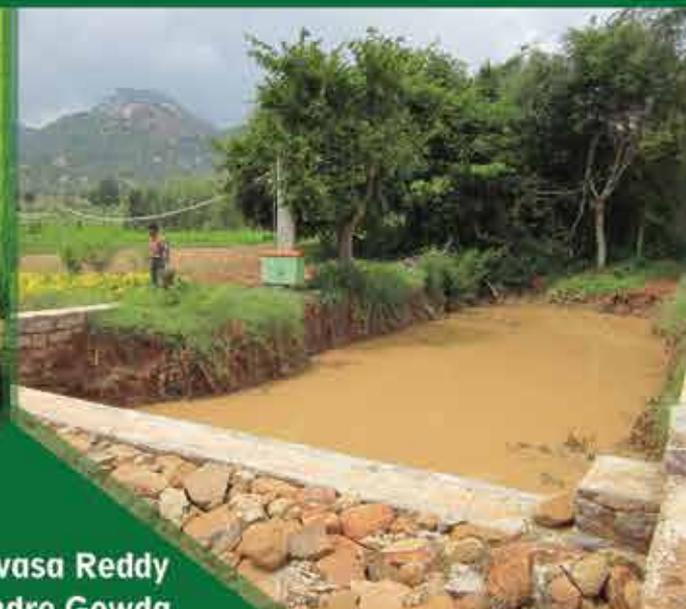
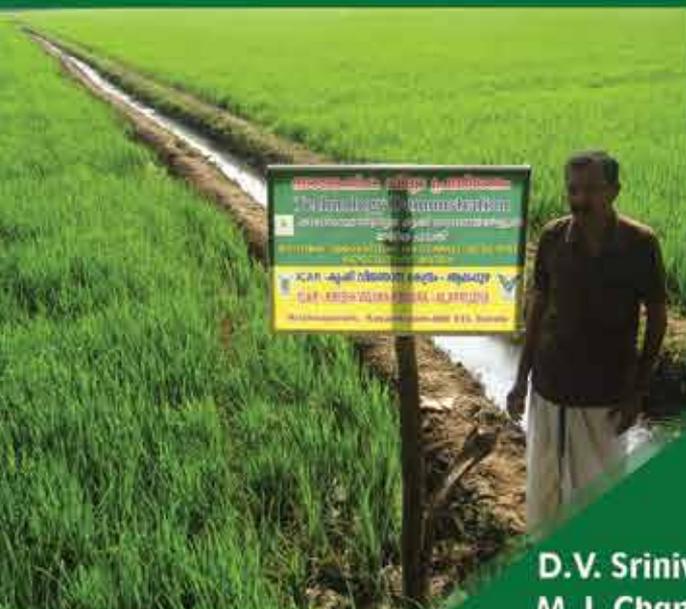


CLIMATE SMART AGRICULTURAL TECHNOLOGIES FOR CLIMATIC ABERRATIONS



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**Climate Smart Agricultural Technologies for
Climatic Aberrations
Experience of NICRA**

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2019



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PREFACE

It is a privilege to present the compilation on **Climate smart agricultural technologies for climate aberrations-Experience of NICRA** which is an outcome of the activities carried out by the KVKs under the project National Innovations in Climate Resilient Agriculture (NICRA). The overall focus of technology demonstration 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. Sustainability is the immediate goal in highly intensive production systems facing natural resource degradation. Therefore, the central objective 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.

In this backdrop, proven technologies were demonstrated in climatically vulnerable Belagavi, Gadag, Kalaburagi, Davanagere, Chikkaballapura and Tumkuru districts in Karnataka and Alleppy in Kerala since 2011.

The publication highlights the significant achievements in alleviating the climatic aberrations in NICRA adopted villages. These centres have now become hubs of learning on climate resilient agriculture in a short span, opening up opportunities for horizontal and vertical diffusion of the successful interventions. The contents of this publication will add to the knowledge and will contribute towards horizontal spread of these technologies in similar farming situations.

The authors take this opportunity to gratefully acknowledge the co-operation and assistance of Heads and Subject Matter Specialists of NICRA KVKs under ICAR-ATARI, Bengaluru, farmers and VCRMC members of the NICRA village and Department officials for their valuable contribution. The authors also acknowledge the financial support and technical assistance of ICAR-CRIDA, Hyderabad for the study through NICRA.

