conservation furrow was opened in between the pigeonpea rows in finger millet (MR-1) + pigeonpea (TTB-7) intercropping system (8:2) in 12 farmers' fields. Further, in the intercropping system, pigeonpea was much affected due to moisture stress at vegetative stage. Hence to conserve the available moisture, thinning (Fig. 8) and intercultivation was done in pigeonpea while one intercultivation was done in finger millet.



Fig. 8 Thinning in Pigeonpea in pigeonpea+finger millet intercropping system

c. Performance: With the opening of conservation furrow, moisture conservation was enhanced resulting in increased grain yield of finger millet by 19 % with additional net returns of Rs. 6469/ha and BC ratio of 2.72 compared to no conservation furrow and sole finger millet. However, due to severe moisture stress at various stages, the pigeonpea could not perform better further, no yield was obtained (Table 3).

Table. 3 Effect of *in-situ* moisture conservation in finger millet + pigeonpea (8:2) intercropping system during 2012

Intervention	Rain fall (mm)	Crop duration (days)	Finger millet		RWUE (kg/ha-mm)	Net Returns (Rs. /ha)	B:C Ratio
			Yield (kg/ha)	Straw Yield (kg/ha)			
Finger millet + pigeonpea (8:2) with conservation furrow	350	154	2106	4296	6.08	28642	2.72
Farmers' practice (Sole finger millet in Akkadi system and no conservation furrow)	247	120	1770	4030	7.16	22173	2.36

Note: Pigeonpea yield was not obtained

Similarly, opening of conservation furrow in between pigeonpea rows in groundnut (TMV-2) + pigeonpea (TTB-7) in 8:2 ratio, resulted in increased groundnut pod equivalent yield (718 kg ha^{-1}) by 9.4 % with higher RWUE (2.14 kg/ha-mm), higher net returns (Rs. 17,950 /ha) and B: C ratio (2.00) compared to sole groundnut and no conservation furrow (Table 4).

Table. 4 *In situ* moisture conservation in groundnut + pigeonpea intercropping system (2012-13)

Intervention	Yield (kg/ha)		RF (mm)	Duration of Crop 1 & 2	Yield (kg/ha) Y1 + Y2 (PEY)	RWUE (kg/ha-mm)	Net Returns (Rs/ha)	BC Ratio
	Ground-nut	Pigeon pea						
Groundnut + pigeonpea (8:2) with conservation furrow	418	375	335	176	718	2.14	17,950	2.00
Farmer's Practice (Sole crop)	382	-	249	112	-	1.53	1,600	1.09

Lessons Learnt: The midseason drought at various stages of finger millet and groundnut was managed by intercropping with two rows of pigeonpea and a conservation furrow in between two pigeonpea rows. This is a simple low cost technology for tackling midseason drought.

ii. Contingency Plan Implemented: In 2012 in the Chikkamaranhalli village, under delayed onset of monsoon, a real-time contingency i.e. medium duration finger millet variety i.e. GPU-28 was introduced as direct sown sole crop in 57 farmers fields replacing direct sown long duration finger millet variety i.e. MR-1.

Performance: Under delayed onset of monsoon, GPU-28 (Fig. 9) performed better which gave higher grain yield, net returns and B:C ratio (1720 kg/ha, Rs.21161/ha and 2.30, respectively) than long duration variety (MR-1) (1555 kg/ha, Rs. 18096/ha and 2.11, respectively). The higher RWUE of 10.17 kg /ha- mm was obtained with GPU-28 compared to 6.17 kg /ha-mm with MR-1 (Table 5)

Table. 5 Performance of medium duration finger millet cv. under delayed onset of monsoon

Intervention	DOS	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Straw Yield (kg/ha)	RWUE (kg /ha- mm)	Net Returns (Rs/ha)	BC Ratio
MR-1 (Long duration)	15 th Aug 2012	252	123	1555	4328	6.17	18096	2.11
GPU-28 (Medium duration)	31 st Aug 2012	169	115	1720	4015	10.17	21161	2.30



Fig. 9 Performance of medium duration finger millet cv. GPU-28 under delayed onset of monsoon in 2012

2. Ballawal-Saunkhri, S.B.S.Nagar District, Punjab

Rainfall Situation and Type of Contingency

(Delayed and deficit rainfall): In 2012, at AICRPDA centre, Ballawal-Saunkhri, a rainfall of 521.9 mm (Fig. 10) was received during the *kharif* season which was deficit by 419 mm. The deficit rainfall was recorded in June, July, September and October.

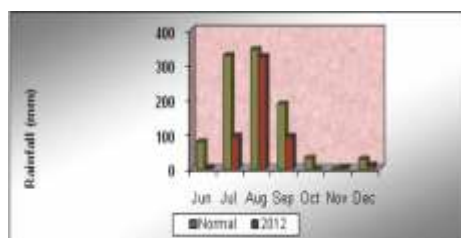


Fig. 10 Normal and actual (2012) monthly rainfall at Ballawal Saunkhri

Contingency Plan Implemented: Under normal situation, maize is the predominant *kharif* crop in the Kandi region of Punjab. Due to delayed onset of monsoon, contingent crops viz., greengram, blackgram, clusterbean, sesame, groundnut, pearl millet (grain) and pearl millet (fodder) were sown in the first week of July.

Performance: Amongst the contingent crops viz., greengram, blackgram, clusterbean, sesame, groundnut, pearl millet (grain) and pearl millet (fodder), sesame performed better with higher maize equivalent yield (237 kg/ha) (Table 6)

Table. 6 Performance of contingent crops during delayed onset of monsoon

Crops	Grain/seed yield (kg/ha)	Straw yield (kg/ha)	Maize equivalent yield (kg/ha)
Maize	2091	4011	2359
Greengram	472	4072	1729
Blackgram	509	2441	1695
Clusterbean	-	12099	686
Sesame	356	1582	2370
Pearlmillet (G)	482	3162	491
Pearlmillet (F)	-	45600	1840
CD (0.05%)			244.0

3. NICRA Village: Muthukrishnapuram, Thoothukkudi district, Tamil Nadu

Rainfall Situation and Type of Contingency (Delayed onset of monsoon) : In 2012, the onset of north-east monsoon was delayed i.e. second fortnight of October

Contingency Plan Implemented: In the village, due to delayed onset of monsoon, as contingency crops, maize, sorghum, pearl millet and pulses were sown during 15th to 30th October.

During crop growing season, only 97.7 mm was received (76.6 mm from seedling to vegetative stage), (12.1 mm flowering to grain filling) and (9.1 mm grain filling to harvesting stage).

Performance: Pearlmillet performed better (Fig. 11) while maize, sorghum and pulses failed. Pearlmillet gave a grain yield of 2300 kg/ha with income of Rs 8,500/ha



Fig. 11 Performance of Pearlmillet under delayed onset of monsoon

4. NICRA Village: Nakkalamuthanpatti, Thoothukkudi District, Tamil Nadu

Rainfall Situation and Type of Contingency (Mid season drought) : The village received 503 mm which was 26 % excess compared to the normal (399 mm) (Fig. 12). There were dry spells during 41st and 52nd SMW in 2011 and 1st to 13th SMW in 2012.

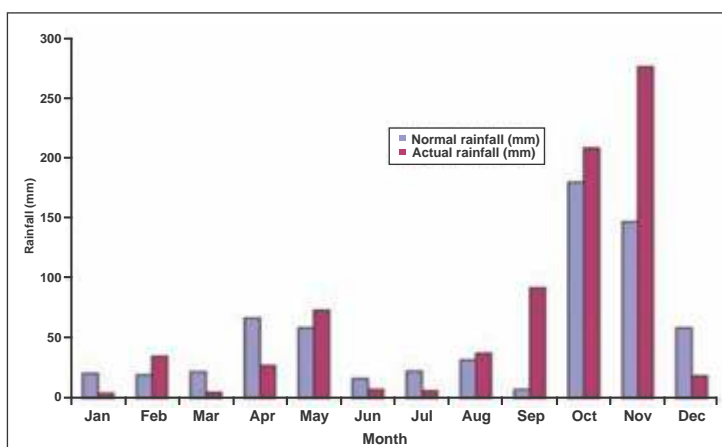


Fig. 12 Normal and actual (2011) monthly rainfall at Nakkalamuthanpatti Village

Contingency Plan Implemented: The cotton crop experienced dry spells during 41st (8th – 14th October) and 52nd SMW (24th – 31st December) in 2011 and 1st to 13th SMW in 2012 (except 6th and 11th SMW) which coincided with boll opening, ripening and maturity stages. A supplemental irrigation of 5 cm from farm pond was given during these stages.

Performance: The supplemental irrigation mitigated dry spells during flowering and reproductive stages in cotton (Fig. 13) and resulted in increased seed cotton yield by 18 % (1860 kg/ha) with a BC ratio of 1.88 and additional net returns of Rs 8975 compared to no supplemental irrigation (Fig. 14) (Table 7).

Table. 7 Performance of cotton (RCH II) with supplemental irrigation from harvested rainwater

Yield (kg/ha)		Increase in yield (%)	Net returns (Rs./ha)		BC ratio	
With supplemental irrigation	Without supplemental irrigation		With supplemental irrigation	Without supplemental irrigation	With supplemental irrigation	Without supplemental irrigation
1860	1575	18.1	34,475	25,500	1.88	1.68



Fig. 13 Performance of cotton with supplemental irrigation



Fig. 14 Cotton without supplemental irrigation

5. NICRA Village: Warkhed, Akola District, Maharashtra

Rainfall Situation and Type of Contingency (Midseason drought) :

In 2011 in the village, a rainfall of 640 mm rainfall was received during *khari* which was deficit by 103.6mm compared to normal (743.6 mm) (Fig. 15) and the deficit was observed during June to September as a result cotton crop experienced dry spells during 38th and 39th SMW (September).

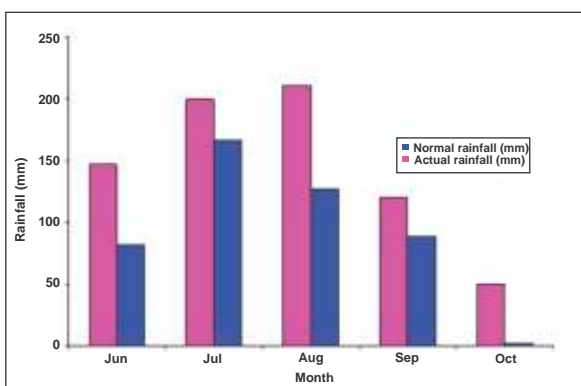


Fig. 15 Normal and actual (2011) monthly rainfall, Warkhed village

Contingency Plan Implemented: To mitigate the dry spells, a conservation furrow was opened across the slope after 30 DAS in cotton.

Performance: Opening conservation furrow across the slope after 30 DAS in cotton had resulted in maintaining/enhancing soil moisture, better crop performance (Fig. 16 & 17), increase in seed cotton yield was by 19 %, higher RWUE (1.82 kg/ha-mm), additional net returns of Rs.10,753/ha with B:C ratio of 3.02 as compared to farmers' practice (without furrow opening) (Table 8).

Table. 8 Impact of conservation furrow at 30 DAS in cotton

Intervention	Rainfall (mm)	Duration of crop	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	BC ratio
With conservation furrow opening at 30 DAS*	768	215	1397	1.82	38738	3.02
Without conservation furrow opening at 30 DAS	751	219	1175	1.56	27985	2.36

*Mean of 5 locations



Fig. 16 Better cotton crop with conservation furrow at 30 DAS



Fig. 17 Cotton without conservation furrow

6. NICRA Village: Pangri, Parbhani District, Maharashtra

Rainfall situation and Type of Contingency (Midseason drought) :

In 2011 during south-west monsoon (*kharif*), the village received 637 mm which was deficit by 198 mm compared to normal (835 mm) (Fig 18). The *kharif* rainfed crops experienced dry spells in the month of September.

