

# Smart Practices & Technologies

for Climate Resilient Agriculture



NICRA

Central Research Institute for Dryland Agriculture, Hyderabad  
Natural Resource Management & Agricultural Extension Divisions  
Indian Council of Agricultural Research (ICAR), New Delhi

National Initiative on Climate Resilient Agriculture

**SMART PRACTICES & TECHNOLOGIES**  
for Climate Resilient Agriculture

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## FOREWORD

Enhancing the resilience of Indian agriculture to cope with climate variability and climate change is imperative to the livelihood security of millions of small and marginal farmers in the country. Devising appropriate adaptation strategies will enable farmers to cope with various climate risks, promote efficient use of natural resources to bring sustainability to farm production and stability to their incomes. The Indian Council of Agricultural Research (ICAR) has responded to this challenge of climate change on Indian agriculture and launched National Initiative on Climate Resilient Agriculture (NICRA) in 2011. The project has major aim of evolving climate resilient agricultural technologies to address the concerns of projected climate change scenarios in the country and also to demonstrate the best bet practices that can help farmers cope with current climate variability.

Technology Demonstration component is the lifeline of NICRA and is being implemented through Krishi Vigyan Kendras (KVKs) in 100 climatically vulnerable districts of the country. The aim is to build the resilience of the farming community to face extreme weather events such as droughts, floods, cyclones, unseasonal rains, heat and cold wave. Demonstration of appropriate practices and technologies with a climate focus evolved by the National Agricultural Research System (NARS) is taken up in farmer participatory mode in NICRA villages. These practices broadly fall into four modules: natural resource management, crop production, livestock, fisheries, and institutional interventions. The NICRA villages have become hubs of learning on climate resilient agriculture in a short span of three years, opening up opportunities for horizontal and vertical diffusion of the successful experiences in other parts of the districts.

This publication documents the climate resilient practices and technologies that are successful in farmers' fields with potential for up-scaling under the National Mission on Sustainable Agriculture (NMSA) and other such programmes. Some of the adaptation technologies have potential co-benefits to contribute towards reduction in emissions.

I compliment all the NICRA farmers and KVKs for their excellent field work and the entire NICRA team for compiling smart practices and technologies for climate resilient agriculture in the form of a publication. Mainstreaming these practices under NMSA will go a long way in transforming Indian agriculture into a climate resilient production system.

**Dated the 25th July, 2014**  
**New Delhi**

**(S. AYYAPPAN)**



## PREFACE

The National Initiative on Climate Resilient Agriculture (NICRA) is a multi-institutional, multi-disciplinary network project launched by ICAR in 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and technology demonstrations. Technology Demonstration Component (TDC) of NICRA offers a great opportunity to work with farmers to address current climate variability with matching responses. On-farm participatory demonstrations of available technologies are being implemented in 100 most vulnerable districts. Climatic vulnerabilities addressed are drought, flood, cyclone, heat wave, cold wave etc. Interventions include resource conservation practices and technologies for natural resource management, and efficient use of resources and inputs for improved crop, livestock and fisheries production. Realizing the need for support in the form of better access to farm machinery and implements for wider adoption of resilient practices and technologies by farmers, custom hiring centres (CHCs) were established in the NICRA villages. Village climate risk management committees were established to prioritize the interventions, resource allocations and running of village level institutions like CHCs.

The overall focus of technology demonstrations under NICRA is to enhance resilience of farms and the farming community to climate risks so as to ensure sustainability over a period of time. Enhancing resilience is the key to achieve sustainability in agriculture especially in the context of climate vulnerability. Thus the focus is on adaptation to climate variability and entails appropriate responses to contingency situations. Sustainability is the immediate goal in highly intensive production systems facing natural resource degradation. Therefore, the main focus of technology demonstrations in such regions is not on enhancing productivity but on interventions related to coping with vulnerability as well as improvement in natural resource use efficiency for sustaining the productivity gains already achieved.

This publication attempts to capture and highlight some of the key interventions that were successful in participatory demonstrations and have the potential for further up-scaling through various Missions under the National Action Plan for Climate Change (NAPCC), especially under the National Mission on Sustainable Agriculture. Technology demonstrations will be expanded to cover more climatically vulnerable districts in the XII plan and we believe that many more resilient practices and technologies to address climate risks will be identified for mainstreaming and further up-scaling.

Authors



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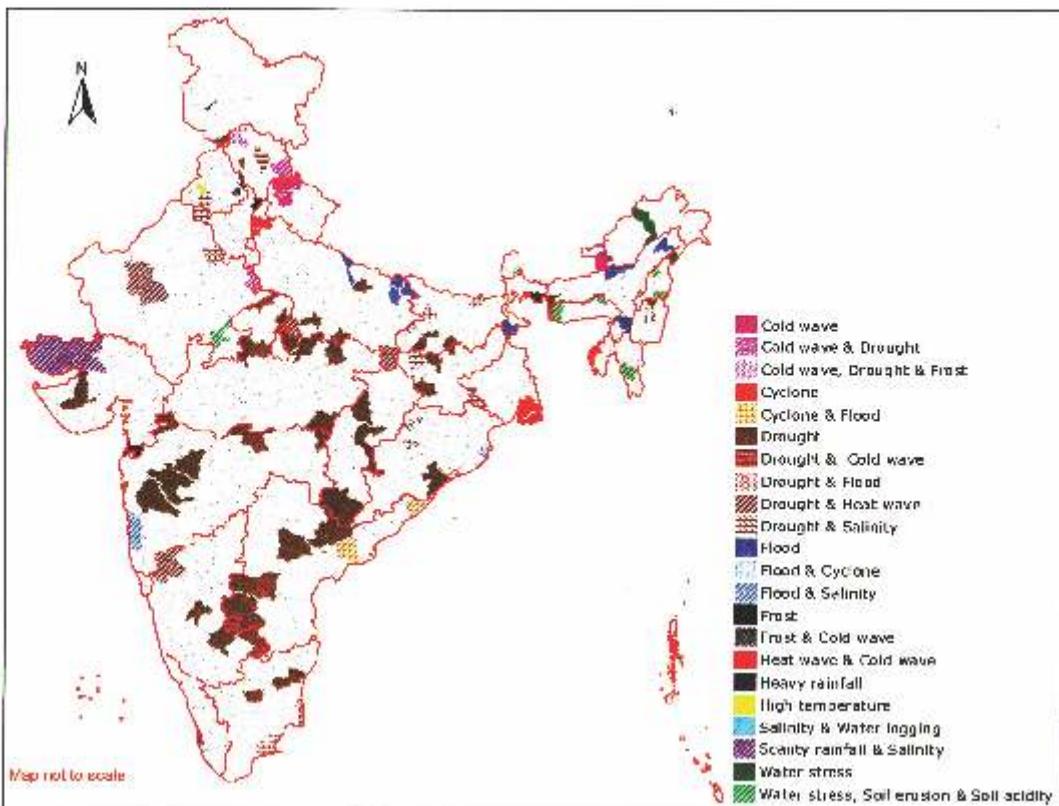
Climate change pertains to increase in atmospheric concentration of carbon dioxide (CO<sub>2</sub>) and global warming. Present day atmospheric CO<sub>2</sub> level hovers around 397 ppm which is a significant increase over the pre-industrial level of 280 ppm. It is anticipated that the concentration level will double by the end of this century (IPCC, 2007). A consequence of increased green house gas (GHG) emissions is the entrapment of heat within the earth's atmosphere leading to an alarming rate of global warming. Global average increase in mean annual temperatures is estimated at 0.8°C till now. An increasing rate of warming has taken place across sampling areas spread across the globe over the last 25 years. For example 11 of the 12 warmest years on record have occurred in the 1996-2005 period (IPCC, 2007). Global mean temperatures are likely to witness significant increase towards the end of this century. Between seasons, warming in the rainy season will be less pronounced than in the winter months in India (IMD, 2010). Another climate change feature significantly influencing agro-ecosystems is the change in seasonal rainfall patterns. Increased frequency in occurrence of extreme weather events such as cyclones, heat wave, cold wave, frost and hail storm over short periods exert adverse influence on crop performance.

Rainfall is predicted to be highly erratic with fewer rainy days but with greater intensity. A combination of higher average annual temperatures and water stress (excess or deficit) can have serious implications for crop production in the tropics. The frequency of occurrence of extreme weather events such as tropical cyclones and heat waves is on the rise (NATCOM, 2004; IPCC, 2007) and compounds the adverse effects on agriculture.

Farmers need to intelligently adapt to the changing climate in order to sustain crop yields and farm income. Enhancing resilience of agriculture to climate risk is of paramount importance for protecting livelihoods of small and marginal farmers. Traditionally, technology transfer in agriculture has aimed at enhancing farm productivity. However, in the context of climate change and variability, farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events. Over the years, an array of practices and technologies have been developed by researchers towards fostering stability in agricultural production against the onslaught of seasonal variations. Adoption of such resilient practices and technologies by farmers appears to be more a necessity than an option. Therefore, a reorientation in technology transfer approach is necessary. Efficiency in resource-use, environmental and social safeguards, sustainability and long-term development of agriculture assume greater importance. Participatory on-farm demonstration of site-specific technologies will go a long way in enabling farmers cope with current climate variability. Such an approach can ensure adaptation gains and immediate benefits to farmers along with possible reduction in GHG emissions and global warming potential of agriculture.

Technology demonstrations under the National Initiative on Climate Resilient Agriculture are currently in operation in 100 vulnerable districts identified based on their exposure to recurrent climatic vulnerability. The goal of technology demonstration component under NICRA is to mainstream some of the successful practices and technologies that promote resilience to climate risk under the National Mission on Sustainable Agriculture (NMSA), other National Missions and on-going government schemes such as Rashtriya Krishi Vikas Yojana (RKVY), Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGP) and National Food Security Mission (NFSM). The aim is to upscale the proven practices in all the vulnerable districts in the country by the end of XII five year plan to make Indian agriculture more resilient to climate variability. This bulletin documents the smart practices and technologies that proved successful and helped farmers cope with climate variability faced during the last three years of project implementation. In the following pages, smart practices and technologies are described in the context of the climate variability addressed along with their impact and application domains for replication and up-scaling in the entire country.

Overall implementation framework was formulated through interactions with all stakeholders by NRM and Extension Divisions of the Indian Council of Agricultural Research (ICAR), the Central Research Institute for Dryland Agriculture (CRIDA) which is the lead centre for NICRA project and 8 Zonal Project Directorates located across the country. Identification of appropriate coping practices and technologies relevant to address specific climatic vulnerabilities was accomplished through interactions with farmers in selected villages by KVKs based on participatory rural appraisal (PRA) and focus group discussions (FGDs). The National Agricultural Research System (NARS) comprising of ICAR and State Agricultural Universities (SAUs) served as the source of proven technologies along with the indigenous technical knowledge (ITK) of participating farmers. Technology needs of farmers fell into four broad categories viz., natural resource management especially rainwater harvesting and efficient use; practices and technologies for efficient crop, livestock and fisheries production, and promotion of village level institutional interventions to rope in communities in the decision making processes.



Map of NICRA project sites in 100 vulnerable districts and climatic constraint addressed

### Institutional framework for implementation of technology demonstrations

Zone	State (s)	#KVKs
I	Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab	12
II	Bihar, Jharkhand, West Bengal, A & N Islands	15
III	Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim, Tripura	17
IV	Uttar Pradesh, Uttarakhand	13
V	Andhra Pradesh, Telangana, Maharashtra	13
VI	Rajasthan, Gujarat	7
VII	Chhattisgarh, Madhya Pradesh, Odisha	14
VIII	Karnataka, Tamilnadu, Kerala	9
	<b>Total</b>	<b>100</b>

Plus implementation at 7 sites by Technology Transfer Divisions of core ICAR research institutes implementing NICRA (IARI, NDRI, CMFRI, CRIDA, IIHR, ICAR RC for NEH and CIAE)



# Rejuvenation of farming in cyclone and flood prone coastal agro-ecosystems through land shaping

**Climate vulnerability :** Floods, Cyclone

The coastal region of West Bengal is ecologically vulnerable to the vagaries of climate variability such as cyclones and floods. These extreme events play havoc with agriculture and livelihoods of farmers. One such event in the recent past was the occurrence of the super cyclone 'Aila' on 25<sup>th</sup> May, 2009. The village Bhongeri of South 24 Parganas district situated close to the brackish water river Matla experienced extreme cyclonic weather and ingression of saline water into cultivable areas rendering the fields saline and unfit for farming. Reclamation of saline affected fields is a slow process and the problem of salinity continued to persist even after 2-3 monsoon seasons.

### Existing practice

Farmers in this village predominantly practice paddy-fallow cropping system. The low lying village suffers from inundation of paddy fields up to 3-4' of rainwater which is a recurrent problem during the monsoon season due to high rainfall (1600 to 1800 mm) and use low yielding deep water paddy varieties. During the *rabi*-summer season, scarcity of water for irrigation and soil salinity are the main problems limiting the possibility of a second crop.

### Resilient practice / technology

**Land shaping for rainwater harvesting, utilization & integration of farm enterprises:** In order to overcome submergence during *kharif*, salinity problem in *rabi* and augment availability of irrigation water during the *rabi*-summer season, an engineering solution was promoted by the KVK, Nimpith. About 20% area in selected lowland fields was excavated up to 8-9 feet depth. This dugout pond was used for harvesting rainwater. The excavated soil was spread over the adjacent field area (80%) so as to raise the field level up to 1 to 1.5 feet and also to raise the field border embankments of land (3' H x 5' W) and pond (4' H x 5' W). On the elevated main field, paddy was cultivated during *kharif*. Vegetables could be grown during the *rabi*-summer in the main field, also on land and pond embankments. Fish and duck rearing were introduced in the harvested freshwater in the pond. Thus, this technology of land shaping offered a model for harvesting rainwater in *kharif*, vegetable cultivation during *rabi* and fresh water fish culture in the ponds. Monocropped land (98% paddy and 2% vegetables) got converted into a diversified land (92% paddy and 8% vegetables) enhancing productivity and reducing risk. The intervention was initially taken up in 10 farmers' fields at a cost of Rs 40000-50000 (approx.) for 20 m x 20 m size of pond.

Sri Ananta Naskar is one such farmer who took up the intervention in his paddy field (0.266 ha) which suffered from inundation during the rainy season seriously affecting his income from monocropping of low yielding traditional deep water paddy varieties (Sabita, 155 days). Adoption of land shaping treatment facilitated taking up of short duration high yielding varieties of paddy in *kharif* and a second crop of vegetables such as okra, chillies, tomato and brinjal during the *rabi*-summer season. Harvested rainwater in the dugout pond was used for fish & duck rearing and to provide irrigation to vegetable crops. Seeing the benefits of the technology, several farmers in the village came forward to adopt the technology in the succeeding year. An alternative for resource poor farmers owning vulnerable farms is adoption of 'ail' or embankment cultivation which involves raising an embankment all around a low lying field with soil excavated by digging a field drainage channel all around. Vegetable crops are raised on the land embankment area which otherwise was impossible in low lying fields and also the practice helps in overcoming the salinity problem affecting crops in the *rabi*-summer season.

### Impact of land shaping, rainwater use and crop diversification

Before land shaping treatment, monocropping of low yielding long duration deep water paddy variety was cultivated which gave a return of Rs.3100 from 0.266 ha (Rs.11650/ha). Land was kept fallow in *rabi* due to late release of land from inundation and water scarcity for irrigation.

Cost of land shaping treatment (dugout pond with embankment, raising the level of main field and land embankment with excavated soil) is approx. Rs.40000 - 50000.

