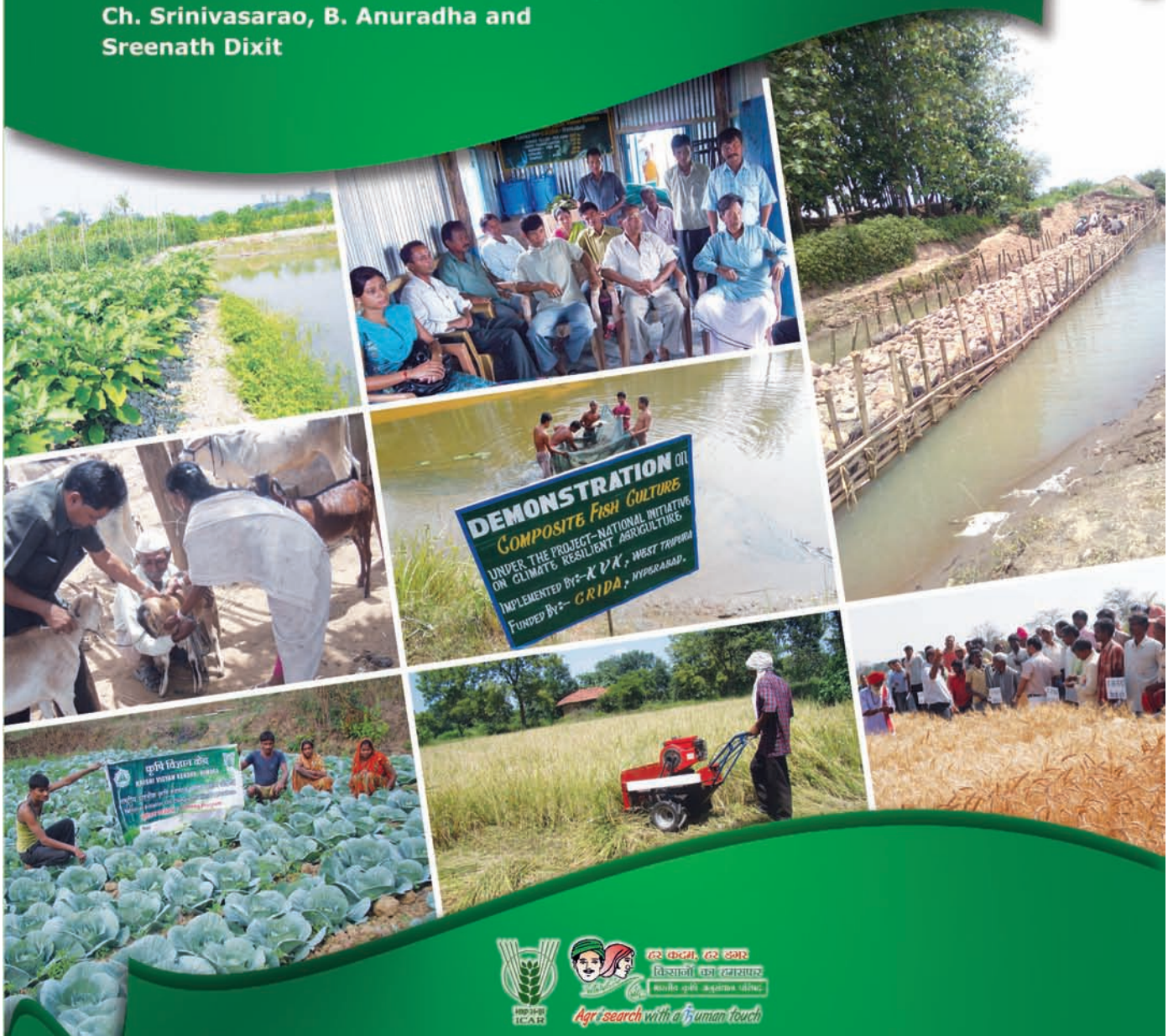
Coping with Climate Variability

Technology Demonstration on Farmers' Fields in Vulnerable Districts

B. Venkateswarlu, K.D. Kokate, K.A. Gopinath,
Ch. Srinivasarao, B. Anuradha and
Sreenath Dixit



National Initiative on Climate Resilient Agriculture
Indian Council of Agricultural Research
CRIDA, Hyderabad

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शरद पवार
SHARAD PAWAR

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भारत सरकार
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FOREWORD

Agriculture production is already under pressure due to degrading natural resource base. Current threat due to climate variability will only exacerbate this vulnerability, particularly for small and marginal farmers owing to their lack of risk bearing ability. There is enough evidence now that shows increased frequency of droughts as well as high intensity rainfall are affecting agriculture production. We are increasingly witnessing drought and flood like situations during the same season. While increased drought frequency is a real cause of concern, high intensity rainfall can also be turned into opportunities, provided the community is enabled to harvest the runoff and use it efficiently. Similarly, delay in onset of monsoon and its early cessation are limiting production and productivity of rainfed areas threatening food security of poor households. While there is not much that can be done in short term to reverse the trend in climate variability, certainly there is much to do in terms of enhancing the capacity of the farming community to adapt to variable climatic patterns.

Keeping this in view, a nation-wide project 'National Initiative on Climate Resilient Agriculture (NICRA)' has been launched in early 2011. As part of this initiative, the Technology Demonstration Component addresses the issues of enabling farmers through demonstration of climate resilient technologies. I am glad that this component in a short period of time has generated enormous interest and enthusiasm among farmers. Many interesting lessons and outcomes have emerged in this period. I complement the team at CRIDA that has compiled initial outcomes from across the country in the form of a publication. I also complement all the Krishi Vigyan Kendras (KVKs) and the farmers who are working with the KVKs in taking part in this very important initiative. The experiences and lessons generated through this initiative, will have a significant impact on shaping our strategy towards securing a climate resilient agriculture.

(Sharad Pawar)

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PREFACE

Agriculture in India is practiced for over 5000 years and during this long history, the agrarian communities have faced various climate related challenges. During the past five decades, challenges in agriculture are being dealt through application of science and technology. Over the years, a range of technologies suiting to different situations have been developed by the National Agricultural Research Education System (NARES). Though these technologies cannot be termed as climate resilient they were applied in situations challenged by climate variability in different agro climatic environments. However, in the recent past, agriculture has been frequently affected by climatic variability threatening, food production. A nation-wide project, National Initiative on Climate Resilient Agriculture (NICRA), has been launched in 2011 to address this challenge by application of science and technology.

NICRA deals with demonstration of an integrated package of proven technologies for adaptation of the crop and livestock production systems to climate variability. This is implemented in 100 most vulnerable districts of the country by demonstrating location specific technologies through Krishi Vigyan Kendras in a participatory mode. The technology demonstration component addresses climatic vulnerabilities such as droughts, floods, salinity, frost, cyclone, heat wave, cold wave and the like. The interventions are categorized into four modules one each on natural resource management, crop production, livestock & fisheries and institutional innovations.

The project has made some significant impact in a span of two years. Large number of water harvesting structures have been dug across the drought-prone areas, besides promoting on-farm water conservation practices. This has led to

increased moisture availability to crops leading to higher yields and cropping intensity. Increasing the rainwater harvesting capability along with crop production activities such as introduction of improved cultivars, addressing micro nutrient deficiency through site specific nutrient management, supplemental irrigation, mulching, use of zero till drill etc. have brought in new options to farmers in NICRA villages.

Though it is early days yet, the outcomes so far have many interesting lessons that is worth sharing with a wide group of stakeholders. Therefore, an attempt is made to put together some of these lessons in the form of a document. This publication shows how simple and time tested interventions can help the communities to cope with the challenges of climate variability. I congratulate the team at CRIDA for putting together this publication and also complement each of the KVKs that have contributed to this compilation.

(S.Ayyappan)

Dated the 14th November, 2012
New Delhi

CONTENTS

Introduction

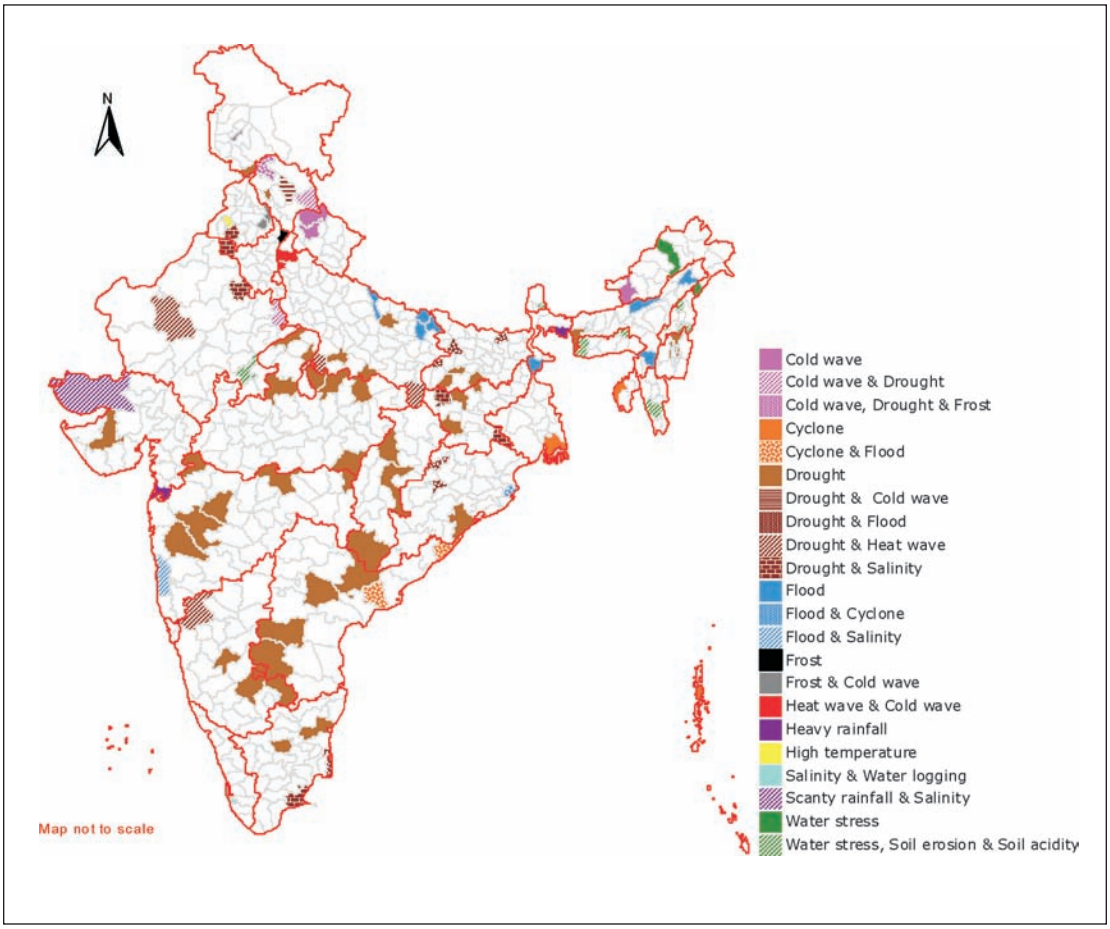
National Initiative on Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and Sponsored/ Competitive Grants. The project was sanctioned by the Council vide F.No.4-3/2010-I.A.II dated 12th January, 2011, with a total outlay of 350 crores for 2010-11 (200 crores) and 2011-12 (150 crores) of XI Plan. The project was formally launched by the Hon'ble Union Minister for Agriculture & Food Processing Industries Shri Sharad Pawarji on 2nd February 2011.

The rationale for Technology Demonstration Component (TDC) is based on the premise that an array of technologies is available to cope with different types of climate related vulnerabilities in the NARS and that these technologies can be adapted to the current challenges of climate variability. Besides, the farming community also has long standing experience and inherent adaptive capability to various kinds of weather related vagaries. This component is being implemented with the following partners:

1. Krishi Vigyan Kendras (KVKs) in eight zones -100
2. Co-operating centres of AICRP on Dryland Agriculture - 25
3. Technology Transfer Divisions of Core Institutes - 7

Under this component, an integrated package of proven technologies would be demonstrated in one village panchayat in each district for adaptation and mitigation of the crop and livestock production systems to climate variability based on the available technologies. The available climate resilient technologies were selected for demonstration by following the steps mentioned hereunder:

1. Analysis of climatic constraints of village based on long-term data
2. Assessment of the natural resources status of the village
3. Identification of major production systems
4. Studying of existing institutional structures and identify gaps through focus group discussion with the community to finalize the interventions



The interventions planned under this component are categorized into four modules:

Module I : Natural resources

This module consists of interventions related to *in-situ* moisture conservation, 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.

Module II : Crop production

This module consists of introducing drought/temperature tolerant varieties, advancement of planting dates of *rabi* crops in areas with terminal heat stress, water saving paddy cultivation methods (SRI, aerobic, direct seeding), frost management in horticulture through fumigation, community nurseries for delayed monsoon, custom hiring centres for timely farm operations, location specific intercropping systems with high sustainable yield index.

Module III : Livestock and Fisheries

Use of community lands for fodder production during droughts/floods, improved fodder/feed storage methods, preventive vaccination, improved shelters for reducing heat stress in livestock , management of fish ponds/tanks during water scarcity and excess water, etc.

Module IV : Institutional interventions

This module consist of institutional interventions either by strengthening the existing ones or initiating new ones relating to seed bank, fodder bank, commodity groups, custom hiring centre, collective marketing, introduction of weather index based insurance and climate literacy through a village level weather station.

The Process

The KVK team for each district carried out a detailed exercise on the needs of the village, the climatic vulnerability (drought/floods/heat wave/frost/cyclone) and the available technology options from the concerned Zonal Agricultural Research Stations of the SAU. After a careful study of the gaps, specific interventions from each of the module are selected and an integrated package from all modules formulated. Majority farmers are to be covered with one or more of the interventions in order to demonstrate a discernable effect. As an outcome of this exercise, location specific climate resilient practices and constraints in its adoption are documented.

This publication is an attempt to share the initial outcomes of Technology Demonstration Component being implemented by selected KVKs. In this, significant lessons learnt and initial impact of the interventions on helping the farmers to cope with climate variabilities are presented. The outcomes are presented zone-wise in which each KVK tries to bring out successful interventions in the backdrop of the climatic challenges faced by the project village. Although this publication has brought out the initial outcomes reported by 67 KVKs, the list of all the 100 KVKs where NICRA is implemented in provided as Annexure. We hope this publication interests all those having stake in agricultural research and development in relation to climate change.

Zone - I

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Chhoel-Gadouri, Kullu, Himachal Pradesh

Climatic Vulnerability

Kullu district of Himachal Pradesh is known for apple production and recently vegetable cultivation has gained popularity. The village Chhoel-Gadauri is about 20 km from the district headquarter. Drought is a major constraint in the village. During *rabi* 2011-12 and *kharif* 2012, the village was affected by drought.

Name of the village : Chhoel-Gadouri
District : Kullu
No. of households : 286
Total cultivated area : 250 ha
Major soil types : Coarse loamy soils
Mean annual rainfall : 919.13 mm
Major crops : Maize, wheat, black gram, apple, pear, plum, pomegranate and vegetables
Climatic vulnerability : Drought
Major interventions : Introduction of drought tolerant varieties of wheat and rainwater harvesting

Interventions

***Introduction of drought tolerant varieties*:** Demonstrations on drought tolerant varieties of wheat (HPW-236, HPW 155 and HPW-242) were conducted during *rabi* 2011-12 on 10 ha area of 117 famers. All the varieties performed better and gave higher grain yield (30 q/ha) compared to local varieties (22.2 q/ha). Similarly, during *kharif* 2012, late onset of monsoon resulted in delayed sowing of maize and the farmers were advised to go for sowing of composite maize varieties (Early Composite, Girja and Bajaura Makka). Demonstrations on black gram and soybean cultivation were also conducted to minimize the losses due to drought.

Drought tolerant wheat variety 'HPW 236'

Performance of drought tolerant varieties in farmers' fields

Crop/variety	No. of farmers	Area (ha)	Demo. yield (q/ha)	Yield of local check (q/ha)
Maize (Girija, EC, Bajaura Makka)	63	4.5	27.3	16.3
Soybean (Hara Soya, Palamsoya)	62	5.8	11.5	8.3
Blackgram (P-93, UG-218, Kullu-4)	90	10.0	8.1	6.2
Wheat (HPW-236, HPW 155, HPW-242)	117	10.0	30.0	22.2
Barley (BHS-380, HBL-276)	12	1.0	25.5	18.6

***Rainwater harvesting and utilization*:** Major focus was on rainwater harvesting to cope with droughts. At present there are 12 water storage tanks compared to only 5 prior to project implementation, and the irrigated area has increased to 50 ha from 20 ha during the period. Further, the number of sprinkler sets has increased from 2 to 20. These interventions on water harvesting and micro-irrigation methods have resulted in change of cropping pattern. The area under maize has reduced and the area under vegetables like tomato, pea and cabbage has increased significantly.

Change in cropping pattern due to rainwater harvesting and utilization

Crop	Initial (ha)	Present (ha)
Maize	100	60
Soybean	5	8
Maize + soybean	10	15
Blackgram	15	20
Maize + blackgram	30	37
Tomato	5	10
Cauliflower	7	12
Cabbage	5	5

Renovated water storage tank

Lagga, Chamba, Himachal Pradesh

Climatic Vulnerability

The Chamba district is situated in the bosom of the Himalayan mountains between north latitude 32^0 11′ 30" and 33^0 13′ 6", and east longitude 75^0 49′ 0" and 77^0 3′ 30". The District is wholly mountainous with altitude ranging from 559 meters to about 6162 meters above msl and the climate is semi-tropical to semi-arctic. The high lands of the district are under seasonal snow cover and the climate is cold to very cold during the winters whereas, it is not so cold in the lower parts. Maize, wheat, off-season vegetables and apple are the predominant crops in the village Lagga which is at a distance of 45 kms from Chamba.

Name of the village : Lagga
District : Chamba
No. of households : 96
Total cultivated area : 89 ha
Major soil types : Sandy loam
Mean annual rainfall : 1590 mm
Major crops : Maize, wheat and apple
Climatic vulnerability : Delayed onset of monsoon, rise in winter temperature
Major interventions : Plantation of low chill apple cultivars, protected cultivation, off- season vegetable cultivation

Interventions

***Spur type Apple cultivation*:** Due to the erratic behavior of weather and under the changing climatic scenario, the areas under apple cultivation have been experiencing increase in winter temperatures. As a result, apple cultivation has become vulnerable to climatic change especially in the lower altitudes and has shown a drift towards the higher altitudes. The delicious group of apples are particularly sensitive to higher winter temperatures as it requires a minimum of 1000 - 1200 hours of chilling temperature (<7^0C) for breaking dormancy. Recently, spur type apple cultivars have been found to be particularly promising in the lower altitudes and 2000 plants of low chill requiring

Mechanical weeding in apple orchard

Spur type apple plantation

spur type apple cultivars (Red Chief, Oregon spur, Golden spur, Well spur, Silver spur and Early Red One) were planted in an area of 8 ha to overcome the vulnerability of apple to low chill units and the plant survival has been 92%. The farmers have also been trained in the training, pruning and top working of apple trees. The newly planted cultivars will also serve as mother plants for top working in old and senile orchards and for up-gradation of the varietal status of the existing orchards. The top working with improved cultivars and the provision of bee colonies in the orchards increased the fruit set by 22% resulting in an overall yield increase of about 31%.

***Adoption of improved package of practices in vegetable cultivation*:** Demonstrations on improved varieties of off- season vegetables showed an increase in yield of french beans (78.7%), radish (70.5%) and spinach (90.3%) over the traditional varieties. These off-season vegetables also fetch premium price in the market. Further, two polyhouses of 105 m^2 each with facilities for drip irrigation and foggers have been constructed in the village for the demonstration of cultivation of low volume high value cash crops under limited water availability.

Off-season cabbage cultivation

Polyhouse for protected cultivation of vegetables

Drubgam, Pulwama, Jammu & Kashmir

Climatic Vulnerability

Name of the village	: Drubgam
District	: Pulwama
No. of households	: 472
Total cultivated area	: 165 ha
Major soil types	: Sandy, silty clay loam
Mean annual rainfall	: 692 mm
Major crops	: Apple, pear and paddy
Climatic vulnerability:	Water scarcity
Major interventions	: Water harvesting and micro-irrigation

Drubgam village of district Pulwama is one of the drought prone villages. The village is located at a distance of 13 kms from Phulwama town. Horticulture crops (apple, pear) and paddy being the major crops get affected due to dry spells during *kharif* season. Most of the area in the village is rainfed and the rainfall is erratic. During *kharif* 2011, the rainfed area of the village was affected by drought resulting in loss of crop yields by 20-30%. These conditions also affected the growth, yield and quality of apple.

Interventions

***Drought mitigation through rainwater harvesting and micro-irrigation*:** Awareness among farmers was created through frequent meetings and trainings. Demonstration of *in-situ* moisture conservation through mulching was conducted in selected apple orchards. Further, farm ponds were constructed for rainwater harvesting. Efficient utilization of harvested rainwater was ensured by adoption of micro-irrigation systems. The yield and quality of horticulture crops improved and also the weed problem was minimized by adoption of drip irrigation system.

Improved water storage structure

***Diversification of farm enterprises*:** Farmers were encouraged to take up poultry and fishries to tide over the losses due to drought. Selected farmers were trained to establish the poultry units and manage fish ponds. So far two farmers have been trained in fishries and 40 farmers in poultry. These systems are gradually creating awareness among other farmers and many of them are approaching the KVK to help them set up the integrated farming system on their farms.

Drip irrigation in apple orchard

Killi Nihal Singh, Bathinda, Punjab

Climatic Vulnerability

Climatically, the district has a very hot summer and frequent heat waves during peak summer. It has a moderate rainy season with annual rainfall of 410 mm and a dry winter. The major climatic variability/ weather aberrations in Killi Nihal Singh village are water stress and heat wave. Water stress was the major constraint observed during 2011-12.

Name of the village : Killi Nihal Singh
District : Bathinda
No. of households : 363
Total cultivated area : 810 ha
Major soil types : Loamy sand
Mean annual rainfall : 292 mm
Major crops : Paddy, wheat and cotton
Climatic vulnerability: Water stress and heat
Major interventions : Zero tillage wheat, knotter for paddy straw management

Interventions

***Zero-tillage wheat cultivation*:** Demonstrations on zero-tillage wheat were conducted on 8.4 ha of 11 farmers. This technique saved labour, diesel, time (7-10 days) and irrigation requirement due to efficient utilization of residual moisture. Sowing of wheat with Happy Seeder machine in the standing stubbles of rice without any tillage is a new practice adopted by the farmers in the village.

Wheat sowing with happy seeder

Efficient management of paddy straw: Burning of paddy straw was a common practice in the village resulting in environmental pollution including respiratory and allergic problems in both human as well as animals. Further, valuable crop residues were wasted in addition to micro- and macro-nutrients. Hence, use of baler cum knotter was demonstrated on 20 ha during 2011-12 for paddy straw management in the village. Initially the farmers were not responding well but after the persuasion and motivation by the KVK staff, the farmers were ready to use this machine. The capacity of this baler to bale the paddy straw is 5-7 acres/day. About 20 to 30 q of straw was baled from one acre. The bundles of straw were sold @ ₹ 50/q from the farmers' field and ₹ 110/q at the factory site. In this way farmers have earned an additional income of ₹ 1000 to 1500/ acre.

Baler cum knotter in operation

Badaushi Kalan, Fatehgarh Sahib, Punjab

Climatic Vulnerability

The climate of the district is extreme being very hot in summer and cold in winter. The temperature ranges from 45^{0}C (in May/June) to 4^{0}C in December/January. The climatic variability observed in the village during last year was temperature variation during winters and change in rainfall pattern.

Name of the village	: Badaushi Kalan
District	: Fatehgarh Sahib
No. of households	: 750
Total cultivated area	: 1000 ha
Major soil types	: loam/sandy loam
Mean annual rainfall	: 877 mm
Major crops	: Rice and wheat
Climatic vulnerability	: Terminal heat stress in wheat
Major interventions	: Zero-till wheat

Interventions

Wheat sowing with 'happy seeder': Combine harvesters have recently been introduced, with exponential growth in mechanical harvesting of rice and wheat in the better endowed rice-wheat growing area of NW India. In these combine-harvested areas, managing heavy loads of rice residues is a major issue. Farmers generally burn rice residue prior to wheat sowing as a cheap and easy option for residue management, but burning leads to losses of soil organic matter and nutrients (especially N, P, K, S and C), and creates environmental pollution (particulates and greenhouse gases). Wheat sowing with 'Happy Seeder' provides an alternative to burning for managing rice residues and allows direct drilling of wheat in standing as well as loose residues. Use of happy seeder for wheat sowing was demonstrated on 4 acres. Wheat sowing with happy seeder gave a grain yield of 44-45 q/ha with an average increase in yield by 9.5% compared to check plots. Further, weed infestation was very low due to the presence of straw mulch on demonstrated plots. The farmers were very much convinced with the

Sowing with Happy Seeder

Germination of seed after sowing with Happy Seeder

technology, and in association with Village Climate Risk Management Committee (VCRMC), they have set a minimum target of 100 acres for sowing with the seed drill in the coming season. Further, some farmers are coming forward to buy this machine on subsidy.