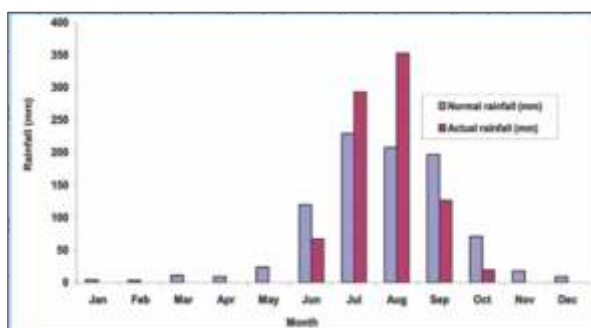


Fig. 18 Normal and actual (2011) monthly rainfall at Pangri Village

Contingency Plan Implemented: To mitigate dry spells a conservation furrow was opened at 30 DAS after every 4 rows in soybean crop.

Performance: Opening of conservation furrow after every 4 rows at 30 DAS helped in conserving the moisture and resulted in better performance of soybean (Fig. 19 & 20) and increased seed yield by 33.6% (2075 kg/ha) compared to no conservation furrow (1553 kg/ha) (Table 9).

Table. 9 Managing mid season drought with conservation furrow in soybean

Intervention	Yield (kg/ha)	Increase in yield (%)
Conservation furrow at 30 DAS in soybean	2075	33.6
No Conservation furrow in soybean	1553	-



Fig. 19 Opening conservation furrow at 30 DAS in soybean



Fig. 20 Good soybean crop with conservation furrow

7. NICRA Village: Ningnoti, Indore district, Madhya Pradesh

Rainfall Situation and Type of Contingency (Midseason drought) :

During 2012, in the village, the onset of south-west monsoon was delayed i.e., 29th June. There was deficit rainfall of 96 %, 30 % and 100 % during June, August and October, respectively (Fig. 21) coinciding with the seedling stage/vegetative stage of blackgram, maize, soybean, and horsegram.

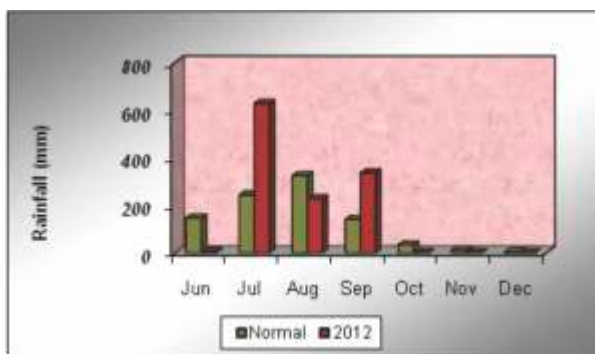


Fig. 21 Normal and actual (2012) monthly rainfall at Ningnoti village

Contingency Plan Implemented: As a midseason correction to mitigate dry spells, foliar spray was done with VAM-C 50 % SL @ 3.75 l/ha; potassium solution @ 2%; thio-urea @ 250 g/ha at the reproductive stage of blackgram (JU-86), maize (HQPM-1), soybean (JS-60), and horsegram (HG-563).

Performance: Foliar spray of VAM-C 50 % SL @ 3.75 l/ha recorded significantly higher yield of soybean 2365kg/ha, maize 1870 kg /ha, blackgram 462 kg /ha and horsegram 667 kg/ ha as compared to no spray. Higher net returns and BC ratio was also obtained with foliar spray of VAM-C 50 % SL @ 3.75 l/ha in all the crops compared to other sprays and control (Table 10).

Table. 10 Seed yield and economics of *kharif* crops as influenced by foliar sprays under aberrant monsoon condition

Main and Sub plot treatments	Blackgram	Maize	Soybean	Horsegram
Seed /grain yield (kg/ha)				
T1-Spray of VAM-C 50 % SL @ 3.75 l/ha	462	1870	2365	667
T2-Spray of potassium solution @ 2%	433	1643	2148	640
T3-Spray of thiourea @ 250 g/ha	450	1767	2098	658
T4-Polythene mulch	419	1548	2331	614
T5-Control	400	1500	1817	597
Mean	433	1666	2152	635
CD 5%	Main (42.5), Sub (30.3) and Int. M x S (60.7)			
Net returns (Rs./ha)				
T1-Spray of VAM-C 50 % SL @ 3.75 l/ha	8497	16185	56452	16667
T2-Spray of potassium solution @ 2%	7312	13000	49944	15598
T3-Spray of thiourea @ 250 g/ha	8000	14741	48437	16328
T4-Polythene mulch	6762	11667	55421	14550
T5-Control	6011	11000	40024	13894
Mean	7316	13319	50056	15407
CD 5%	Main (923), Sub (860) and Int. M x S (1720)			
B: C Ratio				
T1-Spray of VAM-C 50 % SL @ 3.75 l/ha	1.85	2.62	4.89	2.67
T2-Spray of potassium solution @ 2%	1.73	2.30	4.44	2.56
T3-Spray of thiourea @ 250 g/ha	1.80	2.47	4.34	2.63
T4-Polythene mulch	1.68	2.17	4.82	2.46
T5-Control	1.60	2.10	3.76	2.39
Mean	1.73	2.33	4.45	2.54
CD 5%	Main (0.07), Sub (0.06) and Int. M x S (0.12)			

8. Anantapur, Anantapur District, Andhra Pradesh

Rainfall Situation and Type of Contingency (Delayed onset of monsoon/Early season drought): In 2011, 18 mm and 29.2 mm rainfall was received in June 2nd and 3rd, respectively, followed by long dry spell and a rainfall of 11 mm was received on 7th July and after a long dry spell a rainfall of 17 mm and 22 mm was received on 26th and 27th July. In 2012, after initial long dry spell in June, an amount of 20.4 mm and 9.4 mm rainfall received on 27th and 29th June followed by a long dry spell and a rainfall of 19 mm, 49 mm and 27.4 mm was received on 16th, 17th and 22nd July, respectively. In 2013, a rainfall of 15.6 mm was received on 8th June and 38.4 mm was received on 8th July. Either delayed onset of monsoon and or early season drought June- July during *khariif* in Anantapur district created a short sowing window for groundnut crop due to limited soil moisture. This necessitated covering sowing of groundnut crop in larger area in short time and with precision by utilizing limited sowing window available.

Contingency Plan Implemented: The small and marginal farmers in the region with no or insufficient bullock drawn power. Even some farmers having tractors also use them for preparatory cultivation. AICRPDA centre, Anantapur, made available of tractor drawn 8 row Ananta groundnut planter in the custom hiring centre and was hired to 260 farmers from the nearby villages. This implement was used for timely sowing of groundnut under favourable soil moisture conditions in June and July in 2011, 2012 & 2013,

Performance : The hiring and use of Ananta planter (Fig. 22) helped the farmers in timely and precision sowing of groundnut crop in an area of 2676 ha. The correct placement of the seed in the moist zone and maintenance of proper seed to seed distance resulted in uniform germination, establishment and maintenance of optimum plant population and finally higher groundnut pod yield up to 1000 kg/ha with a RWUE of 3.2 kg/ha/mm. Another advantage with mechanization of sowing was overcoming the labour and draught power shortage but also in efficient use of available tractor in the village.



Fig. 22 Timely sown better groundnut crop using Tractor Drawn 8 Row Ananta Groundnut Planter

9. NICRA Village: Girigetla, Kurnool District, Andhra Pradesh

Rainfall Situation and Type of Contingency (Midseason drought) :

In 2011, the onset of monsoon was normal and the village received 343 mm which was deficit by 277mm compared to normal (620 mm) (Fig. 23). The *kharif* crops experienced dry spells during 36, 37, 38 and 39 SMWs. The intense rainfall event of 51.2mm was experienced on 16th August 2011.

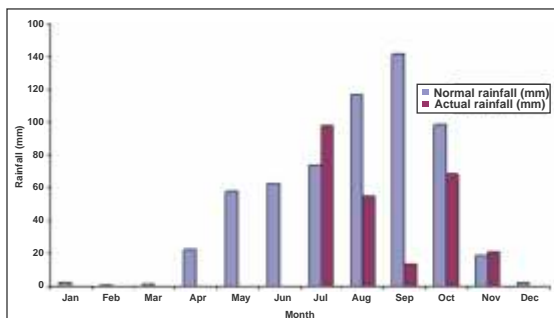


Fig. 23 Normal and actual (2011) monthly rainfall at Girigetla village

Contingency Plan Implemented: Groundnut is the normal *kharif* crop in red soils in the village. Farmers in the district normally sow pearl millet in July to August in red soils. To develop climate resilient alternative cropping system, pearl millet + pigeonpea (5:1) intercropping system was introduced with early sowing of pearl millet in the second week of June 2011 to avoid midseason/terminal drought and was compared with the performance of normal sown pearl millet during second week of July.

Performance: The early sown pearl millet performed better (Fig. 24) and gave a grain yield of 750 kg/ha and pigeonpea gave a yield of 625 kg/ha while the normal sown pearl millet crop failed due to moisture stress at knee high stage.



Fig. 24 Performance of early sown pearl millet, as contingency strategy, in pigeonpea + pearl millet intercropping systems (5:1)

Contingency Plan Implemented (Supplemental irrigation) : In 2011, in Girigetla village due to dry spells during 36, 37, 38 & 39 SMWs in September, groundnut crop experienced moisture stress at pod filling and pod development stages. A supplemental irrigation of 10 mm from the stored rainwater in the farm pond was given at these stages. The supplemental irrigation was also given to castor at seed development stage.

Performance: The supplemental irrigation to groundnut (Fig. 25 & 26) and castor (Fig. 27 & 28) increased pod yield by 46 % (683 kg/ ha) and castor bean yield by 20 % (410 kg/ha), respectively, with higher net returns and BC ratio compared to no supplemental irrigation (341.5 kg/ha in castor and 467 kg/ha in groundnut) (Table 11).

Table. 11 Managing mid-season droughts with supplemental irrigation of pond water

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)	BC ratio
		Supplementary irrigation	Without irrigation			
Castor	GCH-4	410	341.5	20%	7570	1.7
Groundnut	TMV-2	683	467.0	46%	13811	1.9



Fig. 25 Performance of groundnut supplemental irrigation from farm pond



Fig. 26 Performance of groundnut affected with midseason drought



Fig. 27 Performance of castor supplemental irrigation from farm pond



Fig. 28 Performance of castor without supplemental irrigation

Rainfall Situation and Type of Contingency (Midseason drought):

In 2012 in the NICRA village, a rainfall of 271 mm was received during cropping season which was deficit by 159 mm compared to normal (430 mm) and the deficit was about 34, 20, 73 and 60 percent during June, August, November and December, respectively causing moisture stress in cotton.

Contingency Plan Implemented: Due to dry spells, cotton crop suffered with moisture stress at flowering and boll formation stages, there was reddening of leaves in cotton (Fig 29). As a real-time contingency, spraying of micronutrients viz. 19:19:19 @ 1%, ZnSO_4 , Mg SO_4 @ 1% boron @ 1% was done at flowering and boll formation stages in 20 farmers' fields covering 8 ha.

Performance: Spraying with micronutrients resulted in increase in lint yield up to 50% compared to no spraying (315 kg/ha).



Fig. 29 Reddening of cotton leaves

10. NICRA Village: Pata Meghpar, Jamnagar District, Gujarat

Rainfall Situation and Type of Contingency (Midseason and Terminal Droughts): In 2011 in the village, there were midseason dry spells during 33rd and 34th SMW (13th to 26th August) and terminal drought during 37th to 38th SMW (10th to 23rd September). The village also received excess of 340 mm compared to normal (585 mm). the excess runoff was harvested in farm pond.

Contingency Plan Implemented: Due to dry spells at flowering stage in groundnut and at flowering/reproductive stage in cotton, the crops experienced moisture stress. A supplemental irrigation of 5 cm (through drip system) from the stored rainwater in the farm pond was given at critical stages of groundnut and cotton.