After land shaping treatment, the farmer cultivated short duration high yielding variety of paddy (Shatabdi) (in 0.17 ha area of main field with a net income of Rs.2800) and diversified with other crops such as okra on land embankment (in 0.17 ha, Rs.1600 net income), ridge gourd on pond embankment (in 0.011 ha, net income Rs.3850) during *kharif*. Bottle gourd was raised on pandals which gave a net income of Rs.3050. *Kharif* income shot up to Rs.11300 from 0.198 ha.

Early release of main field for *rabi* crop allowed cultivation of tomato (in 0.17 ha, net income Rs.19300), french bean on land embankment area (in 0.017 ha, net income Rs.1400), bitter melon on pond embankment (0.011 ha, net income Rs.4150) and aerial cultivation of bottle gourd (Rs.3350). Additional income from *rabi* season was Rs.28200. Income from fish & duck rearing in the dugout pond (0.05 ha) was Rs.8300.

Total income from both the seasons by Sri Ananta Naskar of Bhongeri village jumped from a paltry sum of Rs.3100 from 0.266 ha to Rs.47800.

Seven other farmers who took up land shaping, rainwater harvesting and enterprise diversification in 1.74 ha area realised a net income of Rs 143105 during 2012-13.

In 2013-14, raising of land embankment and cultivation of vegetables on the 'ail' by 24 farmers in 7.26 ha area, gave additional return of Rs 60200/ha.



Before land shaping treatment in Bhongeri village



Dugout pond for rainwater harvesting and preventing inundation of main field



Cultivation of paddy on raised main field and vegetables on embankment during *kharif* season



Cultivation of vegetables in main field and on embankments during *rabi* season

### Scope for upscaling

Coastal region of West Bengal, Odisha, Andhra Pradesh & Tamil Nadu.

# Community paddy nursery as a contingency measure for delayed planting

**Climate vulnerability :** Drought

## Existing practice

Transplanted paddy is cultivated in the lowlands of Bihar. Paddy is often the only option available to farmers in the lowlands as it can withstand water stagnation due to high rainfall unlike other crops. Farmers' raise nursery of long duration paddy varieties (150 days) after the onset of monsoon in mid June. Seedlings of 20-30 days age are transplanted in July so as to complete flowering of photosensitive varieties before October and harvesting by mid November to facilitate taking up of timely sowing of *rabi* crops such as wheat, mustard, lentil, chickpea/vegetable. Such a practice ensures optimum performance of both *kharif* and *rabi* crops. However, Bihar experienced aberrant rainfall situations in 5 out of the previous 10 years impacting adversely rice production and livelihood of farmers. It appears that failure of rain in July is responsible as transplantation of paddy is delayed with resultant adverse affect on productivity and a cascading negative impact on *rabi* crops. Delay in transplanting of paddy affects productivity as over aged seedlings suffer from low tillering ability. Farmers' preference for long duration varieties is overwhelming and often wait for transplanting in lowlands till end of August in anticipation of rains. The existing practice has led to abandoning of nurseries and vast areas remained un-transplanted in several rainfed districts in South Bihar due to deficit rainfall in *kharif* 2013 season. Failure to transplant also creates an additional problem of shortage in fodder in the slack season for livestock which contributes up to 45% of total agricultural income in Bihar.

## Resilient practice / technology

**Establishment of community paddy nursery:** Establishing a staggered community nursery was explored as a local adaptation strategy at the village level to combat the problem experienced by farmers during deficit rainfall seasons in lowlands. The technique involves raising a staggered community nursery under assured irrigation in the village at an interval of 2 weeks. In the anticipation of a two weeks delay in monsoon the first nursery is taken up as a contingency measure by 15 June with the long duration variety (>140 days) in order to transplant 3-4 weeks old seedlings by first fortnight of July. If the monsoon delay extends by 4 weeks, the second nursery is raised with medium duration varieties (125-135 days) by 1st July to supply 3-4 weeks old seedlings for transplanting in the 3<sup>rd</sup> or 4<sup>th</sup> week of July. In case of anticipation of further delay or deficit rainfall conditions, the 3<sup>rd</sup> nursery is raised by mid July

with short duration varieties (<110 days) to take up transplanting of 3-4 week seedlings in the first fortnight of August.

During 2012 *kharif* season, KVK, Saran implemented this strategy and demonstrated the concept of community nursery in Affaur village. Farmers adopted this technique and jointly produced seedlings to ensure timely transplanting of correct age seedlings for higher productivity and reduce the risk associated with deficit/delayed onset of monsoon.

During *kharif* 2013 traditional paddy nurseries were taken up by the community with staggered sowings on 15<sup>th</sup> June, 1<sup>st</sup> & 15<sup>th</sup> July. However, due to scanty rainfall (-70% of normal) transplanting could not be taken up in July and the first two nurseries were abandoned and the seedlings were used for fodder purpose. Only the seedlings from the 3<sup>rd</sup> nursery (short duration varieties Prabhat and Turanta dhan) could be used for transplanting in August after receipt of rain.

### **Impact of community nursery technique**

In Affaur village of Saran district (Bihar) community mat nursery of paddy with long duration variety (Sarayu-52), medium duration variety (Rajendra Bhagwati & Sahbhagi) and short duration variety (Prabhat & Turanta dhan) were taken up on 15<sup>th</sup> June (1<sup>st</sup> nursery), 1<sup>st</sup> July (2<sup>nd</sup> nursery) & 15<sup>th</sup> July (3<sup>rd</sup> nursery), respectively each in 10 farmers fields.

The total cost of cultivation ranged from Rs.29,270 to Rs.33,335/ha. Grain yield obtained was in the range of 25 q/ha using seedlings from first nursery for transplanting, 30 q/ha with seedlings from second nursery and 35 q/ha with seedlings from third nursery in 2012 season. Highest net returns of Rs.13,164 and benefit cost ratio of 1.39 was obtained by transplanting of seedlings from third nursery in this season.

In 2013-14, the village experienced deficit rainfall situation in July and first fortnight of August. Community nursery was demonstrated on 12 ha covering 36 farmers. Farmers could take up transplanting using seedlings from the 3<sup>rd</sup> nursery raised on 15 July. These farmers' benefitted with an additional yield of 4-5 q/ha (13% increase in yield) compared to farmers who transplanted over aged seedlings in August.

In Bihar, State Department of Agriculture has launched a scheme for promoting farmer managed community nurseries under assured irrigation to make available paddy seedlings for transplanting to meet contingent situations. Under the scheme, a community nursery in 5 acres/panchayat and 150 acres in each district is taken up. The subsidy for each nursery given to the farmer is Rs.6500/acre to cover the cost of production and Rs.1000/acre to farmers for purchasing of seedlings for transplanting in 10 acres from 1 acre of nursery. The total amount supported by the department for 1 acre of community nursery worked out to Rs.16,500. It is suggested to promote community nursery with short duration varieties in the event of deficit rainfall situation in July as being experienced in several districts in Bihar in recent years.



Preparation for mat nursery



Community mat nursery  
(Sahbhagi dhan variety, 2012-13)



Community nursery in Affair village (2013-14)

### Scope of upscaling

Community nursery was demonstrated in 565 ha covering 1274 farmers farmers in Ropar(Punjab); Saran, Jehanabad, Nawada, Saran (Bihar); Chatra, Gumla, Koderma (Jharkhand); Umain, Ri-bhoi (Meghalaya); Linglei (Mizoram); Dhubri (Assam); Sonapur (Odisha); Dantewada (Chhattisgarh); Gondia, Sonbhadra (Uttar Pradesh); Valsad (Gujrat); Datia (Madya Pradesh) with an yield advantage ranging between 9.4 to 80.2% and benefit cost ratio of 1.4 to 5.1 compared to farmers' practice.

# Direct seeded rice for promoting water use efficiency

**Climate vulnerability :** Drought

## Existing practice

In the North-Western Indo-Gangetic Plains (IGP), transplanted rice is predominantly cultivated. Transplanting requires at least 25 ha-cm of water for puddling operation, which creates a dense clay layer in the sub-soil to prevent seepage losses. The crop requires about  $130 \pm 10$  ha-cm of irrigation in addition to adoption of suitable variety and application of recommended dose of fertilizers to realize yield levels of about  $6 \pm 2$  t/ha. Generally, about 40% of all irrigation water goes to paddy cultivation in the region. It is estimated that flooded rice fields produce about 10% of global methane emissions. Also, injudicious use of nitrogenous fertilizers is a common feature in paddy cultivation which is a source of nitrous oxide emissions. In Punjab, farmers generally take up transplanting of coarse rice. The current practice of excessive exploitation of ground water has led to a decline in the quality of natural resources i.e. land and water.

## Resilient practice / technology

Researchers have developed suitable direct seeding alternatives to transplanted paddy. In direct seeded rice (DSR) cultivation, raising of nursery for transplantation is done away with. Farmer can avoid the major problem faced in Punjab i.e., labour shortage for transplanting due to peak demand. In case of delay in monsoon or shortage of water, DSR gives the farmer flexibility to take up direct sowing of paddy with a suitable duration variety to fit into the left over season. This allows timely sowing of the succeeding *rabi* wheat. Direct sown rice consumes relatively less water compared to transplanted flooded rice. Energy demand for pumping of irrigation water is also less and saving can be much higher during deficit rainfall situations compared to transplanted rice. Direct sowing can be practiced for cultivating both coarse rice and basmati rice wherever feasible in the North-West IGP region.

***Direct seeded rice in un-puddled field to cope with water shortages:*** Direct seeding of drought tolerant varieties of rice in dry soil is done in June with pre-emergence herbicide application (pendimethalin 1 kg/ha) under sufficient soil moisture conditions followed by a post-emergence herbicide application (bispyribac sodium 25g/ha) at 25-35 days after sowing or hand weeding at 35-45 days after sowing to effectively manage weed problem. Direct seeding in moist field with receipt of rains in June or by using ground water along with the application of pre-emergence herbicide is another option attempted. Control of weeds by use of glyphosate followed by zero till direct seeding of rice after one day of herbicide use is also practiced. In Bihar, direct seeding of medium duration varieties (125 days) can be done

during second fortnight of July in midlands followed by a post-emergence herbicide application. In uplands, direct seeding of rice can be taken up with the onset of monsoon rains. Direct seeding of rice is done with a zero till drill. The quantity of seed required is 20-25 kg/ha compared to transplanted paddy which required 60-80 kg/ha.

### Impact of direct seeded rice

Gurpreet Singh of Pindi Blochan village, Faridkot district in Punjab practices rice-wheat cropping system in about 32 acres (12 own and 20 acres on lease). After exposure to NICRA project activities he showed interest in direct seeding of rice. Initially he could not take up direct seeding of coarse rice due to rains. For the first time he cultivated Basmati rice in 5 acres adopting direct seeding practice and traditional transplanted coarse rice in another 15 acres. Average yield of direct seeded basmati rice was 51 q/ha while that of transplanted coarse rice was 46.3 q/ha. With DSR he saved about Rs 3000 - 4000 per hectare in labour cost and irrigation water (less by 7 irrigations). However, he had to spend on herbicide applications. In 2013-14 season, he doubled the area under direct seeded basmati rice.

DSR with reduced tillage is an efficient resource conservation technology that holds great promise in the Indo-Gangetic Plains in view of the following advantages:

- Saving in water up to 25% in DSR
- Saving in energy up to 27% of diesel as pumping energy is saved for field preparation, nursery raising, puddling and reduced frequency of applying irrigation water
- Saving of 35 to 40 man days / ha
- Enhanced fertilizer use efficiency due to placement of fertilizer in the root zone
- Early maturity of crops by 7-10 days helps in timely sowing of succeeding crops
- Reduction in methane emissions and global warming potential
- Little disturbance to soil structure
- Enhanced system productivity

### Scope for upscaling

Direct seeded rice is relatively more popular in the rainfed rice growing states like Chhattisgarh. There is scope to upscale the technology in the north-west Indo-gangetic plains to promote higher water use efficiency and also in rainfed rice growing areas in Odisha and Andhra Pradesh.



Direct seeding in dry soil



Crop stand after sowing



Low water use in DSR compared to flooded rice



Direct sown rice at maturity stage

# Drum seeding of rice for water saving and timeliness in planting

**Climate Vulnerability:** Drought

### Existing practice

Farmers cultivating transplanted rice in irrigated and rainfed areas are increasingly faced with water shortages due to deficit rainfall, declining groundwater table due to insufficient recharge, late and limited release of irrigation water from canals or poor inflows into tanks. Land preparation for nursery and main field require copious amounts of water and involve labour for nursery raising of seedlings and subsequent transplanting. Water shortage at the transplanting time leads to delay and use of over aged seedlings with limited tillering capacity. Farmers' face these situations during *khariif* season in NICRA villages in Saran, Aurangabad, Jehanabad (Bihar), Koderma (Jharkhand) and Gondia (Maharashtra); and during both *khariif* and *rabi* seasons in Khammam (Telangana), West Godavari and Srikakulam (Andhra Pradesh). In Muttar village located in the Kuttanad region of Allapuzha, Kerala farmers' practice broadcasting paddy seed in the “*Puncha*” crop (November – March), which results in low productivity. Water and labour saving technique of drum seeding of rice is a feasible option to farmers in these areas.

### Resilient practice / technology

Drum seeding technique involves direct seeding of pre-germinated paddy seeds in drums made up of fibre material to dispense seeds evenly in lines spaced at 20 cm apart in puddled and levelled fields. About 35 to 40 kg paddy seed/ha is soaked overnight in water and allowed to sprout. Care should be taken not to delay sowing as seeds with long shoot growth are not suitable for drum seeding. The sprouted seed is air-dried in shade briefly (<30 minutes) prior to sowing for easy dispensing through the holes in the drum seeder. Excess water in puddled field is drained out ensuring the soil surface is moist. Drums are filled with sprouted seeds (3/4<sup>th</sup> full) and pulled across the field maintaining a steady speed for evenly sowing. Number of drums could vary between 4 and 8 with number of lines sown ranging from 8 to 16 in one pass. Irrigation water should not be applied for 2-3 days after sowing to allow rooting and anchoring to soil. However, heavy rainfall immediately after sowing is likely to wash away the newly sown seeds. As the seedlings grow, water level in the field can rise for better weed control. Intermittent irrigation is given till the panicle initiation stage. Where weed problem is severe, herbicide is applied within 1-2 days after seeding and if necessary, a second application is given 30-35 days later. Line sowing permits operation of modified conoweeder (width between wheels reduced to 15 cm instead of 25 cm) between the rows in the same direction adopted for drum seeding. Drum seeding in one ha area can be completed in 5 to 6 hours time by three persons compared to transplanting operation which requires about 30 to 40 man days. This technique can help in saving seed, water, labour

requirement apart from improving productivity because of line sowing (spacing of 20 cm between rows) and early maturity of crop (by 7-10 days). Drum seeding reduces the cost of cultivation as it does away with the requirement for raising paddy nursery and transplanting thereafter. The technique fits into contingency planning as it provides flexibility in timing of sowing in lands prepared using irrigation water or immediately after receipt of monsoon rains with a crop variety of suitable duration to fit into the left over season.

### Impact of drum seeding technique in paddy

Rice is the major crop in Nacharam village in Khammam district. Farmers cultivate long duration (145–160 days) rice varieties like BPT-5204, WGL-482 and JGL-18047. These varieties are usually sown in the nursery in mid June and transplanted in mid-July. Farmers use a seed rate of 75 kg /ha and face serious shortage of labour for manual rice transplanting. Initially in 2012, direct sowing with drum seeder was introduced to five progressive farmers in the village in 3 ha area and sowing was taken up during 2<sup>nd</sup> and 3<sup>rd</sup> week of July. Cost of cultivation came down by Rs 10000/ha. Yield obtained ranged between 42 to 54 q/ha compared to 35 to 46 q/ha with transplanted paddy. Increase in grain yield ranged from 13 to 28%. In 2013, farmers took up direct seeding both in *kharif* and *rabi* seasons. Drum seeded paddy was applied four irrigations (two less than transplanted paddy). Advantage in net income due to drum seeding ranged from Rs 13000-14000/ha in both the seasons and B:C ratio was higher (2.3 to 2.9) with drum seeding compared to transplanted paddy (1.5 to 2.0).