Authors

Dated: 5th December 2019

Place : Bengaluru



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FOREWORD

Climate change is a challenge for global food and nutritional security for a growing human population. ICAR launched the “*National Innovations in Climate Resilient Agriculture*” (NICRA) with an aim to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and technology demonstration. The Technology Demonstration Component (TDC) of NICRA as on-farm participatory demonstration of available technologies is being implemented in 121 most vulnerable districts of the country. Climate vulnerabilities being addressed are drought, flood, cyclone, heat-wave etc. Demonstration of appropriate practices and a technology with a climate focus evolved by the NARS is taken up in farmer participatory mode in NICRA villages. I am glad that this initiative has generated enormous interest and enthusiasm amongst farmers, administrators and policy makers.

This publication documents successful interventions related to climate resilient practices and technologies that have potential for up-scaling in other parts of the country facing similar vulnerabilities. I compliment the team ATARI, Zone-XI, Bengaluru for compiling successful interventions from seven NICRA KVKs in Karnataka and Kerala. I also appreciate the Krishi Vigyan Kendras and NICRA farmers who have taken active part in this very important initiative. The experiences and lessons learnt through this initiative will have a significant impact on shaping our strategy towards securing a climate resilient agriculture.

(A.K Singh)

Dated: 25.11.2019

Place : New Delhi



त्रिलोचन महापात्र, पीएच.डी.

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FOREWORD

Climate change and inconsistency in whether are threatening the agricultural production globally. Countries like India are more vulnerable as millions of small holders have poor capacity to cope with climate risks and disasters. The Technology Demonstration Component of National Innovations in Climate Resilient Agriculture (NICRA) is being implemented in 121 climatically vulnerable districts of the country to address the climatic variability issues and to enhance resilience and adaptive capacity of farmers. Proven resilient practices are being demonstrated in the NICRA villages based on the climatic vulnerability. In perennially drought affected districts, prioritized soil moisture and nutrient management measures, resilient crops, varieties, cropping systems and profitable farming systems are being demonstrated, which minimized the impact of dry spells. Emphasis has been given to strengthen the livestock systems for minimizing the risk at household level. Efforts are being made to spread the proven resilient practices in the NICRA villages by leveraging convergence with developmental programs. Framework for quantification for resilience has been developed and mitigation co-benefits of the adoption practices were quantified.

I compliment the team at ICAR-Agricultural Technology Application Research Institute (ATARI), Bengaluru and ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, for bringing out the Climate Smart Agricultural Technologies for Climate Aberrations with the support of all the participating farmers and KVKs. I am sure that this publication will contribute towards better understanding of the performance of resilient technologies across varied agro-ecosystems of the country.

(T. MOHAPATRA)

Dated : 4th December, 2019

Place : New Delhi





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National Innovations for Climate Resilient Agriculture

INTRODUCTION

Climate has been the primary determinant of agricultural productivity since the inception of civilization. However, the recent trends in climate change manifest this as a global environmental challenge ensured by both natural and anthropogenic activities. The impacts of climate change are global, but countries like India are highly vulnerable as large population depends on agriculture. Concern over the potential effects of long term climate change on agriculture has motivated a substantial body of research over the past decades and findings to portray that irregular rainfall patterns and increased temperature, affects production and reducing yield up to 63 to 82 % by the end of the 21st century (Smith et al., 2007). The current scenario is that weather parameters are influencing agriculture strongly (67%) compared to other factors like soil and nutrient management (33%) during the cropping season. Researchers have confirmed that crop yield falls by three impacts which include an adjustment in sowing and plant development stage that is more resilient to climate variability and improvement in agricultural practices. As per the latest report, the global average temperature rise is 0.940. (NASA, 2018). The predicted temperature rise for India is in the range of 0.5-1.2°C by 2020, 0.88-3.16° C by 2050 and 1.56-5.44° C by the year 2080. Agriculture sector is contributing about 16% of India's GDP; a 4.5 - 9.0% negative impact on production implies a cost of climate change to be roughly up to 1.5% of

GDP per year.

Increase in mean seasonal temperatures, erratic rainfall patterns and increased frequency of extreme weather events pose a serious threat to agriculture and in turn to the food and nutritional security of resource poor small and marginal farmers. Changes in temperature and precipitation can indirectly impact productivity of crops in the form of outbreaks of pests and diseases thereby reducing harvest. Rainfed crops which occupy 60% of cultivated area take the brunt of impact of climate change and farmers in these regions being less endowed in terms of financial, physical, human and social capital are the worst affected. Delayed onset of monsoon, mid-season and terminal droughts in rainfed areas cause huge losses to agriculture and livestock production. Incessant and unseasonal rains that occur in fewer rainy days cause heavy losses to standing crops and also to the harvested farm produce in the fields. Coping with the impact of climate change on agriculture will require careful management of resources like soil, water and biodiversity. By incorporating various adaptation measures in agricultural systems, one can increase the resilience and adaptive capacity of the small land holders.