Wheat yield under different methods of sowing

Farmer	Variety	Soil type	Grain yield (q/ha)		% increase in yield
			Demo	Control	
Bhupinder Singh	PBW 621	Sandy loam	44.0	40.25	9.31
Palwinder Singh	PBW 550	Silt loam	45.50	41.50	9.63

A net saving of ₹ 5100/ha was achieved from wheat sowing with happy seeder over the wheat sown with conventional tillage after burring of rice stubbles.

Economics (₹/ha) of wheat sowing with 'Happy Seeder' and conventional sowing

Particulars	Method of sowing	
	Happy seeder	Conventional (seed drill)
Cost of field preparation based on custom hiring charges	2450	6450
Herbicide and labour charges	450	1650
Rodenticide	100	--
Total	3000	8100
Net saving	5100	--

Rasidpur, Ropar, Punjab

Climatic Vulnerability

Name of the village	: Rasidpur
District	: Ropar
No. of households	: 176
Total cultivated area	: 282 ha
Major soil types	: Sandy Loam
Mean annual rainfall	: 750 mm
Major crops :	Rice, wheat and poplar
Climatic vulnerability :	Drought and frost
Major interventions :	Protection of seedlings through low tunnel technology

Ropar is a very diverse district embodying sub-montaneous tract and riparian wet land. The climate of the district is subtropical, characterized by hot and dry summer during May-June with average maximum temperature of 43 ± 2^0C and cold winters with temperature of 5 ± 2^0C. The adopted village Rasidpur has experienced high weather aberrations during the past five years; frost caused a huge damage to vegetables and fruit crops in 2003 and 2008. In 1988, 1992, 2000 and 2008, floods damaged the field crops. The major cropping systems are rice-wheat and agro-forestry. Besides, some farmers are engaged in vegetable cultivation.

Interventions

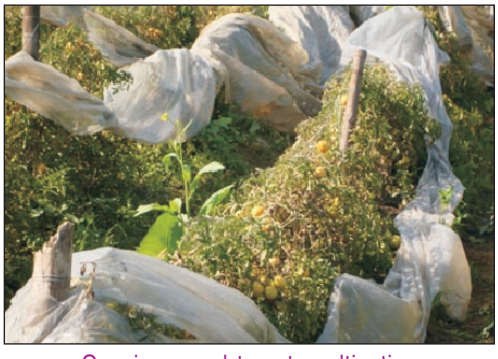
***Low-tunnel technology for vegetable nurseries*:** Low-tunnel technology was promoted for protecting vegetable nurseries from cold wave. Plastic sheet of 2.0 meter wide was used to make low tunnels on the 90 cm wide beds. The height of the tunnel was 45 to 60 cm from the centre of the bed depending upon the crop. To support the plastic sheet, iron rods were used as arcs and these supports were installed at 180 cm apart.

a) **Raising of chilli nursery under low tunnels:** To disseminate the technology of raising of chilli ('CH-1') nursery through low-tunnel technique, demonstrations were conducted under low tunnel (45 cm height and 35 cm width). The results of these demonstrations revealed that low tunnel technology helped the farmers to increase the number of saleable (healthy) seedlings by 77%. On the other hand, the seedling mortality rate in the open field was up to 50% which resulted in the reduction of saleable seedlings. Besides, a remarkable advancement in nursery production by 12-15 days was achieved under low-tunnel than open field raising of chilli nursery.

b) **Cultivation of capsicum under low tunnels:** During *rabi*, the average fruit yield of capsicum was 200 q/ha under open field conditions compared to 580 q/ha under low tunnels, resulting in 190% increase in yield. Additionally, the fruit size, quality and shelf-life of fruits picked from low tunnels were better than fruits from open

field conditions. Furthermore, the crop started bearing fruits about 45 days earlier than open field conditions.

c) **Low tunnel cultivation of tomato:** Tomato crop has also been observed to be damaged by frost in open fields during the winter season. Hence, tomato (Naveen) cultivation under low tunnel conditions was demonstrated on farmers' fields. Tomato yield from the plots under low tunnel was 36% higher compared to that of open fields.



Capsicum and tomato cultivation under low tunnels

***Irrigation management in paddy using tensiometers*:** Water requirement of rice during its vegetative growth stage is high. To meet this high requirement, timely and frequent irrigation to crop is of prime importance. However, it is difficult to provide adequate irrigation particularly during dry spells. Tensiometers are used for accurate measurements of soil moisture potential and provide a guide for irrigation practices so that wastage of water can be prevented. Hence, about 50 Tensiometers were installed in different farmers' fields for efficient scheduling of irrigation as per the crop requirement. This helped in saving of irrigation water by 30% and farmers were convinced with the technology for saving precious water. Tensiometer installation at the farmers' fields in the adopted village has not only served the purpose of saving the irrigation water but also the extra cost incurred for running the diesel engine pumps for irrigating the field during the drought situations due to very low rainfall during June-August, 2012. To promote this technology of water saving, five training programmes were organized both in adopted and adjacent villages. In addition, several demonstrations were conducted on installation of tensiometers along with distribution of relevant technical literature.

Installation of Tensiometer in paddy field

Rupana Khurd, Sirsa, Haryana

Climatic Vulnerability

Name of the village	: Rupana Khurd
District	: Sirsa
No. of households	: 515
Total cultivated area	: 780 ha
Major soil types	: Sandy loam
Mean annual rainfall	: 300 mm
Major crops	: Rice, wheat, cotton and sorghum
Climatic vulnerability:	Drought and heat wave
Major interventions	: Laser land leveling

The climate of this district is characterized by its dryness, extremes of temperature and scanty rainfall. The annual rainfall ranges between 320-530 mm. The mean daily maximum temperature during May and June, which is the hottest period, varies from 41.5 to 46.7^{0}C. On individual days, the maximum temperature during the summer may raise up to 49^{0}C. Major climatic variability observed in the village during last year was high temperature in February, warm winds in May and prolonged rainy period particularly at the end of rainy season (September).

Interventions

***Laser Leveling to increase water use efficiency*:** Most of the agricultural fields in the village Rupana are undulated resulting in poor crop establishment, low nutrient and water use efficiency. Hence, land leveling is a prerequisite to good agronomic, soil and crop management practices. Laser leveling is a user guided precision leveling technique used for achieving very fine leveling with desired grade on the agricultural field. Demonstrations were conducted on laser land leveling on farmers' fields involving rice-wheat and cotton-wheat systems. Laser land leveling resulted in increase of rice yield by 22% besides saving significant amount of water. This gave the farmers an opportunity to irrigate additional area with the available water resources.

Laser leveling in progress

Adoption of laser land leveling resulted in the following benefits:

- Less water requirement for land preparation
- Better crop establishment and uniformity in crop maturity

- Less weed infestation
- Higher water use efficiency: leveled field required 10% less water than the control plot
- Saved fuel/electricity used for irrigation
- Increase in area under irrigation
- The crop yields increased by 22% compared to control plots

***Use of KNO_3 in cotton*:** Bt-cotton suffers severely due to occurrence of parawilt, flower drop and late opening of bolls due to aberrant weather conditions. In the later stage, the bolls in the majority of fields didn't open even during last week of November resulting in yield loss as well as delayed sowing of wheat. Hence, demonstration on spraying of KNO_3 @ 2.5% thrice, during last week of August to first week of October at 10 days interval, was carried out on selected farmers' fields. The results indicated that spraying of KNO_3 resulted in good boll opening as compared to control. Yield of seed cotton averaged 23.9 q/ha with KNO_3 spraying as compared to 21.6 q/ha in control. An overall increase of 10.7% in yield was observed in fields sprayed with KNO_3. Benefit cost ratio was 2.45 in treated field as compared to 2.11 in check.

Field sprayed with KNO_3

Zone - II

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Kukurha, Buxar, Bihar

Climatic Vulnerability

Buxar is one of the drought prone districts of Bihar. Rice- wheat cropping system is predominant in the district and is leading producer of paddy in the State. Farmers grow long duration rice varieties 'MTU-7029' & 'BPT-5204' in large scale. Scanty rainfall during the last two years and prevailing drought conditions have resulted in drying of shallow tube wells, lowering of ground water level and reduction in area and productivity of rice.

Name of the village	: Kukurha
District	: Buxar
No. of households	: 637
Total cultivated area	: 622 ha
Major soil types	: Sandy loam
Mean annual rainfall	: 835 mm
Major crops	: Rice and wheat
Climatic vulnerability	: Drought
Major interventions	: Low-energy water application system in rice

Interventions

***Low Energy Water Application (LEWA) for saving water under prevailing drought condition*:** Scanty rainfall for the last two years and the prevailing drought conditions have rendered the tube wells dysfunctional in Kukurha village. Under these adverse situations, interventions for efficient use of available water are necessary. Proper irrigation of field crops is limited to the year when monsoon is normal. Farmers mostly practice flooding method of irrigation in this area. No micro-irrigation system exists in the village and paucity of water for irrigation limits the acreage under plough. Existing sprinkler systems are not popular among small and marginal farmers due to high initial and operational costs involved. Hence, Low Energy Water Application (LEWA) devices were introduced to encourage farmers to adopt pressurized irrigation system. Demonstrations on LEWA were conducted in farmers' paddy fields. A total of eight demonstrations covering 4 ha of paddy were conducted. The results were encouraging with an average yield of 4.8 t/ha compared to 3.8 t/ha in control plots. Further, this technology benefited the farmers by reducing operational cost, energy use and increasing water use efficiency.

Farmers observe LEWA in paddy

Khagribari, Cooch Behar, West Bengal

Name of the village	: Khagribari
District	: Cooch Behar
No. of households	: 1431
Total cultivated area	: 534 ha
Major soil types	: Coarse textured acidic soils
Mean annual rainfall	: 2983 mm
Major crops	: Rice, jute, potato and vegetables
Climatic vulnerability	: High intensive rainfall with erratic distribution during *kharif* season, negligible rainfall during winter
Major interventions	: Rainwater harvesting

Climatic Vulnerability

A highly humid atmosphere and abundant rains characterise the climate of this district. The atmosphere is highly humid throughout the year except February to May when relative humidity is 50 to 70%. About 70% of the annual rainfall is received during the southwest monsoon season, June being the rainiest month. On an average, there are about 102 rainy days with records of more than 400 mm rainfall in 24 hours. During 2011, about 682 mm of pre-monsoon rains were received followed by 2989 mm during *kharif* season. However, the rainfall during *rabi* 2011-12 was negligible (29 mm).

Interventions

Rainwater harvesting to cope with dry spells : A large area of the village Khagribari remains uncultivated during *rabi* season as only 32% of total cultivated area is irrigated through bore wells. Though there exists a number of small and large sized water bodies, most of them are seasonal and can not be used as source of irrigation during critical stages of *rabi* crops. This is because water holding capacity of the soils is very poor due to their coarse texture and average depth of ponds ranges from 5.5 - 7.0 ft from the ground level.

Pond renovation work in progress

The village receives an average annual rainfall of about 3000 mm, mostly during the period from April to August. This calls for taking measures to harvest the excess runoff during high rainfall events and reuse the same for life saving irrigation during dry spells. Considering the huge scope of harvesting the rain water, a number of existing water bodies were renovated to utilize the harvested rainwater for life saving irrigation to *rabi* crops emphasizing vegetable cultivation and to convert the seasonal water bodies into perennial ones suitable for year round pisciculture.

A total of 10 ponds of the village were selected for renovation. Most of the water bodies of the village are of 5 - 7 ft deep and remain dry from December onwards. However, it was also observed that water bodies having depth of 9 ft or more can retain water throughout the year. Considering this, the average depth of renovated ponds was increased from 5.5 - 7.0 ft to 10.5 - 11 ft (from ground level) involving the farmers, so that water to be stored in the water bodies could be used for life saving irrigation to *rabi* crops during December to March. This intervention helped increase the total rainwater harvesting capacity of these ponds from 478410 ft^3 to 811339 ft^3. List of 10 farmers, along with respective increase in storage capacity of the water bodies and depth of water as on July 15, 2012 is presented below.

Renovated farm pond

Name of farmer	Volume of pond (ft^3)		Increase in volume (ft^3)	Depth of water (ft) as on July 15, 2012
	Before renovation	After renovation		
Shyamal Sarkar	56160	98,280	42,120	11.0
Utpal Dey	59,670	1,00,980	41,310	11.6
Nandalal Sarkar	50,160	83,600	33,440	10.2
Jantu Ram Singh	53,382	90,405	37,023	10.8
Prasenjit Talukdar	51,480	90,090	38,610	10.4
Khageswar Barman	47,530	74,690	27,160	11.2
Akbar Ali	42,624	69,930	27,306	10.4
Amal Sarkar	41,736	73,038	31,302	10.8
Bikram Sarkar	38592	67,536	28,944	10.5
Dulal Talukdar	37,076	62,790	25,714	10.3
		Total:	**3,32,929**	

Lowkeshra, East Singhbhum, Jharkhand

Climatic Vulnerability

About 53% of total area of the district is covered by residual mountains and hills consisting of granite, gneiss, schist and basalt rocks. The rainfall in this district is erratic and delayed onset of monsoon followed by early cessation is a regular phenomenon. Paddy, the main crop in the region during *kharif*, suffers from moisture stress during flowering and grain filling stages. Further, pulses and oilseeds like chickpea and linseed also suffer from soil-moisture stress resulting in poor yield during *rabi* season.

Name of the village : Lowkeshra
District : East Singhbhum
No. of households : 593
Total cultivated area : 465 ha
Major soil types : Sandy loam
Mean annual rainfall : 1750 mm
Major crops : Rice and chickpea
Climatic vulnerability: Erratic rainfall
Major interventions : *In-situ* moisture conservation, cultivation of chickpea and linseed in rice fallows

Interventions

***In-situ moisture conservation for enhancing productivity of rainfed crops*:** *In-situ* moisture conservation adopting 5% model was promoted in medium lands to harvest the rainwater. Water stored in 5% model increased the moisture level and helped in paddy transplanting. It also helped in reducing moisture-stress during dry spells. In this region mid land paddy suffers from moisture stress at the time of flowering and grain filling in case of early cessation of monsoon. Stored water in these structures provided sufficient moisture and life saving irrigation. During *kharif* 2011, paddy was transplanted in about 5 ha in time due to adoption of 5% model.

***Cultivation of chickpea, linseed and mustard on residual moisture under rice fallow system*:** To utilize residual soil moisture after paddy harvesting, chickpea cultivation was demonstrated on 4.5 ha as a second crop in rice-fallows of lowland (un-irrigated) areas. In this practice, farmers used desi plough for land preparation and seeding. Chickpea yielded about 11 q/ha compared to 8 q/ha in check plots. Similarly, linseed cultivation was also demonstrated on 8 ha as relay/*Paira* cropping of linseed under rice-fallow system to utilize the residual moisture in lowlands. The yield of linseed ranged from 7.5-8 q/ha.


Chickpea cultivation in rice fallows

Technology	Yield (q/ha)		% increase in yield	Economics of demonstration	
	Demo	Local		Net return (₹/ha)	Benefit cost ratio
Paira cropping of linseed under rice-fallow system	8	6	33.3	11000	2.2
Chickpea cultivation in lowlands	11	8	37.5	26500	3.2

Gunia, Gumla, Jharkhand

Name of the village : Gunia
District : Gumla
No. of households : 320
Total cultivated area : 523 ha
Major soil types : Sandy loam and clay loam
Mean annual rainfall : 1233 mm
Major crops : Paddy, maize, black gram, groundnut, niger and wheat
Climatic vulnerability : Drought, heat weave and cold wave
Major interventions : Rainwater harvesting, introduction of short duration varieties, crop diversification

Climatic Vulnerability

Gumla has a sub-tropical climate with temperatures of 20 - 40^{0}C during summer and 3-21^{0}C during winter. The major climatic variability faced in the village during 2011-12 was less number of rainy days coupled with high intensity rainfall events.

Interventions

***Sandbags check dam 'Bora-Bandi' for water harvesting*:** Before implementation of the project, farmers of Gunia and adjoining villages were compelled to follow mono-cropping due to scarce water resources. After assessing the available water resources in the area, the KVK mobilized the villagers to store water by building a sand bag dam locally called *"Bora-bandi"* across the seasonal rivulet Mahsaria. This changed lives of Gunia villagers and opened up the opportunity for double and triple cropping by providing source for irrigation during *rabi* and summer seasons.

Construction of sandbags check dam by villagers

In addition, 11 farm ponds (jalkund) were constructed on selected farmers' fields. Three existing farm ponds were renovated by cleaning and plugging of seepage losses. As a result, water storage capacity of farm ponds was increased by 60% and seepage losses were reduced by 80%.

Renovated farm pond

***Promotion of wheat cultivars*:** Earlier farmers cultivated wheat in 2 to 3 ha area only. After the *Bora-bandi* about 50 ha area was brought under wheat cultivation

Economics of improved wheat cultivation

Technology	No. of farm-ers	Area (ha)	Yield (q/ha)		% increase in yield	Economics of demonstration (₹/ha)			
			Demo	Local		Gross cost	Gross return	Net return	BCR
HYVs of wheat and recommended fertilizer use	35	50	32.7	26.5	23.3	17300	35948	18648	2.07

***Summer paddy cultivation*:** Summer paddy cultivation was taken up in 10 ha after *Bora-bandi* on Mahsaria rivulet. Necessary inputs including seeds of an improved variety 'Anjali' and fertilizers were made available by the KVK. Regular follow-up and advisory services were provided through training and farmer-scientist interaction. A grain yield of about 30-35 q/ha was obtained ensuring food security to the farmers. A net return of ₹ 12600 and benefit: cost ratio of 1.7 was recorded with paddy cultivation during summer.

Field day on summer paddy

***Vegetable cultivation*:** After creation of water resources, demonstrations on off-season vegetable cultivation were conducted in 10 ha involving 85 farmers. This included cultivation of okra, tomato, vegetable cowpea, bottle gourd, ridge gourd and bitter gourd by using stagnant water of the rivulet. All the vegetables were grown by ridge & furrow method, which enhanced water use efficiency.

Ridge and furrow method of vegetable cultivation

Outcome of off-season vegetable cultivation:

- Crop mortality rate was reduced by 70-75%
- Time saving (25-30%) in irrigation (1.5 hr/ha/irrigation)
- Required 20-25% lower seed rate
- Water saving was up to 25-30%
- Better crop management
- Reduced crop lodging in tomato
- Obtained 10-15% higher yield

Further, crop diversification was promoted due to creation of additional water resources and crop production during *rabi* and summer seasons. Multi-crop planter was used for maize sowing on 5 ha of 27 farmers. Similarly, vegetable cultivation during summer and spring planting of sugarcane was demonstrated on selected farmers' fields.

Interventions	Area (ha)	No. of beneficiaries	Net income (₹ in lakhs)
Maize sowing through multi crop planter	05	27	0.67
Summer vegetable cultivation	10	139	7.54
Spring planting of sugarcane	03	08	4.08

Promotion of drought tolerant crop varieties: Demonstrations on cultivation of drought tolerant varieties of sweet potato, finger millet and maize were conducted on selected farmers' fields. All the varieties performed better and gave higher yields than local varieties.

Crop	Variety	No. of farmers	Area (ha)	Total yield (q)	Net income (₹ in lakhs)
Sweet Potato	Birsa Sakarkand-1	10	3	349.2	2.03
Ragi	GPU-28	12	3	48.5	0.40
Maize	Jaunpuri makka	27	5	132.5	0.67

Sakrorha, Jehanabad, Bihar

Name of the village	: Sakorha
District	: Jehanabad
No. of households	: 350
Total cultivated area	: 300 ha
Major soil types	: Clay loam
Mean annual rainfall	: 952 mm
Major crops	: Paddy, wheat, lentil and redgram
Climatic vulnerability:	Drought
Major interventions	: Rainwater harvesting

Climatic Vulnerability

The climate of Jehanabad is of extreme nature with very hot summers and biting cold in winters. The average rainfall of the district is 1074.5 mm. The village has been witnessing severe drought conditions for the last two years and similar conditions prevailed during 2011-12 as well. The number of tube wells in the village is very less mainly due to lack of availability of underground water and secondly the soil layer just above the ground water is very soft due to which, the tube wells installed earlier got collapsed. So farming is mostly dependent on rainfall in this village.

Interventions

***Rainwater harvesting and utilization*:** *Ahar* (reservoir of water) is the only source of irrigation and *Pyne* as the drainage channel in this village. However, presently they have mostly become defunct due to poor maintenance and excessive silting. Keeping this in view, five ponds were renovated for enhancing the rainwater harvesting capacity of the village. Surprisingly in one of the five ponds, just after the renovation work, water level began to appear only at four feet depth. The remarkable thing is that this water became available to the farmers when there was no rainfall and the temperature

Field day on rainwater harvesting through farm ponds

was at the peak (44.3^{0}C). Under this adverse situation, just after digging, the filling up of pond with water up to three feet was a boon for the villagers. This brought happiness among the villagers. Gradually, the news spread to the nearby villages and people from all the surrounding localities visited the site and named this a "MAGICAL POND". Under the guidance of KVK staff, paddy seedlings were raised on community basis. Even under water scarce situation, paddy transplanting has been completed in almost 80% of cultivable fields. Of the total area under paddy cultivation, almost 60% area was due to the use of water from these newly renovated ponds. In other words, these five ponds have provided protective irrigation for almost 200 acres during 2011-12. Further, as a result of rainwater storage in the pond, the water table of nearby open wells has also increased. Thus, these newly renovated ponds have proved as a boon for the farming community in this locality.

Majhila, Nawadah, Bihar

Name of the village : Majhila
District : Nawada
No. of households : 272
Total cultivated area : 114 ha
Major soil types : Sandy loam
Mean annual rainfall : 1037 mm
Major crops : Pigeonpea , paddy, maize, chickpea and wheat
Climatic vulnerability: Drought, soil erosion and heat and wave
Major interventions : Renovation of water harvesting structures

Climatic Vulnerability

The climate of the district is sub-tropical to sub-humid in nature. It is generally hot and dry, the winter temperature ranges from 16^0C to as low as 4^0C whereas during summer the mercury shoots to 46^0C. Nawada is one of the drought prone districts of the state. The village Majhila suffers from numerous biophysical constraints such as erratic rainfall, huge on-farm water losses and land degradation. Since 3-4 years, the area is facing the problem of delayed onset of monsoon and water scarcity. During 2011-12, drought affected several crops in the village.

Renovated water reservoir

Interventions

***Rainwater harvesting to stabilize crop yields*:** The rainfall is erratic and inadequate, and the crops are mostly dependent on monsoon. The Source of irrigation in Majhila cluster is open well, bore well and *Aahar* (water reservoir). The only *Aahar* in the village was filled with silt and was unable to store enough rainwater and recharge other wells in the village. As a result, the village suffered from acute water shortage both for human and livestock during summer. This also resulted in poor productivity of paddy, the major crop of this area which depended mostly on groundwater for irrigation. One way to cope with this climate variability is to collect the rainwater in the water harvesting structures to increase the irrigated area as well as crop productivity. Awareness among the farmers was created through frequent group meetings, trainings and exposure visits. Renovation of *Aahar* (water reservoir) and construction of farm ponds were taken up in the village. The major impact of these interventions is given below:

- The volume of defunct *Aahar* was increased by 20,000 m^3 after excavation and renovation. This provided protective irrigation for 24 ha in *kharif.*
- Increase in paddy productivity by 20.7%
- Increase in ground water level by one feet
- Better availability of drinking water for livestock

Bhongeri, South 24 Paraganas, West Bengal

Name of the village	: Bhongeri
District	: South 24 Paraganas
No. of households	: 110
Total cultivated area	: 35.8 ha
Major soil types	: Clay and silty clay
Mean annual rainfall	: 1750 mm
Major crops	: Paddy and pulses
Climatic vulnerability	: Cyclone and floods
Major interventions	: Integrated farming systems

Climatic Vulnerability

The village Bongheri of South 24 Parganas district is situated close to the brackish water river Matla. Extreme cyclonic weather and ingression of saline water into the main field particularly during high tides, renders most of the lands saline. Even after 2-3 seasons of monsoon, the salinity problem continues to persist. On the 25th of May, 2009 the super cyclone "Aila" hit the village and resultant salinity problem persists even today. The area is traditionally mono-cropped with paddy. The region being low lying, water stagnates up to 3 to 4 feet. During monsoon, with heavy rainfall up to 1600 to 1800 mm, the entire region becomes inundated with fresh rainwater. Water scarcity is the problem in *rabi* season, because of high evaporation and seepage losses.