Sprouted seed ready for drum seeding



Drum seeding in operation



Observing crop stand few days after seeding



Crop at maturity stage

Farmers in Matsyapuri village, West Godavari district cultivate paddy in tail end areas during *rabi* season. These farmers are forced to go for delayed planting due to late release of canal water. Farmers took up direct sowing with drum seeder to overcome this situation. Initially six farmers came forward and drum seeding was practiced in 9.5 acres during *rabi* 2012-13. Cost of cultivation was reduced by Rs 10000/ha compared to the transplanting method. Crop yield in direct sown paddy was 4% higher and benefit cost ratio was also higher (2.3) with less water compared to transplanting method. More farmers in the village came forward to take up drum seeded paddy in *rabi* 2013-14 in 50 acres. The duration of crop was reduced by 7-9 days in direct sowing compared to transplanting method. This helped in saving the crop from excess rains during the month of May 2014 as the harvesting was completed before the rains.

In Muttar village, Alapuzha district, Kerala farmers take up the '*Puncha*' paddy by broadcasting seed in the low lying fields after receding of flood waters as is the general practice in the Kuttanad region. Farmers took up line sowing of paddy (20 cm x 10 cm) with eight row drum seeder. One hectare could be covered in 10 hours time. Drum seeding required less quantity of seeds (30 kg/ha) compared to broadcasting (100 kg/ha). Apart from saving in seed, fertilizer to the extent of 30% could be saved due to soil test based nutrient application along with application of lime/dolomite to counter the soil acidity problem in the village. The results of the demonstrations in three consecutive years in different '*pada sekharams*' were encouraging. Biometric observations showed better growth of crop, more number of productive tillers and higher grain number in panicles. While cost of cultivation was reduced by about Rs 2900 to 6000/ha, net income ranged from Rs 13000 to 24000/ha in different years. Benefit: cost ratio ranged between 2.2 to 3.0 with drum seeding and 1.6 to 2.5 with broadcasting. Farmers in Muttar village are now willing to purchase drum seeders in view of the benefits demonstrated in their fields. The integrated crop management practices followed in the paddy fields sown with drum seeder will go a long way in reducing GHG emissions and environmental pollution in this fragile agro-ecosystem in the Kuttanad region.

### Scope for upscaling

Under NICRA, drum seeding of paddy was demonstrated in 194 ha covering 367 farmers in Aurangabad, Jehanabad, Saran (Bihar), Gonda, Sonbhadra (Uttar Pradesh), Khammam, Nalgonda (Telengana), West Godavari, Anantapur, Kurnool, Srikakulam (Andhra Pradesh) and Alapuzha (Kerala) with an average yield increase of 9 to 29 % and benefit cost ratio of 1.9 to 2.9 compared to current practice of transplanting. There is scope for wider adoption of drum seeding in these states under the National Mission on Sustainable Agriculture.

## Drought tolerant paddy cultivars to tackle deficit rainfall situations

**Climate vulnerability:** Drought in rainfed areas

### Existing practice

In recent years, deficit rainfall in July is affecting the timely transplanting of paddy in the eastern region in several rainfed districts in Bihar, Jharkhand and Odisha. Long duration (140-150 days) cultivars are preferred by farmers who take up sowing of nursery in June and transplanting in July. However, due to deficit rainfall situation in July, farmers wait for transplanting till August. This results in low productivity and can affect the timely sowing of succeeding *rabi* crop on the same land. The remedy therefore lies in the promotion of stress tolerant paddy varieties of shorter duration that are amenable both for transplanting and direct sowing. Short duration and drought tolerant varieties fit well into contingency plans for all types of farming situations (upland, midlands and lowlands) prevalent in the eastern states. Yields with short duration varieties are slightly lower compared to long duration varieties due to early maturation. However, short duration varieties serve as best bet options for drought proofing in rainfed rice cultivation as they provide a significant yield advantage in drought years over the traditional long duration varieties. This implies a trade-off between risk and expected returns in areas experiencing increased frequency of droughts in states such as Bihar and Jharkhand.

### Resilient practice / technology

Short duration and drought tolerant varieties that can withstand up to 2 weeks of exposure to dry spells in rainfed areas were demonstrated in NICRA villages. Drought tolerant cultivars demonstrated in farmers fields include: 'Sahbhagi dhan' (105-110 days duration in plain areas and 110-115 days in uplands, highly resistant to leaf blast and moderately resistant to brown spot and sheath blight. 'Naveen' (115-120 days duration, released in 2005 for cultivation in Odisha), and 'Anjali' (90 days duration released in 2003 for Jharkhand). Other early maturing varieties that have potential in the eastern states include: 'Birsa Vikas Dhan 109' (85 days duration), and 'Abhishek' (120 days duration).

## Impact of drought tolerant varieties of Paddy

Average yield in farmers fields with *Sahbhagi dhan* was 34.6 q/ha with an yield advantage of 26% over traditional long duration variety in seasons that experienced deficit rainfall situation as in 2013 at Jehanabad, Aurangabad, Buxar, Saran and Supaul in Bihar; Koderma, Palamu and Gumla in Jharkhand; Jharsuguda in Odisha. Average yield of Anjali variety was 41.2 q/ha with an yield advantage of 41% in Gumla and Chatra in Jharkhand. Average yield with Naveen variety was 39 q/ha with an yield advantage of 20% over traditional varieties in East Singhbhum in Jharkhand and Buxar in Bihar. Average yield with Abhishek variety was 35 q/ha with an yield advantage of 31% over traditional variety at Koderma, Jharkhand.

### Scope for upscaling

Drought tolerant paddy varieties were demonstrated on 185 ha covering 463 farmers in Buxar, Jehanabad, Saran, Aurangabad, Supaul in Bihar; Koderma, Gumla, Chatra, East Singhbhum and Palamu in Jharkhand; Jharsuguda, Sonapur and Ganjam in Odisha; Bilaspur in Chhattisgarh, East Sikkim and Port Blair. Yield advantage with these varieties in drought years ranged between 8.3 to 38.4% with a benefit cost ratio of 1.5 to 3.2 when compared to the existing practice of growing long duration varieties.

Availability of suitable varieties of paddy for delayed planting situation is a serious constraint for implementation of contingency plans in districts experiencing deficit rainfall. Solution lies in the promotion of seed production (breeder/ foundation / certified) of high yielding short duration varieties (less than 115 days) and medium duration varieties (125-135 days) for both direct seeding and transplanted conditions. Effective linkages and coordination among the State line departments and State Agricultural Universities is highly desirable for implementation of a successful seed production plan well in advance. Strengthening of scientific storage infrastructure is warranted. In the event of a normal season, mechanism/schemes should be put in place to absorb the difference in cost of disposal other than as seed material. Making villages self-reliant in the local seed requirement of those varieties not in the normal seed chain is imperative for increasing the resilience of the farming community. In case of acute shortage in availability of early or extra early maturing paddy varieties (Prabhat, Turanta Dhan etc.) that were released 10 years back, relaxation for procurement and supply of such varieties in contingent situations provided under the National Food Security Mission (NFSM) can also be explored. Scope exists for promotion and up-scaling of drought tolerant varieties in the rainfed areas in Bihar, Jharkhand, Odisha, Jharkhand and the north-eastern states.



Demonstration of transplanted Sahbhagi dhan variety at Jehanabad



Demonstration of SRI method with Sahbhagi dhan variety



Demonstration of Naveen variety at Buxar



Demonstration of Anjali variety at Gumla

# Short duration finger millet varieties for delayed monsoon / deficit rainfall districts in south interior Karnataka

**Climate vulnerability:** Drought

## Existing practice

Finger millet is an important staple rainfed crop in south interior Karnataka. A sizable area under finger millet is also cultivated with limited irrigation during *khari*. Long duration varieties with higher productivity such as MR-1 and MR-6 are grown with irrigation facility by farmers. Although sowing of finger millet can be taken up from 2<sup>nd</sup> week of June to end of August, productivity with long duration varieties goes down with delayed planting especially under rainfed situations. Alternative is to opt for short duration varieties of about 100-110 days duration so as to ensure higher productivity and profitability to farmers.

## Resilient practice / technology

When the delay in monsoon is about 4 weeks, medium duration varieties like GPU-28 (110 days duration) performed better while in case of further delay, short duration varieties like ML-365 (105 days) and GPU-48 (100 days) performed better. These short duration varieties of finger millet are also tolerant/ resistant to blast disease and can be sown till August under rainfed conditions in medium to deep red soils.

## Impact of short duration finger millet varieties

Farmers in D. Nagenhalli, Tumkur, Karnataka adopted short duration finger millet variety ML-365 in 2011 and 2012 when faced with delayed onset of monsoon. ML-365 performed significantly better with an average yield advantage of 33% and a benefit cost ratio of 2.7 compared to other varieties cultivated in the village. Shri Muddha Hanumaiah, a finger millet farmer in the village, obtained an additional income of Rs.5250 from his 0.5 ha. Similarly, 70 other farmers benefitted from the introduction of this short duration variety in the village in the first season. Apart from good grain quality and fitting into contingency situations, this variety has good fodder quality and improves milk productivity in milch animals.

At Siddanuru village in Davangere district, Karnataka in the Central Dry Zone average annual rainfall is about 653 mm. In this drought prone village during 2011 and 2012, 15 farmers took up sowing of short duration variety of finger millet (GPU-48, 100 days) in 7 ha area. The variety performed better with an average yield of 22.5 q/ha with a yield advantage of 38% compared to PR-202 variety (115 days) and a benefit: cost ratio of 2.8.

## Scope for upscaling

Short duration varieties of finger millet which are suitable for tackling contingency situations under rainfed conditions should enter into the seed supply chain. In D. Nagenahalli NICRA village, ML-365 variety is produced by farmers and the village has become self-reliant in seed availability in about three years time. Scope exists for wider adoption of such short duration varieties which are suitable for late planting in case of delay in monsoon or due to deficit rainfall conditions in July. Finger millet is grown as a rainfed crop during *kharif* season in all the 11 districts in South Interior Karnataka and scope exists for imparting resilience to finger millet cultivation by creating seed banks and ensuring seed supply to meet contingency situations arising out of an aberrant monsoon rainfall.



Ragi ML-365



Ragi field day celebrations at D. Nagenahalli village at Tumkur



Farmer sharing opinion about ML-365



Ragi GPU-48 in Siddanuru village, Davangere

### Short duration crop varieties suitable for late sowings

**Climate vulnerability:** Drought

#### Existing practice

Pulse and oilseed crops are predominantly grown under rainfed conditions. Increasing frequency of rainfall changes leading to early, mid and late season droughts is affecting the production of these crops grown under resource constrained situations with consequent effect on livelihoods of poor farmers. In interior villages of Odisha, Madhya Pradesh, Gujarat, Rajasthan, Karnataka and Andhra Pradesh, farmers still cultivate local varieties of pulse crops that are susceptible to viral diseases which are triggered by insect vectors under drought like situations. The productivity of these local cultivars is low and often crop failures are experienced either due to rainfall extremes or disease occurrence. Improved high yielding short duration varieties along with proper management practices are to be introduced and promoted so as to improve the resilience of farming in the drought prone areas.

#### Resilient practice / technology

Short duration variety of green gram (TARM-1) of 60-65 days duration tolerant to yellow vein mosaic disease was introduced in Ganjam, Odisha. Similarly, K-851 a short duration variety of green gram (65-70 days), was demonstrated in Jharsuguda, Odisha. In black gram, Azad Urd-1, a high yielding and YMV resistant short duration variety (65 days) was demonstrated on 50 ha in Kanti village, Tikamgarh, Madhya Pradesh. Rajkot district in Gujarat receives low and erratic rainfall resulting in delayed onset of monsoon and mid season droughts in July and August. Due to this, sometimes traditional groundnut varieties (spreading type) cannot be taken up for sowing in July. Instead farmers in Magharwada village adopted bunch type variety of groundnut (GG-5) which is a short duration, high yielding that performs better under late planted conditions. In Maharashtra, Madhya Pradesh and Kota district of Rajasthan, soybean is an important crop with a large acreage under JS-335 variety. In recent years, due to delay in onset of monsoon, planting of soybean is extending to July first fortnight and the crop at maturity stage is vulnerable to late season dry spells. Farmers in NICRA villages adopted short duration variety JS-93-05 in Maharashtra, and JS-95-60 (85-95 days) in Madhya Pradesh and Kota, Rajasthan as against the traditional variety (105-110 days).

## Impact of short duration varieties

Pradeep Sahu of Chopara village, Ganjam district, Odisha adopted short duration green gram variety TARM-1 and realized an yield of 7.8 q/ha with an additional income of Rs.5400/ha compared to local cultivars despite facing water shortages during crop growth. Twenty farmers who adopted GG-5 groundnut variety in Magharwada village, Rajkot, Gujarat in about 8 ha area realized an average yield of 11.3 q/ha with an yield advantage of 10% compared to the traditional variety despite late planting. Short duration soybean varieties performed better at Amravati during the drought season of 2012, matured early in about 87-93 days and escaped terminal moisture stress.



Green gram variety (TARM-1)



Blackgram variety (Azad-1)



Groundnut variety (GG-5)



Soybean variety (JS 9305)

## Scope for upscaling

Short duration soybean variety JS-95-60 has been widely adopted in about 15000 ha in Datia, Madhya Pradesh as an outcome of the varietal performance in NICRA village. Short duration varieties of pulse and oilseed crops need to be included in the seed supply chain for making them available under NFSM.

# Crop diversification for livelihood security and resilience to climate variability

**Climate Vulnerability :** Drought/heat wave, frost/cold wave and floods

### Existing practice

In scarce rainfall zones of India, practice of sole cropping is predominant but is risky and often results in low yields or sometimes even in crop failure due to erratic monsoon rainfall and skewed distribution. In such areas intercropping is a feasible option to minimize risk in crop production, ensure reasonable returns at least from the intercrop and also improve soil fertility with a legume intercrop. Cotton, soybean, pigeonpea and millets are the major crops in the scarce rainfall zones. Intercropping of these crops is more profitable and is a key drought coping strategy.

### Resilient Practice / technology

Pigeonpea, cotton, sunflower and sorghum are the main crops cultivated in NICRA village in Kurnool district, Andhra Pradesh which are affected due to late onset of monsoon followed by dry spell at critical crop growth stages. Intercropping of Setaria (foxtail millet, SIA-3085 variety) with pigeonpea (5:1 ratio) sown in July showed that the intercropping system was more profitable with highest benefit cost ratio in all the 3 years despite prolonged dry spell of up to 25 days in 2012. Intercropping of soybean + pigeonpea (4:2), pearl millet + pigeonpea (3:3), pigeonpea + green gram (1:2) and cotton + green gram (1:1) performed significantly better than their sole crops at Aurangabad, Maharashtra. Similarly, demonstrations on crop diversification by inclusion of HYVs of black gram, sesamum, gobhi sarson, gram, lentil, toria and okra were conducted in Said-Sohal village in Kathua district of Jammu and Kashmir.

### Impact of crop diversification

Farmers in Yagantepalli village, Kurnool district took up sole and intercrops of Setaria and pigeonpea for 3 years in this predominantly rainfed village (70%). Performance of the intercropping system of Setaria + pigeonpea (5:1) gave the highest benefit cost ratio ranging from 1.7 to 3.1 compared to the sole crops of Setaria and pigeonpea (1.5 to 2.6). At Shektha village, Aurangabad, Maharashtra farmers realized the advantage of higher net incomes with intercropping of the main crops such as cotton, pearl millet, pigeonpea and soybean ranging from Rs.9216 to Rs.12330/ha.