Govt. of India has accorded high priority on research and development to cope with climate change in agriculture. The Prime Ministers National Action Plan on Climate Change has identified Agriculture as one of the eight National Missions. With this background, to meet the challenges of sustaining domestic

food production in the face of changing climate and to generate information on adaptation and mitigation in agriculture, the Indian Council of Agriculture Research (ICAR) launched a flagship network project “National Initiative on Climate Resilient Agriculture” (NICRA) during XI Plan in February 2011, and continued during XII Plan as National Innovations for Climate Resilient Agriculture (NICRA).

The project aims to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and technology demonstration. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and Sponsored/Competitive Grants.

Objectives

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

Under Technology Demonstration Component (TDC) of NICRA, technological interventions were implemented in farmer participatory

mode in seven most climatically vulnerable districts namely Alappuzha in Kerala and Belagavi, Gadag, Kalaburagi, Tumkuru, Davanagere, Chikkaballapura in Karnataka through Krishi Vigyan Kendras (KVKs). The team in each KVK documented the impact of climate resilient technologies with measurable indicators. The progress of the project activities were guided and monitored by ATARI, Bengaluru and CRIDA, Hyderabad.

The interventions being implemented are based on four modules, (1) natural resources management (2) crop production (3) livestock and fisheries, and (4) institutional interventions. Climate vulnerabilities addressed are drought, flood, cyclone and heat wave. Demonstration of appropriate practices and technologies with a climate focus evolved by the NARS are taken up in farmer participatory mode in NICRA villages. The NICRA villages have become hubs of learning on climate resilient agriculture in a short span; opening up opportunities for horizontal and vertical diffusion of the successful interventions in other parts of the district.

This publication documents the successful interventions related to climate resilient practices and technologies that have been adopted by farmers besides having higher potential for up-scaling under similar situations. Some of the technologies have potential co-benefits towards reduction in emissions. These successful interventions of seven KVKs have been discussed in this publication.



2. Climate Smart Agricultural Technologies for Climatic Aberrations

2.1 Alappuzha, Kerala

(P. Muralidharan and M.S. Rajeev)

ICAR-KVK Alappuzha, Krishnapuram Post, Kayamkulam, Alappuzha (Dist.) Kerala

Kuttanad is a region covering the Alappuzha, Kottayam and Pathanamthitta districts of the state of Kerala, well known for its vast paddy fields and geographical peculiarities. The region has the lowest altitude in India, and is one of the few places in the world where farming is carried on around 1.2 to 3.0 metres (4 to 10 ft) below the mean sea level. Kuttanad is historically important in the ancient history of South India and is the major rice producer in the state.

2.1.1 About NICRA village

ICAR-KVK Alappuzha implemented NICRA in the Kuttanad region of the district, and follows a unique farming situation of paddy in low lands and coconut, banana, vegetables in the uplands. Since this region is vulnerable to water logging for almost 4 months in a year (June – September) during the South-West monsoon, cultivation of crops is restricted to a maximum of 7-8 months from October to May.



During the first phase, the project was implemented in Muttar village of Veliyanadu Block. The village is located at the Eastern part of Kuttanadu region sharing the boundary with Ramankari, Paippad, Nedumpuram and Thalavadi villages. The major occupations of the people of the village are agriculture, livestock, poultry and duck rearing. The village lies up to 2 m below MSL and hence often under submergence during the South West monsoon period (June – Sept). Paddy cultivation is the major agricultural activity in the large stretches of padasekharam in one season from November to March. The padasekharams are submerged with water during the remaining parts of the year without any cultivation. The average productivity of paddy is 4.66 t/

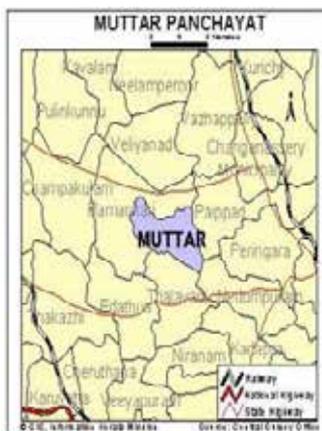
ha which is higher than the district average. This is mainly due to the deposition of fertile soil from the uplands during monsoon season. Muttar village is rich in animal population. The major allied enterprises in the village are dairy, poultry, buffalo and goatary. Inland fisheries is also practiced by the farmers in the small ponds of homesteads. The entire village has a network of canals for dewatering during the monsoon period. This canal water is used for irrigation during summer season for crops.