Performance: The supplemental irrigation at critical stages to groundnut (Fig. 30) and cotton (Fig. 31) crops resulted in increased pod yield by 25.8 % and cotton yield by 21.9 % compared to no supplemental irrigation (Table 12).

Table. 12 Performance of groundnut and cotton with supplemental irrigation during midseason/terminal droughts

Crop (Variety)	Yield (kg/ha)		Increase in yield (%)
	With supplemental irrigation	Without supplemental irrigation	
Groundnut (GG-20)	1825	1450	25.8
Cotton (Bijdhana BG II)	3475	2850	21.9

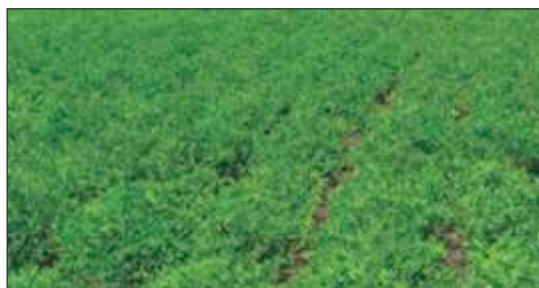


Fig. 30 Groundnut with supplemental irrigation



Fig. 31 Supplemental irrigation through drip system in cotton

Rainfall Situation and Type of Contingency (Midseason drought): In 2012, during *kharif*, in Pata Meghpar village, a rainfall of 180 mm was received which was 67 % deficit than normal (543.6 mm). Further, long dry spells were experienced during for 49 days during 14th June to 2nd August and for 27 days during 5th August to 22nd September. This severely affected the performance of cotton crop.

Contingency Plan Implemented: Due to long dry spells during June to September, the cotton crop was affected severely resulting in very low plant population. As a real-time contingency, castor was sown as relay crop in the gaps of cotton crop.

Performance: Sowing of castor as relay crop in the gaps of cotton (Fig. 32), resulted in overall yield and economic benefit of Rs. 16188/ha as compared to sole cotton (Fig. 33) (Table 13).

Table. 13 Castor as relay crop in cotton, Pata Meghapar village (as a gap filled relay crop)

Yield (kg/ha)			Net returns (Rs/ha)		Increase in net returns (Rs/ha)
Sole cotton	Relay cropping		Sole cotton	Relay cropping (cotton castor)	
	Base cotton	Relay castor			
700	525	675	29750	45938	16188



Fig. 32 Castor as relay crop in cotton (as a gap filling)



Fig. 33 Cotton as sole crop affected with midseason drought

Rainfall Situation and Type of Contingency (Midseason drought) : In 2012 in the village, there was no rain during rabi season i.e. (October and November) (Fig. 34) water stress.

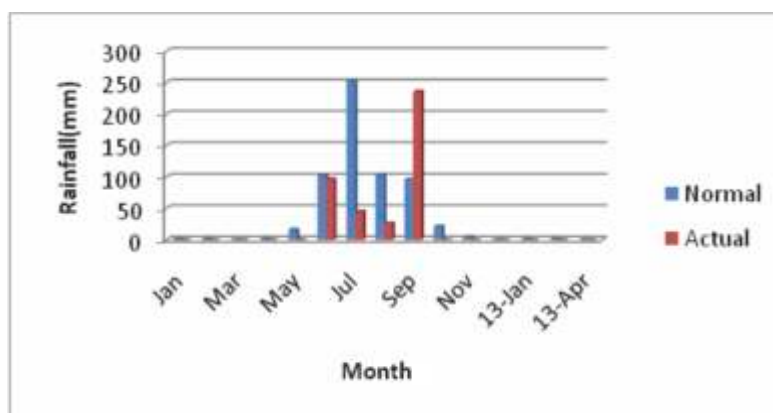


Fig. 34 Normal and actual (2012) monthly rainfall at Pata Meghapar village

Contingency Plan Implemented: To overcome moisture stress in post-rainy season in chickpea, foliar spray with KNO_3 at 2% and urea at 2% was done in chickpea (Gram G-3) and compared with water spray as check.

Performance: The foliar sprays improved the performance of chickpea (Fig. 35) and resulted in the yield increase by 30.3 % and 26.3 %, with KNO_3 @ 2% and urea @ 2%, respectively as compared to water spray (Table 14).

Table. 14 Effect of foliar spray on the yield and economics of chickpea

Foliar Spray	Seed Yield kg/ha	Increase in yield (%)	Additional net returns (Rs./ha)	BC ratio
KNO_3 @ 2%	2278	30.2	15190	3.55
Urea @ 2 %	2211	26.3	13180	3.42
Water Spray	1750	-	-	2.65



Fig. 35 Water stress tolerance in post-rainy season chickpea with foliar spray of KNO_3 and Urea

11. NICRA Village: Narotiwada Village, Solapur District, Maharashtra

Rainfall Situation and Type of Contingency (Midseason drought): In 2012, the village received 281 mm rainfall during *kharif* which was deficit by 254 mm compared to normal (535 mm). There was deficit rainfall of 51%, 54%, 63% and 28 % during June, July, August and September, respectively (Fig. 36) due to which the *kharif* experienced moisture stress at various stages of growth.

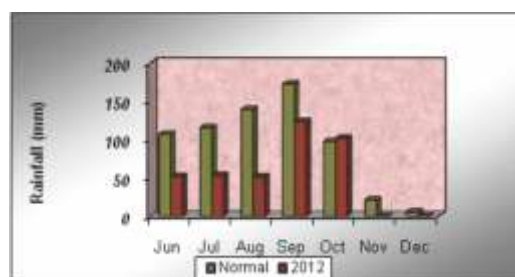


Fig. 36 Normal and actual (2012) monthly rainfall at Narotiwada village

Contingency Plan Implemented: To conserve moisture during dry spells, in pigeonpea (Vipula) + sunflower (Bhanu) (1:2) intercropping system, one hoeing at 20 DAS and one weeding at 30 DAS was done in pigeonpea and two hoeings viz., at 20 DAS and at 40 DAS was done in sunflower in 19 farmers' fields.

Performance: The hoeing and weeding maintained/enhanced moisture conservation resulting in mean (19 locations seed yield of 584 kg/ha and 824 kg/ha in pigeonpea and sunflower, respectively as compared to farmers practice of one hoeing after 15 to 30 DAS which gave low seed yields of 484 kg/ha and 724 kg/ha in pigeonpea and sunflower, respectively.

12. NICRA Village: Chamua, Lakhimpur district, Assam

Rainfall Situation and Type of Contingency (Mid-season drought) : In 2011 in the village, the crops experienced dry spells during 27 & 28 SMW (July), 32 & 35 SMW (August), 36, 39 SMW (September), 41& 44 SMW (October) at tillering, panicle initiation and grain filling stages of *Sali* rice. The intense rainfall events were also experienced on 2nd July (108 mm), 15th August (53), 17th August (171 mm), 21st August (66 mm), 9th September (54 mm) and 15th September (66 mm). These events impacted the stand/ performance of *Sali* crop adversely due to flash floods during August. These events otherwise helped in rainwater harvesting and storage in the renovated/existing/new farm ponds.

Contingency Plan Implemented – Alternate Crops: The *Sali* rice in the region normally prone to midseason drought and crop failure is not uncommon. Crop diversification strategy with vegetable crops viz., turmeric, ginger, potato, rapeseed, pigeonpea and black gram, was implemented.

Performance: Crop diversification (Fig. 37) with crops like blackgram, frenchbean, sesame, okra and cow pea etc. helped the farmer to get more income compared to monocropping of *Sali* rice which experienced the moisture stress (Table 15).

Table. 15 Impact of crop diversification over *Sali* rice under delayed onset of monsoon and mid season drought in North Bank Plain zone of Assam

Crop	Improved practice (Diversified cropping)		BC ratio	Farmers Practice (Growing local cultivar)	
	Variety	Yield (kg/ha)		Crop & variety	Yield (kg/ha)
Rice	Basundhar	3718	1.7	Rice Jaha (A scented local variety)	825
Turmeric	Local	67500	21.4		
Potato	K. Pokhraj	32500	4.5		
Rapeseed	TS-36	911	1.69		
Napier	Hy Napier	5000	-		
Black gram, french bean, sesame, bhendi, cowpea etc					



Fig. 37 Mid-season drought management with alternate crops (crop diversification)

Contingency Plan Implemented: During 2011 in Chauma village, during dry spells at stolon formation and tuber formation stages in potato, a supplemental irrigation of 9.4 cm from the harvested rainwater in farm pond was given to potato (K. Pokhraj).

Performance: The supplemental irrigation to potato at critical stages resulted in higher tuber yield of 26,7500 kg/ha with net returns of Rs 1,09,475 as compared to 12000 kg/ha without supplemental irrigation.

Rainfall Situation and Type of Contingency (Delayed onset of monsoon): In 2011 in Chamua village, the rainwater was harvested in farm ponds due to pre-monsoon rainfall. The onset of monsoon was delayed by 15 days and in June about 50% deficit rainfall than the normal was received in the village. During the season *Sali* this adversely affected the sowings/nurseries of rice in the village.

Contingency Plan Implemented – Nursery with pond water: Utilizing the rainwater in the farm pond was efficiently utilized for raising rice nurseries (Fig. 38&39). This helped in timely transplanting of *Sali* rice under delayed monsoon onset conditions.

Performance: Timely transplanting of rice seedlings in the main field facilitated in better establishment of the crop, better crop growth (Fig. 40) and better yields compared to the other fields in the village where delayed rice transplanting was done. About 15-20% higher yield obtained due to timely transplantation.



Fig. 38 Rainwater harvested during pre-monsoon months



Fig. 39 Efficient utilization of rainwater for raising rice nurseries



Fig. 40 Better rice nurseries

Rainwater harvesting in farm ponds during premonsoon months and efficiently utilized during delayed onset of monsoon

Rainfall Situation and Type of Contingency (Midseason drought): During 2011-12 and 2012-13, in the NICRA village, the crops experienced midseason droughts at various stages during *kharif*.

Contingency Plan Implemented - Mulch-cum-Manuring: As contingency to mitigate midseason drought mulching was done in ginger and turmeric with locally available organic material like rice husk, thatch etc for *in situ* moisture conservation

Performance: The mulching helped moisture conservation and better growth and performance of ginger and turmeric (Fig. 41 & 42) Rainfed rice required higher quantities of water during crop growth season. As major part of Lakhimpur district are often experienced mid season droughts, as a alternate crop strategy several high value crops like ginger, turmeric were taken up in place of rice. With mulch-cum manure with rice husk, straw areca nut leaves and water hyacinth, mid season droughts were managed and productivity and farm income improved even with un even weather conditions. Mulching resulted in higher yields, RWUE and net returns in ginger and turmeric (Table 16) Crop diversification with high value crops with organic mulch- cum manuring the farm profits were many folds higher than traditional rice, often affected by mid season droughts.

Table. 16 Managing midseason drought with mulch-cum manuring

Crop (Cultivars)	Yield (kg/ha)	Increase in yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	BC ratio
Turmeric					
BC collection	36949	6900	20.84	5, 07,605	11.7
Tall clone	42291	12229	23.86	5,86,970	13.4
Ginger					
Jati ada	22887	2887	12.97	4, 14, 488	10.8
KA Collection	30538	10538	17.23	6,58, 255	14.4



Fig. 41 Mid season drought management with various organic mulches in Lakhimpur district, Assam.



Fig. 42 Water-hyacinth available in the local farm ponds is being collected for mulch - cum manuring

13. NICRA Village: Kochariya, Bhilwara District, Rajasthan

Rainfall Situation and Type of Contingency (Midseason Drought)

: In 2011, the village received a rainfall of 540.5 mm and there was a deficit of 117.2 mm compared to normal (657.7 mm) (Fig. 43). The onset of monsoon was normal. The crops experienced dry spells during third week of September onwards. Further, no rains were received during the post monsoon period against normal rainfall of 16.5 mm. The *kharif* crops experienced moisture stress during reproductive stages.