District/State	Treatment	Grain yield (kg/ha)	Cost of Cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Kurnool, Andhra Pradesh	Sole Setaria	1562	15973	23430	7457	1.5
	Sole pigeonpea	785	20500	29830	9330	1.5
	Setaria + pigeonpea (5:1)	1731	22856	33900	11044	1.7
Aurangabad, Maharashtra	Sole soyabean	1250	22620	47500	24880	2.0
	Soyabean + pigeonpea (4:2)	1450	16900	50996	34096	3.0
	Sole pearl millet	2200	12000	26400	14400	2.2
	Pearl millet + pigeonpea (3:3)	3160	13700	37920	24220	2.7
	Sole pigeonpea	800	14560	32000	17440	2.2
	Pigeonpea + greengram (1:2)	1300	16250	52000	35750	3.2
	Sole cotton	1080	20230	48600	28370	2.4
	Cotton + greengram (1:1)	1440	24450	65150	40700	2.6

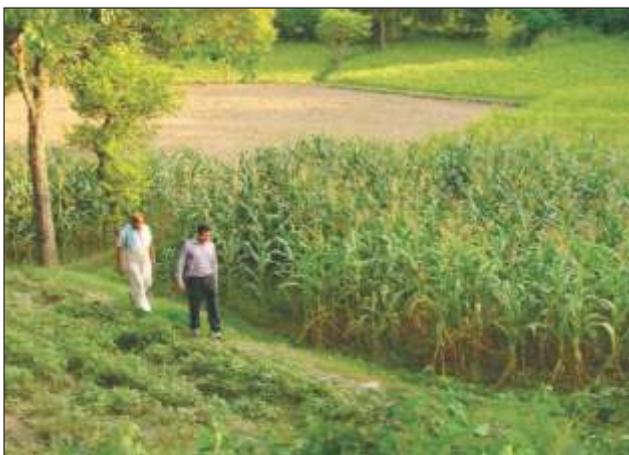
In Kathua district of Jammu & Kashmir, results of demonstrations on high yielding varieties (HYVs) of maize showed 81.4% increase over traditional cultivar. Demonstrations on crop diversification by inclusion of HYVs of black gram, sesamum, gobhi sarson, gram, lentil, toria and okra resulted in a yield increase to the tune of 62.5, 62.8, 51.3, 96.8, 76.5, 88.4 and 38.1%, respectively over traditionally grown varieties. In maize + cowpea intercropping, due to synergy existing between two intercrops, an yield enhancement of 75.3% in maize and 2.3% in cowpea was observed over the traditional system with a net return of Rs. 24200/ha in maize and Rs. 32400/ha in cowpea. Net return in case of cowpea was more because, no additional input other than seed was applied to the cowpea crop.



Soybean + Pigeonpea (4:2)



Setaria + Pigeonpea (5:1)



Gram + gobhi sarson crop in *rabi*



Maize + Cowpea



Maize + Cucumber

### Scale of demonstration

Inter cropping was demonstrated in 2654 ha covering 2033 farmers in Kathua (Jammu & Kashmir); Hamirpur, Chamba (Himachal Pradesh); Ropar (Punjab); Saran, Jehanabad, Supaul (Bihar); Sonitpur, Dhubri (Assam); Sonapur, Kendrapara (Odisha); Dantewada, Bilaspur (Chhattisgarh); Gondia, Amravati, Aurangabad (Maharashtra); Kushinagar, Chitrakoot (Uttar Pradesh); Kutch, Valsad (Gujrat); Satna, Datia (Madya Pradesh); Nalgonda, Anantapur (Andhra Pradesh); Davangere (Karnataka) and Nammakal (Tamil Nadu) with an yield advantage ranging from 10.5 to 85.2% and benefit cost ratio of 1.3 to 4.2 compared to farmers' practice.

### **Introduction of drought tolerant variety of bottle gourd in rainfed condition: Gondia**

Rice is a major crop grown during *kharif* in Katangtola and Chandanitola villages in Gondia district. Farmers incur facing high cost of production and low remuneration from rice cultivation. Hence, drought tolerant variety (Warad) of bottle gourd crop was introduced as an alternate crop to rice along with micro-irrigation system. The crop was sown in the first week of June 2012 in 0.35 ha and the net income was Rs. 33,500 by cultivation of bottle gourd whereas with rice crop it was only Rs. 7,500/ha.



Most of the farmers from nearby villages visited the demonstration plot and eight farmers came forward and started cultivating vegetable crops by using drip irrigation by availing subsidy from the state department of agriculture, Maharashtra.

### **Scope for Upscaling**

Crop diversification including intercropping of rainfed crops is an important risk minimizing strategy for drought proofing in the scarce rainfall zones and paddy growing areas. In contingency situations such as delay in onset of monsoon, adoption of intercropping for delayed plantings can be remunerative instead of sole cropping. However, availability and access to farm implements for taking up the intercropping systems is to be ensured for wider adoption. In this context, village level custom hiring service centers for making available farm implements can help increase the adoption by small and marginal farmers in the states of Andhra Pradesh, Assam, Gujarat, Punjab, Himachal Pradesh, Meghalaya, Tripura, Jammu & Kashmir.

# Flood tolerant varieties impart resilience to farmers in flood-prone areas

**Climate vulnerability:** Flood, cyclone and unseasonal rains

### Existing practice

Flooding is a major challenge for rice production in the country. Heavy and intense rainfall events cause flash floods due to overflow of rivers and canals or sometimes tidal movements in coastal areas. Continuous high rainfall in a short span leading to water logging and heavy rainfall with high speed winds in a short span due to cyclonic storms cause inundation of paddy fields and lodging of the crop at grain filling and maturity stages causing huge losses to the farmer. Floods due to heavy rainfall in upstream areas in Assam, Bihar and Uttar Pradesh often lead to spate of rivers causing flooding of adjacent crop lands. Further, flood is a recurrent phenomenon in coastal Andhra Pradesh, Odisha, West Bengal, Kerala and south Gujarat. The problem is accentuated due to poor or non-existent drainage and in some cases due to the topography of the land which impedes fast drainage from crop lands. Apart from improving drainage and other preventive measures, farmers can adopt flood tolerant varieties that can withstand inundation for an extended period and reduce the risk from flood damage.

### Resilient practice / technology

Rice varieties Swarna-sub1, MTU-1010, MTU-1001 and MTU-1140 are high yielding with good grain quality apart from possessing submergence tolerance and perform better under flood situation. Demonstration of these varieties in flood-prone areas showed that Swarna-sub1, a variety developed by IRRI and CRRI, Cuttack and released in 2009, could tolerate submergence up to two weeks and could perform significantly better compared to other improved and local cultivars. MTU-1010 is a short duration, dwarf variety resistant to lodging and can withstand moderate wind velocity. This attribute of lodging resistance saves from not only loss in grain but also straw yield which is the main source of dry fodder. MTU-1140 is also a promising, non-lodging variety comparable in grain quality to BPT-5204.

### Impact of flood tolerant varieties

In Sirsuwada, a village of Kothuru mandal in Srikakulam district of Andhra Pradesh, farmers prefer to grow improved varieties of paddy such as BPT-5204, Swarna and MTU-1001 due to high yield potential and market demand in the district but are susceptible to flooding. However, in recent years due to heavy and intense rainfall and cyclonic storms, paddy crop is experiencing damage due to flooding. KVK, Srikakulam encouraged farmers to adopt flood tolerant varieties to minimize crop damage due to submergence. Farmers found that Indra-MTU-1061 with a seed dormancy of 2-3 weeks was non-lodging and tolerated inundation up to 10 days at later stages of crop growth. Swarna-sub1 was demonstrated in flood-prone NICRA villages in

Nimpith and Coochbehar in West Bengal; Supaul and Jehanabad in Bihar; Gondia in Maharashtra, Kushinagar, Maharajganj and Bhaich in UP and gave an average yield of 44 q/ha with an yield advantage of 40% and a benefit cost ratio of 2.4 compared to other varieties. Demonstrations with MTU-1010 in NICRA villages in Valsad, Gujarat; Dantewada, Chhattisgarh and West Tripura resulted in an average yield of 34 q/ha with an yield advantage of 26.7% and benefit cost ratio of 1.98. Demonstrations with MTU-1061 in NICRA villages in Ganjam, Odisha and Dantewada, Chhattisgarh gave an average yield of 37 q/ha with an yield advantage of 40.7% and a benefit cost ratio of 1.75.

Similarly, submergence tolerant varieties 'Jalashree' and 'Jalkuwari' which can tolerate submergence of 12-15 days produce about 53% higher grain yield compared to traditional rice variety in Udmari village of Dhubri district, Assam.



Swarna-sub1



RGL-2537



PLA - 1100



No lodging in MTU-1061 (Indra)

### Scale of demonstration

Flood tolerant varieties of paddy were demonstrated in 232 ha covering 957 farmers in Jehanabad, Supaul (Bihar); Coochbehar, Nimpith (West Bengal), Dhubri (Assam), West Tripura (Tripura); Ganjam (Odisha); Dantewada (Chhattisgarh); Gondia, Kushinagar, Maharajgunj, Bhaich (Uttar Pradesh); Rajkot, Valsad (Gujrat); West Godavari, Srikakulam (Andhra Pradesh) with an yield advantage ranging from 18.1 to 77.2% and benefit cost ratio of 1.6 to 3.3 compared to farmers' practice.

## Improving the resilience of poor farmers reclaiming cultivable wastelands

**Climate vulnerability:** Drought, soil erosion & land degradation

### Existing practice

Cultivable wastelands located in the fringe areas of the forests are not cultivated regularly despite being fertile. Besides, the undulated lands require leveling and bunding. Poor farmers lack the investment required to make these lands cultivable. A few enterprising farmers now and then broadcast seeds of horse gram or redgram and harvest some grains depending on the season. Most households continue to remain poor despite owning fertile land. Some farmers cultivate these lands for a while and abandon cultivation after the bunds disappear due to runoff erosion. These lands completely depend on rainfall for cultivation as the traditional rainwater harvesting and storage structures (*ahars*) cannot convey water to these lands due to their higher elevation. As a result the land remained fallow over time, unprotected from overgrazing leading to soil erosion and deprived the farmers of their livelihood.

### Resilient practice / technology

Scientists of KVK-Sokhodeora, Nawada, Bihar evolved a systematic programme to bring the cultivable fallow land back into crop production by motivating the community to participate in reclaiming the lands by leveling and bunding. The community initially was hesitant due to past experience. As per the plan, each farmer actively participated by contributing his labour in laying out the bunds while the project facilitated leveling of the land. Farmers took up shapening of the bunds with increased height for better *in situ* rainwater conservation and to prevent erosion by runoff. The process of laying bunds started during later part of *kharif* season (2011) and went on until the beginning of summer, 2012. Those farmers who could complete bunding and leveling early, planted pigeonpea and short duration paddy. The experience of these farmers was encouraging and many farmers started participating in this programme with renewed vigor and enthusiasm.

Similarly, in Umrani village of Nandurbar district, Maharashtra, the soils are shallow and are prone to moderate to severe soil erosion. Hence, trench cum bunding practice was demonstrated in 67 ha area covering 167 farmers' fields in order to trap the top fertile soil in trenches, allowing safe disposal of excess rainwater and to conserve precious soil moisture.

## Impact

In Sokhodeora village, about 15 ha was planted with pigeonpea during *kharif* 2012 leading to harvest of 10,000 kg of pigeonpea worth Rs.3,50,000. For the first time, the farmers of these villages could realize such a harvest and this helped them to appreciate the worth of their land due to bunding and leveling.

The outcome of this intervention caught the attention of farmers in the neighboring village of Upper Manjhila. About 4 ha of land belonging to 13 farmers remained fallow due to undulated topography and unabated erosion. These farmers contributed labour for bunding and leveling of their lands. Community participation in this bunding and leveling intervention drew the participation of many more into the NICRA project. Having witnessed the effect of this intervention over the past two years, a large group of farmers (107) came together and raised the height of their field bunds in about 24 ha during early *kharif* 2013 period when this area experienced delay in onset of monsoon and deficit rainfall conditions. The raised bund height was useful in harvesting and conserving rainwater for a successful late *kharif* crop or in some cases an early *rabi* chickpea crop.

Similarly, at Umrani village, the soil trapped due to trench cum bunding was in the range of 11.5-21.2 m<sup>3</sup>/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, up scaling of the technology was taken up in convergence with MGNREGA on 229 farmers' fields. An amount of Rs 8,00,000 was sanctioned for this intervention by the district authority as convergence.



Land before intervention



Bunding in progress



Farm bunding and levelling after intervention



Pigeonpea crop after farm bunding

## Scope for upscaling

Land improvement through leveling and bunding in slopy cultivable wastelands in upland areas can systematically bring back farming opportunities to small and marginal farmers and also arrest the unabated land degradation. Such land improvement activities require careful planning and critical need assessment. Support is possible from Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGP) and the Integrated Watershed Development Programme (IWMP) in Bihar, Jharkhand, Chhattisgarh and Odisha.

# Community tanks / ponds as a means of augmentation and management of village level water resources

**Climate vulnerability:** Drought

### Existing practice

Large number of tanks with substantial water storage capacity constructed long ago have become defunct due to neglect, non-maintenance and silting up. Due to neglect of community tanks, surplus rainfall (runoff) during *kharif* is not stored properly and used. Hence, due to prolonged dry spells at critical stages, crop failures are experienced in some years or production is seriously affected. Rainfed crops in *rabi*, experience soil moisture deficit which results in low productivity. *Kharif* crops suffer due to prolonged dry spells sometimes leading to crop failures. Farmers face these situations in NICRA villages in Namakkal (TN), Kurnool (AP), Rajkot (GJ) and Kullu (HP).

### Resilient practice / technology

One of the first works accomplished in NICRA villages was to identify these structures to carry out desiltation tanks with farmer's participation. The rich silt deposited in these structures was used by farmers for spreading in the fields, wherever necessary, to improve the water holding capacity of soils. This intervention helped in increasing the surface water resource availability, increased the ground water recharge observed through water table measurements in wells located nearer to the tanks.

At Vadavathur and Jambumadai, Namakkal, village tanks are predominant in these parts of Tamil Nadu since a long time, but have been discontinued due to individual irrigation facilities through wells / canal irrigation facilities. Revival of this traditional practice of water storage in a large community/village based tanks was considered as one option for augmentation of water resources. The villages identified for interventions under NICRA were surveyed and suitable plan was prepared.

### Impact of desilted community pond

Desiltation and renovation of three community ponds were done with community participation in ponds namely Senguttai, Aayiramkuttai and Periyakalingikuttai covering a surface area of 1045, 5035 & 3605 m<sup>2</sup> and having storage capacity of 5735, 23000 & 16500 m<sup>3</sup>, respectively. An additional increase in water storage of 36617 cu.m was created through intervention after desilting and renovation in two phases during the year 2012 and 2013.