The neighboring village Thalavady is brought under the project during the extended phase of the NICRA project. This village too has similar climate vulnerabilities that of Muttar village.

Basic information about NICRA cluster

District: Alappuzha

Item	Existing NICRA village	Additional villages selected in the programme
Village name	Muttar	Thalavady
Name of mandal/Block	Veliyanadu	Champakkulam
Total area (ha)	1048	1576
Major soil types	Clayey Alluvial soils	
Mean annual rainfall	2809 mm	
No. of households	2264	5250
Extent of rainfed area (ha)	1048	1576





Climatic Variability

The project area receives rainfall during both South-West and North-East monsoon. June, July, August, September and October months receives maximum rainfall. As the village is geographically placed 2m below MSL in a deltaic plain formed by the three rivers Pampa, Manimal and Achencovil, the village is at risk

of intermittent flood and water logging for almost 5 months. During this time, commonly grown crops in the region cannot be cultivated. Inherent soil acidity is another problem in this area.

The rainfall received in the NICRA village during project period is presented in Table 1.

Table 1. Actual rainfall received and % deviation from normal during 2015 to 2018 in Muttar village

Month	Normal (mm)	2015		2016		2017		2018	
		Actual (mm)	% deviation	Actual (mm)	% deviation	Actual (mm)	% deviation	Actual (mm)	% deviation
January	8.5	0	-100	1.2	-608.3	30.8	72.4	0	0
February	14.9	19.5	30.87	49.4	69.8	0	-	0	0
March	30.1	53.5	77.74	29.6	-1.7	96.9	68.9	8	-276.3
April	108.5	274.75	61.60	15.8	-586.7	52.2	-107.1	135	19.6
May	238.1	117.5	50.65	343.2	30.6	51	-366.9	422	43.6
June	652.2	527.9	-19.06	542	-20.3	325.3	-100.5	400.1	-63
July	733.6	185.9	-74.66	395.7	-85.4	251.4	-191.8	497.8	-47.4
August	422	98.55	-76.6	152.5	-176.7	178.9	-135.9	469.2	10.1
September	242.9	241.6	-0.53	86	-182.4	475	48.9	69.6	-249
October	290.9	411.4	41.42	113.6	-156.1	236.5	-23	271.9	-7
November	149.5	241.6	-0.53	74.4	-100.9	-23	26.5	120.2	24.4
December	37.1	204.7	36.92	41.6	10.8	26.5	-97.3	58.6	36.7
Annual Average	2928.3	2376.9	28.88	1845	-36.99	1920.2	-34.43	2452.4	-16.25

Module I: Natural Resource Management

1. Composting of aquatic weeds using EM solution

Paddy cultivation is possible in the village only during one season (November-March) and during the remaining period paddy fields are waterlogged leading to the multiplication and accumulation of aquatic weeds like water hyacinth. While preparing the paddy fields for cultivation, these weeds are to be

cleared every year. Removed weeds provide huge bio-mass, but was not profitably utilized. Demonstrations were conducted in convergence with MGNREGS for converting/recycling these collected weeds to compost by using EM solution. The semi-dried water-weeds were heaped in beds of size 10x2x1 m (20 m³). Each layer of weeds was sprinkled with cow dung slurry and EM solution. The EM solution hastened the decomposition and thus composting was completed by 45-50

days. The compost thus prepared was utilized for the cultivation of banana and vegetables by the women SHGs (Table 2).

Table 2. Impact of aquatic compost to ecosystem

Year	Participating farmers (No)	Quantity of compost produced (t)	Application of compost Area covered (ha)
2014-15	100	25	45.1
2015-16	350	65	117.1



Impact

The technology had a significant impact in the region, as it converted a weed menace into wealth. During 2014-15, Muttar was the only one panchayat in the district where the removal of aquatic weeds was allowed as an activity under MGNREGS. Now, the other

panchayats in the districts have also initiated projects under MGNREGS for the effective recycling of the removed aquatic weeds. The increase in number of participating farmers and the quantity of compost produced using the waste weeds is an indication of the positive impact of the intervention.