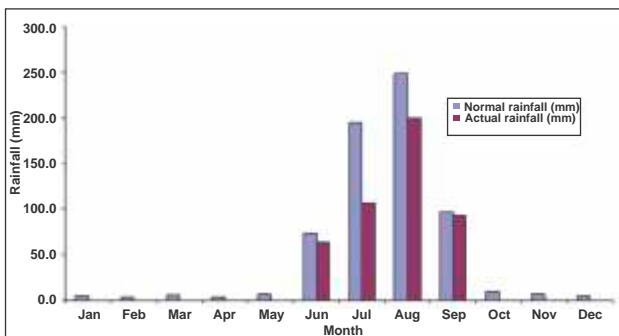


Fig. 43 Normal and actual (2012) monthly rainfall at Kochariya village

Contingency Plan Implemented: A supplemental irrigation from the stored rainwater in the farm pond was given to the vegetable crops.

Performance: The supplemental irrigation to vegetable crops resulted in higher pod equivalent yield upto 7083 kg/ha and water productivity, upto 1.58 kg/cu.m further by adoption of drip irrigation saved water up to 46 % as compared to surface irrigation. (Table 17)

Table. 17 Productivity and economics of vegetable crops as influenced by supplemental irrigation and through different irrigation methods

Crops	Pea pod equivalent yield (kg/ha)	Net returns (Rs/ha)	BC ratio	Water productivity (kg/ cu.m)
Coriander (green)	7083	1,20,134	6.78	1.58
Pea (pod)	5417	94,076	5.87	1.50
Brinjal	3733	51,908	3.46	0.78

14. NICRA Villages: Khalimati/Dholiya village, Banaskantha District and Chandank village, Mehsana District, Gujarat

Rainfall Situation and Type of Contingency (Excess rainfall and Midseason Drought)

The villages viz. Kalimati/ Dholiya and Chandanki received 1028.8 and 1110.3 mm, respectively which were excess of 136.8 mm and 334.3 mm compared to normal 892 and 776 mm during *kharif* (Fig. 44). Castor and cumin crops experienced moisture stress during germination/ maturity stages.

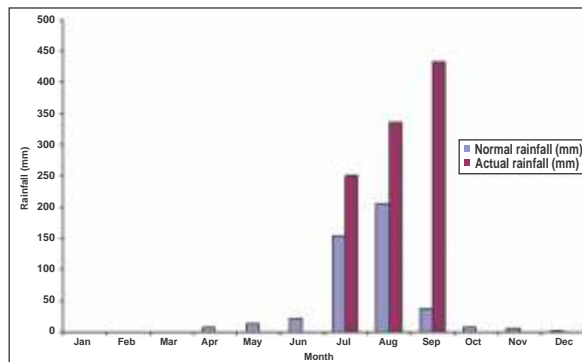


Fig. 44 Normal and Actual (2011) monthly rainfall at Kalimati villages

Contingency Plan Implemented: The supplemental irrigation from the stored rainwater in the farm pond (Fig. 45) was given to castor and cumin at germination and reproductive stages.

Performance: The supplemental during dry spells resulted in better performance of castor (GCH-7) (Fig. 46) and cumin (GC-4) (Fig. 47 & 48) Increased the yields by 41.7 % and 43.2 %, respectively with higher RWUE and BC ratio compared to no supplemental irrigation (Table 18).

Table. 18 Effect of supplemental irrigation from farm pond on the yields of castor and cumin

Crop	Yield (kg/ha)		Increase in yield (%)	RWUE (kg/ha -mm)	BC ratio
	With Supplemental irrigation	Without Supplemental irrigation			
Castor	1280	903	41.74	1.15	5.57
Cumin	616	430	43.25	0.55	8.90



Fig. 45 Harvester rainwater in farm pond



Fig. 46 Supplemental irrigation to castor (drip)



Fig. 47 Cumin with supplemental irrigation



Fig. 48 Cumin without supplemental irrigation

15. NICRA Village: Achalpur, Hoshiarpur District, Punjab

Rainfall Situation and Type of Contingency (Terminal drought) : During 2012 in the village, the withdrawal of south-west monsoon was early and there were no rains in October and November causing unfavourable conditions for sowing of *rabi* crops, particularly wheat crop.

Contingency Plan Implemented: Due to early withdrawal of south-west monsoon coupled with no post-monsoon rains, there was no sufficient moisture in the top soil for sowing of wheat crop, sowing of wheat was done in the moist zone using seed drill and the furrow was kept open.

Performance: As the seed was timely sown and properly placed in the moist zone, there was uniform and good germination of wheat crop (Fig. 49 & 50) as compared to broadcasting method.



Fig. 49 Sowing of wheat with Seed drill



Fig. 50 Uniform germination and better crop stand of Wheat

2.2. Extreme Weather Events

1. NICRA Village: Tahkapal, Bastar District, Chattisgarh

Rainfall Situation and Type of Contingency (Excess rainfall) : In 2012, the village experienced continuous high rainfall during June which was excess of about 345 mm compared to normal (477 mm). Further, there was excess rainfall of 39 % during 120 % during the month of August and September, respectively.

Contingency Plan Implemented: The excess rainfall events affected the field preparation and sowings of *kharif* crops, further the excess rainfall also affected the seedlings due to submerged condition. As contingency measures *viz.*, change in crops, rainwater and crop management practices under upland, midland and lowland situations were implemented in the NICRA villages.

a) Upland Situation

1. **Alternate Crops :** The black gram (var. - *Pant U-30*) and green gram (var. - *Hum-1*) (Fig. 51) were sown in uplands during August and September in 20 farmers fields where finger millet/ pigeonpea/ maize/vegetable crops were damaged due to high rainfall in the month of June–July, 2013. 100 kg/ha of DAP was applied in furrows.



Fig. 51 Performance of black gram, green gram and horsegram as alternate crops

2. **Transplanting of pigeonpea** (*Rajeev lochan*) across the slope was done in 3 farmers fields (Fig. 52) where the normal crop was failed due to high rains. The seedlings of pigeonpea were prepared in polyethene bags in shaded area. For achieving proper growth spot application of FYM and DAP was done.



Fig. 52. Performance of transplanted Pigeonpea as alternate crop

3. **Niger for late sowing condition:** Lot of land was remained fallow due to heavy rains in the month of June. As a contingency crop, Niger (var. *JNC-9*) (Fig. 53) was introduced in 20 farmers fields during 15th to 20th September (which is also the normal sowing time for niger).



Fig. 53 Sowing and crop condition of Niger crop under very late sown condition

4. **Alternative high value vegetables with artificial drainage:** Seedlings of brinjal (Muktakeshi), tomato (Pusa Ruby) and chilies (Pusa Jwala) were prepared by creating artificial drainage conditions in poly shade and was transplanted in fallow upland fields (Fig. 54) and homestead gardens covering 15 farmers. Proper care was taken for draining excess water during August–September and full package of practices were implemented.



Fig. 54 Alternative high value vegetable crops of chili, tomato and brinjal crops with artificial drainage under excess rainfall

5. **Short duration horsegram as a contingency crop :** Due to high rainfall, maize and other upland crops were not sown or the sown crops were failed. Horsegram (BK-1) as a contingency crop (Fig. 55) was sown in upland situation in 20 farmers fields in NICRA villages.



Fig. 55 Performance of horsegram as a contingency crop in uplands after failure of maize

6. **Change of variety:** The sowing of finger millet in uplands was not possible in time due to heavy rains. However, in some fields, the sowing was done but due to heavy rains the germination was affected. As a real time contingency measure, resowing of finger millet with GPU-28 (Fig. 56) was done during first week of August in 10 farmers fields. Crop condition was good.



Fig. 56 Short duration finger millet cv. GPU -28, for delayed sowing

b) Midland Situation

1. **Short duration rice variety for delayed sowing:** In 20 farmers fields in midland situation, where rice was not sown in time due to heavy rains, late sowing in the last week of August was taken up with early maturing variety of rice (MTU-1010) (Fig. 57) through transplanting in *lehi* method (sowing of sprouted seeds) with higher seed.



Fig. 57 Early maturing transplanted rice (MTU-1010) in midland in *lehi* method

c) Lowland Situation

1. **Lehi method of establishment of rice under delayed condition:** In this region, dry aerobic seeding of rice is generally practiced in lowland situation in the last week of May to first week of June. The sown crops were damaged due to water logging. In this situation, farmers were advised to adopt *lehi* practice of rice establishment (in this practice pre germinated rice seeds (MTU-1001) are sown in the puddled field). As an intervention drum seeder was used for sowing within limited time with high seed rate and fertilizer. The fields were prepared by tractor with cage wheel. In this situation the drainage system was created by digging the trench in lower side and cutting of bunds to avoid water logging (Fig. 58).



Fig. 58 Waterlogged fields in low lying area and rice crop sown by *lehi* method after draining excess water

2. NICRA Village: Achalapur, Hoshiarpur District, Punjab

Rainfall Situation and Type of Contingency (Hailstorm): During 2012-13 and 2013-14, the NICRA village experienced heavy intense hailstorm. The villages experienced hailstorm with high speed winds of 120-130 kmph.

Contingency Plan Implemented: The maize crop lodged at the time of grain filling stage due to heavy rainfall and heavy winds. As a contingency measure, the lodged crop was cut and vertical stacking was done (Fig. 59 to 61) this reduced the rotting and rodents problem compared to normal practice of removing cobs of the lodged crop.

Performance: Vertically staked crop showed proper grain filling and with better grain quality. Late sown maize also lodged at tasseling/milking stage. As a contingency measure, the crop was cut and used for green fodder while where the crop was milking stage the green cobs was sold in the market.



Fig. 59 Maize crop affected by hailstorm



Fig. 60 Bundle formation of lodged maize crop



Fig. 61 Vertical staking of maize crop

3. NICRA Village: Chanter, Samba District, Jammu & Kashmir

Rainfall Situation and Type of Contingency (Excess rainfall): In 2011, the village received 1263 mm rainfall during south-west monsoon, which was 408 mm above normal (47.7%) (Fig 62). During *kharif*, four excess rainfall events (102.6 mm (7th July), 103.7 mm (8th August), 108.0 mm (11st August) and 96.0 mm (13rd August, 2011) amounting to 272.1 mm, were experienced during 32nd SMW (August).

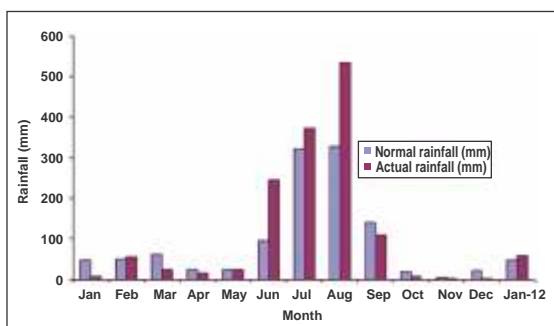


Fig. 62 Normal and Actual (2012) monthly rainfall at Chanter village

Contingency Plan/Best bet Practice Implemented (Improved cultivar + proper drainage + earthing up) : As a contingency measure, the excess water was drained out followed by earthing up in maize which facilitated better performance of maize crop (Fig. 63 & 64) resulting in increased yield up to 22.7 % and RWUE up to 2.15 kg/ha-mm compared to no draining excess water and no earthing up (Table 19).