Interventions

***Land shaping for rainwater harvesting and utilization*:** In order to overcome the soil salinity and augment availability of irrigation water during *rabi* season, an engineering solution was promoted by the KVK, Nimpith. In this, 1/5th portion of a lowland was excavated up to 9 feet deep. The excavated soil was spread over the adjacent field so that it was elevated up to 1 to 1.5 feet. On this elevated patch paddy was cultivated during *kharif* and *rabi* vegetables were grown on the main land, land embankment and pond embankment. Fresh rainwater was harvested into the excavated pond in which fish culture is being practiced. Thus, this technology of land shaping is offering a model for harvesting rainwater in *kharif*, vegetable cultivation in *rabi* and fresh water fish culture in the

Interaction with farmers for land shaping

ponds by converting monocropped land into a diversified land with enhanced productivity and reducing risk. The intervention was taken up in affected fields of 10 farmers. The cost of the intervention was ₹ 40000-50000 (approx.) for 20 m X 20 m size of pond.

Sri Ananta Naskar is one such farmer benefitted from rainwater harvesting and land shaping (0.26 ha) under the project. His average income from traditional paddy cultivation was only ₹ 1250/year (mono-crop). After upgrading his land through the

Cultivation of *Kharif* rice and *rabi* vegetables after land shaping

land shaping technology, he cultivated paddy in *kharif* and vegetables (okra, chilli, tomato and brinjal) in *rabi* season. He earned ₹ 5500 from paddy and ₹ 37500 from the vegetables in 2011-12. Vegetables were cultivated on pond embankment during *kharif* and also on the main field during *rabi*. The rainwater so harvested in the newly excavated pond (1/5th of the total land with 8 ft depth) was not only used for irrigation purpose but also for fish farming, which fetched an additional income of ₹ 8350. Within one year, Mr. Naskar earned a net profit of ₹ 32000 from his small piece of land by integrating different farm enterprises. This also helped him to reduce risk due to aberrant weather events.

Re-excavation of canal for water storage: A canal inundated with brackish water from nearby river due to cyclone 'Aila' was re-excavated for water storage. This work generated an employment of 9000 man-days for 4 months. About 3600 acre-inch of rainwater was harvested in the canal. This benefited about 500 families through cultivation of sunflower (40 ha), chilli (20 ha) and other vegetables (20 ha).

Re-excavated canal

Port Mount and Badmas Pahad, Port Blair, A & N Islands

Climatic Vulnerability

Name of the village	: Port Mout & Badmas Pahar
District	: Andaman
No. of households	: 174
Total cultivated area	: 80 ha
Major soil types	: Clay loam
Mean annual rainfall	: 3,100 mm
Major crops	: Paddy, vegetables, arecanut and coconut
Climatic vulnerability	: Cyclone, floods & drought
Major interventions	: Rainwater harvesting, *in-situ* moisture conservation, housing for backyard poultry

The A&N Islands receive 3080 mm rainfall annually. Of this, about 95% is received during May-December. Nearly 75% of the rainfall received in the islands is lost by runoff due to undulated terrains, steep slopes, porous soil stratum and its proximity to the sea. As rainwater is the only source of fresh water in these islands, its harvesting, storage and recycling are the most important strategies for water resource management. The topography of Port Mount and Badmas Pahar villages is rolling with low range hills to narrow valleys at the foothills resulting in an undulating terrain ranging from steep slopes to coastal plains. Thus the actual water availability is much less and the villagers face severe problem of water scarcity.

Interventions

***Rainwater harvesting for vegetable cultivation in summer*:** Five farm ponds were renovated with the involvement of farmers to store runoff water. These ponds were able to provide irrigation to transplanted rice in *kharif* and vegetables during summer. The seepage loss from these ponds as well as percolation loss from the paddy fields was harvested back in an open dug well downstream of each pond. This well serves for providing water for nursery raising of paddy and vegetables in pre-monsoon period and to irrigate additional area under vegetables during summer. About 8 ha area was brought under vegetable cultivation in summer which was only 1 ha before the intervention.

Tank cum well system of irrigation

***Soil moisture conservation*:** Mulching with coconut husk, paddy stubbles and green banana leaves in vegetable and plantation crops (coconut) was introduced for soil moisture conservation resulting in more infiltration, reduced evaporation and less crop water requirement during the dry period (Jan-April).

Mulching with coconut husk, paddy straw and banana leaf for soil moisture conservation

***Improved housing facilities for backyard poultry*:** Every year there is a mass mortality in the indigenous non-descriptive desi birds in villages due to high humidity caused by heavy rains and the resulting diseases. *Salmonella* disease breakout is common during post-monsoon causing mass mortality of birds. Further, farmers used to rear the birds in natural scavenging conditions. A training programme was organized with emphasis on proper housing and feed management for ruminants and poultry birds. The farmers were advised to renovate the shelter and provide proper cross ventilation. After providing cross-ventilated housing facilities, proper feeding and clean drinking water, it was observed that the mortality rate came down to 25% and there was no attack of any predators.

Netted housing and raised housing for disease-free poultry production

Affaur, Saran, Bihar

Climatic Vulnerability

Name of the village	: Affaur
District	: Saran
No. of households	: 4000
Total cultivated area	: 1500 ha
Major soil types	: Sandy loam
Mean annual rainfall	: 1140 mm
Major crops :	Rice, wheat and maize
Climatic vulnerability:	Drought
Major interventions :	Rainwater harvesting and *in-situ* moisture conservation

Saran district of Bihar is facing acute drought since last 4-5 years. Against 1140 mm of normal rainfall, the district is receiving just half and as such the productivity of major crops has gone down. Late onset of monsoon leads to delayed transplanting and late harvest of paddy and late sowing of *rabi* crops that faces the terminal heat. Farmers are forced to give presowing irrigation in *rabi* that adds to their cost of cultivation. The efficiency of applied inputs is going down due to lack of moisture in the soil, and salinity. The long to medium duration traditional paddy varieties and also hybrids face water shortage during critical stages of growth thereby reducing overall productivity.

Interventions

***Enhancing rain water harvesting capacity*:** Renovation of old and defunct water reservoirs with inlet channels could harvest 30000 m^3 of additional water from surface run-off that was used as a source of irrigation water. Leveling of paddy fields and bund formation using equipments supplied through Custom Hiring Center helped in moisture conservation. This also reduced weed population and there was increase in crop productivity (15-20%). Drought tolerant paddy variety 'Sahbhagi' was introduced for the first time in the village that surpassed all other varieties including the hybrid rice. In the flood prone areas, 'Swarna Sub-1' was introduced that survived at least for 15 days under totally submerged condition and gave good yield to the farmers who could get nothing otherwise.

Direct seeded rice

***Direct seeding*:** The resource conservation technologies like zero tillage, FIRB Planter, drum seeder and direct seeded rice with brown manuring enabled farmers to sow the crops in time and the crop productivity was enhanced. Further, there was saving in

diesel, labour, irrigation water, and less weed density and occurrence of pests and diseases. Also, the crop matured one week earlier giving scope to timely sowing of wheat thereby increasing the yield of *rabi* crops. Direct seeded rice, it was estimated, saved nearly 25 l diesel, 5 tractor hours, and 35 mandays in land preparation, uprooting and transplanting of seedlings per hectare. Overall reduction in water usage was estimated to be 3 h water pumping per ha.

***Community nursery for staggered seedling production*:** The farmers generally sow the seeds of paddy in the nursery and transplant them with the onset of monsoon. Delayed transplanting of 40-45 days old seedlings decreases the yield as seedlings have low tillering capacity. Community nursery was tried for the first time in NICRA village and farmers were supplied with ready stock of paddy seedlings as and when needed by them. This enabled the farmers to cope up with monsoon vagaries. Also, short duration paddy varieties like Prabhat, Rajendra Bhagwati and Sahbhagi were introduced that escaped dry spells very efficiently.

***Mulching*:** Spreading of paddy straw as a mulch especially in the vegetable fields was promoted for moisture conservation. This enabled less weed growth, less pest infestation and less water application, thereby increasing the yield and productivity. Introduction of sesbania and green gram as green manuring crops before rice enhanced the water holding capacity of the soil and apart from yield enhancement in the subsequent rice crop, there was saving in irrigation water. Organic Matter was also applied in the fields (5 t/ha) to enhance the water holding capacity of the soil. *In-situ* vermicomposting in mango, litchi and guava gardens was also encouraged to enhance the organic matter content of the soil. This increased fruiting capacity of these gardens to a considerable extent.

The rice-wheat cropping system was diversified/intensified with introduction of maize both in *kharif* and *rab*i season, green gram in summer, red gram in *kharif,* and lentil and gram in *rabi*. This showed improvement in productivity (15%) of these crops besides increasing overall returns (20%) in comparison with rice-wheat system.

Zone - III

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Salchapra, Cachar, Assam

Name of the village	: Salchapra Part I
District	: Cachar
No. of households	: 125
Total cultivated area	: 190 ha
Major soil types	: Clay
Mean annual rainfall	: 3181 mm
Major crops	: Rice and potato
Climatic vulnerability:	Flood
Major interventions :	Early short duration *Ahu* rice variety 'Disang'

Climatic Vulnerability

Cachar district receives an average annual rainfall of 3200 mm. Recurrent flood is most common phenomenon in most parts of the district. Generally, flood occurs during April – May. So farmers quite often lose their *Boro* and early *Ahu* crops during harvesting time. Incidentally, last year the district had very low rainfall (2100 mm). The recurrent flood phenomenon didn't occur but under post-flood situation, rice variety 'Disang' faced drought and hence yields were low. Similarly during *rabi*, vegetables faced drought like situation. Due to unavailability of the irrigation facilities, the farmers incurred losses in vegetable cultivation.

Interventions

***Introduction of flood coping varieties*:** Farmers in the village traditionally grow local varieties of different crops resulting in poor crop productivity. Hence, improved varieties of different crops were introduced for achieving higher crop yields. The early short duration paddy variety 'Disang' was demonstrated on seven farmers' fields. The improved variety yielded 4 t/ha which was 60% higher than that of local variety (2.5 t/ha). Similarly, improved potato variety 'Kufri Jyoti' was demonstrated on 15 farmers' fields. The performance of 'Kufri Jyothi' was better in all the farmers' fields and it gave 55% higher yield (9.3 t/ha) than the local variety (6.0 t/ha).

Bumper harvest of early short duration rice variety 'Disang'

Field day on Potato (Variety 'Kufri Jyoti')

Introduction of poultry breeds: In order to generate subsidiary income to the landless farmers, five hundred 'Vanaraja' chicks were distributed amongst 45 families. The performance of improved poultry breed 'Vanaraja' gave much satisfaction to the farmers. While brooding for first 30 days the mortality was 1-2%. The chicks were found to be well adapted to the local climatic conditions. The growth performance of the chicks was very good compared to the local chicks. At 5 months of age, the body weight of male bird was 2.5 to 3.5 kg and that of female bird was 2.0 to 2.5 kg. Mortality rate up to 5 months of age was 8-10%. The male:female ratio was recorded as 38:62. The female laid first egg at the age of 156 days and body weight at the time of egg laying was 2.25 to 2.50 kg.

Vanaraja birds well adapted to local conditions

Udmari, Dhubri, Assam

Climatic Vulnerability

Dhubri district experiences a warm humid climate. Monsoon usually starts from June and continues up to early September. The district also experiences substantial amount of pre-monsoon rain starting from April. The average annual rainfall is about 2233 mm. Flood is the major constraint affecting productivity of rice in the village Udmari Part IV & V.

Name of the village	: Udmari Part IV & V
District	: Dhubri
No. of households	: 237
Total cultivated area	: 204 ha
Major soil types	: Sandy loam, clay loam & clay
Mean annual rainfall	: 3280 mm
Major crops	: Rice
Climatic vulnerability	: Floods
Major interventions	: Short duration rice varieties for post flood situation & submergence tolerant rice varieties.

Interventions

***Promotion of varieties tolerant to submergence*:** Rice is the most important crop of Udmari part IV & V villages under Bilasipara sub-division of Dhubri district, Assam. Floods affect *kharif* rice during July-August and sometimes do not allow farmers to transplant rice seedlings in time resulting in very low yields. Double transplanting with traditional/improved varieties, adoption of traditional late *Sali* varieties like 'Panisali', 'Goyaswari', 'Malchira' etc and delayed sowing/transplanting with traditional late *Sali* varieties are some coping strategies adopted by farmers under adverse situations. During *kharif* 2011, interventions were made in the farmers' fields to popularize some situation specific rice varieties which can suitably be grown in flood affected areas. The main characteristics of these varieties are:

i. Submergence tolerant varieties 'Jalashree' and 'Jalkuwari' can tolerate 12 to 15 days water submergence once seedlings are established.

ii. Staggered planting variety 'Gitesh' can be transplanted with 30 to 60 days-old seedlings

iii. Short duration varieties 'Luit' and 'Kolong' (105 days) can be transplanted up to last part of August and also suitable for direct seeding with sprouted seeds if there is no time for nursery raising. These varieties are suitable for post-flood as well as pre-flood situation.

Simultaneously, seed production programme was also initiated with submergence tolerant variety 'Jalashree', staggered planting variety 'Gitesh' and short duration variety 'Luit' to ensure supply of quality seed in the farmers' field. Adoption of these varieties

gave about 50 to 60% higher grain yield than the existing varieties. About 15% farm families have adopted these varieties to cope with climatic variability in the village.

Performance of situation-specific rice varieties in the farmers' fields (*kharif* 2011)

Technology	Average grain yield (q/ha)	Yield of local check (q/ha)	Yield increase (%)	Net return (₹/ha)		B:C ratio	
				Demo	Local check	Demo	Local check
Submergence tolerant rice variety 'Jalashree'	36.5	24.0	52.1	15200	7200	2.1	1.6
Submergence tolerant rice variety 'Jalkuwari'	37.0	24.0	54.2	15600	7200	2.1	1.6
Delayed planting rice variety 'Gitesh'	39.0	24.0	62.5	17200	7200	2.2	1.6
Short duration late *Sali* variety 'Luit'	37.5	24.0	56.3	16000	7200	2.1	1.6
Short duration late *Sali* rice 'Kolong'	36.0	24.0	50.0	14800	7200	2.1	1.6

Demonstration on rice varieties 'Jalkuwari' and 'Luit'

Crop production during summer: Paddy cultivation during summer is gaining more emphasis due to crop failure during *kharif* season. However, traditional rice varieties produce low yields and harvesting of these varieties is difficult due to floods and lodging. Hence, HYV of summer rice 'Joymoti' was promoted for cultivation. The HYV performed better in farmers' fields and gave 21% higher yield than local varieties and a net return of ₹ 19,000/ha. In addition, SRI method of rice cultivation was promoted for saving irrigation water and enhancing yields of summer rice. SRI method saved about 40% water, gave 29% higher yield (5.4 t/ha) and a net return of ₹ 21, 000/ha. Similarly, HYV of toria 'TS-36' was introduced for replacing local varieties. The variety produced 62% higher yield than local varieties and gave a net return of ₹ 20,400/ha.

Fish management during floods: Escape of cultured fish and entry of predatory fish during flood were restricted by placement of nylon net at desired height along the periphery of pond dykes and through renovation of dykes. For management of fish pond during post-flood condition, interventions such as liming in fish pond, de-weeding and application of potassium permanganate as disinfectant were also made which helped in maintaining water quality and productivity improvement. Similarly, restocking in some selected fish ponds helped to compensate the loss of fishes during flood.

Phutahola, Dibrugarh, Assam

Name of the village : Phutahola
District : Dibrugarh
No. of households : 605
Total cultivated area : 250 ha
Major soil types : Sandy loam and Clay loam
Mean annual rainfall : 2000 mm
Major crops : Paddy, toria, vegetables (Pumpkin, potato, brinjal and cabbage) and Perennial crops (Tea, arecanut and coconut)
Climatic vulnerability : Flash-floods & terminal drought
Major interventions : Introduction of high yielding *Boro* rice variety, development of fodder bank, vermicompost production, banana cultivation for nutritional security

Climatic Vulnerability

Dibrugarh district of Assam receives about 2000 mm rainfall annually. This district is vulnerable to floods, flash-floods and water stagnation for longer period in crop fields. Terminal drought also occurs sometimes. During 2011-12, the village received a rainfall of 1789 mm and was badly affected by flash-floods in an area of 40 ha.

Interventions

***Paddy community nursery*:** Though the flash-flood was of moderate, prolonged stagnation of water delayed the transplanting of rice. Hence, community nursery was raised with rice variety '*Gitesh*' (suitable for transplanting old seedlings up to 60 days) in the flood affected areas. A mass varietal replacement programme on rice was also taken up to introduce quality seed material.

***Diversification of exiting farming systems for higher income and employment*:** A young farmer, of thirty years age, Rajib Buragohain from Phutahola village is highly motivated and involved in farming activities to earn livelihood for his family but the income generated from the farm was not sufficient to meet the family needs. Due to high degree of variations in weather during the recent years, he was unable to raise crops successfully and sometimes failed to recover the cost of cultivation.

He was advised to take up fodder production as a measure to diversify his farming system. Fodder saplings of perennial grasses such as guinea, hybrid napier, para grass and setaria were provided for planting. Technology on fodder cultivation was given to him and with few other villagers in a training programme. After 3-4 months of planting, the crop was ready for first harvest. Apart from feeding his own livestock, he started selling fodder saplings to other farmers which fetched him additional income in quick succession. His success inspired other villagers to go for fodder production. Now, three more farmers have come forward for fodder cultivation. Round the year fodder production is expected from this fodder bank and this will certainly meet the fodder crisis during dry spells of the year.

Promotion of fodder cultivation for improved milk production

Looking at his work and dedication in fodder cultivation, he was assisted to procure a crossbred Jersey cow along with a 4 month-old calf on cost sharing basis. The animals were fed with concentrates, from the income generated in fodder cultivation, as well as green grasses from his farm. He is now following yearly vaccination for FMD and HS+BQ and supplementation of mineral mixtures and fertility inducers as per requirement. The cow is yielding about 10 l milk/day and the farmer is earning additional income through sale of milk in the village.

Dhansiripar, Dimapur, Nagaland

Climatic Vulnerability

The climate of Dimapur district is hot and humid in the plains during summer (reaching a maximum of 36°C) while winters are cool and pleasant. The average annual rainfall of the district is 1505 mm. In spite of high rainfall during rainy season, water scarcity is a major problem during dry season due to which farmers face untold hardship. This is due to lack of proper water management specially rainwater harvesting and utilization.

Name of the village	: Dhansiripar
District	: Dimapur
No. of households	: 305
Total cultivated area	: 352 ha
Major soil types	: Sandy loam
Mean annual rainfall	: 1657 mm
Major crops	: Rice, maize and mustard
Climatic vulnerability:	Late onset of monsoon
Major interventions	: Consortium of farm ponds

Interventions

***Low-cost farm ponds for rainwater harvesting*:** Interventions were taken up to popularize low-cost rainwater harvesting structures 'Jalkund' with silpaulin (5x4x1.5 m) having a storage capacity 30,000 liters, for harvesting rainwater during rainy season and subsequent use during dry periods for life saving irrigation in high value winter vegetables.

Selection of beneficiaries was done with the help of Village Climate Risk Management Committee and Farmers club members. Altogether 15 beneficiaries were randomly selected including individual farmers and SHGs. Training was imparted to the selected beneficiaries and inputs like silpualin (4x5x1.5m size), digging charge (₹ 1500) and seeds of high value winter vegetables like broccoli, celery, capsicum etc. were distributed to the farmers.

Presently, all the 15 Jalkunds are in good condition and the farmers are happy with the technology as they can harvest 30,000 liters of water for use during dry season for their kitchen gardens and as a source of drinking water for livestock.

Rainwater harvesting in 'jalkund' and utilization for vegetable cultivation

***Construction of rock-fill dam and concrete irrigation channel*:** Langlung river is the main source for irrigating 150 ha of rice fields covering 76 farm households in the village. The villagers divert the water from the river with the help of rock-fill dam supported by bamboo structures to two water harvesting ponds and then to their fields through *Kaccha* irrigation channel. However, due to heavy rains and strong river current, farmers were forced to spend 60-70% of their working days in repairing and renovation

Site survey by KVK staff & VCRMC members for dam construction

Rock filled dam constructed by villagers

of the dam and irrigation channel every year. Hence, a rock-fill dam was constructed using sausage wire and a concrete irrigation channel (1000 ft.) was also constructed as a means to reduce the wastage of time in regular repair and renovation of the dam. With this, it is expected that farmers will utilize 80-90% of their working days in farm activities which will subsequently increase the production and productivity of their crops.

Rock filled dam and the irrigation channel constructed under NICRA

Nandok, East Sikkim, Sikkim

Climatic Vulnerability

East Sikkim district is characterized by cool and humid climate. The temperature in the district ranges from 1.50 (min.) to 27.5°C (max.) The annual rainfall is about 3800 mm. However, the district suffers from drought, water scarcity and cold stress during winter. The climatic constraints observed during the last year were drought (water stress) and hailstorms.

Name of the village : Nandok
District : East Sikkim
No. of households : 194
Total cultivated area : 104 ha
Major soil types : Sandy loam
Mean annual rainfall : 2500 mm
Major crops : Maize, ginger and paddy
Climatic vulnerability : hailstorms & drought (winter)
Major interventions : Introduction of HYVs & water stress tolerant varieties of crops

Interventions

Rainwater harvesting and utilization: There is no source of irrigation for the *rabi* vegetable crops although the village receives an annual rainfall of around 2500 mm. Hence, the best way to cope with this climatic challenge is to harvest the available rainwater during heavy rainfall season and use the same water for irrigating the fields during winter season. Awareness among farmers was created through frequent meetings, trainings and exposure visits.

"Jalkund" is a low-cost rainwater harvesting structure, developed on a hilltop for accumulating run-off water. This technology of water harvesting is gaining popularity in the village. About 25 Jalkunds of size 5 x 4 x 1.5 m (capacity of 30,000 l/Jalkund) have been constructed in the village. The farmers have started cultivating winter crops in larger area through rainwater harvesting and utilization for supplemental irrigation.

Jalkund

***Introduction of short duration cultivars in vegetable cultivation*:** The demonstrations of high yielding short duration varieties of cabbage (BC-76 and Wonder Ball), cauliflower (White Excel), tomato (Romeo), broccoli (TSX-0788), garden Pea (TSX-10) were conducted. These varieties were promoted to cope with drought due to their short duration. Low cost vegetable nursery structures (8 Nos.) have been constructed

benefitting about 94 families. Self help groups (8 Nos) are managing the nurseries to supply good quality planting materials. Demonstrations on vegetable nursery raising techniques were conducted to impart improved vegetable nursery technologies to the members of SHGs. This has brought 5 ha of additional area under vegetable cultivation. Farmers are now enthusiastic about cultivating winter vegetables with improved drought tolerant varieties and better water management practices.

***Diversification through backyard poultry*:** The poultry production systems in Nandok and other nearby villages are traditional and poorly remunerative. Interventions were made with dual purpose improved birds (Vanaraja and Gramapriya), which can thrive well under poor feeding and management practices, grow faster than indigenous birds and lay more eggs, thus leading to improvement in the livelihood security of the poor. The best poultry producers (having interest, skill and locally available indigenous resources to rear birds) within Self-Help Groups of the adopted village, were identified as first line beneficiaries.

The KVK organized several training and demonstration programmes on "Backyard Poultry Rearing" for farmers and farm women. Exposure visits were also conducted to gain more practical knowledge particularly on rearing of Vanaraja and Gramapriya birds. Later, about 400 chicks each of Vanaraja and Gramapriya were supplied to 40 beneficiaries of the adopted village. The birds were also given timely vaccination as per the need. This has proved to be a successful venture among farm women and is becoming popular in the area.

Backyard poultry under improved housing for protection from cold

As a success story of this enterprise, an example of Mrs. Pabitra Sharma is cited. With a stock of 60 birds, Mrs. Sharma earned a net profit of ₹ 11,300 with a B:C ratio of 1.78. With the excellent performance of Gramapriya backyard poultry, she purchased 100 more chicks. She has also started using local hens for hatching of eggs and sells chicks to fellow farmers thus making a horizontal dissemination of the technology. The village has become a hub for backyard poultry production with improved birds. Mrs. Sharma has become a role model for the farm women and landless farmers for taking up backyard poultry as a potential practice for agri-preneurship development leading to sustainable livelihood security.