Module II: Crop Production

1. Resource conservation and eco-friendly technologies for climate resilience in paddy

The major problems faced by the paddy farmers were lack of mechanization, soil acidity, use of higher seed rate, indiscriminate use of chemicals and increased input cost for fertilizers and pesticides. Farmers practiced broadcasting method of sowing requiring higher seed rate. Unscientific method of farmers' nutrient management without soil test was evident by the fact that, liming was not properly followed. Over-doses of fertilizers had led to crops becoming susceptible to pests and diseases forcing indiscriminate use of plant protection chemicals for pest and disease management.

To achieve climate resilience in paddy cultivation, integrated management consisting use of drum seeder, soil test based application of dolomite and fertilizers and eco-friendly pest and disease management were promoted under the project. Details of each of these interventions are given below:

i. Mechanization: Drum seeder was

demonstrated for seeding in comparison to broadcasting method followed by farmers. The seed requirement in eight row wet land paddy seeder (Drum seeder) was only about 50 kg/ha thereby saving 100 kg seeds/ha as broadcasting needed 150 kg/ha.

ii. Site specific integrated nutrient management: Soil test based dolomite and fertilizer application was adopted. Clayey Alluvial soils and Clay soils are the predominant soils found in the project area. The P^H ranges from 4.5 to 5.5. For correcting the soil acidity, liming material such as lime or dolomite was applied @ 600 kg/ha.

iii. Eco-friendly Integrated Pest and Disease Management: Seed treatment and foliar application of *Pseudomonas*, use of trichocards and spraying of fish amino acid were adopted. These demonstrations had been spread over an area of 118.2 ha in 5 years with the participation of 161 farmers.

Impact: Demonstrations made a significant impact to the paddy farmers in terms of reduced use of seeds, fertilizers and plant protection chemicals, leading to savings in cost of cultivation (Table 3-5).

Table 3. Cost of inputs for demonstration and check

Particulars	Demonstration		Check	
	Quantity (kg/ha)	Cost (₹)	Quantity (kg/ha)	Cost (₹)
Lime /Dolomite	600	-	-	-
Fertilizers				
Factomphos	250	4725	250	4725
Urea	37.5	201	100	536
Potash	25	423	80	1352
Bio agents				
<i>Pseudomonas</i>	2 lit solution+ 3.5 kg powder	945	1.5 kg of powder	105
Trichocards	30 cards	1500	-	-

Chemical pesticides				
Pesticides			1375 ml	1037
Weedicides	200 ml	1634	300 ml	2450
Fungicides	-		1000 ml	650
Total		16628		17855

Table 4: Impact of resource conserving and ecofriendly technologies on input use/economics of paddy cultivation

Particulars	Technology adoption	Conventional farming	Savings in cost (₹/ha)	Total savings due to adoption (118 ha)
Seeds(kg/ha)	30	125	3800	448400
Fertilizer (kg/ha)	312	430	1264	149152
Harvest time (hrs/ha)	3.8	7.6	6460	762280
Net profit (₹/ha)	86163	55715	30448	3592864

Table 5: Growth and yield performance under demonstrations

Parameter	Demo	Check
Plant height (cm)	103.2	95.9
No.of plants/m ²	50.0	228
No.of productive tillers /m ²	779	627
Panicle length (cm)	21.6	19.6
No of grains /panicle	189.5	151.5
Yield (t/ha)	6.76	5.98
Cost of cultivation (₹/ha)	56928	64556
Net income (₹/ha)	71635	48093
B:C Ratio	2.28	1.76





2. Improving nutritional security and income through mushroom cultivation

The paddy crop being a major crop of the village, paddy straw is available in sufficient quantities. Cultivation of mushroom using paddy straw as a substrate was found to be a better way of utilization of available paddy straw and the farmers could obtain reasonable income in addition to the nutritional security and self-employment. The farmers collectively marketed their produce in one brand name as “Muttar fresh” mushroom. There was a production of 2.7 ton mushroom/year. The

gross return from a unit of 15 beds/month was ₹ 2250 with a B: C ratio of 2.2.