Table. 19 Effect of proper drainage and earthing up on the performance of maize under excess rainfall condition

Variety/ Hybrid	Yield (kg/ha)		Increase in yield (%)	RWUE (kg/ha -mm)	BC ratio
	Draining out excess water and earthing up	No draining excess water and no earthing up			
K-99	2108	1765	19.4	1.88	0.98
K-9451	1913	1610	18.8	1.84	0.86
Shaktiman	2300	1875	22.7	2.15	1.06
K-517	1713	1485	15.4	1.65	0.66
Mean	2008	1684	19.2	1.88	0.89



Fig. 63 Maize crop under water logged condition



Fig. 64 Maize crop after draining out excess water and earthing up

4. NICRA Village: Ganakdalani village, Lakhimpur District, Assam

Rainfall Situation and Type of Contingency (Flash floods) : During 2012, the flash floods occurred for a period of 32 days viz., 23rd June to 1st July (9 days), 12th -19th September (8 days), 21st-28th September (8 days) and 2nd -8th October (7 days) during 2012 and 36 days during 2013 i.e. 18-27th July (10 days), 7-13 August (7 days), 14-20 August (7 days) and 28 August-8th September (12 days). The rice crop experienced to intermittent flash floods for 4 times during the season

Contingency Plan/Best bet Practice Implemented (Flood tolerant rice varieties) : As a contingency measure in the start of the season, flood tolerant rice varieties viz., Jalashree, Jalkunwari were introduced. Introduction of submergence tolerant varieties of rice viz. Jalashree and draining of excess water from field which resulted in better *Sali* rice.

Performance: All other varieties of rice including *Jalkunwari* were affected but Jalashree performed better (Fig. 65 & 66). With Jalashree, the grain yield of 900 kg /ha and net returns of Rs.11, 400/ha were obtained while the local varieties failed (Fig. 67). Though the yield of Jalshree was very low (as compared to normal year), still there was 100 % benefit to the farmers compared to local varieties (Table 20).

Table. 20 Performance of submergence tolerant variety of rice CV. Jalashree during flash floods

Improved Variety	Local Varieties	Grain yield (kg/ha)	Increase in yield (kg/ha)	Net returns (Rs/ha)
Jalashree	-	900	900	11400
-	Jalkunwari, Ranjit, Laodubi, Monohar Sali	No yield	No yield	No yield



Fig. 65 After receding flash floods in October



Fig. 66 Performance of flood tolerant rice variety - Jalashree



Fig. 67 Failure of Local rice variety under flooded condition

Contingency Plan/Best bet Practice Implemented: During 2012, flood tolerant staggered rice varieties Gitesh and Profulla were introduced for late transplantation condition these two varieties can be transplanted even at 65-75days seedling stage after reducing flood

Performance: Performance of rice varieties viz. Gitesh and Profulla, was better (Fig. 68) than the popular variety Ranjit under delayed transplanting conditions due to flash floods received in mid and low land conditions of Assam.



Fig. 68 Performance of rice varieties Gitesh and Profulla with staggered planting ability (65-70 days old seedling) after recession of flood

Contingency Plan Implemented (Kneeing ability Bao rice):

Floods: Introduction of Bao rice which has kneeling ability under flood conditions. As flood water level increases this variety develops another knee to avoid rice panicles from water inundation (Fig. 69). Thus, this *Bao* rice cultivar adjusts its height according flood water level and makes its panicle above water level. This resulted in safe harvest and improved grain quality.



Fig. 69 Kneeing ability of deep water rice(Bao rice)

3. Real Time Contingency Planning: Initial Preparedness

Agriculture in rainfed areas is essentially rain dependent characterized by diverse agroecological and socioeconomic settings viz. climates, soil types, production systems. Farmers are relatively resource poor with low adaptive capacity. Weather aberrations make rainfed agriculture highly vulnerable, risk prone and often unprofitable impacting the livelihoods of small holders

Since drought occurrence is not sudden and some regions often encounter various kinds of droughts its mitigation can be planned properly. With the available knowledge and emerging new tools, the effects of droughts can largely be counteracted in many situations, if not eliminated completely. It is rightly said that 'drought is nature's guilt, but the human suffering from drought is man-made'. Effective drought preparedness and management is planning and response process to predict drought and establish timely and appropriate responses to minimum negative consequences of the drought. The drought risk management may consist of four stages: preparedness, mitigation, relief and rehabilitation. A range of administrative and technical measures are needed in dealing with droughts before they occur or when they are in progress. Indian farmers of diverse agro-climatic regions evolved numerous strategies to cope with droughts that include soil and water management, crop management, and contingency crop planning and alternative enterprises. For example India is known for the traditional drought coping. Rainwater harvesting systems like *khadins*, (Aridisols of *Jaisalmer*, western Rajasthan), *nadi* system (Inceptisols of Bhilwara, Rajasthan), percolation tanks (Alfisols of Andhra Pradesh and Karnataka), all of which help in magnitude of agricultural drought depends on the type of crops, soil type, temporal and spatial variability of rainfall etc. To overcome the adverse effects of droughts, effective drought management practice is the need of the hour. There is ample evidence to suggest that productivity of rainfed regions can be enhanced as maintained on a sustainable basis, provided the two basic natural resources-soil and rainwater, are well managed during weather abnormality. Over the last several decades, researchers have concentrated on methods of increasing crop production under rainfed conditions in order to mitigate drought effects at farm level. Simple and easily implementable practices were developed for enhancing the yields even in dry years. This improved crop husbandry insulates crops against mild stress and helps to increase yield stability. To meet the weather aberrations, alternate crop strategies, mid season correction and crop life saving techniques form important components. Above all, drought planning must be viewed as a dynamic process requiring a continued attention and can be tackled by drought coping practices implemented in the form of **Real time contingency planning**.

Any contingency plan implementation should have initial preparedness for meeting any kind of weather aberration (depending upon past weather data and experience) data with appropriate coping strategies during crop season such as late onset, mid season droughts terminal droughts or any kind of extreme events. For these two steps, village level institutions play greater role to provide inputs such as suitable seed, fertilizers, need based farm implements during crop growing season. A four pronged strategy for agriculture contingency is shown in Fig. 70.

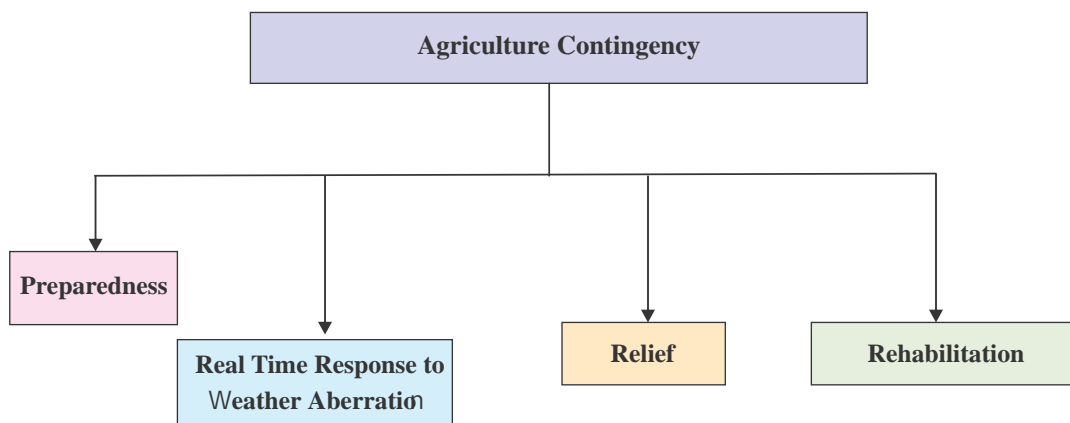


Fig. 70 Drought preparedness is essential for successful implementation of real time contingency planning

Initial Preparedness

In common drought prone regions of India, initial preparedness is must in order to ensure implementation of contingency plan in real time. However, kind's of drought vary and their impacts on crop livestock etc., loss and contingencies vary. Most of the drought management instruments move around conserving soil moisture, harvesting excess water efficient recycling and other crops soil and agronomic strategies that enhance water use efficiency (WUE) and water productivity. A combination of tolerant crop/system, cultivar, soil and nutrient management should be of integral part of the overall Agricultural Contingency Plan. To facilitate these interventions suitable farm implements inputs and need based fodder systems are essential. Various components of “Preparedness”, which are “*Must Do Practices*” are presented in Fig. 71. For example, during current year rainy seasons, heavy rains in Malwa region of Madhya Pradesh resulted in water logging affected most of the standing crops. Land treatment interventions such as ridge and furrow, broad bed furrow (BBF) practiced farmers harvested higher yields while non practiced fields soybean and maize crops damaged completely. Similarly stress tolerant seed availability in village seed banks, required nutrients in nutrient bank along with farm machines will contribute to timely completion of sowing operation particularly when sowing window is limited in most of the regions. For example, Anantapur district in A.P. is the second largest groundnut growing district in India, was limited sowing window which was experienced in June , 2013. This situation could over come effectively by using Ananta groundnut planter on hired basis and

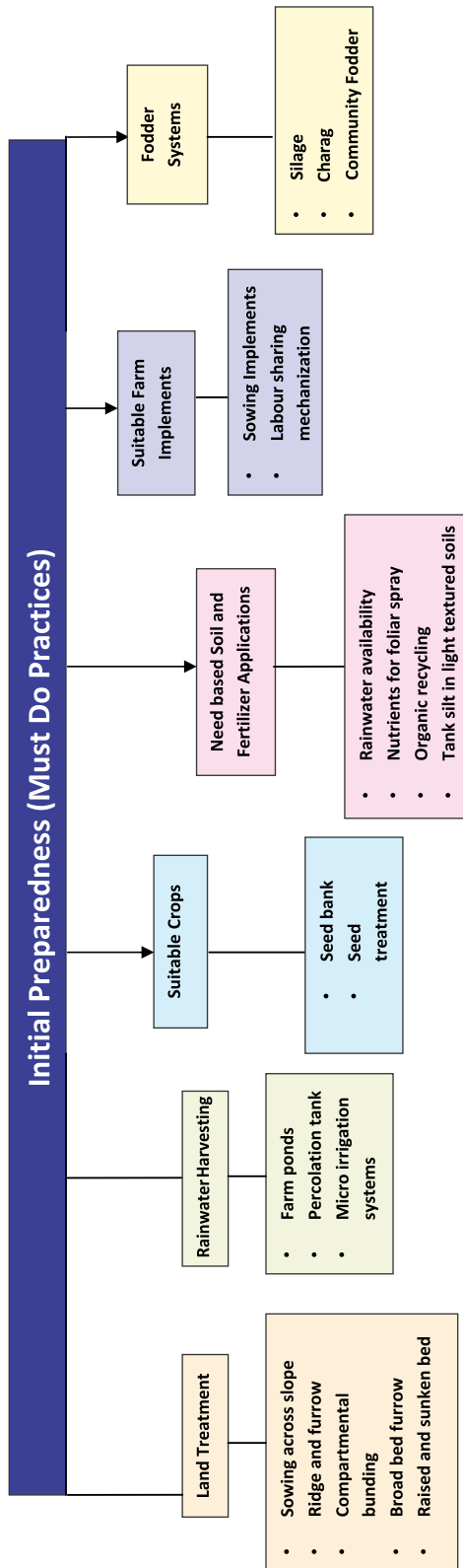


Fig. 71 Must Do Practices (MDP) in Drought Preparedness

completing sowing operation in larger area in short time.

However a consortium of research organizations farmers, farmer groups, agricultural extension officers, KVKs, Line departments, district collectors need to come together to implement real time contingencies at farm level (Fig. 72). Collective action yielded into reducing negative impacts of weather aberrations which ultimately address the food production at farm gate and food security at national level.