- Senguttai pond helped in recharging of 18 open wells and 11 bore wells; as a result crop was cultivated in 13.6 ha
- Aayiramkuttai pond helped in recharging of 45 open wells and 112 bore wells; as a result crop was cultivated in 73.6 ha
- Periyakalingikuttai pond helped in recharging of 45 open wells and 156 bore wells; as a result crop was cultivated in 137.5 ha area

## Increase in storage capacity by desilting of community pond at Vadavathur, Namakkal

Name of the Pond	Dimensions (Before intervention, m)	Dimensions (After intervention, m)	Major Cultivated Crops (Before)	Major Cultivated Crops (After)
Senguttai	36 x 26 x 3.65	38 x 28 x 5.4	Onion and Sorghum	Onion , Groundnut and Sorghum
Aayiramkuttai	30 x 22 x 1.85	92 x 55 x 4.5	Onion and Sorghum	Onion, Paddy and Groundnut
Periyakalingikuttai	49 x 22 x 3.65	112 x 32 x 4.5	Onion and Sorghum	Onion , Groundnut and Sorghum



Before desilting of pond at Namakkal



After desilting

Yagantipalle village of Kurnool is one of the drought prone districts in Andhra Pradesh. The village on an average receives an annual rainfall of 546 mm. Water scarcity, poor soil health and frequent droughts are the major climatic constraints faced by the farming community. About 200 tube wells were non-functional due to low water table during post-monsoon period. Hence, the village committee proposed to desilt the existing Burrakunta tank for deepening and use of tank silt to improve soil physical properties and fertility in farmers' fields.

Desilting was taken up during July 2012 and 1260 m<sup>3</sup> silt was excavated in Yagantipalle village. Deepening of tank increased additional water storage capacity and observed that water table raised by 12 ft in tube wells during November 2012. Silt was applied to 15 acres covering 10 farmers. Cotton and castor were cultivated in silt applied soils. About 15 to 18% yield increase was observed in silt applied plots over the check due to high fertility status of silt.

Rajkot district in 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. 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.

Rainwater harvesting and groundwater recharging were given priority in Magharvada village, Rajkot. Desilting and deepening of two community ponds increased storage capacity upto 37000 m<sup>3</sup> and 30000 m<sup>3</sup>, respectively in convergence with the irrigation department of the State government. From community pond, supplemental irrigation to groundnut crop was applied by 10 farmers and covered an area of 20 ha. In *rabi* season, 15 farmers took up wheat crop in 20 ha area by lift irrigation of water from community pond. The average ground water table has risen by 3 to 4 m as compared to previous years.



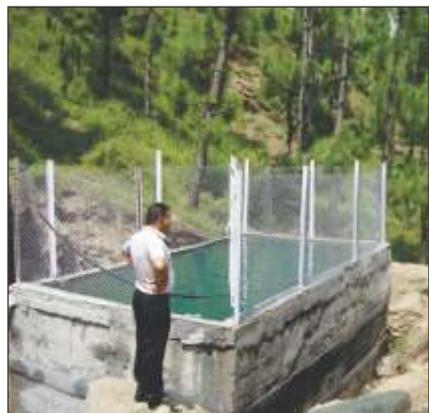
Community pond in Magharvada, Rajkot



Rise in water level in adjacent open well

### Smaller community tanks suitable for hill agriculture in Kullu, HP

Kullu district of Himachal Pradesh is known for apple production. During early nineties apple along with major cereals like wheat and maize were grown by the farmers of Chhoel Gadouri, the selected village of NICRA. However, due to warmer temperature, shifting of apple cultivation from lower valley areas to upper areas owing to non-fulfillment of chilling requirement of the crop is happening. Drought is the other major constraint in the village. Climate variability in terms of historical rainfall trend over last three decades indicated that dry spells of 10-20 days are increasing particularly during *kharif* season.



Therefore, in order to mitigate the drought to some extent, major focus was on water harvesting for life saving irrigation through micro-irrigation system.

Keeping in view the fragile eco-system of the region, a series of inter-linked water storage tanks (one tank of 50 m<sup>3</sup> capacity and three tanks of 20 m<sup>3</sup> each) were constructed under the project in Chhoel Gadouri village. In addition, farmers were motivated to construct water harvesting structures through awareness cum training programme which resulted in construction of 4 water storage tanks of 80 m<sup>3</sup> capacity by dovetailing with developmental schemes (MGNREGS). This intervention helped the farmers to cultivate vegetable crops. These tanks were able to provide irrigation to transplanted tomatoes, cauliflower and cabbage during summer and newly planted pomegranate plants. Through this intervention, there is a significant change in the cropping pattern as the area under vegetable crops like tomato, pea, spinach, okra, garlic, cauliflower and cabbage has increased, replacing area under cereals.

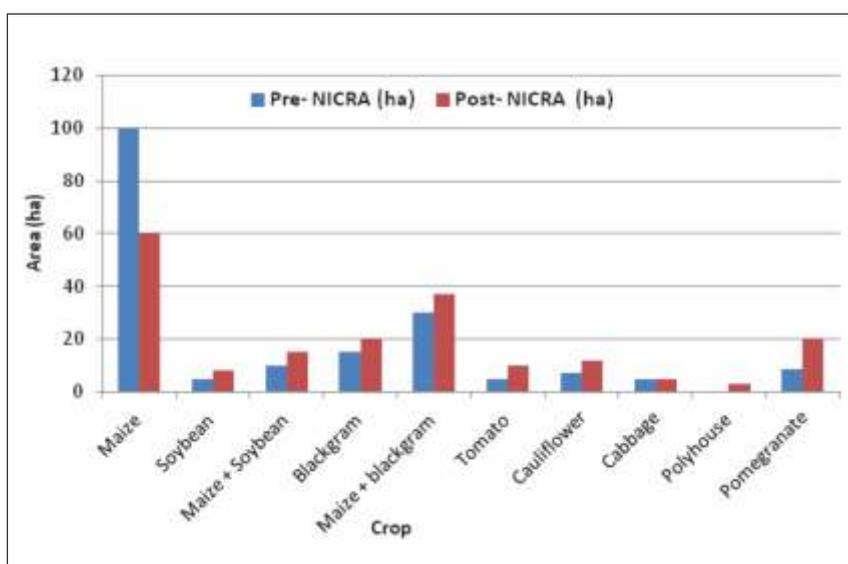


Fig. Rainwater harvesting promoted crop diversification at Chhoel-Gadouri village, Kullu, HP

### Scope for upscaling

Large community ponds in central and southern states and community ponds of smaller size in hilly areas can be up-scaled in convergence with MGNREGS / IWMP / NMSA.

## Individual farm ponds for improving livelihoods of small farmers

**Climate vulnerability:** Drought

### Existing practice

Across the tropics, smallholder farmers face numerous risks in agricultural production. Rainfall is erratic and inadequate, and the crops are mostly dependent on monsoon. Climatic variability is expected to disproportionately affect smallholder farmers and make their livelihoods even more precarious. Small scale water harvesting structures at individual farm level enable reuse of harvested water during critical periods of growth stage or for providing pre-sowing irrigation to *rabi* crop. Various models of small scale water harvesting systems have been promoted by governmental and nongovernmental organizations involving different farm pond sizes, lining material, reuse of harvested water for different crops at critical crop growth stages.

### Resilient practice / technology

One way to cope with climate vulnerability is to collect rainwater in harvesting structures to increase the irrigated areas as well as crop productivity. Farm ponds have been considered as one of the key interventions in NICRA villages and have been widely adopted in the villages. Various cropping system modules were worked out by using harvested water. Majority of farmers opted to cultivate vegetables with harvested water in a ratio of 1:10 (command to catchment area) with sustained profits.

### Impact of individual farm ponds

#### Examples of successful interventions where harvested rainwater was efficiently used for crop production.

Village	KVK/ District	No.	Storage capacity (cu.m)	No. of farmers covered	Protective irrigation potential created (ha)	Increase In cropping intensity (%)
Kukurha	Buxar	1	1800	06	1.75	100
Affaur	Saran	2	11500	42	10	25
Chopanadih	Koderma	1	16560	50	20	40
Takli	Amravati	2	8400	25	10	20
Nacharam	Khammam	4	1460	4	9.6	40
Sanora	Datia	3	9500	10	19	100
Nagenhalli	Tumkur	73	68100	77	65	100

## Major observations :

- Increased irrigation area in the villages
- Increase in crop productivity
- Farmers with farm pond took up at least two assured crops in a year
- Shift to vegetable cultivation is one strong indicator
- Increase in ground water level

Village	KVK/ District	Technology Demonstrated	Crop	Area (ha)	Net Return (Rs)	Benefit : Cost ratio
Lagga	Chamba	Sprinkler	Cauliflower	2	380165	3.9
Kukurha	Buxar	LEWA	Rice	4	27285	2.0
Affaur	Saran	Micro irrigation	Long gourd	2	65988	3.0
Takli	Amravati	Sprinkler	Cotton	10	36300	2.5
Nacharam	Khammam	Drip	Chilli	2	9000	2.0
Nidhan	Morena	Sprinkler	Wheat	8	52200	2.6
Vadavathur	Namakkal	Sprinkler	Onion	35	215565	3.2
Nagenahalli	Tumkur	Drip	Brinjal	2	102500	3.7
Nagenahalli	Tumkur	Sprinkler	Ground nut	1	59500	3.3

Sri Venkatappa is one such farmer in the D.Nagenahalli village of Tumkur district, Karnataka owns one acre of dryland with low soil fertility. He used to grow ragi crop only during the monsoon. The yield of the crop used to be less due to delayed monsoon and uneven rainfall. The NICRA team from KVK, Hirehalli proposed suitable interventions in his small farm. The leveled land was made into compartments to reduce soil erosion.

One farm pond of dimension 20 m x 20 m x 2 m with water storage capacity of 800 m<sup>3</sup> was dugout to harvest runoff water. He now takes three crops in a year with the help of farm pond. He grows tomato, chilies and coriander in one acre. During the first year even though monsoon was not good he still managed to get sufficient yield. It was possible only due to the farm pond. He cultivated tomato in 0.25 ha area which gave an yield of 7 tonnes and an additional income of Rs.28000. He cultivated chilies in 0.25 ha which gave an yield of 1500 kg of green chilies and an additional income of Rs.20000. He also cultivated coriander in 0.25 ha area which gave an yield of 800 kg and an additional income of Rs. 16000. Sri Venkatappa earlier could grow a single crop of ragi for family consumption. With a small farm pond, he could now cultivate high value crops.



Farm pond in D. Nagenahalli village, Tumkur



Farm pond in Nacharam village, Khammam



HDPE lined Farm pond at Namakkal



Supplemental irrigation with micro irrigation

### Scope for upscaling

Farm ponds can be up-scaled in the rainfed districts of Aurangabad, Nawada, Saran, Cooch Behar, Chatra, Port Blair, Supaul, Mokochung, Chitrakoot, Kushinagar, Amravati, Anantpur, Aurangabad, Kurnool, Nalgonda, Khammam, Pune, Kota, Rajkot, Bilaspur, Dantewada, Datia, Ganjam, Kendrapara, Morena, Chikballapur, Davangere, Tumkur, Nagapattinam, Namakkal and Ramanathapuram.

## Jalkund - low cost rainwater harvesting structures

**Climate vulnerability:** Unavailability of adequate amount of water during the dry season is a serious problem for successful farming in high rainfall areas.

### Resilient practice / technology

This problem can be minimized by rainwater harvesting and its judicious use for crop production. Direct rainfall collection through water catch ponds/pits (Jalkund) can be highly beneficial to farmers for providing irrigation to crops during moisture scarcity conditions during dry seasons.

- Rainwater can be stored directly in *Jalkunds* during the rainy season which can be utilized to provide protective irrigation to the crops for successful cultivation. Otherwise, it may cause soil erosion and nutrient loss through runoff.
- Stored water can also be utilized for animal husbandry activities, Piggery, Poultry and Duckery.
- Fish rearing can also be taken up in the harvested water.
- Harvested water can be used for cultivating high value vegetable crops such as Brinjal, Chilly, Tomato, Radish, Amaranthus, Coriander, Cowpea

At Dhansiripar village, Dimapur, Nagaland interventions were taken up to popularize low-cost rainwater harvesting structures 'Jalkund' (5x4x1.5 m) with silpaulin lining having a storage capacity 30,000 liters for harvesting rainwater during the rainy season and its subsequent use during dry periods to provide critical irrigation to high value winter vegetables. Fifteen farmers took up the interventions including self help group members who underwent training at the KVK, Dimapur.

Training was imparted to the selected beneficiaries and farmers were initially supported for lining of ponds with silpaulin sheets and seeds of high value winter vegetables like broccoli, celery, capsicum. Farmers could fully harvest rainwater and use it in the dry season for crop production and as drinking water source for animals.

At Nandok village in East Sikkim, there is no source of irrigation for *rabi* vegetable crops although the village receives an annual rainfall of around 2500 mm. Hence, the best way to cope with this water scarcity is to harvest rainwater during heavy rainfall season and use the harvested water for irrigating the fields during winter season. Awareness among farmers was created by frequent meetings, trainings and exposure visits.

## Impact of low cost small ponds ('Jalkund')

At Dhansiripar village, Dimapur, 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.

At Nandok village, in East Sikkim, Jalkund was 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) were constructed in the village. Farmers have started cultivating winter crops in a larger area through rainwater harvesting and utilization



Rainwater harvesting in 'Jalkund' and utilization for vegetable cultivation

### Scope for upscaling

North eastern states

### Check dam - storing excess-runoff in streams

**Climate vulnerability:** Drought

#### Existing practice

Some of the structures in villages were not robust enough to withstand recurrent heavy rainfall and flash floods. The design used was probably not appropriate in the face of more extreme weather events which are expected to be more frequent and intense as a result of climate variability in the region. Accordingly, renovation and upgrading of these structures was included under NICRA project activities to enhance the resilience of the communities to current and future climate risks.

#### Resilient practice / technology

*Ex-situ* storage of water in seasonal streams at suitable sites is an important strategy to conserve excess runoff water in different rainfall zones. Often, by virtue of the location with reference to nearby hilly areas, the village may receive copious amounts of surface runoff from surrounding areas. This excess runoff could be harvested on streams either for direct use or for improving the ground water availability. In high rainfall areas, though runoff availability is high, often it gets lost due to non-availability of storage structures. In these regions, on-stream storage structures could be built on first order streams to make water available for direct use during long dry spells by farmers. In majority of NICRA villages, check dams (new/desilting of existing ones) were major interventions in drought prone districts in different rainfall zones.

Jalgaon village in Baramati, does not have much runoff from agricultural fields as the rainfall is 550 mm. The village survey indicated two major streams surrounding the village indicating surface inflows from upper catchment areas. Six structures constructed on the streams were not sufficiently catering to the needs due to siltation. One of the major activities carried out over two years is to completely desilt these structures.



Desilted check dam at Baramati

Similarly, five new check dams were constructed in the D. Nagenahalli village of Tumkur district, Karnataka. The total water storage capacity increased to 5300 m<sup>3</sup>. Eleven farmers got benefited from this intervention. Apart from this, eight check dams were desilted and widened with additional water storage capacity of 12000 m<sup>3</sup>.

## Impact of check dam after desilting

At Jalgaon, Baramati, desilting resulted in increasing the total capacity of storage from 47750 m<sup>3</sup> to 165200 m<sup>3</sup>. This benefitted in recharging of 96 wells located in the vicinity of these structures. The total area brought under cropping in *kharif* and *rabi* seasons due to this storage is about 49 ha and 240 ha, respectively and 27 ha in the summer season.

- Increased water storage capacity of the check dams by 40%. The storage capacity of these 6 check dams increased by 150000 m<sup>3</sup>.
- 35 farmers transported it to their uncultivable barren fields covering 25.8 ha
- The silt application made barren lands cultivable and resulted in increase in grain yield of pearl millet and *rabi* sorghum by 5 and 8.75 q/ha, respectively.
- 86 open wells were recharged in the village and water level rose by 7 to 10 feet.
- Provided protective irrigation to crops in 56.4 ha in *kharif* and 34.5 ha in *rabi* in an area which was predominantly rainfed earlier, prior to the intervention.

Desilting of five existing check dams was taken up in Chamaluru village of Anantpur, Andhra Pradesh. This activity resulted in increasing the total capacity of storage from 1150 m<sup>3</sup> to 2922 m<sup>3</sup>.

- About 6-8 bore wells are located in the premises of check dams.
- Ground water table increased by 2-3 meters and discharge increased by ½ inch.