Outcome:

1. Employment generation of 1275 man days/year
2. Production of 2.7 tons mushroom/ year.
3. Quantity of paddy straw used 4.5 t/year
4. Vermicompost production from spent mushroom waste 5-6 q/year
5. Mushroom spawns production 125 pkts/month with a B: C ratio of 2.2



3. Adjusting the time of planting of banana to escape the water logging period in Kuttanad region

Since this region is vulnerable to water logging for almost 4 months in a year (June – September) during the South-West monsoon, cultivation of upland crops is restricted to a maximum of 7-8 months from October to May. Banana which is a profitable upland crop requires 10 months for harvesting and usually get affected by flood during the final stage if planted in November. Adjusting the time of planting of tissue culture banana plants to avoid the water logging period was taken up as technology demonstration in the NICRA project in Muttar village during 2013-14.

Since the planting season of banana (August-September) coincides with the monsoon and water logging in this region, farmers delay the planting up to November. They normally plant the locally available banana suckers after the receding of flood water. Growing of tissue culture banana plants in poly bags kept on raised platforms for 6 weeks (from September) was introduced as an alternative to overcome the climate vulnerability. The growing medium was scientifically formulated to have the required quantity of nutrients for the period in grow bags. By October, the plants are ready to be planted in the main field by which time flood water recedes. Scientific management practices in the main fields ensured a good crop harvested in May end or early June before

the next monsoon and water logging. This technology package could fetch an average yield of 16000 kg/ha and a B:C ratio of 2.02, compared to 9000 kg/ha and 1.3, respectively in farmers’ practice (Table 6).



Table 6: Comparison of yield and economics in tissue culture banana.

Particulars	Conventional Practice	Tissue Culture
Planting materials	Suckers	TC plants
Units (No.)	15	10
Yield (kg/ha)	9000	16000
B:C Ratio	1.30	2.02

Module III: Livestock Activities

1. Dairy farming

Dairy farming is one of the income generating enterprises. Most of the dairy farmers have holdings in the range of 5 – 10 cents per household. The animals often face cold stress, pest and disease infestation as the area remains water-logged. Milk productivity was less than 8 litres per day per animal, due to mastitis, unscientific feeding, infertility and poor management. Being the coastal region, biting flies and mosquitoes population was more due to higher humidity. In order to provide relief from the above stress-factors, following stress and disease management practices were demonstrated in Muttar village.

- i. **Stress management practices:** Floor in the animal sheds was covered with rubber mat (of size 6’x4’x 24mm per cow). To protect the hoof from wetness and provide cushion to the animals while standing and resting.
- ii. **Automatic drinking system (fibre type)** provided near to the cow ensured water supply throughout the day as and when thirsty animals press the knob fitted with the bowl. The animal may take only two days to get adjusted to this system.
- iii. **Pest and disease management:** To control the flies, midges, and mosquitoes (vectors) an Ayurveda preparation called *Kusum* oil was applied externally @ once in 3 days. To prevent the outbreak of infectious



and contagious diseases, disinfectant spray of 1,6 Dihydroxy 2,5 Dioxohexane Polymethyl derivative was used in the cow shed @ 10 ml/l water.

Impact

Cows which were provided with cow mat and automatic drinking water supply system, showed an improvement in milk yield of up to 1 litre/day. Due to the disease management practices, the most prevalent mastitis and FMD could be reduced by 50 %. An additional profit up to ₹ 25000 /cow/ lactation could be achieved compared to the normal practices (Table 7). On an average 10% increase in milk

production was recorded in all the units and incidence of infectious and contagious disease outbreak was reduced. The technologies are being up-scaled in convergence with ATMA, Dairy Development Department and Animal Husbandry Department in the State. Extension Literature, leaflets and popular articles were published in leading agricultural magazines. After becoming aware of these successful technologies through visual and printed media, 45 rural youth and 310 farmers approached KVK to start commercial dairy farming. About 1500 farmers from across Kerala approached the helpline services to know more about technologies



Table 7. Milk production and economics of cow mat housing

Treatments	Milk yield (L/day)	Cost of cultivation (₹/animal/year)	Gross income (₹/animal/year)	Net income (₹/animal/year)	B:C ratio
Farmers practice: No cow mat	11.2	30840	70400	39560	2.3
Improved practice: Dairy unit with cowmat and automatic drinkers	11.9	31740	76952	45212	2.4

Demonstration of housing with cow mat which provides cleaner and more sanitary environment had insulating properties for cold and humidity under high rainfall areas of Muttar village of Alappuzha district in Kerala. The average milk production of cows has increased from 11.2 to 11.9 litres/day/animal with the provision of cow mat. An increase in net income of ₹ 5652 was also observed with an increased BC ratio.