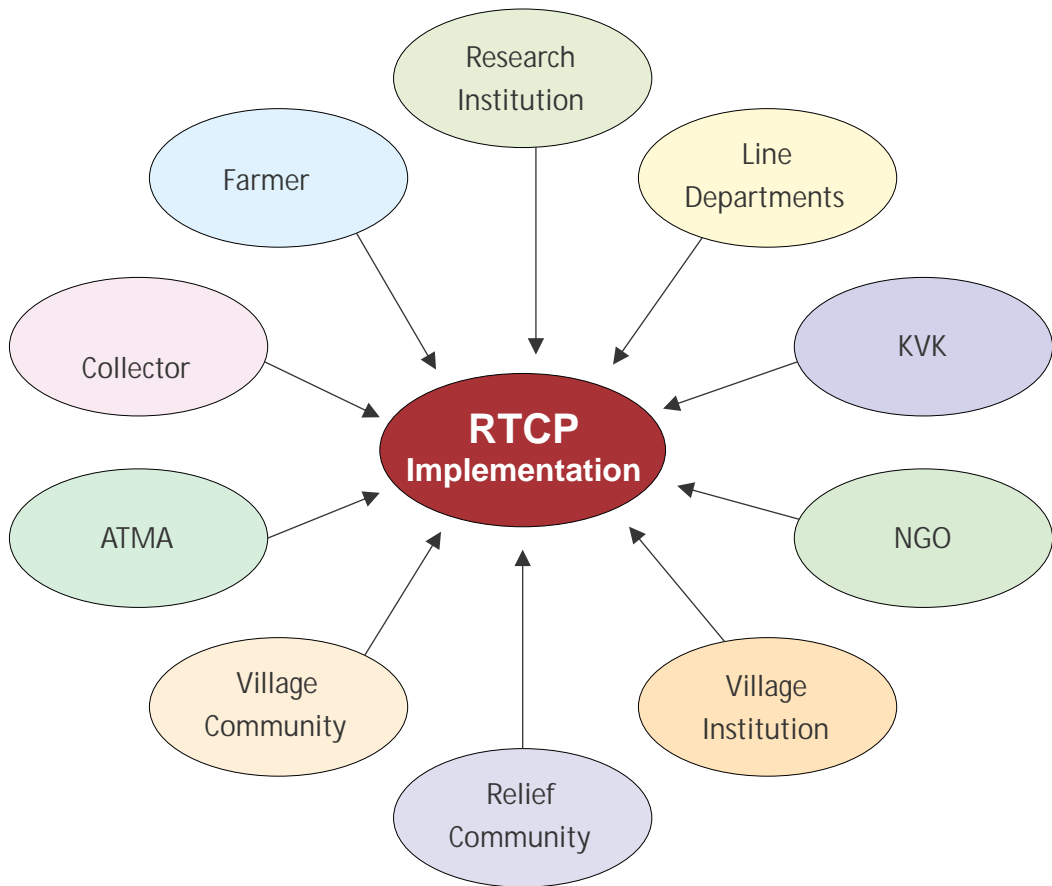


Fig. 72 Stakeholders in Implementation of RTCs

4. Role of Village Institutions

A Village Level Institution (VLI) is a formal body intended to ensure sustainable agriculture and rural development in India. The very purpose of forming VLI is to provide people ownership of any development project by making them an integral part of decision-making, giving them control over their resources, autonomy to implement the project, and carry on the process even after the completion of such projects. The Indian Constitution recognizes that a VLI can be formed by a group of at least seven villagers coming together to fulfill a common developmental purpose. Informal and formal VLIs in the country are increasingly becoming important to strengthen the existing interventions or initiating new ones related to agricultural development *viz.* Village Climate Risk Management Committee (VCRMC).

Custom Hiring Centre (CHC), Seed bank, Fodder bank, *Salaha Samithi*, Commodity groups, Collective Marketing Group etc. Contribution of various village level Institutions in implementing real time contingency are discussed below:

4.1. Village Climate Risk Management Committee (VCRMC)

VCRMC is selected through a meeting of gram sabha and is expected to actively participate and manage the various activities of the NICRA project, further, VCRMC has a greater role in identifying and facilitating implementation of interventions and smooth functioning of the NICRA programmes. The interventions in the village panchayats are finalized through participatory approach through VCRMC after the Participatory Rural Appraisal (PRA), assessing climate related problems in the village and baseline survey. The role of VCRMC is to participate in all discussions leading to finalizing interventions.

In the NICRA villages adopted by AICRPDA centres, the VCRMCs played a greater role in identifying and implementation of need based climate risk resilient interventions such as renovation and or establishing new farm ponds/percolation tanks/ other water harvesting structures for creation of water assets for drought proofing (Ballowal Saunkhri, Bengaluru, Chianki, Arjia, Agra, Indore, Anantapur, Varanasi, Jagdalpur, SK Nagar, Jhansi), crop based interventions, establishing and efficient functioning of custom hiring centres etc. These initial learning experiences indicate VCRMCs in future are likely to participate, identify, innovate and implement real time contingency plans in a participatory mode, further to sensitize and build the adaptive capacity of the farmers in AICRPDA- NICRA villages.

4.2. Custom Hiring Centre (CHC)

Single farm ownership and use of tractors and machinery on these small farms is not economically viable. The marginal and small farmers cannot realize the benefits of mechanization through individual ownership. Custom hiring centre (CHC) was set up by procuring the required agricultural machinery. Custom hiring centers for mechanization at village level are likely to ensure availability of implements at low cost. There is a tremendous support for custom hiring centers as institutions promoting timely agricultural operations in the remote villages across the country.

Custom-hire service of implements for timely operations is very important in drylands. The establishment of CHCs in NICRA villages (Fig. 73 to 75) was based on the vulnerability of agriculture to climatic variability such as prolonged drought, dry-spells, extreme rainfall events, hailstorms, extreme temperatures, floods, sea water inundation etc, whereby farm implements play a vital role in sowing operations as the sowing window period is quite narrow. There was a need for custom hiring centers in NICRA villages to address various natural resource management interventions such as *in-situ* moisture conservation, biomass mulching, residue incorporation instead of burning, foliar sprays, interculture, brown and green manuring, water harvesting and recycling for supplemental irrigation, improved drainage in flood prone areas, conservation tillage where appropriate, artificial ground water recharge and water saving irrigation methods. Some examples of agricultural operations undertaken hiring implements/machinery in NICRA villages are shown in Fig. 76 to 79. The options of increasing farm-power access to small and marginal farmers in rainfed areas must also be pursued, where appropriate, through promotion of tractors and power tillers. In the preparedness for implementation of real time contingency plans, CHC have a greater role to play in implementation of tillage, seed and fertilizer application, *in-situ* moisture conservation practices, water lifting with energy efficient pumps and efficient application (through micro irrigation systems), foliar sprays, harvesting of crops, residue incorporation, relay cropping etc. on a real time contingency basis and further, to cover large holdings/area with precision and in time.



Fig. 73 Phulbani (Odissa)



Fig. 74 Solapur (Maharashtra)



Fig. 75 Parbhani (Maharashtra)

CHCs in NICRA villages adopted by AICRPDA Centres

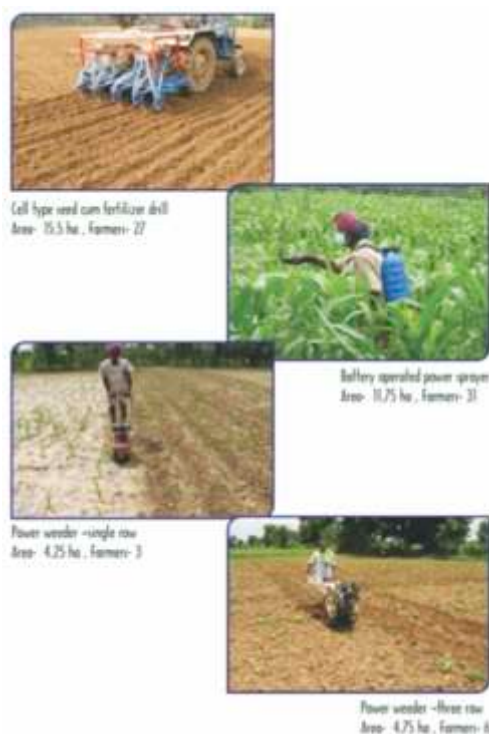


Fig. 76 Use of Farm Implements through Custom Hiring Center-Arjia



Fig. 77 Groundnut Pod Thresher - Anantapur (A.P.)



Fig. 78 Rice Reaper - Biswanath Chariali (Assam)



Fig. 79 Rotavator - Rajkot (Gujarat)

Farm Implements from CHCs in operation in NICRA- AICRPDA villages

4.3. Community Seed Banks (CSB)

Community Seed Bank (CSB) is to make the farmers, mainly small and marginal farmers, to be self reliant for the most important input like seed. In drylands, due to early season drought (normal onset and initial long dry spells and or due to delayed onset of south-west monsoon, due to poor germination/population, it becomes necessary for resowing of the same crop/ variety or contingency/ alternate crop varieties and further depends on the soaking rains or availability of irrigation. In such scenarios, the local availability of seed, in desired quantities, of the suitable variety becomes crucial. Here, the concept of Village Seed Bank advocates village self sufficiency in production and distribution of quality seeds with utmost transparency, mutual trust and social responsibility of the farmer towards fellow farmers. Besides, the seed bank helps the farmer in getting the seed in right time at the door step at lower price than the market price. It is promoted to reduce their dependency on external inputs and to encourage farmers to distribute seeds among themselves. Village seed banks certified at 23 locations of AICRPDA-NICRA in timely sowing, cultivation of tolerant varieties, community nursery change of variety and crop in the delay onset etc. The agriculture

officer/Horticulture expert facilitates seed growers (where seed bank is established) for procurement of breeder/foundation/certified seeds of different crops and their varieties sufficiently ahead of the season. Prior to procurement of seeds, the seeds are dried to the prescribed moisture content, and the quality is inspected by the grower other farmers of the village and women self help group (SHG) members. The farmers in consultation with gram panchayat fix up the selling price of the seeds for the next season taking into consideration the market price of the seeds. Availability of short duration varieties, amounts available etc are displayed at NICRA- Resource centre in the village. In NICRA-AICRPDA villages, seed availability was ensured in subsequent years by arranging stress tolerant seed farmer to farmer exchange basis for this display was made variety of seed material available with different farmers in the village. The seed bank related activities in NICRA-AICRPDA villages are shown in Fig. 80 & 81.



Fig. 80 Activities under community seed bank, Bhilwara district, Rajasthan

Sl · No	Variety	Yield (kg/ha)
Short duration varieties		
1	Luit	3000
2	Disang	3600
3	Lachit	3900
4	Kapilee	2700
5	Kolong	3200
6	Dikhow	2700
Medium duration varieties		
7	Basundhara	4800
8	Satyanranjan	4000
9	Mohan	5400
10	Gandhari	4700
11	Mulagabharu	5600
Long duration varieties		
11	Maniram	6000
12	Ranjit	7600
13	Mahsuri	5400
14	Betguti	-
15	Keteki jaha	4200
16	Gitesh	-
17	Prafulla	-
18	Jalashree	-
19	Jalkunwari	-
20	Black Rice	-
21	Aghoni	6000
22	Swarna sub - 1	-

More than 30 farmers' varieties were grown /maintained.



Fig. 81 Community Seed Banks in NICRA village, Lakhimpur district, Assam

4.4. Fodder Banks (FB)

During the years of drought, firstly, there is acute shortage of dry fodder and secondly, even if available, the poor farmers cannot afford to purchase due to high cost. During such situations, it becomes difficult to manage livestock, considerable reduction in production of livestock products, large out-migration of livestock from the region and consequently reduced livelihood opportunities. Therefore, it is essential for giving high priority for ensuring availability of enough fodder and forage on a continuous basis especially during drought years. One of the viable strategies for achieving this is to establish “Fodder Banks” at strategic locations in the region and utilize the stored material for supply to places of deficit. Use of community lands for fodder production during droughts/floods, improved fodder/feed storage methods help establishing fodder banks. Because fodder banks compete with other farming activities for land, labor and capital, they are best suited to farmers who generate substantial income from the sale of animals or their products, milk for example. Fodder banks were established with various fodder species in the villages along with proper storage of dry fodder.

Animal component is critical for ensuring livelihoods particularly in arid regions during drought years. The concept of *Charag* in Rajasthan i.e. managing village common lands for fodder or forage purposes production by the farmer groups in Rajasthan is a good example of how village level institutions meet the local fodder demand for livestock management and simultaneously earn income locally. This concept has been amply demonstrated in developing fodder systems along with soil and water conservation measures in AICRPDA-NICRA village (Fig. 82).