Aliba, Mokokchung, Nagaland

Climatic Vulnerability

Aliba village of Mokokchung is well known for off-season cucumber cultivation but of late, the district is experiencing prolonged dry spells leading to drying up of irrigation channels. As a result many farmers have given up off-season cucumber cultivation. Even though sufficient rainfall occurs during the summer, there are no water harvesting structures in the village. Further, most of the farmers are reluctant to dig ponds for rainwater harvesting due to the apprehension that they will lose land for cultivation.

Name of the village	: Aliba
District	: Mokokchung
No. of households	: 262
Total cultivated area	: 26 ha
Major soil types	: Non-lateritic red, alluvial & forest soils
Mean annual rainfall	: 1408 mm
Major crops	: Paddy and maize
Climatic vulnerability:	Flood and drought
Major interventions	: Rainwater harvesting through farm ponds

Interventions

***Economic security for farmers through farm ponds and ring wells*:** After convincing the farmers through different meetings, water harvesting tanks and farm ponds with lining were constructed at strategic locations. With this, the farmers are now able to store water for irrigating their crops. An increase in yield of vegetables (15%) was recorded with an additional income of ₹ 27500/ha as compared to earlier years.

Broccoli cultivation using harvested rainwater

Review of ring well site by project staff

Full bearing of off-season cucumber

Ring wells were dug during 2011-12 for rainwater harvesting and supply of assured irrigation. With this intervention, many farmers have started cultivating off-season cucumber which is in high demand. The ring wells are benefitting about 78 farmers by providing irrigation to 12 ha. On an average, the yield of off-season cucumber was 150 q/ha. This intervention has led to increase in area under cucumber cultivation by 50%.

Thipuzumi, Phek, Nagaland

Climatic Vulnerability

Phek district suffers from heavy rainfall and soil erosion during April to October. A high incidence of insect-pests and diseases follows thereafter. Dryness prevails from November to February causing hindrance for cultivation of *rabi* crops. In high ranges of the hill, temperature reaches to the freezing point resulting in frosting during winter.

Name of the village	: Thipuzumi
District	: Phek
No. of households	: 314
Total cultivated area	: 554 ha
Major soil types	: Clay and red *chalka*
Mean annual rainfall	: 1550 mm
Major crops	: Paddy, maize and potato
Climatic vulnerability:	Heavy rainfall, frost and landslides
Major interventions	: Water harvesting, protected cultivation

Interventions

***Rainwater harvesting and protected cultivation of off-season vegetables*:** Rainwater harvesting coupled with protected cultivation was introduced to reduce the effect of climatic variability on crops. Further, protected cultivation helps farmers to grow crops including off-season vegetables round the year.

Twenty farmers were trained on low-cost polyhouse construction and protected cultivation, followed by demonstrations on their fields. Thirteen low-cost polyhouses with an average size of 36 m^2 were constructed using locally available bamboo/wooden material. Farm ponds were also dug adjacent to the polyhouses for rainwater harvesting and to provide supplemental irrigation to the crops. The king chilli or Naga chilli is a traditional food item used as spice by the Naga people. It is highly remunerative crop fetching about ₹ 200/kg of fresh chilli. At present 6 farmers of the village have taken up protected cultivation of king chilli. A progressive farmer Mr. Vecusuyi has earned about ₹ 25000 from cultivation of king chilli in a single season.

Protected cultivation of King chilies

Economics of King chilli cultivation under polyhouse

Farmer	Expenditure (₹)	Area of poly-house (m^2)	Crop	Gross Income (₹)	Net Income (₹)
Veciisuyi	8900	73.8	King chilli seedlings	19800	10900
Sekhosa	3000	34.4	King chilli	5000	2000
Vesakhoyi	2850	25.6	King chilli	5400	2550
Vethisa	5950	34.4	King chilli seedlings	12000	6050
Vetsucho	6500	57.4	King chilli	12500	6000

King chilli @ ₹200/kg; Seedlings @ ₹10/seedling

Kyrdem, Ri-Bhoi, Meghalaya

Climatic Vulnerability

Ri-Bhoi district experiences different types of climate ranging from tropical climate in the areas bordering Assam to the temperate climate adjoining the East Khasi Hills. The areas bordering Assam experience hot and humid weather during summer seasons with an average temperature of 30^{0}C, especially during May to July. In other areas like Lum Raitong and Lum Sohpetbneng Plateaus, the climate is severely cold during the winter months and is pleasant during summer. The major climatic vulnerabilities of Kyrdem village are water scarcity, poor soil health and frost.

Name of the village	: Kyrdem
District	: Ri-Bhoi
No. of households	: 220
Total cultivated area	: 6000 ha
Major soil types	: Red loamy soil
Mean annual rainfall	: 2400 mm
Major crops	: Paddy, ginger and turmeric
Climatic vulnerability:	Erratic rainfall, cold waves during winter
Major interventions	: *In-situ* moisture conservation

Interventions

Low-cost polyhouse for off-season vegetable cultivation: The Kyrdem village produces good amount of cucumber, capsicum and tomatoes during main season, which eventually leads to the market glut and fall in price. On the other hand, weather extremes including high intensity rainfall and hailstorm inflict maximum losses to the cucumber and tomato production during off-season. Therefore, low-cost polyhouse technology was introduced for off-season production of vegetables in the village.

Protected cultivation of tomato and knol-khol (above)

Low-cost polyhouse was constructed using locally available bamboo and metallic wire for developing the frame. UV stabilized film of 200µ (800 gauge) was used for covering the roof and 75% shade net on the side walls. The estimated cost of construction of a 100 m^2 size polyhouse varied between ₹ 13000 to 15000. Proper drainage channels were developed around the polyhouse to avoid water stagnation. Raised beds of 1 m length, 30 cm height and of convenient length were prepared

inside the polyhouse by thoroughly mixing soil: FYM in 2:1 ratio. The beds were disinfected with Formalin (20 ml/l water) and covered with black polythene for 2-3 weeks. The polyhouses are being used for raising of vegetable seedlings as well as off-season vegetable cultivation.

***In-situ moisture conservation in broccoli*:** The villagers were suffering losses from cultivation of traditional vegetables like cauliflower and cabbage due to water scarcity during winter months. During the course of interaction, they showed interest to adopt new crops and technologies. Broccoli cultivation was one of the alternatives, as this could be cultivated during pre-*rabi* season and has huge market demand in Shillong.

An area of 1 ha was selected, with Mrs. Bilma Tamu as leader, for broccoli cultivation. In the 1st week of September 2011, nursery was raised under low-cost polyhouse. Seeds of 'Pushpa' were sown in nursery bed of size 40 x 90 x 20 cm. Transplanting of 4-6 weeks-old seedlings was done with a spacing of 45 x 45 cm. FYM was applied @ 20 t/ha along with recommended dose of fertilizers. Well established 20 days old crop was

In-situ moisture conservation is braccoli

mulched (5 cm thick) with locally available dried biomass/crop residues for soil moisture conservation and weed control. The crop was ready for harvesting at 90 days after transplanting. A total of 183 q yield was recorded from an area of 1 ha. The cost of cultivation was ₹ 105000/ha with gross return of ₹ 297600/ha and a BC ratio of 2.83. The farmers' group sold their produce in the local market as well as in Shillong @ ₹ 30 to 40/ kg. This successful intervention has generated tremendous interest and curiosity in the village towards broccoli cultivation.

Punioni-baghchong, Sonitpur, Assam

Climatic Vulnerability

Sonitpur falls in the sub tropical climatic region and enjoys monsoon type of climate. The temperature goes up to 30°C during summer. Heavy rain occurs during this time and floods are common. Sonitpur is one of the flood-prone districts of Assam. During *kharif* 2012, the village Punioni-baghchong was affected by floods and nearly 110 ha of cultivated area was affected.

Name of the village	: Punioni-baghchong
District	: Sonitpur
No. of households	: 609
Total cultivated area	: 120 ha
Major soil types	: Sandy, loamy sand and sandy loam
Mean annual rainfall	: 1940 mm
Major crops	: *Boro* rice and pea
Climatic vulnerability:	Floods & drought
Major intervention	: Early duration *Boro* varieties

Interventions

***High yielding and short duration Boro rice varieties to cope with floods*:** *Boro* rice, the major crop of the region, gets damaged during the floods which generally occur during mid June-July. Traditional *Boro* rice cultivars are of 180-200 days duration which are transplanted during December-January. If the transplantation is delayed beyond mid January, the likelihood of harvesting of *Boro* rice getting coincided with flood is very high. Therefore, it is necessary to go for short duration *Boro* cultivars (160 days) so that they can escape floods. Drought is another climatic constraint which can be tackled by late transplanting of paddy by promoting protected nurseries.

Boro rice 'Swarnav' after floods

During *kharif* 2012, the village was affected by floods and nearly 110 ha of cultivable land was affected badly. Though the flood was of moderate intensity, local *Boro* rice cultivars in the village were severely affected by the flood (in low lying areas). The extent of loss was about 50-60 per cent as the harvesting stage of local varieties coincided with the flood. However, under NICRA, the demonstration of high yielding short duration *Boro* rice variety *Swarnav* could escape flood due its shorter duration.

Most of the fisheries tanks were flooded, because of which fish fingerlings escaped. Under the project, fish net was introduced in some ponds which demonstrated that the

fingerlings could be saved despite flooding. Farmers raised one community nursery with rice variety *Kanaklata*, for late transplanting of *Sali* paddy in these flood affected areas. The KVK, Sonitpur also promoted rice variety *Gitesh* by raising its nursery for late planting (up to 60 days old seedlings). These interventions are fully capitalized by the farmers in the village and they could realize some reasonable yield by minimizing losses due to flood. The KVK also plans to take up vegetable cultivation during *rabi* on a large scale to compensate for the loss farmers suffered due to flood in *kharif*. Farmers are enthusiastic about cultivating winter vegetables. However, they have no access to improved varieties and better management practices.

Integrated farming systems: The KVK is also striving to introduce integrated rice-fish and poultry farming to help the small farmers cope with the losses due to flood. Select farmers were trained and supported with material and technical knowhow to build low cost poultry sheds which were installed over the paddy fields. So far, five farmers have been trained in the village in this system. Three different fish species *viz* – Rohu, Catla and Mrigal were promoted while 'Vanaraja' poultry birds were made available. These systems are gradually attracting farmers' attention and more farmers are approaching the KVK to help them set up the integrated system on their farms to cope with natural calamities like floods.

Rice-fish-poultry farming

Sipini, Tirap, Arunachal Pradesh

Name of the village : Sipini
District : Tirap
No. of households : 57
Total cultivated area : 140 ha
Major soil types : Acidic sandy to clay loam soil
Mean annual rainfall : 2,505 mm
Major crops : Rice, maize, millet, tapioca, colocasia and banana under mixed cropping system
Climatic vulnerability : Erratic rainfall
Major interventions : Advancement of sowing time; water harvesting

Climatic Vulnerability

Tirap district of Arunachal Pradesh occasionally suffers from erratic rainfall. The village (Sipini) is located at a distance of 8 km from KVK Tirap, Deomali. Heavy rainfall from June onwards hampers timely land preparation for *kharif* crops. On the other hand farmers face acute water scarcity for growing *rabi* crops. Due to natural slope or typical sub-surface characteristics of hill soil, the soil moisture status remains very low to support plant growth. Any sort of opening of soil surface (for tillage) further depletes moisture status under scorching sun.

A short spell of untimely rainfall during January-February often coincides with harvesting of *rabi* crops like rapeseed. This results in reduction in quality and quantity of the produce. Early and heavy pre-monsoon shower during April-May coincide with harvesting of maize and summer rice which reduce yield and quality of product.

'Jalkund' for rainwater harvesting

Liming for acid soil reclamation

Mulching in field crops

Interventions

Rainwater harvesting for higher crop productivity: Six water harvesting structures (*Jalkunds*) of size 30 x 20 x 10 ft^3 were constructed to harvest runoff water. All the ponds are already filled with rainwater and this will be utilized for irrigating the crops during the ensuing *rabi* season.

***Soil management*:** Keeping in view the medium to high acidic nature of soils, liming was done in about 20 ha for enhancing productivity of different crops. *In-situ* green manuring was taken up with green gram and black gram in 5 ha. Mulching through use of both crop residues and plastic mulch was promoted on 10 ha area for soil moisture conservation. Eight vermicomposting units of size 10 x 4 x 2.5 ft^3 were established for efficient recycling of farm residues and on-farm production of vermicompost.

North Pulinpur ADC, West Tripura, Tripura

Climatic Vulnerability

North Pulinpur is one of the drought prone ADC villages of West Tripura district. There are no perennial streams or rivers in the entire village. Cropping system is mainly rice based which is purely rainfed. Water scarcity and unavailability of irrigation facility force farmers towards practice of *Jhumming* which leads to high rate of erosion with rapid loss of top soil.

The village is located at a distance of 50 km from state capital Agartala and 25 km from KVK, West Tripura. The climate variabilities observed during last year (2011-12) were water scarcity during *rabi* and summer, erratic rainfall during *kharif* and shortening of winter duration.

Name of the village : North Pulinpur ADC
District : West Tripura
Total No.of household : 806
Total cultivated area : 250 ha
Major soil types : Red loamy to sandy loam
Mean annual rainfall : 2035 mm
Major crops : Rice, chillies, cowpea and maize
Climatic vulnerability: Water scarcity and cyclone
Major Interventions : Water harvesting, vermicomposting, introduction of potato cultivation and backyard poultry rearing

Interventions

***Rainwater harvesting*:** Rainwater harvesting structures were constructed to minimize water scarcity. Approximately 85000 ft^3 rainwater was harvested by bunding, digging farm ponds (2 nos.), jalkunds (2 nos.) and renovation of 10 old ponds. These helped to provide life saving irrigation for vegetables during *kharif* dry spell as well as during *rabi*-summer season.

Farm pond filled with rainwater

Custom hiring centre for farm mechanization: To assist the farmers with timely supply of essential farm implements, a custom hiring centre has been opened under Kami Humkrai Climate Risk Management Committee (KHCRMC) and is functioning very well. The centre is equipped with modern farm machinery and implements including pump set, power tiller, row paddy transplanter, sprayers, cono weeders, water cans, power operated thresher, wheel-hoes, weed cutter, hand transplanter, hand fork weeder

etc. A sum of ₹ 18000 has already been generated as revenue through lending of different farm implements to the farmers.

Promotion of backyard poultry: The source of dual purpose poultry chicks in Tripura is scanty. Further, due to bird flu and other emerging diseases, parent farms of both the species are affected, thereby creating problem in maintaining constant source stock. Therefore, backyard system of rearing poultry and piggery with scientific management including protection from weather stress was demonstrated in the village. 'Swarnadhara' poultry birds were provided to 18 farmers with the condition that the birds are further multiplied and distributed to fellow farmers. Necessary vaccination was provided at regular intervals. The birds have started laying eggs and the fertile eggs are being sold to other farmers for brooding and hatching of chicks.

Vermicomposting unit

Vermicomposting for on-farm manure generation: Vermicomposting is also being promoted in the village for efficient recycling of farm wastes like cow dung and crop residues. Twenty five vermicompost units have been constructed at farmers' fields. Each farmer is now harvesting about 3 q vermicompost along with 15 l vermi-wash/ chamber/cycle. This is being used to improve soil fertility and yield of vegetables.

Zone - IV

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Sonauli Mohammadpur, Gonda, Uttar Pradesh

Climatic Vulnerability

Gonda district is a part of Central Ganga Plain of the state covering an area of 4425 km^2. The district receives a normal rainfall of 1151 mm in about 49 rainy days. The village Sonauli Mohammadpur is located on the banks of river Ghaghara and often bears the brunt of floods and water stagnation. Only sugarcane crop can sustain under these conditions and gives some returns to farmers.

Name of the village	: Sonauli Mohammadpur
District	: Gonda
No. of households	: 170
Total cultivated area	: 650 ha
Major soil types	: Alluvial soils
Mean annual rainfall	: 1431 mm
Major crops	: Sugarcane, paddy and wheat
Climatic vulnerability	: Floods
Major interventions	: Flood tolerant rice varieties, promotion of backyard poultry

Interventions

***Cultivation of flood tolerant varieties of rice and wheat*:** Cultivation of flood tolerant varieties like 'Swarna sub 1' of paddy and 'Naina' of wheat were demonstrated and now these varieties are being cultivated in the entire village. Cultivation of 'Naina' gave a grain yield of 42.5 q/ha compared to 29 q/ha under farmers' practice. About ₹ 8000-12000/ha more income was obtained with cultivation of 'Naina' variety. Further, the average productivity of different crops has increased by 15-20% due to proper drainage management and bunding. The farmers have formed a group for storing seed of introduced varieties for succeeding years and also to sell seed to other farmers (Seed bank). In addition, crop diversification is being promoted through introduction of crops like maize, vegetables, pigeonpea and mustard either as sole crops or intercropping for ensuring sustainable yields and income.

***Livestock interventions*:** These include promotion of balanced feeding in milch animals for higher productivity, and backyard poultry as a subsidiary enterprise for additional income (Rs 15-20/day) and risk minimization during floods.

Backyard poultry as a subsidiary enterprise

Jhangha, Gorakhpur, Uttar Pradesh

Climatic Vulnerability

Continuous rice-wheat cropping system and frequent floods during *kharif* result in low productivity of rice and wheat. About 170 ha area during *kharif* was not planted due to threat of floods. Most of the soils in village are low in organic carbon (0.2-0.3%). Further, most of the farmers are marginal and cannot afford to purchase costly external inputs including fertilizers. Farmers were not following green manuring and residue burning was a common practice.

Name of the village	: Jhangha
District	: Gorakhpur
No. of households	: 1354
Total cultivated area	: 373 ha
Major soil types	: Sandy loam
Mean annual rainfall	: 1211 mm
Major crops	: Rice and wheat
Climatic vulnerability	: Floods
Major interventions	: Green manuring, residue incorporation, introduction of deep water rice variety and improved fodder varieties

Interventions

***Green manuring and wheat residue incorporation to improve soil fertility*:** Farmers were motivated to avail the scheme of free supply of sesbania seed by Dept of Agriculture, Gorakhpur. Accordingly, about 125 farmers availed the benefit. Similarly, green gram variety 'Malvia-16' of 65 days duration was provided to 20 farmers for cultivation after wheat harvest. Further, in order to promote residue incorporation in the fields, the District Magistrate was convinced to issue an order banning residue burning. The grain yield of rice increased by 3.2, 1.6 and 1.8 q/ha due to green manuring with sesbania and green gram, and wheat residue incorporation, respectively compared to conventional practice. Introduction of green gram in rice-wheat system gave 9.6 q/ha seed yield with a net return of ₹ 24300/ha and B:C ratio 2.28.

***Cultivation of rice varieties tolerant to flood and submergence*:** Demonstrations were conducted on cultivation of rice varieties 'Jalnidhi' and 'Swarna Sub-1' for flood and submerged areas, respectively. Farmers harvested rice yield of 30.3 q/ha from 'Jalnidhi' in deep water areas of the village where farmers were not taking up any *kharif* crop earlier. A net return of ₹ 12224/ha and B:C ratio 1.59 was recorded with the intervention. In

Deep water rice var. 'Jalnidhi'

submerged areas, rice variety 'Swarna sub-1' gave 47% higher grain yield than traditionally grown variety 'BPT 5204'. Further, rice establishment through direct seeding and stale bed technique reduced the cost of cultivation by ₹ 5640/ha.

***Promotion of fodder cultivation*:** Most of the farmers are marginal having agriculture + livestock farming systems. It was observed that poor health of milch animals was one of the reasons for low milk productivity in the village (3.2 l/animal/day). Continuous use of rice and wheat straw for feeding, without use of green fodder is one of the reasons. Hence, the livestock owning farmers were motivated to take up fodder cultivation along with food crops. Demonstrations were conducted on cultivation of different fodder crops (cowpea + sorghum, fodder sorghum, maize, berseem and oats) on 20 farmers' fields. Improved berseem variety 'vardan' gave 29% higher fodder yield than local check. Similarly, improved varieties of cowpea ('UPC 8705') and maize ('African tall') gave two-times higher fodder yield than local checks. Increase in availability of quality fodder throughout the year increased milk productivity by 59% and on an average, each farmer's income increased by ₹ 40/day/animal.

Farmers discussing with KVK scientist on Jowar var. Pantchari-1

Amwakhash, Kushinagar, Uttar Pradesh

Climatic Vulnerability

The climate of the district is sub-humid and is influenced to some extent by the proximity of the north and the existence of Terai swamps. The average annual rainfall is 1202.8 mm. About 90% of rainfall occurs during June to September. During monsoon surplus water is available for recharging of ground water. The village Amwakash was affected by floods during 2011 (July) resulting in low rice yields.

Name of the village : Amwakhash
District : Kushinagar
No. of households : 1682
Total cultivated area : 2379 ha
Major soil types : Sandy loam
Mean annual rainfall : 1228 mm
Major crops : Sugarcane, paddy and wheat
Climatic vulnerability : Floods and water logging
Major interventions : Direct seeded rice, zero-tillage wheat

Interventions

***Direct seeded rice*:** Among different RCTs, direct seeding of rice is most appropriate particularly in waterlogged areas where rice-wheat is a predominant cropping system. Generally, manual transplanting of 21-35 days-old rice seedlings after 2–3 puddlings is common in the District. However, this system is labour intensive and requires huge tractor usage which often delays transplanting of paddy up to second week of August leading to poor tillering, grain formation and low yields of rice. To overcome these problems, direct seeded rice (DSR) was demonstrated on 20.2 ha of 97 farmers. Apart from this, cultivation of improved flood tolerant varieties 'Rajsree' and 'Swarna Sub-1' were also demonstrated. Direct seeded 'Rajsree' gave highest grain yield (47.5 q/ha) followed by 'Swarna sub-1' (29.3 q/ha) compared to local check 'Motha' (16.5 q/ha).

Direct seeded rice

***Zero till wheat cultivation*:** Timely sowing of wheat is important for realizing higher yields. If the sowings are delayed beyond 25th November, the yield of wheat decreases by about 30 kg/ha/day. However, sowing of wheat was getting delayed in the village due to various reasons viz. water logging due to flood, delay in rice harvesting, and time taken for land preparation. In general, farmers perform 2-4 tractor operations after harvesting of rice to prepare the field for wheat sowing and farmers broadcast the

seed and fertilizers in the field and mix the seed with the help of cultivator. Hence, demonstrations were conducted on zero-tillage wheat production for timely sowing, resource conservation and to enhance wheat productivity. Wheat was sown directly after the harvest of rice using a specially designed seed-cum-fertilizer drill on 18.5 ha involving 51 farmers. Zero tillage saved cost of field preparation by ₹ 4000-4500/ha. In addition, line sowing of wheat by using seed drill was demonstrated on 25 ha of 105 farmers. Zero-till sowing of wheat gave a grain yield of 45.5 q/ha compared to line sowing of wheat (40.3 q/ha).

Performance of zero-tillage and line sown wheat

Technology demonstrated	Variety	Farmers (No.)	Area (ha)	Grain yield (q/ha)	Net return (₹/ha)
Zero tillage in wheat	Labh	45	14.6	45.5	53419
	Bazz	6	4.0	45.4	52297
Line sowing of wheat	Labh	26	4.5	40.3	37629
	Bazz	79	20.8	40.6	37807

Bishunpura, Maharajganj, Uttar Pradesh

Climatic Vulnerability

The climate of the district is sub-humid to humid. The average rainfall is 1202.8 mm. About 87% of rainfall occurs during June to September. The major cropping system of the district is rice-wheat system. Other crops grown are sugarcane, lentil, pea and vegetables like tomato, brinjal, chilli and cucurbits. Floods are a perennial problem in this region and cause extensive damage to crops and livelihoods of the people.

Name of the village : Bishunpura
District : Maharajganj
No. of households : 165
Total cultivated area : 323 ha
Major soil types : Sandy alluvial soils
Mean annual rainfall : 850 mm
Major crops : Rice and wheat
Climatic vulnerability : Flood
Major interventions : Flood-tolerant rice varieties

Interventions

***Promotion of flood-tolerant rice variety Swarna Sub 1*:** Floods being a problem in the selected village, demonstrations were conducted to promote cultivation of flood-tolerant rice variety 'Swarna Sub 1'. This variety tolerates submergence up to 2 weeks and yields about 3-3.5 t/ha. In addition, SRI method of rice cultivation was also demonstrated for improving the resource-use efficiency and higher grain yields. Awareness among farmers was created through frequent meetings, trainings and exposure visits.