2. Portable biogas units for providing energy, cleanliness, and greenery in villages

Organic waste management has been an issue of concern everywhere, especially considering its role in greenhouse gas emissions and the resulting global warming. Improper waste disposal practices lead to health issues as well as environmental pollution, particularly in waterlogged areas. Bio-wastes (especially farm yard manure in dairy units and household wastes) were not recycled properly and rather wasted as observed in the initial stage of the project. At the same time, organic matter content in the upland soils of the village was only medium due to application of inadequate quantities and improperly decomposed organic manure.

As part of the NICRA project, portable biogas unit was demonstrated as an effective mechanism for organic residue recycling to generate fuel energy and integrating with crop production activities. Establishing underground biogas unit was neither practical nor useful, as the area was prone for waterlogging. Hence portable units, which could be established on platforms and shifted when required were introduced. During the period from 2011-12 to 2015-16, a total of 58 units were installed benefiting that many farm families in 13 wards of the Muttar Grama Panchayat. Out of 58, twenty six units were established under the project. Realizing the utility of the units, 32 households came forward to establish the portable gas units on cost-sharing basis. In addition to savings in the fuel cost (average savings of 2 LPG cylinders annually), additional crop production (homestead organic vegetables, banana, fodder etc) could be achieved by utilizing the slurry as organic manure. These units helped in organic waste recycling to a tune of 2.8 t per unit annually which in turn would have reduced emission of greenhouse gases to that extent. Hygienic culture among the villagers was introduced, which created awareness against non-polluting the surroundings and water-bodies.





3. Elevated housing, vaccination and *azolla* save backyard poultry in flooded conditions

Backyard poultry rearing is not new to the farmers in Kuttanad region of Alappuzha district and Muttar village is no exception. Dairy and poultry activities in the smaller households in the upland are the other source of livelihood to the people of this village. The housewives earn negligible income from backyard poultry rearing mainly because of the conventional practices like rearing local breeds in conventional wooden cage which are susceptible to flood.

When analyzed the reasons for this declining trend over the past 30 years for formulating action plan under NICRA project, it was realized that submergence/flooding, disease outbreak, and predators were the major threats to this enterprise. Every year, at least one batch of birds was lost due to flood or outbreak of infectious and contagious diseases. To address these problems, demonstrations and training on housing, feeding, and vaccination) in backyard poultry rearing were conducted, by giving emphasis on;

1. Housing of poultry in slatted floor to overcome the flood conditions
2. Disease control programme using automatic vaccinator
3. Cultivation of *azolla* as a feed supplement.



Poultry cages were fabricated in 120cm x 90cm x 75cm size using wire mesh on all the sides, wooden planks at the bottom and tin sheet as roofing material. Each cage could house 20-25 birds and was fixed on GI pipes at the height of 120 cm to withstand flood. The farmers realized that intervention reduced the disease outbreak, mortality, and loss through predators. Since the bottom of this cage is fixed with wooden planks and filled with saw dust, poultry manure could be effectively utilized for homestead farming. At the same time birds could be saved as well as protected from predators as the floor of the cage is fixed at sufficient height. Thus the mortality was reduced from 53 % to 13 %. Realizing the advantages of this cage, 40 farmers came forward to adopt this technology on cost sharing basis. Later this technology was spread among the farmers and more than 50 such cages were established by farmers themselves.



4. Use of Automatic vaccinator

Regular vaccination at desired intervals for the poultry had been a problem for the women farmers as it required the services of skilled persons. Realizing this, automatic vaccinator was introduced through method demonstrations followed by training on vaccination schedule and use of automatic vaccinator. Using the automatic vaccinator, the required quantity of medicine can be adjusted in the syringe once and this can be injected in each shot. This was less complicated than that of ordinary syringe and farm women could use the automatic vaccinator without any difficulties. Now there are 12 women farmers regularly using this for their own units as well as providing service to others.



5. Cultivation of *Azolla* as a nutrition rich feed supplement

In order to harness the abundance of water bodies 44 farmers and housewives were trained on *azolla* cultivation in the homesteads. Seed culture was provided and facilitated for establishment of 26 production units. *Azolla* harvested after 7 days @ 500 -750 g/pit/day was supplemented with poultry feed in daily ration. About 10 –15 % feed could be replaced with *azolla* resulting in improvements in egg yolk colour and egg weight.