Fig. 82 Community fodder bank i.e. *Charag* in NICRA Village, Bhilwara district, Rajasthan

4.5. Nutrient Banks (NB)

The concept of Nutrient Bank is being evolved wherein the essential manures and fertilizers, soil amendments, foliar spray chemicals; biofertilizers etc. are maintained locally and made available in time by the local community for timely completely sowing of various crops if sowing window is limited. The Nutrient banks help farmers in restoring the productive capacity of soils provides overall resistant to stress conditions. These nutrient banks are run by SHGs in conjunction with gram panchayats. During intermittent droughts, farmers can approach nutrient bank to avail foliar sprays like KNO_3 spray, which enhances drought tolerance. Similarly, when there is a shortage of fertilizers, nutrient bank plays a vital role in providing the farmers with the required amount of fertilizers. The nutrient banks are set up at village and mandal level so that farmers have easy accessibility. Such village level institutional arrangements likely to facilitate contingency plans on real time basis.

5. Strengthening the Implementation of Real Time Contingency Plans

Local climate variability, worldwide, can influence peoples' decisions with consequences for their social, economic, political and personal conditions, and effects on their lives and livelihoods. The effects of climate change imply that the local climate variability that people have previously experienced and have adapted to 'changing' at relatively greater speed. Such climate variability has been, and continues to be, the principle source of fluctuations in global food production in the arid and semiarid tropical countries of the developing world. Throughout history, extremes of heat and cold, droughts and floods, and various forms of violent weather have wreaked havoc on the agricultural systems in these regions. Agricultural productivity in tropical Asia is not only sensitive not only to temperature increases, but also to changes in the nature and characteristics of monsoon.

Developing countries like India are among the most vulnerable to climate change and present weather abnormalities as it threatens the food security and livelihoods. This also affects the life of common people in the form of increased price rise in daily food and consumable items. Price rise of vegetables particularly recent price escalation of onion is the one of the examples how the agriculture production of particular commodity affected by weather aberrations such as late onset of monsoon, mid-season droughts and early withdrawal of monsoons. Thus, climate variability, both inter and intra-annual is a fact of life in these regions with a traditionally low agricultural productivity. The recent decades have exhibited an increase in extreme rainfall events over northwest India during the summer monsoon. The water and agriculture sectors are likely to be most sensitive and hence vulnerable to climate change induced impacts in arid and semiarid tropical India. The delay in on-set of monsoon rains, mid-season droughts at vegetative, reproductive and grain formation stages or early withdrawal of monsoon have become frequent phenomenon with consequences of crop failures, low productivity and farm income eventually ending up livelihood impacts negatively. Therefore, technological developments are needed to respond any aberration such as delay in rainfall and various degree of drought occurrence on the farmers fields. This risk ultimately influences farmers' decision on investments and level of management. Besides, droughts, extreme events like cyclone mediated intensive rains and water inundation, heat wave, hailstorm, frost are other important events affecting agriculture production in larger extent.

Therefore, technology development should also address these aberrations, thus agriculture production is better resilient even in uneven situations so that food security of the population is not hampered. The agricultural adaptation to climate change come from a various kinds of approaches, particularly research approaches, that consider geographic

scales viz., plant, plot, field, farm, region, sector, nation and international) employing several different perspectives. At the same time, responsibility can be differentiated among the various stakeholders that undertake or facilitate adaptations in agriculture including individual producers (farmers), agri-business (private industries), and governments (public agencies)

To strengthen implementation of real time contingency plans various options are available and the most important options include technological developments, convergence with government schemes and policy interventions (Ravindra Chary *et al.* 2013)

5.1. Technological Developments

There are many kinds of technological, public policy and farm management options with potential to moderate problematic climate change effects or to realize opportunities, reinforcing the view that the agricultural sector is very adaptable. The mechanisms through which adaptation occurs are widespread and include public research and extension programs, resource management legislation and regulations, agricultural support programs, and economic policies.

Yet the process of adaptation in agriculture itself is rarely researched. Technological adaptations are developed through research programs undertaken or sponsored by public and or private sector. The technological adaptation options could be crop development (to increase their tolerance); weather and climate information systems (to provide forecasts); and natural resource management such as water, land, soil factors (to deal with of climate-related risks). The lead responsibility for developing technological adaptations tends to be governments and agri-business; whereas the employment or adoption of these technologies is a farm-level decision.

The technological needs for contingencies to be implemented on real time basis include:

- 1) Stress tolerant genotypes (drought, flood, heat and cold)
- 2) Short duration cultivars
- 3) Resilient crops and cropping systems
- 4) Agronomic management such as crop calendars in the system, plant time adjustment, plant population, thinning etc
- 5) Addressing new crops such as cotton and maize in non-traditional regions
- 6) *In-situ* moisture conservation
- 7) Rainfall and water storage relationships, water harvesting, farm ponds, catchment and command relationships, lining, silt traps and monitoring ground waters

- 8) Soil management, conservation agriculture, moisture stress management with improved soil carbon stocks, mulch cum manuring, on-farm generation organic matter, cover crops etc
- 9) Balanced nutrition and foliar nutrition towards drought and flood tolerance
- 10) Farming systems in drought prone regions
- 11) Efficient land use system, agroforestry, dryland horticulture etc
- 12) Livestock and vaccinations in various weather aberrations
- 13) Innovations in Village Level Institutions

The development of new crop varieties including types, cultivars and hybrids, has the potential to provide crop choices better suited to temperature, moisture and other conditions associated with climate change. This involves the development of plant varieties that are more tolerant to such climatic conditions as heat or drought through conventional breeding, cloning and genetic engineering. Crop/cropping system based technologies need to be centered on promoting the cultivation of crops and varieties that fit into new cropping systems and seasons, development of varieties with changed duration that can overwinter the transient effects of change, release of varieties for high temperature, drought and submergence tolerance, evolving varieties which respond positively in growth and yield to high CO₂. Improved and novel agronomic and crop production practices like adjustment of planting dates to minimize the effect of high temperature increase-induced spikelet sterility can be used to reduce yield instability, by avoiding flowering to coincide with the hottest period. Adaptation measures to reduce the negative effects of increased climatic variability as normally experienced in arid and semi-arid tropics may include changing the cropping calendar to take advantage of the wet period and to avoid extreme weather events during the growing season. In addition, improved crop management through crop rotations and intercropping, integrated pest management, supplemented with agroforestry and afforestation schemes will be an important component in strategic adaptation to climate change in India. Intercropping is an efficient strategy that can be followed with desirable outcome in the present climate change scenario. Grain-legume intercrops have many potential benefits such as stable yields, better use of resources, weeds, pest and disease reductions, increased protein content of cereals, reduced N leaching as compared to sole cropping systems (Venkateswarlu and Shanker, 2009). Soil and water conservation measures in arable lands based on land capability and rainfall are given in Annexure - II.

In Indian context, the key resource conservation-based technologies include in situ moisture conservation, rainwater harvesting and recycling, efficient use of irrigation water, conservation agriculture, energy efficiency in crop production and irrigation and use of poor quality water and the suggested strategies are: characterization of bio-physical and socio-economic resources utilizing GIS and remote sensing; integrated

watershed development; developing strategies for improving rainwater use efficiency through rainwater harvesting, storage, and reuse; contingency crop planning to minimize loss of production during drought/flood years. The soil and water conservation in arable lands based on land capability and rainfall are given in Annexure-I. Balanced and Site-Specific Nutrient Management (SSNM) along with foliar sprays of K and Zn controls crop water relations through reduction of transpiration by stomata movement. Spraying KNO_3 during droughts reduces water loss during intermittent droughts and small dose of N application after rain rejuvenates the plant system and recovery from drought damage would be faster. Similarly optimum K nutrition reduced the lodging effect during floods, cyclones and water inundations. Agroforestry systems buffer farmers against climate variability, and reduce atmospheric loads of greenhouse gases. Agroforestry can both sequester carbon and produce a range of economic, environmental, and socio-economic benefits.

Conservation agriculture is an important system, which brings overall resilience to any kind of weather aberrations. It conserves soil moisture, reduces evaporation and soil erosion, contributes in-situ moisture conservation, and reduces runoff besides providing lowering root zone temperature, congenial to better soil health (Srinivasarao *et al.*, 2013). Zero tillage (ZT) has effectively reduced the demand for water in rice-wheat cropping systems in more than 1 million ha of area in the Indo-Gangetic Plains, further with ZT higher yields and reduce production costs were achieved. In addition, ZT has a direct mitigation effect as it converts the green house gases like CO_2 into O_2 in the atmosphere and carbon, and enriches soil organic matter (Srinivasarao *et al.*, 2013 a and b). Integrated Nutrient Management (INM) and organics improve soil organic carbon and better aggregation that would result in improved profile moisture storage. Such improvement in profile moisture storage contributes to water requirements of crop plants during mid season droughts (Srinivasarao *et al.*, 2012). However, forth coming strong net work research platform under NRM division of ICAR would provide opportunity to address the constraints of implementing CA in India particularly in rainfed systems.

Another type of technological advance is the development of information systems capable of forecasting weather and climate conditions. Weather predictions over days or weeks have relevance to the timing of operations such as planting, spraying or harvesting. Seasonal forecasts have the potential to aid risk assessment and production decisions over several months. Information on longer-term climate change can inform farmers about future norms and variability, and the probability of extreme events. In these ways, weather and climate information systems can assist farm level adaptation. Farmers may use this information with respect to the timing of operations viz. planting and harvesting, the choice of production activities (i.e. crop varieties), the type of production (i.e. irrigation or dry-land agriculture), and financial management activities (i.e. use of crop insurance and water rights).

5.2. Convergence with Government Schemes

Farm production adaptations include farm-level decisions with respect to farm production, land use, land topography, irrigation, and the timing of operations. Changing or modifications farm activities have the potential to reduce exposure to climate-related risks and increase the flexibility of farm production to weather aberrations/conditions. For these modifications, the several components included in Government schemes such as MGNREGA, RKVY (Rashtriya Krishi Vikas Yojana), Mega Seed Project, NFSM (National Food Security Mission), NHM (National Horticulture Mission), IWMP (Integrated Watershed Management Programme), Soil Health Schemes at National level, Farm Machinery and Implements etc provide an opportunity to respond to different kind of weather aberrations as contingencies on real time basis. Rainwater management interventions like water harvesting and storage structures are capital and labour intensive thus, can be converged with RKVY, MGNREGA, NHM and IWMP programmes of GoI. Further in situ moisture conservation interventions which are land based activities can be converged with MGNREGA and DRDA (District Rural Development Agency) programmes in a district. Efficient utilization of stored rainwater in farm ponds with micro-irrigation systems like drip, sprinkler etc could be converged with government schemes like Micro-irrigation Project in Andhra Pradesh, NHM and SHM (State Horticulture Mission), Government schemes etc. Seed multiplication programmes in State Agricultural Universities and State governments and District authorities have greater role to provide suitable drought tolerant and short duration seed material in the delayed on set of monsoons. Several options are available in RKVY to provide the needful at district and sub-district level when any unforeseen weather situation arises. Subsidy is available for various farm implements. Watershed management schemes of the government provide a great resilience to agriculture system in the event of mid season and terminal droughts. If MGNREGA is linked with agriculture an activity, applying tank silt in light textured soils provides higher moisture retention and crops suffer less during mid-season droughts thus prolong the wilting of crop plants (Srinivasarao *et al*, 2013).