Swarna Sub 1

SRI paddy

Performance of flood-tolerant variety 'Swarna Sub 1'

Technology demonstrated	Variety	No. of farmers	Area (ha)	Grain yield (q/ha)		% yield increase
				Demo	Local	
Flood-tolerant rice variety	Swarna Sub-1	45	20.0	64.3	40.3	59.5

Shahdabbar, Muzaffarnagar, Uttar Pradesh

Climatic Vulnerability

Muzaffarnagar is located in western plain zone of Uttar Pradesh. The mean maximum and minimum temperatures in the district range from 39-47^{0}C and 1.5-5.0^{0}C, respectively. The district receives 650 mm annual rainfall. The major climatic vulnerability of the village during 2011-12 was heat wave.

Name of village : Shahdabbar
District : Muzaffarnagar
No. of households : 650
Cultivated area : 227 ha
Major soil types : Sandy loam to Clay loam
Mean annual rainfall : 670 mm
Major crops : Sugarcane, wheat and sorghum
Climatic vulnerability : High temperature during May & June, heat stress during mid-*rabi* season
Major Interventions : Improving soil health through green & brown mannuring

Interventions

***Sesbania brown manuring for improving soil health and productivity of spring planted sugarcane*:** Sugarcane is a major crop in the district and is cultivated on 60-70% of total cultivated area. Sugarcane-wheat- sugarcane is the main cropping system of the district. About 40% sugarcane is planted during April-May just after wheat harvesting. Due to extreme hot weather, the crop germination is severely affected resulting in lower sugarcane productivity. Further, the soils are poor with organic carbon content of 0.2 to 0.3%. Hence, demonstrations were conducted on Sesbenia brown manuring in late spring planted sugarcane for improving soil health and crop productivity. Brown manuring involves seeding of sesbania together with sugarcane planting and then controlling the growth (knocking-down) of sesbania after 25-30 days with 2, 4-D. Sesbania seeding was done @ 25 kg/ha just after sugarcane planting. Application of 2, 4-D was done on 30-35 days-old sesbania. This is also helpful in areas where soil crust formation is a major problem for the crop emergence.

Sesbania brown-manuring in sugarcane field

Sugarcane after sesbania brown-manuring

Major impact:

- Sugarcane germination increased by 31% compared to farmers' practice
- Reduction in early shoot borer attack by 45-51%
- Weed infestation decreased by 35%
- Saving in irrigation water by 30-35% due to better water holding capacity of soils
- Sugarcane yield with brown manuring was 80-85 t/ha compared to 55-60 t/ha under farmers' practice.

Parameter	Sugarcane (Sole)	Sugarcane + Sesbenia brown manuring
No. of Germinants/100 m^2	370	485
Shoot borer Attack (No/100 m^2)	41	27
Weed infestation (No/m^2)	472	355
No. of irrigations	8-9	6-7
Yield (t/ha)	55-60	80-85

Dunda, Uttarkashi, Uttarakhand

Climatic Vulnerability

Lying in the upper Himalayas, Uttarkashi has varying geographic environments ranging from snow-free valleys and outer hills to the high peaks with perpetual snow and glaciers. The terrain runs into series of ridges and valleys. Generally forests occur on the upper ridges that bound the valleys. On their sloping hill sides lie a chain of sparsely populated settlements interspersed with terrace cultivation. Agriculture in the district suffers from many constraints viz. shorter agricultural season, cold wave, floods in valleys, hail storm and soil erosion due to steep slopes. Most of the cultivated area in the village is rainfed.

Name of the village : Dunda
District : Uttarkashi
No. of households : 484
Total cultivated area : 169.85 ha
Major soil types : Sandy loam
Mean annual rainfall : 2500 mm
Major crops : Millets, wheat, rice, horse gram and toria
Climatic vulnerability : Cold wave, drought and hail storm
Major interventions : Drought tolerant pigeon pea, rainwater harvesting

Low-cost water harvesting structures

Interventions

***Rainwater harvesting and cultivation of off-season vegetables*:** There is acute shortage of water particularly during winter and summer months, and vegetable cultivation is almost impossible. Hence, priority was given to rainwater harvesting, through construction of low-cost farm ponds, and utilization for cultivation of off-season vegetables. A total of 10 multi-layered cross linked silpaulin based tanks were constructed at farmers' fields, with a total capacity of about 120 m^3. Further, demonstrations were conducted on cultivation of different off-season vegetables like cabbage and cauliflower in *rabi*, french bean and summer squash in *zaid* while tomato, capsicum, brinjal and okra in *kharif* season by utilizing harvested rainwater. Cultivation of off-season vegetables resulted in net return of ₹ 3500 to 4000 per year for each farmer. Now farmers of the area are convinced with the performance of these interventions and more farmers are showing keen interest in rainwater harvesting and growing of off-season vegetables.

***Promotion of drought tolerant pigeonpea*:** Considering the lack of irrigation facilities and uneven rainfall distribution in the area, cultivation of drought tolerant pigeonpea variety 'VL Arhar -1' was promoted in Dunda village during *kharif* 2011 in 2.7 ha area. 'VL Arhar 1' gave higher yield (12.5 q/ha) as compared to local cultivar 'Tor' (8.75 q/ha).

Further, cultivation of 'VL Arhar 1' gave higher monetary return (Rs 32100/ha) compared to that of local cultivar.

Performance of drought tolerant pigeonpea variety 'V L Arhar-1'

Variety	Farmers (No.)	Area (ha)	Yield (q/ha)		Yield increase (%)	Net return (₹/ha)	
			Demo	Local cultivar		Demo	Local
VL Arhar 1	67	2.7	12.50	8.75	42.85	32100	20050

In order to create awareness among farmers about the performance of drought tolerant pigeonpea 'VL Arhar 1' at field level, Arhar Diwas was organized on 19th October, 2011 at Dunda village. About 200 farmers attended the field day and shared their experiences. The farmers who are cultivating 'VL Arhar 1' have promised to retain the seed and share it with their fellow farmers.

Field day on pigeonpea

'VL Arhar-1' in farmers' field

Similarly, high yielding varieties of wheat and lentil were cultivated on farmers' fields. These varieties performed better than local varieties and more farmers are coming forward to cultivate HYVs of different crops.

Performance of HYVs of wheat and lentil

Crop/variety	Area (ha)	No. of farmers	Yield (q/ha)		% increase in yield
			Demo	Local	
Wheat (VL Gehun 829)	1.0	12	24.5	18.0	36.3
Lentil (VL Masoor 103)	0.5	19	11.3	7.0	61.8

***Backyard poultry for subsidiary income*:** Baseline survey of 100 farm families revealed that many farmers were interested in poultry farming, but they lack the technical and financial assistance. Dual purpose kroiler birds were identified for intervention, considering their similar appearance with indigenous breed, multiple color and social acceptability. Twenty interested farmers were selected for backyard poultry farming. They were provided with the skill oriented training about scientific backyard poultry farming and were supplied with 600 kroiler chicks with some amount of starter feed in September, 2011. Till date around 18000 quality eggs have already been produced by these birds earning supplementary income of ₹ 90000 (@ ₹ 5-6/egg). As a result 23 more farmers have started rearing of newly introduced kroiler birds with their own investment. This intervention is to diversify livelihoods in case of crop failure due to drought.

Zone - V

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Nirmal Pimpri, Ahmednagar, Maharashtra

Climatic Vulnerability

Name of the village : Nirmal Pimpri
District : Ahmednagar
No. of households : 1675
Total cultivated area : 2330 ha
Major soil types : Sandy loam
Mean annual rainfall : 425 mm
Major crops : Soybean, bajra, bengal gram, onion and fodder sorghum
Climatic vulnerability: Drought
Major interventions : De-silting of tanks, micro irrigation, vermicomposting, short duration drought tolerant varieties, water absorbent polymers, nutrient management, perennial fodder, improved housing for dairy

Ahmednagar district of Maharashtra comes under drought prone area. The average rainfall of the district is 562 mm, which in highly variable and unevenly distributed. About 72% area in the district is under rainfed agriculture. The major climate variability observed in Nirmal Pimpri village was recurring drought and water scarcity. Although the average rainfall of village is 450 mm it was only 278 mm in 2011 resulting in both early as well as terminal drought. Further, delayed monsoon and terminal drought affected both *kharif* and *rabi* crops. In pomegranate, water scarcity affects the *bahar* timing and fruit setting. Dairy is another major enterprise of the village. Fodder availability and livestock health is also affected due to climate variability.

Interventions

***Rainwater harvesting and utilization*:** De-silting of 9 water storage tanks/structures was taken up for enhancing water storage capacity in the villages. As a result, storage capacity the structures increased by 49.08 lakh l and also helped in recharging of about 126 open wells and 183 tube wells in the area. Further, incentives were provided to 25 farmers for installation of drip irrigation systems resulting in saving of irrigation water by 30-40% particularly during summer. The area under pomegranate was increased by 50 ha within a year due to better rainwater water harvesting, recharge of wells and efficient use of irrigation water through drip systems.

Water storage tanks after de-silting

***Agronomic interventions for soil moisture conservation and coping with terminal drought*:** Field demonstrations involving different agronomic interventions were conducted in 294 farmers' fields. Cultivation of short duration varieties of soybean and *kharif* onion was promoted in the village to cope with terminal drought. The yields increased by 11.5% in onion and 20.8% in soybean due to early maturity of the varieties. Demonstrations on use of water absorbent polymers @ 10 kg/ ha (cross linked acrylate polymers) were conducted in onion and pomegranate for improving soil moisture retention. The cost of polymer is ₹ 870 per kg. Use of these polymers saved about 3 to 9 irrigations in *rabi* onion and about 14.3 lakh l of water/ha in pomegranate. Further, onion yield increased by 22% over farmers' practice (141.7 q/ha).

***Livestock nutrition and health*:** Cultivation of perennial fodder (Jayvant) and multi-cut fodder sorghum was promoted for enhancing fodder availability in the village. An additional green fodder of 185.5 q/ha was harvested during late *rabi*, due to this intervention. De-worming of calves minimized the pot belly syndrome by 16.4% and improved health, particularly during heat stress. Osmanabadi buck was introduced for up gradation of local goat which improved their twining by 29.6% and also minimized the kid mortality by 2.5%. For sustainable family income, improved poultry breeds like Vanraja and Gramapriya were introduced in the village for backyard poultry. About 517 farmers have benefited from the livestock interventions.

Improved breed 'Osmanaabadi' bucks

Takali BK., Amaravati, Maharashtra

Name of the village : Takali BK
District : Amravati
No. of households : 424
Total cultivated area : 880 ha
Major soil types : Medium black cotton soil
Mean annual rainfall : 650 mm
Major cropping systems : Cotton, soybean, pigeonpea, chickpea and wheat
Climatic vulnerability : Drought, water stress, heat wave
Major interventions : Drought tolerant, short duration varieties

Climatic Vulnerability

The climate of Amaravati district is characterized by hot summer and general dryness throughout the year except during the south-west monsoon season. The average annual rainfall in the district is 877.4 mm in the plains. The rainfall at Chikhaldara which is a hill-station is about twice as much as in the plains. The rainfall generally increases from the south-west towards the north-east of the district. The rainfall during June to September constitutes 85% of the annual total, July being the rainiest month. The variation in the rainfall from year to year in the district is large. On an average, the number of rainy days in the plains of the district is 49/year. The temperature crosses 40^0C during summer and at times heat waves affect the district. The major climatic variability in the adopted Takali Bk. village is drought, water stress and heat wave.

Interventions

***Introduction of drought tolerant short-duration varieties*:** Drought tolerant, short-duration varieties of soybean, sorghum and pigeonpea were promoted for cultivation in the village. Short duration variety 'JS-9305' of soybean gave 68% higher yield (21.1 q/ha) than local check. Similarly, sorghum (CSH-14) and pigeonpea (AKT-8811) gave about 60 and 37% higher yields, respectively compared to local checks.

Short-duration sorghum hybrid 'CSH-14'

Performance of short-duration crop varieties

Crop	Variety	Duration (days)	Yield (q/ha)	
			Improved variety	Local check
Soybean	JS-9305	90-95	21.1	12.6
Sorghum	CSH-14	100-105	36.6	22.7
Pigeonpea	AKT-8811 (Vipula)	140-160	12.0	8.8

***Groundwater recharging and water harvesting*:** Several activities including farm bunding, stone pitching, digging of farm ponds and desilting of *nalas* were carried out for rainwater harvesting and recharging of groundwater. Farm bunding was done on 73 farmers' fields covering an area of 108 ha. The water levels in the open wells have increased by about 2 feet due to these interventions.

Introduction of rabi chickpea cultivation: Most of the farmers in the village leave the land fallow during *rabi* season. The NRM activities in the project had positive impact on recharging of open wells. Hence, with the availability of water for supplemental irrigation, chickpea cultivation was promoted during *rabi* season. About 110 ha was planted with chickpea during 2011-12 and farmers on an average harvested about 19 q/ha.

***Soil incorporation of crop residues*:** The traditional method of land preparation involves ploughing, harrowing, removal of stubbles, grass and crop residues with help of labour and finally land leveling by *patti-pass*. This is time consuming, costly (up to 2500/ha) and results in loss of soil moisture. Hence, use of rotavator was promoted through custom hiring centre, leading to saving in time, money (up to 1750/ha) and conservation of soil moisture. Impressed with the benefits of using rotavator, 6 farmers from the village and another 17 farmers from nearby villages have purchased rotavators with their own resources.

Rotavator for residue incorporation

Chakrayapeta, Anantapur, Andhra Pradesh

Name of the village : Chakrayapeta
District : Anantapur
No. of households : 36
Total cultivated area : 104 ha
Major soil types : Red soils (25%)
Black soils (75%)
Mean annual rainfall : 552 mm
Major crops : Groundnut and pigeonpea
Climatic vulnerability : Drought
Major interventions : Cost reduction technologies and crop diversification

Climatic Vulnerability

Anantapur is one of the most drought affected districts in Andhra Pradesh. It is the only arid district of the State receiving annual rainfall of 536 mm. This district lies in the rain shadow area of the State and suffers from frequent droughts. It has only 10% of area under irrigation with groundnut occupying maximum area under rainfed condition accounting for over 75% of the cropped area. The village chakrayapeta is located at a distance of 25 km from Anantapur. Groundnut + pigeonpea intercropping is the major cropping system during *kharif*. Generally, groundnut crop is affected by long dry spells and late leaf spot (LLS) at pod filling stage. During *kharif* 2011, the crops were affected by drought in the village.

Interventions

***Crop diversification*:** Demonstrations on crop diversification were conducted on farmers' fields to reduce crop losses due to frequent dry spells. Cultivation of castor, foxtail millet and intercropping systems with groundnut were promoted in the village as alternate crops.

Yield and economics of alternate crops

Crop	No. of farmers	Area (ha)	Yield (q/ha)	Gross cost (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	BCR
Groundnut	3	5	7.7	18500	24640	6140	1.33
Castor	15	6	8.83	16250	32671	16421	2.01
Foxtail millet	15	15	12.3	7500	23000	15500	3.07

***Rainwater harvesting and utilization*:** Renovation of existing farm ponds was carried out to enhance rainwater storage capacity of the ponds. Farmers were encouraged to open conservation furrows for *in-situ* rainwater harvesting in groundnut + pigeonpea

intercropping system. Further, plastic mulching was demonstrated in horticultural crops including water melon for better soil moisture conservation and to reduce weed infestation.

***Cost reduction technologies for groundnut + pigeonpea intercropping*:** Since the sowing window is very narrow in the region, timely sowing of crops is very difficult under rainfed conditions. Hence, sowing with 'Anantha groundnut planter' was popularized in the village. This helped in saving the seed requirement by 25 kg/ha and reduced the drudgery of sowing operation. Further, soil test based fertilizer application reduced the cost of cultivation by ₹ 1700/ha.

Groundnut sowing by Anantha planter

Effect of soil test based fertilizer application and management of LLS in groundnut

Technology demonstrated	No. of farmers	Area (ha)	Economics of demonstrations (₹/ha)		Economics of farmers' practice (₹/ha)	
			Net return	BCR	Net return	BCR
Soil test based fertilizer application	05	08	7100	1.4	3655	1.2
Management of Late Leaf Spot	01	3	31882	2.4	22825	1.0

Shekta, Aurangabad, Maharashtra

Climatic Vulnerability

Gangapur taluka of Aurangabad district comes under scarcity zones of Maharashtra, where rainfall is highly erratic and the annual average rainfall is 500-600 mm. Further, prolonged dry spells during crop season is common in the village. Sole cropping is predominant even under rainfed conditions. Rainfall during 2011-12 was 530.8 mm as against the normal 620 mm.

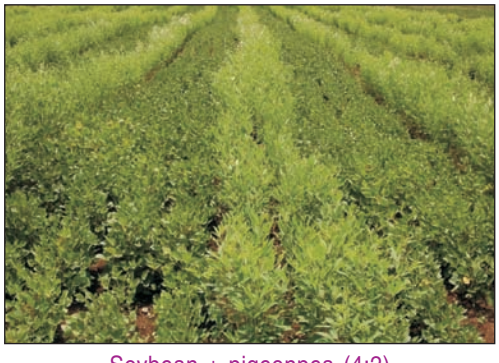
Name of the village	: Shekta
District	: Aurangabad
No of households	: 115
Total cultivated area	: 380 ha
Major soil types	: Shallow to light
Mean annual rainfall	: 644.3 mm
Major crops	: Cotton, pigeonpea, wheat and chickpea
Climatic vulnerability	: Drought
Major interventions	: Short duration varieties, intercropping, land configuration

Interventions

***Intercropping systems to cope with erratic rainfall pattern*:** Intercropping systems involving soybean + pigeonpea (4:2), pearl millet + pigeonpea (3:3) and pigeonpea + green gram (1:2) were demonstrated in 20 farmers' fields. Farmers harvested about 25-30% higher yields from different intercropping systems compared to sole cropping.

***Cultivation of short duration and drought resistant crop varieties*:** Short duration and drought resistant varieties of pigeonpea ('BDN-708'), green gram ('BM 2002-1') and chickpea ('Digvijay' & 'Vijay') were grown on selected farmers' fields. These varieties gave 20-25% higher yield than local varieties. Further, heat tolerant variety 'HD-2189' of wheat also performed better under farmers' fields and gave 22.5% higher yield than local varieties.

Pigeonpea + green gram (1:2)



Soybean + pigeonpea (4:2)

Katangtola and Chadanitola, Gondia, Maharashtra

Climatic Vulnerability

Gondia district experiences extreme variations in temperature with very hot summers and cold winters and an average relative humidity of 62%. A minimum temperature of 7.4^{0}C and maximum temperature of 47.5^{0}C was recorded in 2011. The average rainfall in the district during last four years was 1212 mm. Rice and sugarcane are major crops in the district.

Name of the village	: Katangtola & Chadanitola
District	: Gondia
No. of households	: 862
Total cultivated area	: 571.76 ha
Major soil types	: Sandy, loamy sand and sandy loam
Mean annual rainfall	: 1400 mm
Major crops	: Rice and sugarcane
Climatic vulnerability:	Drought
Major interventions	: Crop diversification, rainwater harvesting

Interventions

***Crop diversification*:** Majority of the farmers grow only rice and sugarcane in the region. Due to variable rainfall and lack of irrigation sources, the crop yields and incomes are stagnating/ falling. Hence, demonstrations on cultivation of different *kharif* vegetables like bottle gourd, cowpea, ridge gourd, okra and cucumber were conducted on farmers' fields to promote crop diversification. The farmers realized higher net returns from vegetable cultivation compared to rice. Similarly, during *rabi* season, farmers were encouraged to cultivate tomato, cabbage, brinjal and leafy vegetables. Further, chickpea 'JAKI 9218' (wilt resistant variety suitable for rainfed conditions) cultivation was also promoted in the village. Diversification helped farmers to realize reasonable income even with less water.

***Pigeonpea seed production*:** Although many farmers were interested to grow pigeonpea, timely availability of seed in the village was a major constraint. Hence, few farmers were motivated to take up pigeonpea seed production. Seed of improved variety 'PKV Tara' was distributed to 60 selected farmers and necessary guidance was provided for pigeonpea cultivation. All the farmers realized higher yields (10-12 q/

Seed production of pigeonpea 'PKV Tara'

ha) and many farmers have sold the harvested seed to neighbouring farmers for sowing in the succeeding season. This has worked as an informal seed bank. With this intervention, the area under pigeonpea cultivation has increased from less than 1 ha to more than 13 ha in 2012.

***Rainwater harvesting through farm ponds*:** Two farm ponds were dug in selected farmers' fields in convergence with MGNREGS. The harvested water was used for providing protective irrigations for different crops in 4 acres and the cropping intensity was increased by 50%. Improved fingerlings of rohu, katla and mrigal were also released in farm ponds for generating additional income.

***Crystoscope measures appropriate time of heat detection*:** Animal reproductive performance has greater impact on the animal production and economy of the farmer. Measure of reproductive performance is the calving interval. Normally 12 months of calving interval is considered as optimum to maximize milk production. The success of artificial insemination (AI) or natural service depends upon the detection of right time of estrus and subsequently, insemination at right time. Crystoscope (Lykascope) is used to detect the time of standing heat and ultimately right time for the insemination. In order to demonstrate the use of Crystoscope, few cows were selected for artificial insemination at the right time as indicated by crystoscope and were compared with traditional methods of breeding. The conception rate in the animals receiving AI was 62% compared to traditional method (26%), indicating that use of crystoscope plays a major role in improving the conception rate in cows.

Demonstration of cryptoscope

Nacharam, Khammam, Andhra Pradesh

Name of the village	: Nacharam
District	: Khammam
No. of households	: 150
Total cultivated area	: 400 ha
Major soil types	: Black cotton soil, red soil
Mean annual rainfall	: 1150 mm
Major cropping systems	: Cotton, paddy and pulses
Climatic vulnerability	: Drought
Major interventions	: Introduction of pulses for crop diversification

Climatic Vulnerability

The district receives 1096 mm rainfall annually but occurrence of drought is regular. Irrigated area in the district accounts for 39%. Rice has maintained its major share in the cropping and accounts for over 37%. While area under cotton has gained since 1995, crops like greengram and sorghum have lost the area.

Interventions

Introduction of drought tolerant pigeonpea variety: Cultivation of drought tolerant pigeonpea variety 'LRG-41' was demonstrated on 25 ha of different farmers. All the recommended package of practices including use of pendimethalin for weed control were followed by the farmers. On an average, a grain yield of 680 kg/acre was recorded with a net income of ₹ 18,360/acre.

Direct seeding of rice: This technology was demonstrated to cope with late onset of monsoon. It also helped in reducing the cost of cultivation and early harvesting of the crop compared to transplanted rice.

Zero tillage maize: Intensive tillage operations are energy and time consuming, accelerate soil erosion and loss of soil organic C and nutrients. Hence, zero tillage maize after rice harvest was introduced for efficient utilization of residual soil moisture.

Crop diversification: Farmers were encouraged to diversify crop production by cultivation of green gram ('MGG 295') and fodder crops ('CO 3' and 'CO 4') in addition to transplanted rice.

Drought tolerant pigeonpea variety 'LRG-41'

Yagantipalle, Kurnool, Andhra Pradesh

Climatic Vulnerability

Kurnool is one of the drought prone districts of Andhra Pradesh. Yagantipalle village which is located at a distance of 4 km from Banaganapalle Panchayat of Banaganapalle mandal has 70% area under rainfed agriculture. Cotton and pigeonpea are the main crops grown during *kharif,* and sorghum and sunflower are predominant *rabi* crops. Most of the crops get affected due to late onset of monsoon followed by dry spells during critical crop growth stages, severely affecting yields.

Name of the village : Yagantipalle
District : Kurnool
No. of households : 361
Total cultivated area : 640 ha
Major soil types : Sandy clay loam-clay loam
Mean annual rainfall : 546.4 mm
Major crops : Pigeonpea, cotton, sorghum and sunflower
Climatic vulnerability : Drought, delayed onset of monsoon
Major interventions : Crop diversification, drip irrigation, farm ponds, bore well recharge, feed/ fodder augmentation

Interventions

***Crop diversification*:** During *Kharif* 2011, monsoon onset was late (third week of July) and cotton sowing could not be taken up. Hence, short duration variety of foxtail millet 'SIA 3085' with 70-75 days duration and tolerant to drought and downy mildew was introduced in place of sorghum and *desi* cotton in 25 acres. Results on performance of alternate crops revealed that highest gross income was obtained.

Yield and economics of alternate crops

Crop	Farmers (No)	Yield (kg/ha)	Cost of cultivation (₹/ha)	Gross income (₹/ha)	CB ratio
Setaria	25	1885	11972	23900	1:1.9
Castor	20	921	11772	36840	1:3.1

Further, intercropping systems such as foxtail millet + pigeonpea and castor + pigeonpea were also demonstrated under rainfed conditions through varietal replacement of pigeonpea with 'PRG 158' and introduction of castor hybrids 'PCH 111' and 'PCH 222'. Foxtail millet 'SIA 3085' escaped terminal moisture stress and gave higher yields and income than from sorghum cultivation. Similarly, PRG 158 of pigeonpea, due to early maturity, gave higher yields than LRG 30.