Similarly, at D. Nagenahalli village of Tumkur

- 7 open wells and 5 bore wells were recharged.
- Crop diversification from coarse cereals to vegetables/flowers was observed in few cases
- The yield of Chrysanthemum was 2.2 tonnes/ha. The farmer realized an additional income Rs. 48,000 during 2012-13.

At Boring thanda village, Nalgonda district of Telangana, two new check dams were constructed in addition to desilting and renovation of two existing check dams. A total of 13607 m<sup>3</sup> of storage capacity was created.

- Groundwater recharging of 15 open wells and 13 bore wells benefitted 39 farmers.
- About 35 open wells and 9 bore wells were recharged in surrounding areas, benefiting 99 farmers.



Check dam in D. Nagenahalli village



High value crop

## Scope for Upscaling

Central and southern India under IWMP

## Rainwater harvesting and recycling through temporary check dam

**Climate vulnerability:** Farms in lowland areas remain fallow due to excess rain and often flooding out from the farms leads to loss of fertile soil during monsoon season. Production of *rabi* crops is low due to the unavailability of water for pre-irrigation & sowing and also to provide irrigation at critical crop growth stages.

### Resilient practice / technology

Rainwater harvesting and recycling was demonstrated by construction of temporary check dams. The villagers contributed labour through *shramdaan*.

- Temporary check dams were constructed by using low cost gunny bags. These bags were filled with sand from stream beds. The sand filled bags were placed one above the other in two or more rows. The gap between two rows was filled with clay to check water leakage. An outlet was provided to each dam to allow excess water to flow downstream.
- These check dam helps in ground water recharge and rising of water table in the area.
- Harvested water in the temporary check dams is used for life saving irrigation in *rabi* and summer crops.

Several temporary check dams were constructed using cement bags in which sand/soil was filled by villagers. Most of the dams were constructed in the river basins. Low cost temporary check dams (sand bag check dams) were demonstrated at Gumla, East Singhbhum, Nandurbar, Ratnagiri, Dantewada, Datia and Kendrapara.

At Gunia village, Gumla district, Jharkhand, the vulnerability of the farmers to the current climate variability is very high, as they are able to cultivate only one crop in *kharif* season which also faces intermittent dry spells. The cropping intensity is also low because of non availability of water for cultivation of crops during post rainy season.

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. The district agricultural department acknowledged that it was for the time wheat was cultivated on such a large scale in any one block of the district.

## Impact of sand bag check dam

During the year 2012, the area under second and third crop increased significantly. Over 120 acres of wheat was sown in this cluster of village and many more farmers took to cultivation of vegetables. Farmers cultivated Wheat in 50 ha area which gave an yield of 32.0 q/ha and an income of Rs. 17,900 per ha with benefit cost ratio of 2.03. Similarly, Farmers cultivated Okra in 0.75 ha area which gave an yield of 128.2 q/ha and an income of Rs. 51,474 per ha with benefit cost ratio of 3.0. Farmers cultivated Tomato in 0.5 ha area which gave an yield of 215.3 q/ha and an income of Rs. 89,210 per ha with benefit cost ratio of 3.2.

- Crop stand improved by 70-75%
- Time saving (25-30%) in irrigation (1.5 hr/ha/irrigation)
- Water saving was up to 25-30%
- Obtained 10-15% higher yield
- Required 20-25% lesser seed rate



Low cost sand bag check dam in Gunia village, Gumla      Vegetable cultivation through supplemental irrigation

Similarly, at Sanora and Barodi village, Datia, Madhya Pradesh, construction of 5 'Bori bandhans' (poly bag check dams) was taken up by farmers. During, monsoon season, 42500 m<sup>3</sup> water was harvested in 'bori bandhans'.

At Sanora and Barodi village, Datia, harvested water created 85 ha supplemental irrigation potential. Recharging of 31 open wells in downstream side made available water for irrigation till March which was unprecedented earlier. Recharged open wells generated 20 ha extra irrigation facility to the farmers in the village. Farmers took up mustard crop during *rabi* season in 199 ha resulting in yield of 12.8 q/ha and boosting their net income to Rs. 29,167 per ha with a benefit cost ratio of 3.1. This enhanced the crop yield by 26-32%. Through production of mustard, villagers generated 255.5 tonne produce with Rs. 76.6 lakh additional monetary returns from previous fallow (199 ha) land. 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 Rs. 60,000 per ha. Similarly, Chilli was cultivated on 5 ha with a net return of Rs. 30,000 per ha.



Poly bag check dam at Datia



Musturd cultivation through micro sprinklers

### **Scope for Upscaling**

The additional yield and livelihood opportunities of farmers in areas having no irrigation facility, attracted the attention of 84 watershed societies working in the district to initiate similar interventions. Low cost temporary structures can be promoted under MGNREGS.

## Enhancing resilience through improvement in conveyance efficiency

**Climate vulnerability:** Drought / Flood

### Existing practice

One of the reasons for gap between potential created and utilized under canal irrigation systems is the lack of maintenance of conveyance channels which became silted up. As a result, tail end villages do not get the intended irrigation water supplied and often the envisaged benefits cannot be realized. As part of NICRA interventions, emphasis was on clearing of conveyance channels for providing irrigation to target areas. In Bihar, the age old 'Aahar' and 'Pyne' systems were renovated at the local level, so that water could be made available to intended beneficiaries. Some of the case studies on this initiative are presented below.

### Resilience practice / technology

'Aahar' in Majhilla village of Nawada district 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 uses during summer. This also resulted in poor productivity of paddy, the major crop of this area which depends mostly on groundwater for irrigation. Renovation of *Aahar* (water reservoir) and construction of farm ponds were taken up in the village.

Similarly, NICRA village Matsyapuri in West Godavari district (Andhra Pradesh) receives an average annual rainfall of 1185 mm with frequent floods which submerge croplands resulting in crop failure. There are two irrigation channels, namely Mentepudi channel and VWS channel which are the major irrigation water source covering 640 ha (Mentepudi channel 400 ha and VWS channel 240 ha). Rice is the major crop cultivated in this village by 300 farmers. Over the years, these channels became nearly defunct due to silting and wild growth resulting in reduced capacity to supply irrigation water to tail end areas in the village. It also led to flooding of nearby fields during monsoon. Renovation and deepening of these two irrigation channels was taken up under NICRA project during 2012-13.

## Impact of renovated irrigation channel

At Majhilla village of Nawada, prior to the project interventions, the village did not have any ponds. Old 'Aahar' was defunct. Rainwater harvesting increased by 20,000 m<sup>3</sup> after renovation and excavation. This helped in providing protective irrigation in 24 ha during dry spells in *kharif*.

- Paddy productivity increased by 20.7%
- Groundwater level increased by one feet
- Drinking water for livestock was made available

At Matsyapuri village of West Godavari, as a result of this intervention, rice cultivation could be taken up by farmers in the tail end area. It also helped in efficient disposal of rainwater by avoiding flooding and submergence of crops at times of intense rainfall events. There was heavy rainfall in the first week of November 2012 due to '*Neelam*' cyclone and excess flood water was disposed-off safely. This prevented submergence of fields adjacent to the canals. It was noticed that there was flood water only up to a height of 42 cm in command area under the deepened channels and there was no overflowing of flood water. In other untreated areas submergence was up to 122 cm height and the crop was completely submerged due to flood water. This resulted in avoiding yield loss to the extent of 41.3 q/ha with MTU-1061, 33.8 q/ha with BPT-5204 and 26.3 q/ha with MTU-7029 in paddy areas under the renovated channels whereas the actual yield was only 15 q/ha in untreated areas that suffered submergence.



Pynes choked due to silting up



Pynes after desilting, Nawada



Irrigation channel silted up in Matsyapuri village



After desilting of channel

## Recharge of wells to improve shallow aquifers

**Climate vulnerability:** Low and erratic rainfall

### Existing practice

During last 10 years in Sitara village, Bharatpur, farmers suffer from water shortages for crop production due to declining water table. *Rabi* crops often suffered due to moisture stress affecting productivity. As farmers were not aware of in-situ soil and moisture conservation techniques, 35-40% of total rainfall was being lost as runoff.

### Resilient practice / technology

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 rings were descended into the dugout around the tube well. Harvested rainwater is collected in a cement tank and allowed for the silt to settle down and then conveyed to the dugout using a PVC pipe. Material required for recharging included cement rings (8-10 numbers, 4.5 ft radius, 2 ft height), bricks (500), cement (1 bag), pipe (10 ft long) and one perforated pipe (6ft long). Average cost incurred was Rs.10,000 out of which 25 per cent of total cost and labor was shared by the farmer.

### Impact

During 2012-13, 54 bore wells were recharged in the village. This intervention led to significant increase in the shallow aquifer levels (2.5 to 4 m). Despite prevalence of high temperature (36 to 40°C) in the pre-rabi period of 2012-13, farmers could give pre-sowing irrigation before taking up the *rabi* 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 critical crop growth stage with warmer temperatures affecting seed setting and yield reduction.

During 2013-14, about 60 tube wells were recharged (95% were successful) and water table rose by 8 to 10 ft. This water was made available for irrigation in 242 ha land out of 365 ha in the NICRA village. Major crops sown in the rabi season viz. wheat, mustard and barley benefitted due to availability of recharged groundwater.



Silt trap adjacent to tube well



Rise in water level

In Chamaluru village of Anantapur district (Andhra Pradesh.) new farm ponds were constructed in farmers' fields to recharge bore wells. The size of the farm ponds was  $22 \times 22 \times 1.5$  m each having water storage capacity of  $726 \text{ m}^3$ .

The farm pond of Eshwar Reddy got filled twice with runoff water with the receipt of 174 mm of rainfall in September 2013. Five bore wells located in the premises of farm pond were recharged. One defunct bore well started functioning and irrigated area increased by 2 ha.

Another farmer (Ravi ) recharged 2 bore wells located around his farm pond. The depth of the water table on 11<sup>th</sup> September in functioning well was 7.75 m as against 28.5 m on 11<sup>th</sup> April 2014.

Another farm pond was dug in Sri Gopal Reddy's field with a storage capacity of  $750 \text{ m}^3$ . About 5-6 bore wells located in the vicinity of farm pond were recharged. The depth of water table in bore wells increased by 9 feet.

### Monitoring of water table in wells adjacent to farm pond

Well no.	Name of the Farmer	Distance from farm pond (m)	Water table depth (m)								Rainfall details		
			Sep, 13	Oct, 13	Nov, 13	Dec, 13	Jan, 14	Feb, 14	Mar, 14	Apr, 14	Month	Rainfall (mm)	Rainy days
1	Eshwar Reddy	64 m	9.4	9.8	13.0	14.9	17.1	11.75	12.50	12.50	Sep,13	174	6
2	Y.Ravi	128m	11.1	10.5	13.5	12.6	17.4	12.12	13.25	13.50	Oct,13	24	3
3	S.Adi Narayan	75 m (defunt)	9.4	10.8	12.2	12.4	17.8	12.37	11.75	13.0	Nov,13	0	0
4	Gopal Reddy	248 m	11.4	11.3	16.5	15.0	16.6	14.25	16.25	14.50	Dec,13	0	0
5	Venkateswar	270 m	9.6	11.9	16.0	16.1	18.9	15.25	16.25	13.0	Jan,14	0	0
											Feb,14	0	0
											Mar,14	28	2
											Apr,14	13	1
		<b>Average</b>	<b>10.2</b>	<b>10.9</b>	<b>14.1</b>	<b>14.2</b>	<b>17.6</b>	<b>13.1</b>	<b>14</b>	<b>13.3</b>			

Similarly, desilting of open wells is another intervention taken up in many NICRA villages. Open wells (14 wells) in Sarkho village, Guna, Madhya Pradesh were used as irrigation sources in the distant past. They have now become defunct due to silting up.

At Sarkho village, Guna, farmers took up de-silting works of three open wells during 2011-12 and three open wells during 2012-13 in summer to benefit 23 farmers. Irrigation efficiency doubled while irrigated area increased by 50% due to de-silting.

- Depth of open wells increased by 21.3% through de-silting in two consecutive years.
- Productivity of Wheat, Gram and Coriander increased by 26, 28 and 29%, respectively due to recharge of open wells through de-silting.
- Average cropping intensity across farmers increased by 17%.



Desilting of open well, Guna



Rise in water level after desilting

### Scope for upscaling

Scarce rainfall areas in Rajasthan, Andhra Pradesh, Maharashtra, Gujarat and Karnataka.

### Integrated Farming System modules

**Climate vulnerability:** Drought, flood

#### Existing practice

In areas prone to floods and extreme weather events such as frost/ cold stress in addition to water scarcity, monocropping is generally practiced. In these vulnerable areas, dependence on single farm enterprises by farmers is risky as they have limited resilience to cope with climatic constraints.

#### Resilient practice/ technology

Several integrated farming system modules with a combination of small enterprises such as crop, livestock, poultry, piggery, fish and duck rearing were demonstrated to farmers in NICRA villages in the eastern, northern and north eastern states where monocropping is mostly practiced due to climatic constraints.

#### Impact

**Drubgam, Pulwama, Jammu & Kashmir:** Diversification of farm enterprises was encouraged among apple and crop growers in this remote village to augment farm income and build resilience among the farming community to tide over losses due to drought. Selected farmers were trained in establishment of poultry and fisheries units. Two farmers were trained in fisheries and 40 framers in poultry. The success of these enterprises encouraged other farmers in the village to diversify their farm activities with technical support of KVK scientists.

**Phutahola, Dibrugarh, Assam:** Recurrent floods frequently damaged paddy crop in this village. Rajib Buragohain, an young farmer from the village Phutahola was encouraged to take up diversification of his farming by adopting fodder production as a livelihood strategy for higher income and employment. Fodder saplings of perennial grasses such as guinea, hybrid napier, para grass and seed of setaria were provided for planting. Technology on fodder cultivation was given to him along with few other villagers in a training programme. In 3-4 months time, he could meet his own fodder needs and also could sell fodder slips to other villagers for additional income. Three more farmers took up fodder production and together could establish a fodder bank to meet fodder requirement in dry months in the village.

**Punioni-baghchong, Sonitpur, Assam:** Rice-fish-poultry farming enterprise was demonstrated to small farmers in this village to cope with recurrent crop losses due to floods. Select farmers were trained and supported with material and technical knowhow to build low cost poultry sheds installed over paddy fields. Fishes were introduced in to the system for additional income.

**Muttar village, Alapuzha, Kerala:** Most of the villages have a small homestead pond of average size of 5 cents. Duck farming in large flocks is common but fish rearing is practiced only by few farmers. Integrated duck and fish rearing units were established by 25 farmers in the village. Low cost duck shades were erected over the ponds at the edges with PVC pipes and locally available materials. Each unit accommodated 20 ducks and fingerlings of 75 numbers/cent of pond. Each unit could produce 100 kg fish/10 cent unit and 4300 eggs/year from ducks with a net return of Rs.20397 and benefit cost ratio of 1.86.

**Lowkeshra village, East Singhbhum, Jharkhand:** Integrated farming system module with pig-poultry-fish enterprises was demonstrated in this village where monocropping of paddy is regularly practiced. One farmer was encouraged to clear a pond and an outlet of the pig house was let into the pond along with addition of lime @ 4 q/ha and cow dung @ 10 q/ha. He released 5 fish species into the pond. About 15 improved Khaki campbell ducklings and 6 piglets (2 male) were also introduced. Pig and duck excreta was supplied to the pond water as feed to fish and the pond water was used to irrigate *rabi* crops at critical stages. Vegetable wastes were used to feed the birds and pigs. This integrated module could fetch a net profit of Rs.1.71 lakhs in the first year (2013). Seeing the benefits, 50% of pond owners in the village adopted the model of integrated farming system.