5.3. Policy Interventions

Implementation of agriculture contingencies in real time needs a stronger policy support. In India, as an alternative to the existing Area-Yield based National Agricultural Insurance Scheme, the Weather Based Crop Insurance Scheme was launched as a pilot in 2007 with the objective of mitigating the hardship of the insured farmers against the possibility of financial loss associated with low crop yields or crop failure resulting from adverse weather conditions. The scheme is a publicly subsidized -index based insurance scheme. By 2010-11, agricultural year, over 9 million Indian farmers held scheme policies with premium value of over US\$ 258 million. These policies covered over 40 different crops and 9.5 million hectares (Rao, 2011). Better seed systems, fodder systems, ensuring quality seed availability during delayed monsoon conditions and in the

conditions of complete crop failures in severe droughts or flood conditions. In many rainfed regions, often the window for crop sowing operation is limed due to number of rainy days, ensuring farm implement availability in the village to complete sowing of crops. However, farm machinery supply should be for both bullock and motor operated mode as large numbers of farm holdings are small and marginal. Similar to small farm mechanization Mission of the centre, a proper and complementary scheme need to be developed at state level. Strong implementable interventions are needed to ensure the purchase of damaged grain at local level. Every part of India in every year experiences some weather aberration like droughts, floods/cyclones, heat wave, and hailstorm, frost etc. often results in grain damage during harvesting stage. Availability of seed material of contingent crops such as legumes, millets and oil seed crops need to be ensured. Agriculture related to policies such as disaster management, land and water, food security etc should be synergistically converged at the grass root level, so that system becomes more climate resilient.

6. Conclusions and Way Forward

- Globally, the studies on climate change impacts and vulnerability in the agricultural sector is increasingly recognizing the important role of adaptation strategies to cope weather aberrations.
- India is no exception of experiencing such weather aberrations in the form of late on-set of monsoon, mid-season droughts at various crop growth stages and early withdrawal of rains. However, the adverse impacts of these events are stronger in tropical countries like India.
- Therefore an increasing urgency for a stronger focus on adapting agriculture to current and future climate change is envisaged. For this, short term and long term strategies should go hand in hand in spatial, temporal, and sectoral scale.
- Short term responses in the form of real time contingencies to weather aberrations are important to address the farm productivity, food security at house hold level as well as national level, ultimately affecting livelihoods of rural populations. While long-term strategies contribute to mitigation of climate change besides having farm level impacts.
- Implementing real time contingencies needs some sort of preparedness for particular foreseen weather aberration (based on long term experiences or trends) along with actually responding to the situation in a needed way, so that negative impacts of such weather events could be minimized.
- The components of Real Time Contingency Plans (RTCPs) include seed, land, water, crops, implements and supporting systems. Village level institutions (VCRMC, CHC, Panchayat etc.) can contribute immensely with community participation in successful implementation of RTCs at farm or village level.
- CRIDA under ICAR-NRM Division has made a significant contribution of developing District Level Contingency Plans in association with several ICAR Institutes, State Agricultural Universities, KVKs, Line Departments and State Relief Commissioners. These plans are available with Agriculture Ministry Web-Site and with District Authorities.
- However, implementing these contingency plans on a real time, when actually situation demands during crop growing season is the major challenge.

- This is the first ever attempt made by AICRPDA-NICRA model villages to test and study the impacts of contingency plans on real time basis at 36 locations in 24 districts in 15 states in India representing diverse agro-climate conditions subjected to variable weather aberrations.
- The success made in the project needs further strengthening and upscaling in the target districts throughout the country.
- Though, it is a challenge, but achievable if several players come together as a consortium which is the need of hour with the impending climate change/variability.

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Annexure I

The details of NICRA villages adopted by AICRPDA centres

AICRPDA center	Name of the Village (s)	District	State	Total cultivated area (ha)	Rainfed area (%)
Agra	Nagla Duleh Khan	Agra	Uttar Pradesh	981	90
Akola	Warkhed, Belura	Akola	Maharashtra	275	92
Anantapur	Aminabad, Girigetla	Kurnool	Andhra Pradesh	167.5	74
Arjia	Kocharia, Mandpiya, Solakakheda, Lapsiya, Tarakakheda	Bhilwara Rajsamand	Rajasthan	540	77
Ballowal Saunkhri	Naiwan, Achalpur	Hosiarpur	Punjab	465.2	84
Bengaluru	Chikkamaranahalli (Chikkamaranahalli colony, Chickaputtyanapalya, Hosapalya, Mudalapalya)	Bengaluru Rural	Karnataka	409.2	90
Bijapur	Kaulagi	Bijapur	Karnataka	1327	98
Biswanath Chariali	Chamua	Lakhimpur	Assam	133	100
Chianki	Khumbhi-bankheta	Garhwa	Jharkhand	215	70
Faizabad	Hardoiya	Faizabad	Uttar Pradesh	397	35
Hisar	Budhsheli, Charnod, Balawas	Bhiwani	Haryana	2203	77
Indore	Ningnoti	Indore	Madhya Pradesh	248	40
Jagdalpur	Tahakapal, Gumiapal, Pahkapal	Bastar	Chhattisgarh	511.25	98
Jhansi	Kadesara Kala	Lalitpur	Uttar Pradesh	875.10	33
Kovilpatti	Nakkalamuthanpatti, Kalugachalipuram, Muthukrishnapuram	Tuticorin Thoothukkudi	Tamil Nadu	630.65	92
Parbhani	Pangri	Parbhani	Maharashtra	951.06	93
Phulbani	Budhadani	Kandhamal	Orissa	101.21	81
Rajkot	Pata Meghapar	Jamnagar	Gujarat	2793	60
Rakh Dhiansar	Khaner	Rakh Dhiansar	Jammu & Kashmir	55	100
Rewa	Patauna	Rewa	Madhya Pradesh	743.986	34
SK Nagar	Dholia, Kalimati, Chandanki	Banaskantha, Mehasana	Gujarat	1100.9	68
Solapur	Narotewadi	Solapur	Maharashtra	560.7	80
Varanasi	TerhaSaraya	Mizapur	Uttar Pradesh	290	72

*One village with 4 clusters

Soil and water conservation measures in arable lands based on land capability and rainfall

<i>Land capability class</i>	Rainfall <500 mm	Rainfall 500-750 mm	Rainfall 750-1000 mm	Rainfall >1000 mm
I	Conservation furrows Mulching Ridging Sowing across slope Tied ridges Tillage <i>Broad bed-furrow</i> <i>Inter row system</i> <i>Small basins</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Khadin</u>	Conservation furrows Mulching Ridging Sowing across slope Tied ridges Tillage <i>Broad bed-furrow</i> <i>Inter row system</i> <i>Small basins</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Khadin</u>	Conservation furrows Mulching Sowing across slope Tied ridges Tillage Broad bed-furrow <i>Graded ridging(high rf)</i> <i>Lock and spill drains</i> <i>Small basins</i> <u>Field bunds</u> <u>Graded bunds</u> <u>Nadi</u>	<u>Field bunds</u> <u>Graded bunds</u> <u>Choes</u> <u>Level terraces</u> <i>Broad bed-furrow</i> <i>Graded ridging(high rf)</i> Conservation furrows Sowing across slope
II	Conservation furrows Contour farming Mulching Ridging Sowing across slope Tied ridges Tillage <i>Broad bed-furrow</i> <i>Contour strip farming</i> <i>Inter row system</i> <i>Small basins</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Khadin</u> <u>Inter plot water harvesting</u>	Conservation furrows Contour farming Mulching Ridging Sowing across slope Tied ridges Tillage <i>Broad bed-furrow</i> <i>Contour furrows/strip tillages</i> <i>Lock and spill drains</i> <i>Runoff strips</i> <i>Small basins</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Khadin</u> <u>Zingg terrace</u>	Broad bed-furrow Conservation furrows Contour farming Mulching Sowing across slope Tied ridges Tillage <i>Graded ridging-(high rf)</i> <i>Lock and spill drains</i> <u>Field bunds</u> <u>Graded bunds</u> <u>Nadi</u> <u>Zingg terrace</u>	<u>Field bunds</u> <u>Graded bunds</u> <u>Bundhi</u> <u>Zingg terrace</u> <u>Level terraces</u> <i>Contour strip farming</i> <i>Graded ridging-(high rf)</i> <i>Lock and spill drains</i> Contour farming Sowing across slope Tillage
III	Contour farming Mulching Ridging Sowing across slope Tied ridges Tillage <i>Broad bed-furrow</i> <i>Contour furrows/strip tillages</i> <i>Contour strip farming</i>	Contour farming Mulching Ridging Sowing across slope Tied ridges Tillage <i>Contour furrows/strip tillages</i> <i>Contour strip farming</i> <i>Lock and spill drains</i>	Contour farming Sowing across slope Tillage <i>Contour strip farming</i> <i>Graded ridging-(high rf)</i> <i>Lock and spill drains</i> <i>Small pits</i> <u>Field bunds</u> <u>Graded bunds</u>	<u>Field bunds</u> <u>Graded bunds</u> <u>Level terraces</u> <u>Live hedges</u> <i>Contour strip farming</i> <i>Lock and spill drains</i>

<i>Land capability class</i>	Rainfall <500 mm	Rainfall 500-750 mm	Rainfall 750-1000 mm	Rainfall >1000 mm
	<i>Contour strip farming</i> <i>Lock and spill drains</i> <i>Runoff strips</i> <i>Small basins</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Khadin</u> <u>Inter plot water harvesting</u> <u>Zingg terrace</u>	<i>Lock and spill drains</i> <i>Runoff strips</i> <u>Contour bunds</u> <u>Field bunds</u> <u>Nadi</u> <u>Zingg terrace</u>	<u>Graded bunds</u> <u>Zingg terrace</u> <u>Bundhi</u>	<i>Lock and spill drains</i> Contour farming Sowing across slope Tillage <u>Bundhi</u>
IV	Contour farming Ridging Sowing across slope Tied ridges Tillage <i>Contour furrows/strip tillages</i> <i>Contour strip farming</i> <i>Lock and spill drains</i> <i>Runoff strips</i> <i>Small basins</i> <i>Small pits</i> <u>Field bunds</u> <u>Zingg terrace</u>	Contour farming Sowing across slope Tillage <i>Contour furrows/strip tillages</i> <i>Contour strip farming</i> <i>Graded ridging-(high rf)</i> <i>Lock and spill drains</i> <i>Runoff strips</i> <i>Small pits</i> <u>Field bunds</u> <u>Live hedges</u> <u>Zingg terrace</u>	Contour farming Sowing across slope Tillage <i>Contour furrows/strip tillages</i> <i>Contour strip farming</i> <i>Lock and spill drains</i> <i>Small pits</i> <u>Field bunds</u> <u>Live hedges</u>	<u>Field bunds</u> <u>Graded bunds</u> <u>Live hedges</u> <u>Trapezoidal catchments</u> <i>Contour strip farming</i> <i>Lock and spill drains</i> Contour farming Sowing across slope Tillage
V	<i>Outward terraces</i> <i>Semi circular basins</i> <i>Small pits</i> <u>Hillside ditches</u> <u>Live hedges</u> <u>Semi circular catchments</u> <u>Staggered trenches</u>	<i>Outward terraces</i> <i>Semi circular basins</i> <i>Small pits</i> <u>Hillside ditches</u> <u>Live hedges</u> <u>Semi circular catchments</u> <u>Staggered trenches</u>	<i>Outward terraces</i> <i>Semi circular basins</i> <i>Small pits</i> <u>Contour trenches</u> <u>Hillside ditches</u> <u>Live hedges</u> <u>Semi circular catchments</u> <u>Trapezoidal catchments</u>	<u>Contour trenches</u> <u>California type with vegetative barrier</u> <u>Graded terraces</u> <u>Hillside ditches</u> <u>Trapezoidal catchments</u> <u>Vegetative buffer strips</u>
	Land levelling coupled with surface drainage for black soils Check basins for saline soils	Surface drainage for black soils Check basins for saline soils	<u>Surface drainage/ vertical drainage for black soils</u> <u>Subsurface drainage for saline soils</u>	<u>Subsurface drainage for saline soils</u>

Bold*Italics*Underlined**Farmer oriented temporary/recurring measures***Farmer oriented semi permanent measures*Community oriented permanent measures



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