Field day on 'foxtail millet cultivation'

Castor + pigeonpea (1:1) intercropping

Yield and economics of intercropping systems

Cropping system	Yield (kg/ha)		Gross income (₹/ha)	CB ratio
	Seteria/ castor	Pigeonpea		
Redgram + setaria (1:5)	1650	245	27975	1:2.0
Redgram + setaria (1:11)	1792	220	29000	1:2.0
Castor + redgram (1:1)	732	665	49230	1:2.7

***Rainwater harvesting and utilization*:** Four farm ponds were dug in selected farmers' fields and harvested water was utilized for providing life saving irrigations to *kharif* crops. Recharge of bore wells was attempted by digging of recharge pits near bore wells in 10 farmers' fields. Conservation furrows were made in rainfed crops like castor and pigeonpea for conservation of soil and water. Direct seeding of paddy by using drum seeder was demonstrated for saving irrigation water and labour requirement. Most of the soils are alkaline in nature making unfit for cultivation of common crops. Hence, reclamation of such soils was taken up through gypsum application based on soil test.

Drum seeder for direct seeding of rice

Nandyalagudem, Nalgonda, Andhra Pradesh

Name of the village	: Nandyalagudem
District	: Nalgonda
No.of households	: 155
Total cultivated area	: 300 ha
Major soil types	: Sandy loam, loamy sand, light black to medium black soils
Major crops	: Cotton, redgram, greengram, paddy and vegetables
Mean annual rainfall	: 850 mm
Climatic Vulnerability	: Drought and erratic rainfall
Major interventions	: Farm ponds, check dams, micro irrigation, drought tolerant varieties

Climatic Vulnerability

Nalgonda district comes under Southern Telangana Zone of Andhra Pradesh. The major climatic vulnerability of Nandyalagudem village is drought. Late onset of monsoon followed by mid seasonal and terminal drought is common in most of the years. The average rainfall of Atmakoor Mandal is 750-850 mm. In 2011-12, the rainfall was very erratic and there was no rainfall after 2nd week of September, 2011 except 3-4 rainy days with 60 mm of rainfall till the end of January. Out of the total cropped area of 300 ha, 80% is under rainfed crops. Cotton is a major crop followed by pigeonpea and green gram. Under irrigated conditions, paddy, vegetables and chillies are mostly grown.

Interventions

Rainwater harvesting and utilization: Major emphasis was given for rainwater harvesting due to erratic rainfall pattern in the village. Two new check dams were constructed in addition to desilting and renovation of two existing check dams in the village. A total of 13607 m^3 of storage capacity was created. As a result, groundwater recharging of 15 open wells and 13 bore wells was recorded benefiting 39 farmers.

Newly constructed check dam

Similarly, 9 farm ponds were constructed with a storage capacity of 7428 m^3 for storing of 7.428 lakh liters of water. As a result, about 35 open wells and 9 bore wells were recharged in surrounding areas, benefiting 99 farmers.

Ten silt traps were installed for diverting runoff to the wells as well as recharging of wells and bore wells by diverting run-off from the fields during heavy rainfall events.

As a result, silt deposition in the wells was prevented to a large extent. The water level increased by 6-9 feet in these wells.

Micro-irrigation for enhancing water use efficiency: Drip irrigation systems were installed in chilli, tomato and mulberry crops of selected farmers in convergence with APMIP (A.P. Micro Irrigation Project) and Dept. of Horticulture. About 17 farmers adopted drip irrigation on 10.2 ha. Farmers observed saving of irrigation water (50 to 60%), besides increase in area under irrigation.

Fodder supply to livestock: Majority of livestock farmers rely on paddy straw as livestock feed. Hence, cultivation of perennial multi-cut fodder variety 'APBN-1' was promoted in 10 farmers' fields as a source of quality green fodder particularly for milch animals. As a result, the farmers are realizing higher milk yield and economic returns from livestock component.

Rainwater harvesting by diverting run-off

Field day on multi-cut fodder varieties

Preventing residue burning: A custom hiring centre was established in the village and all necessary farm implements and machinery are made available to needy farmers through this centre. These include rotavator, power weeder, seed cum fertilizer drill etc. Farmers are resorting to use of these implements due to labour shortage in the village. Most of the farmers have started using rotavator for incorporation of crop residues in soil, instead of burning the residues. Residues of cotton and pigeonpea were incorporated with rotavator in about 50 ha during the year. Similarly, farmers are using three-row and six-row planters for sowing of crops like green gram and groundnut, and power weeder for weed management in cotton and pigeonpea.

Umarani, Nandurbar, Maharashtra

Climatic Vulnerability

The major climatic variability of Nandurbar district is heat stress and drought. Umarani village is situated in the Satpura ranges. The soils are shallow and are prone to moderate to severe soil erosion. As the events of intense rainfall (>60 mm/day) are increasing every year it is further aggravating soil erosion. During 2011, the onset of monsoon was delayed by one month (6th July 2011). An event of high rainfall occurred on 6th July, before sowing of crops. There was no vegetative cover on the soil resulting in soil erosion. Another event of intense rainfall (86 mm) occurred on 19th July at seedling stage of crops.

Name of the village : Umarani
District : Nandurbar
No. of households : 257
Total cultivated area : 539 ha
Major soil types : Red and black soils
Mean annual rainfall : 813.2 mm
Major crops : Soybean, jowar, maize and pigeonpea
Climatic vulnerability : Soil erosion and drought
Major intervention : Trench cum bunding

Trench cum bunding

Interventions

Trench cum bunding: This technology is suitable for *in-situ* conservation of soil and water. Trench cum bunding was demonstrated on 67 ha area covering 167 farmers. During intense rainfall events, most of the top soil from the cultivated fields was trapped in the trenches allowing safe disposal of excess rainwater. The soil trapped due to trench cum bunding was in the range of 11.5-21.2 m^3/acre. The farmers could save the valuable top soil being eroded from their fields with the treatment of trench cum bunding. Since the benefits of trench cum bunding were very significant, upscaling of the technology was taken up in convergence with MGNREGA on 229 farmers' fields. An amount of ₹ 8,00,000 was sanctioned for this intervention by the district authority as convergence.

***Intercropping for reducing risk*:** Sole cropping is still predominant under rainfed conditions. Frequent dry spells and poor moisture holding capacity of soils make production highly risky and many times complete crop failure is observed. The improved technology involving intercropping of soybean and pigeonpea (3:1) was demonstrated on selected farmers' fields. Soybean crop failed due to poor germination and pearl millet was grown as a contingency crop after discussion with VCRMC. Due to continuous rains, the growth of pearl millet was stunted leading to low yield. However, intercropped pigeonpea ('ICPL-87') yielded better with a net return of ₹ 35100/ha. This intervention demonstrated how risk could be reduced by adopting intercropping.

Jalgaon (K.P.), Pune, Maharashtra

Name of the village : Jalgaon (K.P.)
District : Pune
No. of households : 398
Total cultivated area : 1094 ha
Major soil types : Medium black
Mean annual rainfall : 524 mm
Major crops : Bajra, jowar, maize, onion and wheat
Climatic vulnerability : Drought with long dry spells
Major interventions : Desilting of check dams, introduction of drought tolerant bajra cultivars

Climatic Vulnerability

Baramati in Pune district of Maharashtra is one of the drought prone tehsils under Western Maharashtra Scarcity Zone with an annual rainfall of 530 mm. The major climatic variability/weather aberration in Jalgaon was drought during 2011, only 418 mm rainfall was received as against normal 530 mm which was 23% lower. The onset of monsoon was early with a rainfall of 74.2 mm in first week of June. Thereafter no rains were received till 5th of July, therefore sowing of *kharif* crop was delayed. Further, most of the crops were affected due to five dry spells leading to water stress condition during crop growth period.

Interventions

***Desilting of water harvesting structures*:** Desilting was done in all the six check dams in the village. About 47759 m^3 silt was excavated and applied on 25.8 ha barren/ problematic lands of 35 farmers. This has resulted in efficient *in-situ* and *ex-situ* rainwater harvesting. Farmers are now able to provide protective irrigation to both *kharif* and *rabi* crops on 34.5 ha area, which was mostly rainfed before the intervention. Further, groundwater levels in adjacent open wells have increased by 7-10 feet. Tank silt application improved the soil properties of uncultivable and barren lands and hence, more area was brought under cultivation. Pearl millet, sorghum and onion were grown in tank silt amended land. These crops yielded 5, 8.8 and 43.7 q/ha, respectively.

De-silting in progress

Introduction of drought tolerant bajra variety ICTP-8203: Bajra being the major crop during *kharif,* its production gets affected due to dry spells during mid July-August. Demonstrations with drought tolerant variety ICTP-8203 were conducted on 20 farmers' fields (8.0 ha). ICTP-8203 performed better than other hybrids under uneven rainfall conditions during *kharif* 2011. The variety yielded 7 q/ha while the yield of other hybrids was about 3.75 q/ha.

Bajra variety 'ICTP-8203'


Officials interacting with farmers

Broad beds for in-situ moisture conservation: *Rabi* sorghum is another major crop in the village. The rainfall received during September and October is crucial for *rabi* sorghum cultivation. *In-situ* moisture conservation through broad beds was demonstrated on two farmers' fields. In May, large beds of 20 x 12 m were prepared across the slope. The rainfall received during monsoon was totally conserved in these beds. The crop yield in the plots under *in-situ* moisture conservation was 11.3 q/ha compared to 3.8 q/ha in control plots.


Silage for fodder storage

Silage for off-season fodder supply: In view of water scarcity and drought situation leading to unavailability of green fodder in summer season, silage making was demonstrated in the village. Green stalks of maize, jowar and sugarcane tops available with the farmers were used for silage making. The silage prepared in December, 2011 was made available to feed the livestock during February to May, 2012.

Use of area specific mineral mixture: Dairy is important subsidiary enterprise in the village. Low rainfall in the village resulted in low production of cereal and legume green fodder, which led to unbalanced feeding of greens and legumes to milch animals. This resulted in deficiency of different minerals and vitamins affecting the milk production by 15-20% and reproduction in cross-bred HF cows. To overcome this, the area specific mineral mixture formulated by KVK was provided to 134 dairy farmers for their 402 HF cross-bred animals. It helped to provide strength and rigidity to skeletal system and to reduce the repeat breeding by 70% and increase milk production by 15% in HF cross-bred cows. This has brought awareness amongst livestock owners about role of various minerals and their dietary supplementation particularly for livestock during drought years when green fodder is scarce.

Haral, Ratnagiri, Maharashtra

Climatic Vulnerability

Ratnagiri district of Maharashtra is high rainfall area but moisture stress is prevalent during *rabi* season. The village Haral also receives high rainfall (3500-4000 mm) but scarcity of water for agriculture and domestic needs is felt after December. Due to this, farmers cultivate only horse gram during *rabi*, which is grown on residual soil moisture. Further, water scarcity is main constraint for establishment of new cashew and mango plantations. About 15-20% of seedling mortality is common in new plantations due to moisture stress.

Name of the village : Haral
District : Ratnagiri
No. of households : 353
Total cultivated area : 139 ha
Major soil types : Red lateritic soil
Mean annual rainfall : 3594 mm
Major crops : Rice and fingermillet
Climatic vulnerability: High rainfall with scarcity of water during *rabi*
Major interventions : *Jalkund* for water harvesting, groundnut seed production

Interventions

***Rainwater harvesting in 'jalkunds'*:** Rainwater harvesting in low-cost *'jalkunds'* was demonstrated in selected farmers' fields. The size of each *'jalkund'* was 4 X 1 X 1 m^3 with a storage capacity of 4000 litres of water. The harvested rainwater was used for watering new plantations of mango and cashew. As a result, the seedling mortality was negligible in those orchards.

Low cost *'Jalkund'*

Introduction of new goat breeds: Due to high rainfall in Konkan area, local breed of goat shows poor growth in this region. Hence farmers were reluctant in goat rearing. Considering the wide scope to develop agro-enterprises like goatery, a new goat breed 'Konkan Kanyal', suitable for high rainfall areas and recommended by Konkan Krishi Vidyapeeth, was introduced for rearing in the village. This breed has adapted well to the local conditions in the village and more farmers are coming forward to purchase the new goat breed.

Performance of new goat breed 'Knokan Kanyal'

Growth stage	Kokan kanyal (Kg)	Local breed (Kg)
Birth weight	1.98	1.28
weight at 6 months	13	10
weight at 12 months	23.80	18.40
Weight at 18 months	49	43.3

***Crop diversification*:** Rice is main *kharif* crop in Konkan region followed by horse gram during *rabi.* In order to promote crop diversification, groundnut seed production was taken up on a limited scale (0.8 ha). With the success of this crop this year, more farmers from the village are willing for *rabi* groundnut cultivation.

Sirusuwada, Srikakulam, Andhra Pradesh

Climatic Vulnerability

Name of the village : Sirusuwada
District : Srikakulam
No. of Households : 250
Total cultivated area : 600 ha
Major soil types : Red sandy, sandy loam with clay base
Mean annual rainfall : 982 mm
Major crops : Paddy, cotton, vegetables, pulses, groundnut and sesame
Climatic vulnerability : Floods/mid-seasonal drought due to erratic distribution of rainfall
Major interventions : Introduction of flood tolerant rice & pulses, introduction of elite breeds

Srikakulam district of Andhra Pradesh is one of the flood prone districts in the state. Heavy floods occur in Vamshadhara river generally during September and occasionally in October and November due to heavy rainfall and depressions formed in Bay of Bengal. Sometimes, the crops at early stage are also prone to inundation due to heavy rainfall received in July. Though the average annual rainfall is 1162 mm in Srikakulam district, the rainfall distribution is quite erratic leading to floods/ drought situations at various crop growth stages. The village is prone to floods due to excess rainfall received during monsoon season in low lying areas (150 acres) near to Jagannathanaidu tank either through overflow of hill streams received in Marripadu *gedda* or from Vamsadhara river. The major irrigation sources are Marripadu *gedda* (hill stream water) and Jagannadhanaidu village tank. Some farmers also lift water from Vamsadhara river. The Jagannadhanaidu pond is the biggest one occupying an area of 25.58 acres with a command area of 144.75 acres in the village.

Interventions

Agronomic interventions: Cultivation of green gram and black gram in rice fallows is a common practice in the village. However, the crop productivity is very low due to cultivation of long-duration local varieties which are susceptible to yellow mosaic virus (YMV) and terminal drought due to early cessation of rainfall. Hence, short duration HYVs like TM-96-2 (60-65 days) of green gram, and LBG 20 and LBG 752 (75-80 days) of black gram were promoted for cultivation. TM-96-2 was tolerant to YMV and gave 62.2% higher yield (7.9 q/ha) than local check (4.9 q/ha). In black gram, cultivation of HYVs gave 37.5% higher yield (8.8 q/ha) than check variety (5.5 q/ha).

In groundnut, yield potential is low due to excess vegetative growth as a result of heavy rainfall, high humidity and radial method of sowing. Introduction of line sowing with HYV 'Abhaya' enhanced pod yield by 20% (33.8 q/ha) compared to farmers' practice

of radial sowing with variety 'JL 24' (28.1 q/ha). Further, about 11.1% higher pod yield was observed due to sprinkler irrigation (30 q/ha) compared to flood irrigated crop (27 q/ha). In addition, adoption of sprinkler irrigation method resulted in a saving of irrigation water (25%) and cost (₹ 1,250/ha) compared to flood irrigation.

Sprinkler irrigation in groundnut

Sunhemp seed production was promoted by supplying seed and creating awareness on importance of green manure incorporation during pre-*kharif* season for enriching the soil fertility. Farmers produced about 50 q seed during *rabi* 2011-12 season.

***Introduction of elite breeding rams*:** Small ruminants in the village are mostly local breeds. Hence, genetically superior breeding rams were supplied by replacing the local inferior breeds from the sheep flock to improve genetic potentiality of local sheep by producing superior lambs through these elite breeding rams.

Superior ram introduced for breeding purpose

***Custom hiring centre*:** A custom hiring centre was established in the village by making available several implements & farm machinery like power tiller, paddy reaper, sprayers, winnowing fan, primary tillage implements, drum seeder, oil engines, sprinkler units etc. These implements help in performing timely agricultural operations, reducing cost of cultivation and coping with weather aberrations.

Matsyapuri, West Godavari, Andhra Pradesh

Climatic Vulnerability

Floods and cyclonic storms are the major climatic constraints in the Godavari districts of Andhra Pradesh. Rice is the major crop in the district and most of it gets affected by heavy rains during August to September. Matsyapuri village is located at a distance of 35 km from Bhimavaram and 10 km from Veeravasaram town. During 2012, most of the paddy growing fields were submerged (both nurseries and transplanted fields) due to heavy rains particularly in low lying areas.

Name of the village : Matsyapuri
District : West Godavari
No. of households : 1602
Total cultivated area : 616 ha Paddy & 150 ha fish and prawn ponds
Major soil types : Alluvial
Mean annual rainfall : 1185 mm
Major crops : Paddy and pulses
Climatic vulnerability: Floods & cyclones
Major interventions : Direct sowing in paddy & water quality management in fish ponds

Interventions

***Direct sowing in paddy*:** During *rabi* 2011-12, demonstrations were conducted on direct sowing of paddy through drum seeder and broadcasting. Transplanted rice was affected due to poor release of cannal water, grain shattering due to low temperatures before harvesting and rains at the time of threshing.

Drum seeder for direct seeding of rice

However, direct sown rice matured 15 days earlier than transplanted rice and hence, the crop escaped from the rains at the time of threshing. As a result, the grain yield was 15.4% more from direct sown rice compared to normal transplanted rice. Further, the cost of cultivation was reduced by ₹ 6250/ha under direct sown rice. The farmers were convinced with the performance of direct sown rice and more farmers are coming forward to adopt the technology.


Performance of direct seeded rice

***Renovation of canals*:** Menthipudi and VWS canals are major source of irrigation in the village. Deepening of these canals was taken up to bring more area under irrigation and to prevent flooding of adjacent fields. About 650 ha area was brought under irrigation due to renovation of the canals, benefiting about 300 farmers.

***Management of fish during floods*:** Fish and prawn culture is predominant occupation in the village covering about 150 ha. The fish and prawn ponds also get affected due to heavy rains and continuous cloudy weather. Hence, demonstrations were conducted on water quality management. Regular testing of dissolved oxygen levels, pH, ammonia, nitrate, etc. in fish ponds was carried out for prevention of disease incidence, and the cost of fish and prawn culture was reduced by ₹ 13,200/ha. Demonstrations were also conducted on fish polyculture (culture of *Pangasius* along with major carps) to improve the water quality and to overcome adverse climatic conditions and market price fluctuations. Most of the farmers have started adopting polyculture of *Pangasius* along with major carps instead of monoculture of *Pangasius.*

Demonstration on water quality management in fish ponds

Zone - VI

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Sitara, Bharatpur, Rajasthan

Name of the village : Sitara
District : Bharatpur
No. of households : 275
Total cultivated area : 365 ha
Major soil types : Clay and loam
Mean annual rainfall : 667 mm
Major crops : Guar, bajra, mustard, wheat and barley
Climatic vulnerability : Drought & poor quality groundwater
Major intervention : Recharging of bore wells

Climatic Vulnerability

Bhartpur district comes under the flood-prone eastern plain zone IIIb of Rajasthan. But in last ten years, there is a significant increase in the incidence of dry spells besides a decline in the amount of rainfall. However, there is also an increase of high intensity rainfall in the past few years. The village is situated in a low lying area, as a result crops suffer during high rainfall incidents. In such cases farmers depend mostly on *rabi* crops for livelihood. Due to semi arid tropical condition in the village, it faces higher incidence of solar radiation and highly varying rainfall with intermitting dry spell. Low nutrient content, soil degradation and poor quality of groundwater are some of the related constraints in the village. Shallow tube wells (25-30 ft) are major source of irrigation as deep aquifer is saline.

Interventions

Recharge of tube wells to improve shallow aquifer: During last 10 years, farmers have been suffering from declining water table. *Rabi* crops often failed due to lack of irrigation. As farmers were not aware of *in-situ* soil and moisture conservation techniques, 35-40% of total rainfall was being lost as runoff. To address this problem, recharging of tube wells was taken up as a major intervention. The technique involved diverting runoff to a pit dug around the tube well after trapping the silt. About 8 to 10 cement

Constructed tube well

Tube well recharging

rings are descended into the dugout around the tube well. Into this harvested rainwater, which is collected into a cement tank to allow the silt to settle down, is conveyed using a PVC pipe.

About 25% of total expenditure on construction work and labour work was shared by farmers as farmer participation. The cost of each intervention and the material used are as follows:

Cement rings for fixing into tube well	8 to 10 of 4′ radius
Bricks	500 No.
Cement	1 Bag
Plastic pipe	10′-12′ length
Sand	4 bags
Total cost	₹ 8000 - 10000
Time taken for construction	Two days
Tube well size	30' x 4' - (radius)
Size of silt trapping tank	3'x3'x3'

During last year, 54 bore wells have been recharged in the village. This intervention has resulted in significant increase in the shallow aquifer levels (2.5 to 4 m). Despite prevalence of high temperature (36 to 40^{0}C) in the pre-*rabi* period of 2011-12, farmers could give pre sowing irrigation before taking up the crops such as mustard, barley and wheat. This helped them to take up timely sowing and harvest a good yield. In the absence of such a facility farmers would normally wait for temperature to come down resulting in delayed planting. Delayed planting of *rabi* crops often leads to coinciding of cop maturity with higher winter temperature resulting in severe yield reduction.

Livestock interventions: Improved breeds of buffalo 'Murrah' and goat 'Jamunapari' were introduced for improving the local breeds. About 50 farmers were trained on the importance of using urea molasses bricks as livestock feed. Further, about 20 farmers were imparted training on preparation of balanced feed using wheat straw, chickpea bran, mustard cake, salt and calcium. These farmers have now decided to produce the balanced feed on a commercial basis and supply to fellow farmers through a SHG. About 250 mangers were distributed to livestock farmers for safe and hygienic feeding of livestock. Further, demonstrations on green fodder cultivation (berseem and sorghum) were conducted on 20 ha of selected farmers. The milk production in the village has increased by 20-25% due to adoption of these interventions.

Bharu, Jhunjhunu, Rajasthan

Name of the village : Bharu
District : Jhunjhunu
No. of households : 338
Total cultivated area : 618.09 ha
Major soil types : Sandy loam
Mean annual rainfall : 450 mm
Major crops : Pearl millet, cowpea, cluster bean, wheat, mustard and chickpea
Climatic vulnerability : Frost & heat stress
Major interventions : Short duration high yielding varieties with chemical spray

Climatic Vulnerability

Jhunjhunu district of Shekhawati region is one of the frost prone districts of Rajasthan. Bharu village is located at a distance of 20 km from district headquarter. Mustard, chickpea, barley and wheat are the major crops cultivated during r*abi* season which are usually affected by frost. The intensity of frost is more during December to January. Mustard and chickpea are more sensitive to frost as their reproductive stage coincides with peak point of winter. While late sown crops are generally affected by terminal heat stress, timely sown crops are affected by frost during flowering stage. During *rabi* 2011-12, the crops were affected by frost several times. As a result, the seed yield of mustard and chickpea was reduced by 40-70%.

Incidence of frost during *rabi* 2011-12

Date	Temperature (^{0}C)
9.1.2012	-0.2
10.1.2012	-0.8
11.1.2012	-1.1
12.1.2012	-0.6
12.1.2012	-0.8
21.1.2012	-1.7
23.1.2012	-0.6
30.1.2012	-0.4

Chickpea on farmer's fields

Interventions

***Short duration varieties and chemical spray for protection from frost*:** The demonstration of short duration varieties of mustard ('Laxmi') and chickpea ('GNG-663') along with spray of agro-chemicals like sulphuric acid @ 0.1% and dimethyl sulfoxide (DMSO) @ 75 g/ha was conducted on farmers' fields on 23 ha (mustard 9 ha

and chickpea 14 ha). Spraying of sulphuric acid and DMSO (Just before flowering) were helpful in protection of mustard and chickpea from frost injury and gave higher yields (15%) compared to check plots. The spraying of these chemicals also increased the shining of seed and oil content of mustard crop, and fetched higher market price than non-spray crop produce. In addition, demonstrations were also conducted on high yielding heat stress tolerant varieties of wheat (Raj-3765) and barley (Rd-2035) along with spraying of salicylic acid (100 ppm) and thioglycolic acid (100 ppm) on farmers' fields.