Integrated fish-duck farming



Rice-fish-poultry farming

### Scope for upscaling

Integrated farming system modules minimize risk from a single enterprise in the face of natural calamities and diversified enterprises bring in the much needed year round income to farmers in monocropped paddy growing areas and improve their livelihoods and resilience to extreme weather events. Such models can be upscaled in the north and north eastern states through ongoing government programmes.

## Captive rearing of fish seed - a livelihood opportunity in flood-prone areas

**Climate vulnerability:** Floods, Cyclone

### Existing practice

Availability of quality stock size fingerlings of freshwater fish species for stocking in tanks has been a limiting factor for fish production in the panchayat/ community tanks. Fisher folks face difficulty in procurement of quality fingerlings in required numbers which have to be transported over long distances which often results in poor survival besides increasing the cost of fingerlings. Changes in rainfall pattern cause uncertainty in releasing fish seed on time into community tanks and sometimes results in loss of stocked fish seed due to floods.

### Resilient practice/ technology

Captive rearing of fish seed i.e. rearing of early stages (spawn to fry and fry to fingerling stages) through appropriate feed and health management in nursery pond was demonstrated in Sirusuvada village, Kothur mandal of Srikakulam district, Andhra Pradesh. Required training for captive rearing was provided to the fisher folk by the KVK.

### Impact

Sri Chekka Sanyasi and three other fishermen of Sirusuvada (NICRA village) practiced fresh water fish culture with Indian Major Carps in Jagannath Naidu tank spread over an area of 25 acres during August-September and about 8 acres water spread during February-March. Earlier these farmers used to stock the tank with fish seed at fry stage of 2-3 cm size brought from the local fish seed farm which resulted in poor survival and inappropriate stocking ratios. Cost of fingerling of size 6-8 cm was high (Rs 1.5 to 3.0). During 2013-14, few farmers were identified and trained in nursery rearing of fish seed at fry stage in nursery pond. They were supported with fish seed at fry stage and the feed material. About 25000 numbers of fish seed at fry stage were released on 8th August, 2013 in 25 x 25 m<sup>2</sup> nursery pond. Rearing to fingerling size was done for 29 days and harvested on 6<sup>th</sup> September to release into the village tank. The main learning for the fishermen was on acclimatization of fish seed before stocking and feed made up of rice bran and groundnut cake (1:1 ratio) and on regular sampling for monitoring the growth and health of fish seed. By this technology farmers saved about Rs.10500 on cost of fish seed. This attracted other farmers to adopt the technology in the village.

## Economics of captive rearing of fish seed

Particulars	Cost (Rs)
Cost of fish seed (25000 No's)	9500
Feed cost	1500
Labour charges	1000
A) Total cost for captive rearing per month	12000
B) Cost of fingerling at market price @ Rs1.50 for 15000* fingerlings	22500
Net saving (B-A) (Rs/unit)	10500

*\*calculated based on survival of fish seed to fingerling size in nursery pond estimated @ 60%*



Indian major carp fish seed (Fry stage)



Acclimatisation of fish seed in nursery ponds



Sampling for observing growth and health



Harvesting of fish seed



Harvested fingerlings



Stocking in the main tank

# Management practices to tackle cold stress in backyard poultry

**Climate vulnerability:** Cold stress

## Existing practice

Since time immemorial, villagers in the North Eastern States have been rearing poultry for their livelihood needs. About 10-15 numbers of indigenous fowls were maintained in their backyards for both egg and meat production to generate income and cater to their nutritional needs. However, their productivity is low. Normally chicks scavenge along with hens in open areas. During winter, cold stress affects the backyard poultry especially chicks and causes huge mortality in temperate regions of the country.

## Resilient practice / technology

A brooder house was made using locally available materials such as bamboo and wood and to maintain optimum night temperature in the shelter with the help of light bulbs during cold stress period. Breed improvement was made with the introduction of Gramapriya and Vanaraja chicks in NICRA villages. The movement of chicks was restricted nearer the heat source in brooder house with the help of chick guards made with card board. The chicks were fed with ground maize initially, later fed with vegetable wastes and other kinds of locally available grains like maize and rice bran besides the feed material available from free range scavenging as they grew up. Wholesome fresh water was made available at all times in the watering and feeding trough made of bamboo. Chicks were also supplemented with multivitamins @ 1ml/lit of water.

## Impact of backyard poultry interventions

A small farmer, Mrs. Pabithra Sharma in Nandok village in East Sikkim was initially supported with a stock of 60 chicks. She sold extra male birds @ Rs. 220/ kg live weight and eggs at the nearby local market and generated a net profit of Rs.11,300 with a benefit cost ratio of 1.78. She purchased 100 more chicks from ICAR Sikkim center and also initiated hatchery with a small capacity of hatching 10-12 eggs at a time by using local broody hens. She could sell the improved breeds to fellow farmers and helped in the horizontal dissemination of these breeds. Now, Nandok village under 26 Naitam Nandok GPU in East Sikkim district has become a hub for backyard poultry production with improved birds. Mrs. Sharma has become a role model for the rural youths and farm women for taking up improved backyard poultry as a potential practice for agri-preneurship development leading to sustainable livelihood security by addressing the climate risk adequately through the improved shelter for chicks and introduction of improved breeds.

### Performance of backyard poultry

Parameters	Performance
Mortality up to 10 weeks	<5%
Average age at first lay (days)	145
Average body weight at first lay (Kg)	2.18
Average annual egg production (No./year)	178

### Economics of backyard poultry

Stock per batch	Expenditure (Rs)	Income (Rs)	Profit (Rs)	B:C ratio
60	14446	25720	11274	1.78



Improved housing to protect from cold

### Scope for upscaling

The practice of rearing backyard poultry with improved synthetic breeds like grama priya and vanaraja by providing proper brooding during early life of chicks and supplementation with grains and vitamins has lot of potential in all the states of NEH region in providing nutritional security and income at household level.

## Shelter management for small ruminants to tackle heat stress and rain storm

**Climate vulnerability:** Heat stress and cyclone

### Existing practice

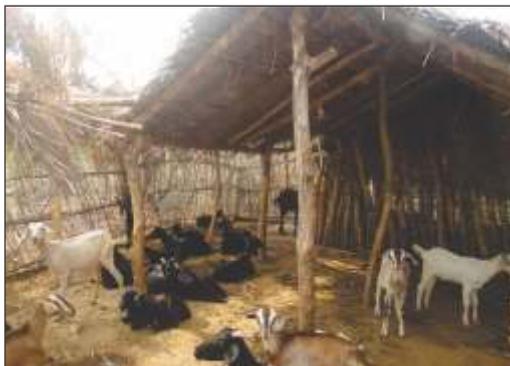
Heat stress and rain storm are the foremost challenges that animals have to deal with for a period of 3-4 months in a year as these lead to disease epidemics in small ruminants. Further, high ambient temperatures outside the thermo - neutral zone cause significant changes in physiological processes including feed intake, production and reproduction. Continuous rain storms predispose the animals to infectious diseases. In general, majority of the farmers may not provide any shelter for small ruminants. Mostly tree shade is provided or the movement of animals during night is restricted by fencing the area with bamboo /wooden/iron material. As the animals are in contact with defecated fecal material, coccidiosis and tapeworm infestation are also common in herds. High temperature during April to August months and high intensity rainfall between September to November result in higher lamb and kid mortality due to heat stress and infectious diseases, respectively.

### Resilient practice / technology

A semi-intensive system of rearing of goats in a slatted floor with proper roof can provide shelter to the animals to tackle heat stress during summer and rain storms during monsoon. Locally available wooden planks were used for making slatted floor. A gap of one inch was maintained between each slat so that the urine and fecal material could be collected from the bottom of the floor. The roof of the shelter was made with bamboo and covered with either thatched material or coarse cereal crop residues.

### Impact

This model of a semi-intensive system of rearing of goats in a slatted floor was demonstrated in Vadhavathur village at Namkkal, Tamilnadu. Due to the gap between the slats, collection of fecal material become easy and there was no accumulation of ammonia in the shed during rainy and winter season. The problem of spread of coccidiosis and tape worm infestation to healthy animals was controlled to a great extent. This resulted in decreased mortality from 10 to 2% and expenditure for treatment of affected animals was also avoided. The live weight gain of animals was enhanced from 60-70g to 78-86g per day as a result of protection from heat stress. This resulted in 3-4 kg more weight gain per animal at marketable age and resulted in additional income to the farmer by about Rs.500-700/animal.



Old shelter



Improved shelter

### Scope for upscaling

The practice of semi intensive system of rearing of small ruminants in a slatted floor with proper roof has a lot of potential in the costal distracts of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Odisha and West Bengal for providing sustainable livelihoods to farmers.

## Small farm mechanization through Custom Hiring Centres for farm machinery

**Climate vulnerability:** Drought, Excess rainfall

### Existing practice

Average operational land holding size in the country is estimated at 1.16 ha. About 80% of the land holdings are operated by small and marginal farmers owning <1 and 1-2 ha holdings, respectively. These farmers cannot invest in costly farm machinery and depend on hiring of implements to carry out agricultural operations in their fields. In rainfed areas, the window for taking up of timely land preparation, sowing and inter-culture operations is narrow especially in the low rainfall zones. Failing to exploit this limited window often leads to a compromise on productivity and efficiency in crop production. In high rainfall areas dominated by heavy soils, drainage is more crucial to prevent damage to crop from excess soil moisture in the root zone especially in pulses, oilseeds and cotton. Labour shortage at peak times of demand is a serious problem faced by farmers. Adoption of climate resilient practices such as soil incorporation of legume catch crops and crop residues to improve soil health and resource conservation technologies are linked to timely access to appropriate farm machinery at reasonable cost. Several options are now available to increase the efficiency and timeliness of agricultural operations even on small farms by using farm machinery.

### Establishment of village level custom hiring centre for farm machinery

Mechanization brings in timeliness and precision to agricultural operations, greater field coverage over a short period, cost-effectiveness, efficiency in use of resources and applied inputs, conservation of available soil moisture under stress conditions and provision of adequate drainage of excess rain and floodwaters. Custom hiring centres (CHCs) for farm implements were established in 100 NICRA villages which could successfully empower farmers to tide over the shortage of labour and improve efficiency of agricultural operations. A committee of farmers' nominated by the gram sabha manages the custom hiring centre. The rates for hiring the machines/ implements are decided by the Village Climate Risk Management Committee (VCRMC). This committee also uses the revenue generated from hiring charges for repair and maintenance of the implements and remaining amount goes into the revolving fund. There are 27 different types of farm machinery stocked in 100 CHCs, the most popular are rotavator, zero till drill, drum seeder, multi-crop planter, power weeder and chaff cutter. Each centre was established at a capital cost of Rs 6.25 lakhs funded by the NICRA project.

## Impact of custom hiring centres

Custom hiring centres for farm machinery enabled farmers to access implements to take up several climate resilient practices and technologies in NICRA villages. Tribal farmers' of Umrani village in Nandurbar, Maharashtra face the problem of long dry spells and low yield and hence demonstration of *in-situ* conservation of soil and water and sowing across the slope in 10 ha area covering 25 farmers resulted in 11-13 % increase in soybean yield and conserving valuable top soil from erosion. In recent years, delay in onset of monsoon rains coupled with deficit rainfall in July is adversely affecting transplanting of paddy in Bihar. Demonstration of direct seeding of rice with drum seeder at Saran resulted in timely sowing, save nearly 25 litres of diesel and 35 man days for transplanting and saving of pumping by 3 hours per ha there by reducing cost of cultivation and increasing grain yield by 17%. Demonstration of *in-situ* moisture conservation through broad beds prepared across the slope for cultivation of *rabi* sorghum in 4.8 ha at Baramati, Maharashtra resulted in increase in crop yield by 3 times i.e., 11.3 q/ha compared to 3.8 q/ha in untreated control. Use of seed cum fertilizer drill facilitated crop diversification in Satna, MP with pulses and oilseed crops where rice-wheat is the predominant system. In NICRA villages in Madhya Pradesh, farmers who adopted broad bed furrow planting method in soybean with BBF planter avoided damage to the crop due to excess rainfall in *kharif* 2013 season and realized about 40% yield advantage compared to flat bed sowing

Terminal heat stress in wheat drastically affects seed set and reduces grain yield. A key adaptation to avoid this stress is to ensure timely planting of wheat. Hence, demonstration of wheat production for timely sowing, resource conservation and to enhance productivity was taken up. Wheat was sown directly after harvest of rice using zero till seed drill in 25 ha involving 105 farmers. Zero tillage saved cost of field preparation, saved labour and increased grain yield.

In Kota, Rajasthan water availability is a major limiting factor for sustaining wheat productivity in the village. Hence, furrow irrigated raised bed (FIRB) system of wheat cultivation was promoted to enhance crop yield (10%) and water productivity in 40 farmers' fields by using FIRB machine. Several advantages with FIRB system over flat bed system of wheat cultivation include saving up to 25% seed, irrigation water by 30% and saved time required for irrigation.

## Management of custom hiring centre

An innovative institutional mechanism was put in place at the village level for management of the custom hiring centre for farm machinery. Village Climate Risk Management Committee (VCRMC) was constituted comprising of 12-20 villagers with nominated members as President, Secretary and Treasurer. A bank account is opened in the name of VCRMC and is operated by any two signatories. The committee fixes the charges for hiring for different implements and hiring rates are to be displayed prominently. Farmers' contributory share towards inputs like seeds, fertilizer, animals etc., is also deposited in the bank account. The revenue and expenditure details must be shared with the general body periodically.

## Advantages of Custom hiring centres

- Provides access to small and marginal farmers to costly farm machinery
- Facilitates timeliness in farm operations and efficient use of inputs
- Promotes adoption of climate resilient practices and technologies by farmers because of availability of appropriate machines at reasonable hiring charges

- Reduces drudgery
- Promotes increase in cropping intensity wherever feasible
- Facilitates crop residue recycling and prevents burning of residues
- Reduction in cost of cultivation
- Provides work opportunities to skilled labour and small artisans

#### **Custom Hiring Centers: Early Lessons**

- Water saving devices especially drip and sprinkler sets are very popular in areas predominant with horticulture crops.
- Seed cum fertilizer drills helped in introduction or expanding the intercropping area.
- This also helped improve fertilizer use efficiency, as fertilizer placement particularly urea, DAP was appropriate. This has implication in reducing nitrous oxide emissions.
- Deployment of power weeders in CHCs helped timely weed control, which improved the water and nutrient use efficiency
- Different kinds of crop threshers available in CHCs enabled farmers in timely harvesting operations at a lower cost. This could help avoid crop damage in weather abbreviations such as cyclone, frost etc.
- Zero till drills helped save time, water, fuel and escape terminal heat stress besides enabling farmers to make early harvest of rabi crops.
- Broad bed furrow technology for wheat, soybean, and maize saved crop damage due to excess soil moisture by aiding quick drainage and avoiding water stagnation
- There is a need for positioning multiple numbers of equipments like planters, zero till drills, harrows, weeders etc.

#### **Revenue generation from hiring**

<b>Zone</b>	<b>KVKs (number)</b>	<b>Revenue (Rs.)</b>
I	12	164540
II	15	284822
III	17	341955
IV	13	94158
V	13	332124
VI	7	519605
VII	14	437986
VIII	9	422648
<b>Total</b>	<b>100</b>	<b>2597838</b>

## Scale of operation

Over 1000 demonstrations with energy efficient implements were successfully conducted in the NICRA villages by hiring from CHCs covering 22000 ha and 30000 farmers. Cumulative revenue generated from CHCs is 26 lakhs with an average revenue generated per centre ranging from Rs. 7000 to 74000.