During *kharif* 2011, demonstrations of high yielding and short duration varieties of cowpea, cluster bean, green gram and pearl millet were conducted on farmers' fields. The yields from demonstration plots were superior by 10 to 15% especially in green gram and cluster bean.

***Balanced nutrition and breed improvement in livestock*:** Demonstration of green fodder production round the year was conducted on farmers' fields. Further, to mitigate the mineral deficiency, mineral mixture and urea molasses bricks were distributed to selected farmers during animal treatment camps. For breed improvement, 10 improved 'Sirohi' bucks and 2 'Murrah' breed buffaloes were provided. To popularize the subsidiary occupation, six goat units (each unit having 10 doe + 1 buck of sirohi breed) were also given to the farmers.

Goat units distributed to farmers

***Custom hiring centre for mechanization*:** Use of several farm implements including reaper binder, posthole digger and power sprayer was promoted through custom hiring centre. Use of reaper binder has become popular among the farmers for harvesting of *rabi* crops and about 50% of wheat and barley crop in the village was harvested by using reaper binder during *rabi* 2011-12. Posthole digger is also becoming popular and about 1500 pits were dug for plantation during rainy season, 2012.

Reaper - binder in custom hiring centre

Choma Kot, Kota, Rajasthan

Climatic Vulnerability

The major climatic vulnerability of Kota district is water scarcity/drought. The district receives rainfall of 730 mm. The major cropping systems are soybean-wheat under irrigated and fallow-mustard under rainfed conditions. Soybean is also grown under rainfed conditions but its productivity is affected due to less number of rainy days coupled with dry spells and sometimes early withdrawn of monsoon.

Name of the village : Choma Kot
District : Kota
No. of households : 125
Total cultivated area: 400 ha
Major soil types : Black clay
Mean annual rainfall: 680 mm
Major crops : Soybean and wheat
Climatic vulnerability : Erratic rainfall, dry spells
Major interventions : *In-situ* moisture conservation, short duration crop varieties, farm mechanization

Interventions

***FIRB system for enhancing yield and water productivity of wheat*:** Water availability is a major limiting factor for sustaining the wheat productivity in the village. Hence, furrow irrigated raised bed (FIRB) system of wheat cultivation was promoted to enhance crop yield and water productivity. Demonstrations were conducted on 40 farmers' fields and raised beds were prepared by using FIRB machine. Several advantages were observed with FIRBS compared to flat system of wheat cultivation. They were: a) required 20-25% less seed rate, b) saving in irrigation water by 25-30%, c) time required for irrigation was reduced (2.4 hrs/ha/irrigation), d) less weed infestation, and e) higher wheat yield.

Wheat cultivation in FIRBs

Crop establishment method	Yield (q/ha)	Variable cost (₹/ha)	Net return (₹/ha)	% increase in net return
FIRB System/Bed planting	61.92	18425	67334	14.0
Conventional sowing	56.25	18850	59056	

***Cultivation of short duration soybean variety to cope with early withdrawal of monsoon*:** Use of long duration variety, uneven rainfall distribution and early withdrawal of monsoon are major factors limiting soybean productivity under rainfed conditions. Demonstrations on cultivation of extra-early maturing soybean variety of ('JS-95-60') were conducted on farmers' fields which performed better than existing variety ('JS-335'). On an average, 'JS-95-60' gave 15-20% higher yield and BC ratio (2.5) compared to check ('JS-335'). As a result, about 80% of farmers in the village have sown 'JS 95-60' variety of soybean in *kharif* 2012. This also helped in timely sowing of succeeding mustard.

Soybean (JS-95-60) at pod filling stage

***Resource conservation and enhanced crop productivity through mechanization*:** A custom hiring centre was established in Choumakot to promote farm mechanization in the village. M.B. Plough, chisel plough and tractor drawn blade-harrow, sprayers etc are made available to farmers on a nominal cost as decided by VCRMC. These implements are being used for field bunding and deep tillage. Chisel plough was also used for breaking compact soil layers and soil moisture conservation.

Field bunding for *in-situ* moisture conservation

Mechanical weed control in soybean

Impact of Custom Hiring Centre

Particulars	Impact
Enhancement of crop productivity	15-20%
Timely field operation	Saving in time
Reduced cost of cultivation	10-15%
Dependence on landlords	Reduced
Dependency of farmers on banks for implement loan	Decreased
Income earned by the centre	₹ 56052

Magharvada, Rajkot, Gujarat

Climatic Vulnaerability

Rajkot district of Gujarat receives low, uneven and erratic rainfall. Cotton and groundnut are the major crops during *kharif* and both crops are affected by drought/dry spells which generally occur during mid July to August. Magharvada village is located at a distance of 23 km from Rajkot. During *kharif* 2011, nearly 600 ha of cultivable land in the village was badly affected by drought. The extent of yield loss was about 50-80% in cotton and 80-100% in groundnut.

Name of the village : Magharvada
District : Rajkot
No. of households : 300
Total cultivated area : 799 ha
Major soil types : Medium & shallow black
Mean annual rainfall : 635.2 mm
Major crops : Groundnut, wheat, gram, cumin, garlic and onion
Climatic vulnerability : Drought
Major interventions : Rainwater harvesting, INM & IPM

Interventions

Rainwater harvesting: Rainwater harvesting and groundwater recharging were given priority in the village. The average depth of the open wells in this area is 13 to 21 m and most of the wells remain dry at the end of winter. A village pond was renovated (37000 m^3) in collaboration with Gujarat Land Development Corporation (GLDC). Under the scheme, 90% of the cost was borne by GLDC. In addition, one community pond was de-silted/deepened (30000 m^3) in convergence with irrigation department of the State government and one check dam was renovated (2500 m^3) in collaboration with GLDC. After deepening/de-silting of ponds and check dam, the average ground water table has raised up to 3 to 4 m as compared to previous years.

Pond de-silting in progress

De-silted pond filled with water

***Integrated nutrient management*:** Mono-cropping and injudicious use of chemical fertilizers have resulted in poor soil productivity. The farmers use mostly chemical fertilizers (DAP and urea) in cotton and groundnut. About 50 INM demonstrations each on cotton and groundnut were conducted through use of caster cake, *Trichoderma,* urea, SSP, MOP, $ZnSO_4$ and $MgSO_4$. The results indicated that cotton and groundnut yields increased by 6.6 and 7.4%, respectively over farmers' practice.

***IPM in Bt cotton*:** Due to mono-cropping and injudicious use of pesticides, the infestation of sucking pests (jassid, thrips, whitefly, mealy bugs etc) has increased in cotton. Twenty demonstrations were conducted on IPM during *kharif* 2011, through use of azadirachtin 1500 ppm and *Verticillium lecanii* in addition to use of chemical pesticides. Maize or cowpea was also grown in 1:10 row ratio or mixed crop in cotton to maintain natural enemies. The results indicated that most of the sucking pests were controlled through IPM and the yield increased by 5-10% compared to farmers' practice.

***Enhancement of nutritive value of low grade fodder through urea treatment*:** Animal husbandry is one of the most prominent enterprises in the village. However, the quality of fodder (wheat straw, husk etc) was very poor resulting in low livestock productivity. Therefore, demonstrations were conducted on enhancement of nutritive value of wheat straw through urea treatment. As a result, the protein content of the fodder was increased from 0.5 to 4.5%.

Khuntli, Valsad, Gujarat

Climatic Vulnerability

Valsad district is located at the southernmost tip of Gujarat, near Gulf of Khambhat in the Arabian Sea. The district receives an annual rainfall of 1500-2200 mm. The major climatic vulnerability of the village is floods in downstream tracts.

Name of the village	: Khuntli
District	: Valsad
No. of households	: 349
Total cultivated area	: 278 ha
Major soil types	: Medium black
Mean annual rainfall	: 2208 mm
Major crops	: Paddy and chickpea
Climatic vulnerability	: Heavy rainfall/flood
Major interventions	: Raising of bottle gourd seedlings, custom hiring centre

Interventions

***Custom hiring centre for cost reduction and timely field operations*:** A custom hiring centre has been opened under Khuntli Climate Risk Management Committee (KCRMC) with a membership of 286 resource-poor tribal farmers. It is equipped with modern farm machineries and implements like diesel pump set, power tiller, reaper, brush cutter etc. Delay in transplanting of paddy is a regular phenomenon due to unavailability of labour/draught animals and excessive rainfall. This results in poor crop yields and delayed sowing of *rabi* crops. Hence, power tiller was found very useful for land preparation including puddling and facilitated timely paddy transplanting. Further, winnowing fan is in high demand for winnowing of rice as it saves labour and time. Weed infestation is a major problem due to heavy rainfall in the village. Brush cutter is being used by many farmers for efficient weed control. In remote hilly tribal area like valsad, where farmers are socio-economically backward with small holdings, custom hiring centre became a boon to the farmers.

Winnower in operation

***Agronomic interventions for bottle gourd cultivation*:** Bottle gourd is grown as a short duration cash crop on slopy lands during *kharif* with supplemental irrigation after monsoon. Normally direct seeding is done to raise the

Bumper crop of bottle gourd

crop but heavy rains during sowing time affect the germination and crop establishment. Hence, raising of bottle gourd seedlings in polythene bags under shade nets was promoted. The seedlings were transplanted after 15 days in the main field and staking was provided using bamboo sticks. Further, PVC rope was used instead of GI wire for netting, as it was more durable, cheaper and light in weight.

Impact of agronomic interventions in bottle gourd cultivation

Before	After
Poor plant population due to direct seeding	Maintained optimum plant population
Bamboo structure could not resist high wind velocity at full productive stage	Boundary with RCC pole provides extra strength to the bamboo structure thus, prevents crop losses
Early production was not possible due to late plantation in field (mortality due to heavy rain and bird damage)	Seedlings grown in nursery were transplanted at appropriate stage resulting in uniform growth and early production
Glut in the market due to higher supply of produce in the market and fetches lower market price (₹ 4-5/kg)	Early production fetched better market price (₹ 12/kg) for the produce
GI wire, due to corrosion in rainy season, shortens the life of support structure	Introduction of plastic rope which is light in weight with good stretching capacity provides longer life to the support structure

Zone - VII

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Khargahna, Bilaspur, Chhattisgarh

Climatic Vulnerability

Bilaspur district is situated between 21^{0}41′ and 23^0 7′ N, and 81^0 12′ and 83^{0}19′ E at an elevation of 231 m above sea level. The climate of the district is sub-tropical. The weather is warm, humid with short winter & hot summer. The hottest months are May & June recording a maximum of 45-47^0 C. The average rainfall is 1000 to 1200 mm. Khargahna village is predominantly tribal with about 200 ha under cultivation.

Name of village : Khargahna
District : Bilaspur
No. of households : 460
Total cultivated area : 200 ha
Major soil types : Alfisols, Sandy loam
Mean annual rainfall : 1100 mm
Major crops : Paddy, wheat and chickpea
Climatic vulnerability : Drought
Major interventions : SRI, short duration Varieties of black gram, wheat & chickpea

Interventions

SRI method of rice cultivation to enhance water and rice productivity: Demonstrations of short duration rice variety (MTU 1010) through SRI was laid out on 15 farmers' fields. It was observed that the cost of land preparation, leveling and weeding was high under SRI technology as compared to conventional method. On the other hand, the input costs (seed, pesticides and fertilizers) were lower in SRI technology compared with conventional method. SRI encouraged rice plants to grow healthy with large root volume, profuse and strong tillers, no lodging, big panicle, well filled spikelets and higher grain weight. The actual benefits of SRI included higher yield of both grain and straw, reduced crop duration by 10 days, lesser chemical inputs, less water requirement, less chaffy grain and higher net returns/ha.

SRI demonstration

***Custom hiring centre for farm mechanization and drudgery reduction*:** A custom hiring centre was established in Khargahna village and is being managed by custom hiring centre committee. The implements are hired by farmers as and when required by paying a nominal cost and ₹ 16,700 has been deposited in custom hiring centre fund in one year excluding maintenance of the tools and implements.

Choukhada, Chhatarpur, Madhya Pradesh

Climatic Vulnerability

Chhatarpur district of Bundelkhand region is characterized by frequent droughts. Apart from recurring drought, other constraints include low and erratic rainfall, light soil with low organic matter and poor water holding capacity. Traditional long duration varieties of black gram, soybean and sesame experience terminal moisture stress at maturity.

Name of the village : Choukhada
District : Chhatarpur
No of households : 125
Total cultivated area : 222.4 ha
Major soil types : Sandy loam
Mean annual rainfall : 1074.9 mm
Major crops : Groundnut, mustard, blackgram, wheat, sesame and chickpea
Climatic vulnerability : Drought
Major interventions : *In-situ* moisture conservation, short duration varieties

Interventions

***In-situ soil moisture conservation*:** During *kharif* 2011, the district received normal rainfall and there were no extreme climatic constraints experienced in Choukhada village. Despite this, the farmers were encouraged to adopt *in situ* moisture conservation techniques through summer ploughing. This activity was undertaken on 10 farmers' fields covering 8 ha.

***Cultivation of disease resistant short duration varieties*:** Short duration and high yielding varieties of black gram ('PU 35') soybean ('JS 9305'), sesame ('JTS 8') and groundnut ('TPG 41') were promoted for cultivation to cope with terminal moisture stress. Demonstrations were conducted during *kharif* 2011 on 26 ha covering 69 farmers. The farmers were encouraged to preserve the seeds and share it with other farmers of the village for sowing in the ensuing season. Similarly, during *rabi* 2011-12, the crop

Summer ploughing for *in-situ* moisture conservation

Short duration black gram variety 'PU35'

production interventions consisted of demonstrations on chickpea ('JG 16'), lentil ('JL 3') and mustard ('JM 2'). These varieties are of short duration, disease resistant and perform well with 1-2 irrigations. The demonstrations were conducted on 25.6 ha belonging to 64 farmers. Black gram variety 'PU 35' performed well in all the farmers' fields and gave higher yield and net returns compared to local check.

Performance of short-duration blackgram variety 'PU35'

Technology demonstrated	Farmers (No.)	Area (ha)	Yield (q/ha)		% increase in yield	Net return (₹/ha)	
			Demo	Local		Demo	Local
Short duration variety of black gram (PU 35)	13	5	12	10	20	22500	18000

Sanora & Barodi, Datia, Madhya Pradesh

Climatic Vulnerability

Datia district is located in the northern part of Madhya Pradesh in the Bundelkhand agro-climatic zone. The district has been suffering from drought since the last 10 years. Recently, the rainfall pattern has also changed with long dry spells and less number of rainy days.

Name of village(s) : Sanora & Barodi
District : Datia
No. of households : 335
Total cultivated area : 246 ha
Major soil typea : Alfisols
Mean annual rainfall : 743 mm
Major crops : Soybean, groundnut, wheat and mustard
Climatic vulnerability: Drought
Major interventions : Rainwater harvesting, *in-situ* moisture conservation, short duration varieties

Interventions

Rainwater harvesting and utilization: De-silting of three farm ponds and renovation of defunct water harvesting structures (3) was done to enhance the water harvesting capacity of the structures. In addition, one poly-bag check dam *(Bori-Bandhan)* was constructed by making use of empty cement bags. Size of *Bori-Bandhan* is 15 m (L) X 2 m (W) X 1.5 m (H). Recharging of about 25 open wells was observed in downstream of check dam and renovated water harvesting structures. Harvested rainwater was used for providing life saving irrigation to soybean and groundnut during pod formation stage. This enhanced the crop yields by 26-32% and an additional net return of ₹ 5000-8000/ha was realized by the farmers. The harvested rainwater was also used for providing pre-sowing irrigation to *rabi* crops such as mustard and chickpea.

Poly-bag check dam

Renovated check dam

Effects of supplemental irrigation on crop yield and economics

Crop	Area covered (ha)	Yield (kg/ha)	Net return (₹/ha)
Mustard	80	1273	27,913
Chickpea	5	1546	33,212

Vegetable cultivation was also promoted by utilizing harvested rainwater and irrigation from recharged wells. Tomato was cultivated on 5 ha and farmers harvested about 270 q/ha and realized a net return of ₹ 60,000/ha. Similarly, chilli was cultivated on 5 ha with a net return of ₹ 30,000/ha. Okra cultivation gave a net return of ₹ 32,000/ha.

Chickpea after pre-sowing irrigation

In addition, improved fisherlings (catla, rohu, mrigal etc) were released in two farm ponds for generation of additional income. This intervention resulted in employment generation of 58 man-days/season and an income of about ₹ 80,000/year.

In-situ soil moisture conservation: Soybean sowing through broadcasting is common in the village, resulting in poor soil moisture conservation and crop yields. Suitable land configuration helps in enhancing the time of concentration, absorption and storage of rainwater in soil. Hence, demonstrations on broad bed and furrow method of soybean sowing were conducted on selected farmers' fields. This method gave about 15-20% higher yield compared to farmers' practice. In addition, deep ploughing during summer was encouraged among the farmers for efficient conservation of soil moisture.

Broad bed and furrow method of soybean cultivation

Introduction of short-duration crop varieties: Demonstrations were laid out on selected farmers' fields for cultivation of short-duration varieties of soybean, groundnut and sesame during *kharif* season. All the varieties performed better and gave 47-58% higher yields than local varieties.

Crop/variety	% increase in yield	Decrease in maturity over local (days)
Soybean (JS-95-60)	58	27
Groundnut (JGN-3)	47	12
Sesame (JTS-8)	58	26

Similarly, short-duration and temperature tolerant varieties of *rabi* crops were promoted for cultivation. The varieties gave 24-32% higher yields than local varieties.

Performance of introduced varieties

Crop/variety	% increase in yield	Additional income (₹/ha)	Varietal character
Mustard (Pusa Jai Kisan)	29.5	9560	Suitable under limited irrigation conditions
Chickpea (JG-11)	23.6	10509	Tolerant to high temperature
Chickpea (JG-130)	31.5	11417	Suitable for rainfed conditions

Mustard (Pusa Jai Kisan)

Chopara, Ganjam, Odisha

Climatic Vulnerability

Ganjam is one of the drought-prone districts of Odisha. Paddy is the major crop during *kharif,* being grown in 2,70,000 ha, and is generally affected by drought which usually occurs in September. During *kharif* 2011, nearly 150 ha of cultivable land in the village was affected due to dry spells and water shortage. Though the drought was of moderate intensity, medium duration local cultivars were affected by the drought (in upland areas) leading to 40-45% reduction in yield.

Name of the village : Chopara
District : Ganjam
No. of households : 315
Total cultivated area : 150 ha
Major soil types : Sandy, loamy sand
Mean annual rainfall : 1020 mm
Major crops : Paddy, groundnut, green gram and maize
Climatic vulnerability : Water stress & drought
Major interventions : Short- duration drought tolerant paddy varieties

Interventions

***Cultivation of short duration rice varieties*:** Farmers usually grow long duration (130-145 days) rice varieties and transplanting is done during last week of July. This results in moisture stress during crop maturity affecting the grain yield. Therefore, demonstrations were conducted on cultivation of drought tolerant short duration rice variety 'Naveen'. The variety could withstand dry spells of about 12 days and gave a grain yield of 28.2 q/ha compared to local check (21.3 q/ha). A net profit of ₹ 10800/ha was realized with cultivation of 'Naveen' variety.

Demonstration of drought tolerant rice variety 'Naveen'

Agronomic interventions to cope with dry spells: Spraying of micro-nutrients (borax and zinc sulphate) during dry spells resulted in better crop growth and enhanced yields by 14.7% compred to farmers' practice. Similarly, herbicide (pretilachlor) use was demonstrated for efficient weed control and soil moisture conservation in rice. Herbicide use resulted in 85% weed control and gave 15% higher grain yield compared to farmers' practice.

***Cultivation of short duration varieties of pulses*:** During *rabi* 2011-12, demonstrations were conducted on cultivation of short duration varieties of green gram (TARM 2) and black gram (PU 31). Both the varieties performed better and gave 61.8 and 63.2% higher yield than local checks.

Sarkho, Guna, Madhya Pradesh

Climatic Vulnerability

Guna of Gird zone is one of the drought prone districts of Madhya Pradesh. The major crops of district are soybean, wheat, chickpea and coriander. The average annual rainfall of the district is 922 mm. The soils are shallow to medium black, low in organic carbon with undulating topography resulting in poor water holding capacity and susceptible to soil erosion. Frost is another problem faced during winter.

Name of village : Sarkho
District : Guna
No. of households : 242
Total cultivated area : 241 ha
Major soil type : Shallow to medium black
Mean annual rainfall : 1000 mm
Major crops : Soybean, black gram, wheat and mustard
Climatic vulnerability : Drought
Major interventions : Rainwater harvesting, short duration varieties

Interventions

***Rainwater harvesting*:** Deepening of one pond (70 m long and 40 m wide) was done with appropriate inlet and outlets. The depth of farm pond was increased from 1.5 m to 9 m. The total rainwater storage capacity is about 25200 m^3 and this water is being utilized for providing supplemental irrigation to different crops covering 8 ha. It is also used for providing pre-sowing irrigation to *rabi* crops. Efforts are being made to introduce fisherlings in the pond for generating additional income. Similarly, de-silting of two open wells was done for improving recharge of groundwater and to facilitate irrigation in about 6 ha.

Renovated pond

De-silting of open well in progress

***Cultivation of short duration varieties*:** To cope with late arrival of monsoon followed by early cessation, early maturing variety of soybean 'JS 9560' was promoted for cultivation. The yields increased by 20% compared to local check 'JS 335'. Similarly, pigeon pea variety 'ICPL 88039' was sown on 30 ha belonging to 70 farmers with an yield advantage of 30-40% over local check, as the variety escaped frost during December-January.

Krushnadaspur, Kendrapara, Odisha

Climatic Vulnerability

Kendrapara lies between 20^0 21′ N to 22^0 10′ N latitude and 86^0 14′ E to 87^0 83′ E longitude. The district has a geographical area of 2,644 km^2 and the coastline covers 48 km. Kendrapara is prone to flood and cyclones. During *kharif*, most of the areas are flooded resulting in failure of crops.

Name of the Village : Krushnadaspur
District : Kendrapara
No. of households : 152
Total cultivated area : 195 ha
Major soil types : Alluvial (sandy loam)
Mean annual Rainfall : 1439 mm
Major crops : Rice
Climatic Vulnerability : Floods & cyclone
Major Interventions : Flood tolerant rice varieties, integrated farming systems

Interventions

Cultivation of submergence tolerant rice varieties: Submergence tolerant variety 'Swarna Sub-1' was grown on selected farmers' fields. However, entire crop was damaged due to submergence of the crop for more than 35 days. Pulses were cultivated on the residual moisture after the harvest of rice. Due to better input management, the demonstration plots realized at least 15% additional yield.

Agronomic interventions for Boro rice cultivation: Improved variety 'Lalata' (135-days old) was introduced to selected farmers and a community nursery was raised for supply of rice seedlings to small and marginal farmers. Further, most of the farmers practiced line transplanting and SRI method of paddy cultivation instead of traditional practice. About 180 ha was covered under improved method of *Boro* rice cultivation and the yields increased substantially from 4 t/ha to 5.75 t/ha.

Flood affected fields

Flood tolerant "Lalata" variety

Nidhan and Jigani, Morena, Madhya Pradesh

Climatic Vulnerability

The climate of Morena is characterized as semi-arid, extremely cold during December-January (-1.5^{0}C) and hot during May-June (49^{0}C). About 58.7% of the cultivable area in the district is irrigated. Canal is the major source of irrigation which accounts for 42.9% of the total irrigated area. The annual rainfall received was 644.4 mm in 2010-11 and 851.2 mm in 2011-12. During cropping period of wheat, 27.7 and 5.8 mm rainfall was received during 2010-11 and 2011-12, respectively.

Name of the village : Nidhan and Jigani
District : Morena
No. of households : 925
Total cultivated area : 2067 ha
Major soil types : Sandy loam
Mean annual rainfall : 700 mm
Major crops : Pearl millet, wheat, mustard and pigeonpea
Climatic vulnerability : Frost and drought
Major interventions : Short duration pigeonpea varieties, zero tillage wheat

Interventions

Cultivation of short duration pigeonpea variety: Long duration varieties of pigeonpea are mostly grown in villages Nidhan and Jigani. These varieties usually mature in 220 to 250 days and consequently only single crop could be grown in a year. Further, the crop suffers from severe frost during December-January. To overcome this problem, a short duration (130-145 days) pigeonpea variety 'ICPL-88039' was introduced for cultivation in fallow lands. This pigeonpea variety matures by mid-November which gives sufficient time for sowing of succeeding wheat crop. Demonstrations were conducted in two villages (Nidhan and Jigani) in an area of 20 ha involving 52 farmers. The rainfall received during the cropping period was 650.8 mm distributed over 31 rainy days. The sowing of pigeonpea under ridge furrow system was recommended to conserve moisture, enhance seed germination and effective management

Frost-affected pigeonpea

Short-duration pigeonpea variety 'ICPL-88039'

of the crop. Farmers harvested about 20-24 q/ha and earned a net income of 45-60 thousand/ha. Further, wheat yields increased by 10-15% under pigeonpea-wheat system compared to fallow-wheat system. A seed bank has been established in two villages and more than 410 q of 'ICPL 88039' seed was produced during 2011. This was accessed by 2387 farmers during 2012. The short duration variety has replaced long duration pigeonpea variety as well as some area under pearlmillet and *kharif* fallow in these villages and also nearby villages. Farmers are now able to grow two crops (pigeonpea-wheat) in place of single crop in a year (long duration pigeonpea).

***Mechanization of pigeonpea cultivation*:** In order to reduce the drudgery, cost of cultivation and facilitate timely operations, mechanization was promoted for pigeonpea cultivation. A tractor drawn reaper was popularized for pigeonpea harvesting. Similarly, a tractor operated thresher was made available for threshing of pigeonpea. Large scale pigeonpea processing facility available near the project village has encouraged farmers to take up the cultivation of this crop more intensively.

Reaper for pigeonpea harvesting

***Zero tillage wheat*:** After harvesting of short duration pigeonpea, timely sowing of wheat is delayed under conventional method due to time required for land preparation (3-5 tillage operations). In addition, land preparation requires high input, energy and increases cost of cultivation. Delay in sowing of wheat result in more input requirement and the crop is affected by terminal heat. To overcome these problems, zero tillage wheat cultivation was demonstrated on 50 ha belonging to 32 farmers in the village. One pre-sowing irrigation was provided just before pigeonpea harvesting. Sowing of wheat was done by using zero-till planter. Adoption of zero tillage reduced the cost of cultivation by ₹ 3760/ha. The grain yield in zero-till plots was 5-6% higher compared to farmers' practice.

Tractor operated pigeonpea thresher

Zero-till planter for wheat sowing

Bhargawan, Satna, Madhya Pradesh

Climatic Vulnerability

Satna district is situated in the Vindhyachal Plateau of Madhya Pradesh. The average minimum and maximum temperature of the district range from 5-46^{0}C. Agriculture in Bhargawan village is highly vulnerable to climatic variability including erratic rainfall, terminal drought, prolonged dry spells and frost. Further, more than 82% of the cultivated area in the village is under rainfed conditions.

Name of the village : Bhargawan
District : Satna
No. of households : 74
Total cultivated area : 151.5 ha
Major soil types : Black soils
Mean annual rainfall : 904 mm
Major crops : Rice, pigeonpea, wheat and chickpea
Climatic vulnerability : Drought and heat stress
Major interventions : Rainwater harvesting, crop diversification, short duration/drought tolerant varieties

Interventions

Rainwater harvesting: There is acute shortage of water particularly during winter and summer months. Hence, priority was given to rainwater harvesting, through construction of low-cost farm ponds (1), check dams (26), percolation tanks (2), earthen embankments (2), renovation of defunct wells (4), and contour trenching on slopy lands (3198 m). The harvested rainwater was utilized for providing life saving irrigation to different crops covering about 90 ha.

Renovated open-well

Renovated tank

In situ moisture conservation: *In situ* moisture conservation through ridge and furrow method of sowing was demonstrated on selected farmers' fields. Different crops including pigeonpea, black gram, green gram and soybean were grown under this method on 12.2 ha of 31 farmers. All the crops performed better under ridge and

furrow method of sowing and the seed yields were increased by 22% in pigeonpea, 28% in black gram, 39% in green gram and 27% in soybean, compared to farmers' practice.

Further, demonstrations on use of tractor-drawn reversible plough for summer tillage were conducted on 47.4 ha of 31 farmers. Rice cultivation after summer ploughing resulted in significantly higher grain yield (32.5 q/ha) compared to plots without summer tillage.

Ridge and furrow method of sowing

Crop diversification : Rice-wheat system is predominant in the village. Hence, crop diversification was promoted by inclusion of different short-duration pulses, oilseeds and vegetables for minimizing water requirement, enhance soil fertility and farmers' income. All the cropping systems performed better and gave higher net returns compared to rice-wheat system.

Rice crop after summer ploughing

Performance of different cropping systems on farmers' fields

Crop seqence	Net return (₹/ha)	B:C ratio
Rice- wheat	4905	1.24
Rice - chickpea	12449	1.67
Rice-mustard	9469	1.55
Soybean- wheat	11204	1.53
Sesame- chickpea	15404	1.77
Okra- chickpea	40383	2.06
Lobia- mustard	41553	2.40
Greengram- musard	25328	2.66

Introduction of short-duration (drought tolerant/frost escaping) varieties: Short-duration varieties of different crops were cultivated on selected farmers' fields. All the varieties performed better than local checks.

Performance of different varieties on farmers' fields

Crop	Variety	Area (ha)	% increase in yield over check
Rice	JR-201, Sahbhagni	30.5	39.9
Backgram	PU-31	6.5	19.0
Greengram	Samrat	11.8	36.8
Soybean	JS-9560	5.8	25.6
Pegionpea	ICPL-88039	12.8	13.7
Sorghum	JJ-1041	6.7	15.1
Wheat	JW-17, Amrita	40.3	50.2
Chickpea	JG-16, JG-11	39.8	40.1
Mustard	Pusa Tarak	17.2	27.2
Total		**171.4**	

Badmal, Sonepur, Odisha

Name of village : Badmal
District : Sonepur
No. of households : 80
Total cultivated area : 102 ha
Major soil types : Red and yellow soil
Mean annual rainfall : 1418 mm
Major crops : Rice, pulses and oilseeds
Climatic vulnerability : Floods in lowlands, dry spells during monsoon
Major interventions : Short duration varieties, bio-intensive pest management

Climatic Vulnerability

Sonepur is one of the drought prone districts of Odisha . The village Badmal is located at a distance of 25 km from the district headquarter. Rice is the major *kharif* crop but most of the crop area gets affected due to drought which generally occurs at the critical stages (reproductive stage) i.e from September to October. Sometimes, early season drought occurs due to delayed onset of monsoon. During *kharif* 2010, about 80 ha of cultivable land in the village was affected by drought. The extent of loss was about 40-45% as there was no rain up to end of July and after 15th September.

Groundnut as alternate crop

Interventions

***Introduction of drought tolerant short duration varieties*:** High yielding short duration rice varieties 'Khandagiri' and 'Lalata' were grown on selected farmers' fields. These varieties escaped the late season drought that occurred after September 15th. Integrated pest management including use of pheromone traps was followed for management of different insect-pests and diseases. Both the varieties performed better and gave 36.4 and 22.3% higher grain yield, respectively compared to local check.

***Promotion of alternative crops to rice*:** Demonstrations were conducted on cultivation of alternate crops like green gram ('Durga'), groundnut ('Smruti'), cowpea ('Utkal manic') and maize ('MH-9468'). Improved varieties of cauliflower ('Damini'), cabbage ('Golden acre'), tomato ('Utkal kumar') and brinjal ('Sufala') were also introduced for cultivation. Insect-pests were managed by using pheromone traps and need based application of chemical insecticides. The yields of different vegetables increased by 26-37% due to adoption of improved cultivation practices compared to farmers' practice.

***Rainwater harvesting*:** Rainwater harvesting was done through construction of different structures like percolation ponds (20), farm ponds (2), and renovation of 3 water harvesting structures. This has resulted in increase in water table in open wells enabling farmers to protect their crops during mid-season droughts.

Kanti, Tikamgarh, Madhya Pradesh

Name of village	: Kanti
District	: Tikamgarh
No. of households	: 242
Total cultivated area	: 241 ha
Major soil type	: Alfisols
Mean annual rainfall	: 1000 mm
Major crops	: Soybean, blackgram wheat and mustard
Climatic vulnerability	: Drought
Major interventions	: *In-situ* moisture conservation, short duration varieties

Climatic vulnerability

The district has been suffering from drought since last five years. Recently, the rainfall pattern has also changed with long dry spells and early withdrawal of monsoon. More than 90% of cultivated area in the village is rainfed and soybean is a major *kharif* crop.

Interventions

***In-situ soil moisture conservation through ridge and furrow method of soybean cultivation*:** Soybean planting through boradcasting is common in the village. This is one of the major causes for low yields. Suitable land configuration helps in enhancing the time of concentration, absorption and storage of rainwater in soil. Hence, demonstrations on ridge and furrow method of soybean sowing were conducted on 50 ha involving 124 farmers. This method of sowing gave about 30% higher yield and an additional income of ₹ 12150/ha compared to farmers' practice. Presently, almost 60% increase in area was found under line sowing and ridge and furrow method of sowing in soybean.

Ridge and furrow method of soybean cultivation

***Deep ploughing during summer for in-situ moisture conservation*:** Most of the farmers in the village have discontinued the practice of deep ploughing during summer for various reasons. This is also one of the reasons for crop failure. Hence, trials were laid out to demonstrate the advantages of deep ploughing during summer such as *in-situ*

moisture conservation, reduction in weed infestation, diseases and insect-pests and increase in yield. Demonstrations were conducted on 27.6 ha by involving 31 farmers. The following observations were recorded:

- Water saving was up to 25-30%
- Better *in-situ* moisture conservation and pest control
- Soybean yields increased by 10.5% compared to farmers' practice
- More farmers are coming forward to adopt the technology

Summer ploughing for *in-situ* moisture conservation

Zone - VIII

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Bilakundi, Belgaum, Karnataka

Climatic Vulnerability

The district of Belgaum is located east of the Western Ghats and is situated in the northwestern part of Karnataka. The district experiences pleasant winters and hot dry summers. The entire district except the south-western part is categorized as semi-arid and drought prone. More than 70% of cultivated area in Bilakundi village is rainfed. The major climatic vulnerability of the village is drought.

Name of the village : Bilakundi
District : Belgaum
No. of households : 419
Total cultivated area : 998 ha
Major soil types : Red and black soils
Mean annual rainfall : 439 mm
Major crops : Sugarcane, maize, groundnut and pigeonpea
Climatic vulnerability : Drought
Major interventions : Rehabilitation of barren lands

Interventions

Rehabilitation of barren lands: A massive effort has been made to cover over 130 ha of barren land (which is highly undulated and not fit for crop production) to convert into a horti-pasture block by digging trench cum bunds across the slope in this area. This is being supported by developing an irrigation system by which water is being lifted to a specially constructed tank located at the highest elevation. This water is redistributed using drip irrigation system under gravity. Currently, water is being sourced from a perennial open well located beside a passing canal. The static storage capacity of this well is about 1000 m^3 of water. Water from this well is lifted to a cemented tank of dimension 20 m x 10 m x 2 m having a capacity of 400 m^3 which is located at a vertical elevation of 60 m through a pipeline of 1.5 km. Water is pumped using 10 hp motor which provides discharge of 6 lps. The irrigation system has been designed such that it could operate at the pressure equivalent to 2-8 m gravity. The designed irrigation system is sufficient to irrigate about 5000 saplings at the spacing of 10 m x 10 m. Farmers have come forward to take up plantation of mango and sapota in this area. Due to poor monsoon during the two consecutive years, the planting is progressing slowly.

Trench cum bunds dug across barren lands

S. Raghuttahalli, Chikkaballapur, Karnataka

Climatic Vulnerability

Chikkaballapur is one of the drought prone districts of Karnataka. The annual average rainfall of the district is 750 mm. S. Raghuttahalli is about 60 km away from the district headquarters and the annual rainfall of the village is 590 mm. Late onset of monsoon coupled with intermittent dry spells during crop season is the common problem. The village received about 684 mm of rainfall during 2011-12.

Name of the village : S. Raghuttahalli
District : Chikkaballapur
No. of households : 251
Total cultivated area : 154.27 ha
Major soil types : Red sandy loam
Mean annual rainfall : 590 mm
Major crops : Finger millet, pigeonpea, groundnut, onion and maize
Climatic vulnerability : Drought
Major interventions : Short duration varieties, intercropping system, farm ponds

Interventions

***Cultivation of short duration crop varieties*:** Cultivation of traditional local cultivars is still predominant in the village. Hence, short duration varieties of finger millet, pigeonpea and groundnut were introduced for cultivation. The demonstrations were conducted on 27 ha of different farmers. Similarly, demonstrations on intercropping finger millet and groundnut with pigeonpea were conducted on 54 ha. The outcome of these demonstrations is presented below.

Performance of short-duration varieties of different crops

Intervention	Technology demonstrated	Area (ha)	Yield (q/ha)		Yield increase (%)
			Demo	Local	
Introducing short / medium duration varieties	Short duration variety of pigeonpea (BRG-1)	8.0	14.5	11.3	28.4
	Short duration variety of pigeonpea (BRG-2)	9.6	12.6	10.4	21.0
	Production technology of Groundnut (KCG-2)	6.0	8.4	6.5	30.0
	Production technology of finger millet (KMR-204 / GPU-28)	15.6	15.1	12.0	26.0

***Rainwater harvesting and utilization*:** Eight farm ponds and 13 percolation ponds were dug in the village depending upon the farmers' need and runoff harvesting potential. Most of the farm ponds were filled with rainwater during *kharif* 2011. The rainwater collected in the farm ponds was effectively utilized for providing protective irrigation to high value crops. One such example in the project village is Mr.Padala

Farm pond

Tomato cultivation using farm pond water

Nanjundappa, who cultivated tomato on half acre by utilizing rainwater harvested in farm pond through protective irrigation once in a week. He also availed the facility of custom hiring center in the village for hiring water lifting pump to irrigate the plot. The farmer earned a net income of ₹ 28000 from tomato cultivation on half acre.

Siddanuru, Davanagere, Karnataka

Climatic Vulnerability

The village comes under the Central Dry Zone (Zone-4) of Karnataka with hot climatic conditions during March to May. The average rainfall is 653 mm and soils are red with good drainage. The major problem faced by the farmers is drought. The main source of water is rainfall and some farmers have tube wells.

Name of the village : Siddanuru
District : Davanagere
No. of households : 205
Total cultivated area : 357.9 ha
Major soil types : Red soils
Mean annual rainfall : 653 mm
Major crops : Maize, cotton, arecanut, banana and tomato
Climatic vulnerability : Drought
Major interventions : Rainwater harvesting, mulching, intercropping, sheep rearing

Interventions

Enhancement of water and crop productivity: Demonstration of *in-situ* moisture conservation through mulching and sprinkler method of irrigation in arecanut was taken up on selected farmers' fields (1.5 acre). Mulching with sugarcane trash helped in efficient soil moisture conservation, less weed infestation and required less number of irrigations (25-days interval). An additional income of ₹ 25000 was generated through these interventions.

Mulching in arecanut

Further, during October-November, planting of tomato, cucumber, brinjal, ragi and fodder crops was taken up on 0.8 ha by using tube well water and irrigation was provided through sprinklers. The farmers earned an additional income of ₹ 50000 from these crops. More farmers are being encouraged to avail the subsidy provided by the Horticulture Department for adoption of sprinkler systems.

Sheep under controlled grazing

***Introduction of new sheep breed*:** Farmers usually purchase local breed of sheep from nearby market for rearing. However, the body weight gain in this breed was poor resulting in less income. Hence, two rams (12-14 months old) and one lamb (5 months old) of 'NARI Suvarna' breed were purchased and

introduced in the village. One ram each was given to 2 farmers and were asked to maintain 20 females with the NARI Suvarna ram and instructed not to mix the herd with other males.

***Rainwater harvesting*:** Six farm ponds were dug on selected farmers' fields and the ponds were filled with rainwater during *kharif* 2011. Fisherlings have been released in the ponds for additional income generation. The harvested water is being used for providing supplemental irrigation to different crops. Further, about 50 tube wells near the farm ponds are expected to benefit through groundwater recharging. Similarly, trench-cum-bunding was completed on 30 ha belonging to 40 farmers for *in-situ* rainwater harvesting.

Farm pond

Trench-cum-bunding

***Custom hiring centre for farm mechanization*:** Farm mechanization was very poor in the village resulting in higher cost of cultivation, farm operations not done on time and lower productivity. Hence, a custom hiring centre was established in the village by procuring rain gun, sprinklers, seed-cum-fertilizer drill, spades etc. An income of ₹ 20000 has been generated through hiring of different farm implements.

Vadavathur, Namakkal, Tamil Nadu

Climatic vulnerability

Vadavathur Village in Erumaipatty Block of Namakkal district is a drought prone village with annual rainfall of less than 400 mm. The mean maximum and minimum temperatures are 46 and 12^{0}C. Undulating and slopy lands have aggravated the drought condition due to non-percolation of rainwater in the catchment and water storage areas. This has led to monocropping (October to January) during north-east monsoon.

Name of the village : Vadavathur
Name of the district : Namakkal
No. of Households : 869
Total cultivated area : 525 ha
Major soil type : Sandy loam
Mean annual rainfall : 400 mm
Major crops : Onion and groundnut
Climate vulnerability : Drought
Major intervention : Farm ponds, drought tolerant groundnut varieties, custom hiring centre

Interventions

***Rainwater harvesting*:** Two community ponds namely Senguttai (1.2 acres) and Ayiram kuttai (1.5 acre) were desilted, repaired and inlet channels were cleaned for rainwater harvesting during rainy season. This helped in recharging 22 bore wells, 10 open wells and increased water table by 6 to 8 feet. In addition, farm ponds were dug on two farmers' fields and lining was done with HDPE 200 GSM plastic sheets. As a result, the area under onion cultivation increased by 50%. Further, fish culture in farm ponds gave an additional income of ₹ 5000 per catch.

HDPE lined farm pond

***Cultivation of drought tolerant groundnut varieties*:** Intercropping of drought tolerant groundnut varieties (CO-6 and TMV-13) with pigeonpea was demonstrated on 6 ha of 10 farmers. The groundnut yield from demonstration plots was higher by 400 kg/ha compared to check plots.

***Management of tip drying in onion*:** Onion, the major commercial crop in the area, is prone to tip drying due to fall in night temperature (14^0C - 12^0C) during late December to early February. A low cost technology to prevent the dew drops by using mobile sprinkler was demonstrated and put into practice on 14 ha. The onion yield improved by 1350 kg/ha due to prevention of tip drying in addition to saving of about ₹ 2000/ha on pesticides and fungicides for control of tip drying.

***Genetic improvement of small ruminants*:** Telicherry male goats (8 nos) were released to 12 flocks for genetic upgradation of native Salem black goat. Similarly, NARI Swarna males (4 nos) and 3 eves were introduced for genetic improvement of native sheep.

Introduction of improved poultry birds: Improved chicks 'Namakkal Chicken-1' were provided to 23 selected farmers. The egg laying capacity of these birds range from 160-200/year compared to 60 eggs/year by local birds. The hatchability rate is also higher in these birds (65%) compared to local birds (45%).

***Custom hiring centre*:** The custom hiring farm implements unit has been a success in the village. The farmers' group has purchased a tractor in the village and a net profit of ₹ 78,395 has been generated through hiring of different implements and tractor.

Tractor drawn implements for farm mechanization

Kalari, Ramanathapuram, Tamilnadu

Name of the village : Kalari
District : Ramanathapuram
No. of households : 150
Total cultivated area : 405 ha
Major soil types : Sandy loam & clay loam
Mean annual rainfall : 850 mm
Major crops : Paddy and chilli
Climatic vulnerability : Drought
Major interventions : Seed treatment, supplemental irrigation

Climatic Vulnerability

Drought is the major climatic challenge in the village. Agriculture in this village is mainly dependent on the north-east monsoon and the water available in the kalari tank.

Interventions

***Management of early season drought in semi-dry rice*:** Paddy is the major crop cultivated in this village in an area of 309 ha. Dry sowing of paddy is practiced in the village. Hence, delay or failure of monsoon results in poor germination and early mortality of seedlings, leading to poor crop stand and low yield. Hence, intervention on management of early season drought in semi-dry rice was demonstrated with seed hardening (1% KCl) and supplemental irrigation through mini portable sprinkler. The crop performance was better and 45% higher grain yield was recorded compared to check. About 60% of rice growers have come forward to adopt the technology during ensuing season.

Effect of seed hardening and supplemental irrigation on rice yield and economics

Yield (kg/ha)		Yield increase (%)	Gross return (₹/ha)		BCR	
Demo	Local		Demo	Local	Demo	Local
5280	3630	45.4	52800	36300	3.1	2.2

Sprinkler irrigation in direct seeded rice

Durgada Nagenahalli, Tumkur, Karnataka

Climatic Vulnerability

Durgada Nagenahalli falls under central dry agro-climatic zone of Karnataka with an average rainfall of 690 mm. The major climatic vulnerabilities of the village are drought and extreme temperature. The village is characterized by acute shortage of water, soil erosion and preponderance of wastelands and common lands.

Name of the village	: D. Nagenahalli
District	: Tumkur
No. of households	: 269
Total cultivated area	: 190 ha
Major soil types	: Red loamy soils
Mean annual rainfall	: 696 mm
Major crops	: Finger millet, maize, groundnut and mango
Climatic vulnerability	: Drought and poor soil health
Major intervention	: Rainwater harvesting, drought tolerant ragi varieties

Interventions

Cultivation of drought tolerant variety of ragi ML-365: To cope with early season drought, demonstration of ML-365 cultivation was conducted on 20 ha belonging to 70 farmers. Seedlings of 'ML-365' were raised in nursery and transplanted after 25 days with the onset of rainy season. The performance of the variety was significantly superior to local varieties. The farmers have retained the seed and also shared with fellow farmers for sowing in the ensuing season. The salient characteristics of the variety ML-365 are:

- Short duration (about 105 days)
- Medium plant height
- High yielding (grain and fodder) due to more panicles and grain filling
- Tolerant to drought
- Resistant to leaf spot, neck blast and lodging
- Good cooking quality
- Suitable for dryland agriculture and late sowing (transplanting)
- Requires low seed rate (5 kg/ha)

Ragi Local

Ragi ML-365

Similarly, short-duration and high yielding varieties of maize, pigeonpea, tomato, chilli etc. were cultivated on selected farmers' fields.

Crop/variety	Area (ha)	No. of farmers	% yield increase over check	Varietal character
Maize (NAH 1137)	3	10	21	Drought tolerant, resistance to leaf blight, downy mildew and rust
Groundnut (GPBD 4)	8	25	19	Tolerant to foliar dieases
Pigeonpea (BRG 2)	6	30	25	Suitable for late sowing under rainfed conditions
Aerobic rice (MAS 26)	1.5	5	-	Tolerant to drought
Tomato (Arka Meghali)	3	20	16	Tolerant to drought
Chilli (Arka Lohit)	1	6	15	Tolerant to drought, multiple diseases and pests

Soil and water conservation: Land leveling and compartment bunding was demonstrated on 5 ha involving 15 farmers for soil and water conservation. This resulted in higher paddy and ragi yields (15-20%) compared to check plots. Trech-cum-bunding was done on 80 ha involving 100 farmers' fields and seedlings of forest trees were planted on the bunds. Similarly, other low-cost interventions like ploughing across the slope and contour bunding were demonstrated on 15 ha which benefitted 40 farmers. Tank silt application was done on 20 ha of 25 farmers for improving water holding capacity and productivity of soils. As a result, the yield of rainfed finger millet was increased by 32% compared to control plots.

Trench-cum-bunding

Finger millet with tank silt application

Finger millet without tank silt application

Rainwater harvesting: About 52 farm ponds with different dimensions (30x20x2m, 20x20x2m and 20x10x2m) were dug with total water storage capacity of 41000 m^3. Eleven percolation ponds were constructed with water storage capacity of 4500 m^3. Five check dams were constructed with water storage capacity of 3000 m^3. The runoff channels of village tank were desilted, widened and leakage was plugged resulting in an additional 150000 m^3 rainwater storage capacity.

Farm pond

Structure	Number	Farmers benefited	Water storage capacity (m^3)	% increase in cropping intensity
New farm pond	52	120	62800	100
Renovation of farm pond	14	32	68040	150
New check dam	5	18	5300	100
Renovation of check dam	6	16	2200	100

Promoting farm mechanization through custom hiring centre: An area of around 80 ha was serviced by the equipments of the custom hiring centre where in the cost saving on account of labour ranged between 30-50%.

Tree plantation: Tree planting was taken up on degraded ridge lands in the village. In order to ensure better survival rate, the planting was done on the bunds after digging trenches in the entire area. Nearly 80 ha area was brought under the cover of plants by involving over 100 farmers. Block plantation of *Melia dubia* and *Acacia auriculiformis* were also established. A total of 82,000 plants belonging to fruit and forest species were planted. Nearly, 80% of the plants have survived despite very poor rainfall during the last two seasons. This exercise has created great awareness among the farmers about the role of trees in improving soil and moisture conservation besides helping in carbon sequestration in the long run.

Technology Demonstration Component

Index of Project Villages

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