Shed for farm implements



Rate board for hiring charges



VCRMC meeting in progress

## Improved planting methods for enhancing water use efficiency and crop productivity

**Climate vulnerability:** Extreme rainfall events, prolonged dry spells and waterlogging at different crop growth stages.

### Existing practice

Generally farmers of Sanora and Barodi village, Datia sow soybean with local country plough which is time and labour intensive. During extreme rainfall events, the crop gets affected either due to dry spells or waterlogging due to lack of proper drainage.

### Resilient practice / technology

There is a need for *in-situ* soil and water conservation and proper drainage technology in deep black soils. Broad bed and furrow (BBF) system involves preparation of a broad bed of 90 cm, furrow of 45 cm and sowing of crop at a row spacing of 30 cm. The cost of BBF implement is Rs. 45,000. The BBF technology has many advantages including *in-situ* conservation of rainwater in furrows, better drainage of excess water and proper aeration in the seedbed and root zone. More than 200 farmers in Sanora and Barodi village adopted the technology. Similarly, furrow irrigated raised bed (FIRB) planting was promoted for cultivation of different crops in Uttar Pradesh, West Bengal, Punjab, Maharashtra, Karnataka, Rajasthan and Tamilnadu. Ridge and furrow method of vegetable cultivation was promoted in Gunia village of Gumla district and in cotton at Amravati and Aurangabad, Maharashtra.

### Impact

Advantage of BBF planting method :

- Increase in water use efficiency
- Increase in crop productivity (5-10%)
- Less moisture stress during non- rainy days
- Time saving (25-30%) in irrigation
- Requires 20-25% lower seed rate
- Water saving up to 25-30%
- Better weed management
- Reduces crop lodging

### Performance of soybean in ridge and furrow method of sowing

Particular	Ridge and Furrow	Farmers' practice	% increase in yield/income
Grain yield (kg/ha)	1937	1152	40.5
Net Return (Rs/ha)	38805	18898	51.3
B:C ratio	3.51	2.41	
Water use efficiency (kg/ha/mm)	2.09	1.24	



Preparation of broad beds



Rainwater in furrows



Crop stand with BBF planting



FIRB planting in wheat

Advantages of FIRB planting method are:

- Management of irrigation water is simpler and more efficient. On an average about 30% less irrigation water was required compared to flat bed method and improved crop yields by more than 20%. FIRB planting saved 30 to 50% wheat seed compared to flat bed planting.
- Better upland crop production is possible under wet spells because of proper drainage.
- Farmers can apply N and irrigation water at grain filling stage to improve protein content without inducing lodging. Reduced lodging can have a significant positive effect on yield as many farmers do not irrigate after heading precisely to avoid lodging.
- Weeds between the beds can be controlled mechanically early in the crop cycle.
- Herbicide dependence is reduced, and hand weeding and hoeing between rows are easier
- Yield of rice transplanted on FIRB was comparable with traditional rice but could save as much as 25-50% in irrigation water.
- Compaction of soil is limited only to the furrows used as tramlines (tractor tracks).

Ridge and furrow method of vegetable cultivation in Gunia village of Gumla district had the following advantages:

- Crop stand improved 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

### **Scope for upscaling**

BBF / FIRB / Ridge furrow planting of crops was demonstrated in Coochbehar (West Bengal), Kushinagar (U.P.), Baramati, Amravati, Aurangabad, Nandurabar (Maharashtra), Nalgonda (A.P), Kota, (Rajasthan) Datia, Morena, Satna (M.P) Chikballapur (Karnataka) and Villupuram (Tamilnadu) in 412 ha covering over 1000 farmers with an average 10 to 40% increase in yield and benefit cost ratio of 2.2 to 4.7 compared to farmers' practice. There is scope for upscaling the technology in soybean, maize and wheat growing areas.

## Zero till drill wheat to escape terminal heat stress

**Climate Vulnerability:** Drought, Heat stress

### Existing Practice

Wheat sowing by conventional methods requires multiple tillage operations to prepare a fine seed bed after harvesting of paddy crop. Generally, 2-3 or even more tillage operations are required which cost both time and money for the farmers. Moreover, shortage of time after paddy harvest to sow wheat creates uncertainty and delay in sowings. This sometimes results in moisture stress during the initial stages of crop growth eventually leading to poor yields. Impeded drainage in low lying fields makes it difficult for carrying out normal tillage operations. In such fields, late planting of wheat exposes the crop at critical stages to heat stress leading to decline in productivity.

### Resilient practice / technology

Demonstrations of zero till drill sown wheat in farmers' fields were undertaken in several NICRA villages. The zero till drill not only saves tillage costs and energy but also eliminates the need for seedbed preparation. Zero till drilled wheat yields were on par with conventionally sown wheat. The machine operated with a 35 hp tractor can cover sowing of wheat in 4-5 ha/day.

### Impact

Zero till sowing of wheat could save 68% in time and 85% on the cost of operation compared to the conventional practice. Zero till drill was more efficient as the crop could be sown in large areas within a limited time of moisture availability. The cost of zero till drill is Rs.45,000 to 60,000. The main advantages include:

- Saves irrigation water up to 10-15% during first irrigation.
- Two days early and uniform germination and better plant stand than traditional.
- No crust formation after rains, hence no effect of rains on germination.
- Improvement in crop yield.
- Improvement in soil structure and fertility.
- No lodging of crops at the time of maturity in case of heavy rains.

Now the farmers are convinced about the performance and benefits of zero till drill in NICRA villages. Demonstrations covered 851 ha and 1227 farmers using the zero till drill from the custom hiring centers established under NICRA. On an average yield advantage was in the range of 16 to 64% and benefit cost ratio was in the range of 2 to 3.2.



Wheat sown with zero till drill



Crop at grain filling stage

### Scope for upscaling

Higher cost of implements is a major constraint in the large-scale adoption of zero till drill practice. State government subsidy can offset the cost to farmer to some extent. Such resource conservation technologies can be upscaled by establishing custom hiring service centers for costly farm machinery. The practice can be upscaled in rice-wheat cropping system areas.

## *In situ* incorporation of biomass and crop residues for improving soil health

**Climate Vulnerability:** Drought, high temperature stress, flood and heat wave

### Existing Practice

Generally, farmers burn crop residues like stalks of pigeonpea and cotton without recycling them. This is a great loss to the farmer as well to the land, as the land is deprived of biomass, which helps build precious soil organic carbon. This harmful practice is leading to increased CO<sub>2</sub> emissions beside depriving crop residue to the soil. Farmers resort to burning of the crop residue as removing it involves higher costs for labour to uproot, chop and mix in the soil.

### Resilient practice / technology

In order to encourage farmers to change this practice, rotavator machine was introduced in the NICRA villages. The harvested crop stalks/ stubbles are chopped into small pieces and incorporated *in-situ* into the soil with varying efficiencies depending upon the left over residue. The cost of implement is Rs. 1.0 to Rs.1.2 lakhs and field capacity of the rotavator is 5-6 ha/day. Rotavator helps in obtaining of early seedbed preparation soon after harvesting of *kharif* crops for sowing of *rabi* crops. This not only requires low energy in tillage operation but also mixes and incorporates the stubbles of previous crop thoroughly in the soil. This improves the soil physical properties and hence, results in increased crop yield. Incorporation of green manuring crops such as daincha, moong and cowpea in wet conditions can be taken up to improve soil health.

### Impact

On an average incorporation of cotton stalks in one hectare field adds about 124 Kg N, 36 Kg P<sub>2</sub>O<sub>5</sub>, with some quantities of Zn, S and other micronutrients into the soil. This results in saving of chemical fertilizers, labour and time. Residue or biomass incorporation improves water retention of soils and benefits the crop. This practice of *in situ* incorporation of crop residues can bring about reduction in the harmful practice of residue burning which aggravates GHG emissions and air pollution. Rotavator use is gaining popularity in view of its multiple operation capabilities with greater efficiency. In NICRA villages the machine was made available through custom hiring centers for wider adoption by farmers of resource conservation practices for improvement of soil health and productivity.

Shri Sanjay Sawalkar, a farmer of Takali village, Amravati, Maharashtra cultivates about 2.4 ha of land out of which 0.8 ha is irrigated. He earlier practiced burning of cotton stalk after harvesting the crop. His average yield of seed cotton was 8.8 q/ha. In the next season tillage operations such as ploughing and harrowing with tractor mounting implements cost him Rs.2500/ha. Under the NICRA project he hired the rotavator from the custom hiring center for incorporating the crop residue in the field and spent around Rs.1750/ha for the operation. His average productivity in subsequent years increased by 2.7 q/ha.



Rotavator for incorporation of cotton stalks



Incorporation of green biomass

### Scope for upscaling

In NICRA villages, *in situ* incorporation of paddy, wheat and cotton residues and biomass of green manuring crops was demonstrated in 1166 ha covering 1698 farmers across several districts: Faridkot, Aurangabad, Buxar, Saran, Jehnabad, Koderma, Malda, Supaul, Kushinagar, Amravati, Baramati, Gondia, Kurnool, Nalgonda, Bharatpur, Kota, Kutch, Bilaspur, Dantewada, Chitrakoot, Datia, Guna, Belgaum and Namakkal.

### Village level seed banks to combat seed shortages

**Climate vulnerability:** Drought, Flood

#### Existing practice

Seed shortage of suitable crop varieties is an important limitation faced by farmers to implement contingency crop plans to tackle aberrant rainfall situations. In vulnerable areas, farmers tend to dispose-off the entire produce as grain and therefore depend on external sources for seed supply in the next season. In crops where the seed multiplication ratio is low, seed rate and seed cost is high (e.g. soybean and groundnut) and this dependence entails significant investment towards seed cost at the start of the season. Early season drought and need for re-sowing will only exacerbate the hardship faced by farmers. Seed of certain contingency crops like minor millets are sometimes left out of the normal seed supply chain. Identification of suitable varieties of main and alternate crops is needed in drought and flood prone areas so that seed production can be taken up well in advance and kept in the village seed bank for use in contingency situations at the local level.

#### Resilient practice / technology

Participatory village level seed production of short duration, drought and flood tolerant varieties was demonstrated in several NICRA villages with the support of KVKs in rice, soybean, groundnut, greengram, finger millet, foxtail millet and pigeonpea. Breeder seed / foundation seed was sourced from research farms for multiplication in farmers fields and the quality seed so produced was mostly used in the village and nearby villages. Farmer to farmer sale as truthful seed was the means of spread.

#### Impact of seed bank

D. Naganahalli village in Tumkur, Karnataka became self-sufficient in seed of short duration variety of finger millet variety (ML-365) suitable for late planting in case of delay in monsoon rains. Similarly farmers in Yagnantipalle village became self-sufficient in seed of foxtail millet (SIA 3805) and successfully switched over to its cultivation instead of risky crops like cotton due to occurrence of prolonged dry spells. Performance of short duration and early maturing variety of soybean (JS-95-60) in Sanora and Boroundi village, Datia, Madhya Pradesh and its seed production was responsible for its spread to nearby villages in about 400 ha in one year's time after its introduction. Production of drought tolerant paddy variety, Sahbhagi dhan in Shokhodeora village in Nawada, Bihar helped the villagers to successfully take up paddy under deficit rainfall conditions in *kharif* 2013 unlike farmers in other villages who had to abandon nurseries of long duration varieties and kept their lands fallow. Crop Variety Quantity (q) NICRA KVK Rice Sahbhagi dhan 160 Nawada MTU-1081200 Balaghat Samleshwari 120 Dantewada Swarna sub-1285 Maharajganj Lalat, Khandagiri 250 Sonapur Greengram Pusa Vishal 24 Dantewada Soybean JS-95-60425 Guna JS-95-608600 Datia Finger millet ML-3652.8 Tumkur Foxtail millet SIA-380510 Kurnool Groundnut GG-552 Rajkot Pigeonpea ICPL-880296.5 Chitrakoot



Seed bank in Gunia village, Gumla



Nearby villagers purchasing seed from NICRA farmers

### Scope for upscaling

Use of farm saved seed is predominantly the means of absorbing the risk associated with contingency situations arising on account of delay in onset of monsoon or in situations warranting re-sowing of crops due to failure of rains immediately after sowing in low rainfall areas. Under the technology demonstration component, NICRA KVKs conducted participatory demonstrations with identified varieties of crops in NICRA villages. Based on the performance of these varieties, seed production was encouraged at the village level. The crucial challenge for NICRA KVKs was to identify the appropriate varieties of crops suitable for meeting location specific contingency situations. Support from the central schemes for establishment and maintenance of seed banks by state seed corporations and the seed village scheme is to be tapped in the ensuing period.

## Fodder cultivars to tackle fodder scarcity

**Climate vulnerability:** Drought in rainfed areas

### Existing practice

Adequate supply of fodder, either green or dry, is crucial to the livelihoods of farmers involved in animal husbandry. Livestock producers meet their fodder requirements through a combination of crop residues, grazing on community and private property resources (CPRs & PPRs), cultivable fallows and crop lands after harvest apart from cultivation of forage crops to a limited extent. In general, livestock farmers do not make special efforts for forage and pasture management during drought years. This leads to severe fodder crisis, which ultimately forces distress sale of valuable animals for slaughter. Early season drought reduces the area under fodder crops, whereas mid-season drought impacts fodder availability especially during lean period. Terminal drought has much less effect on fodder production but it affects the availability of seed material for the succeeding year. The most significant effect on fodder crops during drought conditions are reduced forage yields and greater extent of lignification due to low soil moisture. Further, grazing on such areas severely damages the crop stand and affects their revival even if some rains are received during later period. It is essential to assess availability of various feed resources, their supply and utilization (both quantity and quality) and nutritional requirements of animals. This is essential for targeted increase in production through feeding and to take up appropriate measures required to provide better nutrition to animals during drought period. The critical need is to build proper feed and fodder reserves to tackle the shortages in low rainfall years.

### Resilient practice / technology

Short and medium duration fodder cultivars of several crops that can withstand up to 2-3 weeks of exposure to drought in rainfed areas were demonstrated in NICRA villages. These include: sorghum (Pusa Chari Hybrid-106 (HC-106), CSH 14, CSH 23 (SPH-1290), CSV 17); Bajra (CO 8, TNSC 1, APFB 2, Avika Bajra Chari (AVKB 19); Maize (African tall, APFM 8). These cultivars can be sown immediately after the rains under rainfed conditions in arable lands during *kharif* season and are ready for cutting by 50-60 days. Cultivars of *rabi* crops like Berseem (Wardan, UPB 110) and Lucerne (CO 1, LLC 3, RL 88) were demonstrated in NICRA villages as second crop with the available moisture during winter. Perennial fodders like APBN-1, CO-3 and CO-4 were also demonstrated under limited irrigated conditions.

## Impact of fodder interventions

Feed and fodder reserves increased substantially at both household and village level. Maize fodder was preserved as silage for feeding livestock during summer, whereas crop residues were stored as hay. This resulted in increase in milk production by about 10-15% at household level and reduction in calving period by about 45-60 days in addition to birth of healthy off-spring. As the livestock received optimum nutrition through the available green and dry fodder, incidence of diseases was low and this resulted in lower cost of production of either milk or meat.



Fodder production in NICRA village



Silage from green fodder

### Scope for up-scaling

Short and medium duration fodder varieties were demonstrated in 276 ha covering 762 farmers. Availability of suitable varieties of fodder seed for delayed planting situation is a serious constraint for implementation of contingency plans in districts experiencing deficit rainfall. Solution lies in the promotion of seed production of short duration cultivars (cutting at 50-60 days duration) and medium duration varieties (60-75days). Effective linkages and coordination among the state animal husbandry department and state veterinary universities is highly desirable for implementation of a successful seed production plan well in advance. Strengthening of scientific storage infrastructure is warranted. Scope exists for promotion and up-scaling of short and medium duration varieties of fodder in the rainfed areas in Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Tamilnadu.

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