Impact

Overall, the average no of bird stock per unit increased from 15 to 22 and the mortality rate reduced to 13 % from 53 %. The average egg production increased by 231 % (2684 from 810/T per/year/unit). Each household could obtain a net return of ₹ 3682 as against ₹ 432 before. Self-sufficiency in egg production was achieved besides income to the families with minimum investments and efforts. These poultry cages survived the unprecedented flood occurred in two cycles in July and August 2019 which damaged many of the human habitations and animal sheds on submergence.



2.2 Tumakuru, Karnataka

(N. Loganandhan and P. R. Ramesh)

ICAR-KVK Tumkur - I, Hirehalli, Tumkur (Dist.)Karnataka

Tumakuru is one of the industrial cities located in the state of Karnataka, also known as Shaikshanika Nagari (city of education) and Kalpatharu Nadu (land of coconut trees). Tumakuru hosts India's first mega food park, a project of the ministry of food processing.

2.2.1 Information about NICRA village

ICAR KVK Tumkur-II (Hirehalli) implemented NICRA project in D. Nagenahalli village of Korategere Taluk located in Kolala Hobli, Ellerampura gram panchayat, which comes under Central, Eastern and Southern Dry Zones in Karnataka lying between 77° 13' 23" and 77° 14' 54" E Longitude and 13° 24' 12" and

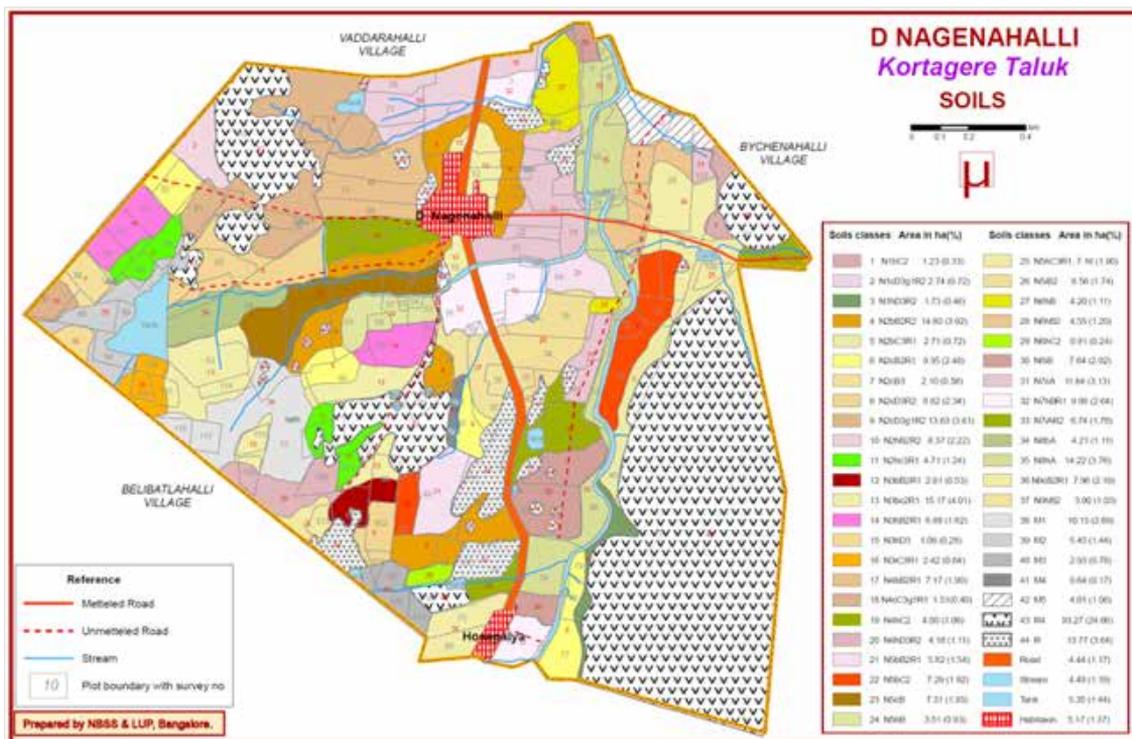
13° 22' 33" N latitude. The total geographical area of the village is 378 ha of which 190 ha (50.24%) is under cultivation while 79.4 ha (20.9%) is under forest. The district occupies an area of 1064755 ha and had a population of 2584711. The annual rainfall of the district is about 584 mm. The main occupation of the district is agriculture and net area sown is 509542 ha. mostly dry lands, as irrigated area is only 30% of the cultivated area. Crops grown in drylands are finger millet, jowar, millets, pulses, castor and groundnut. Paddy, coconut, arecanut, banana and vegetables are grown under irrigation.



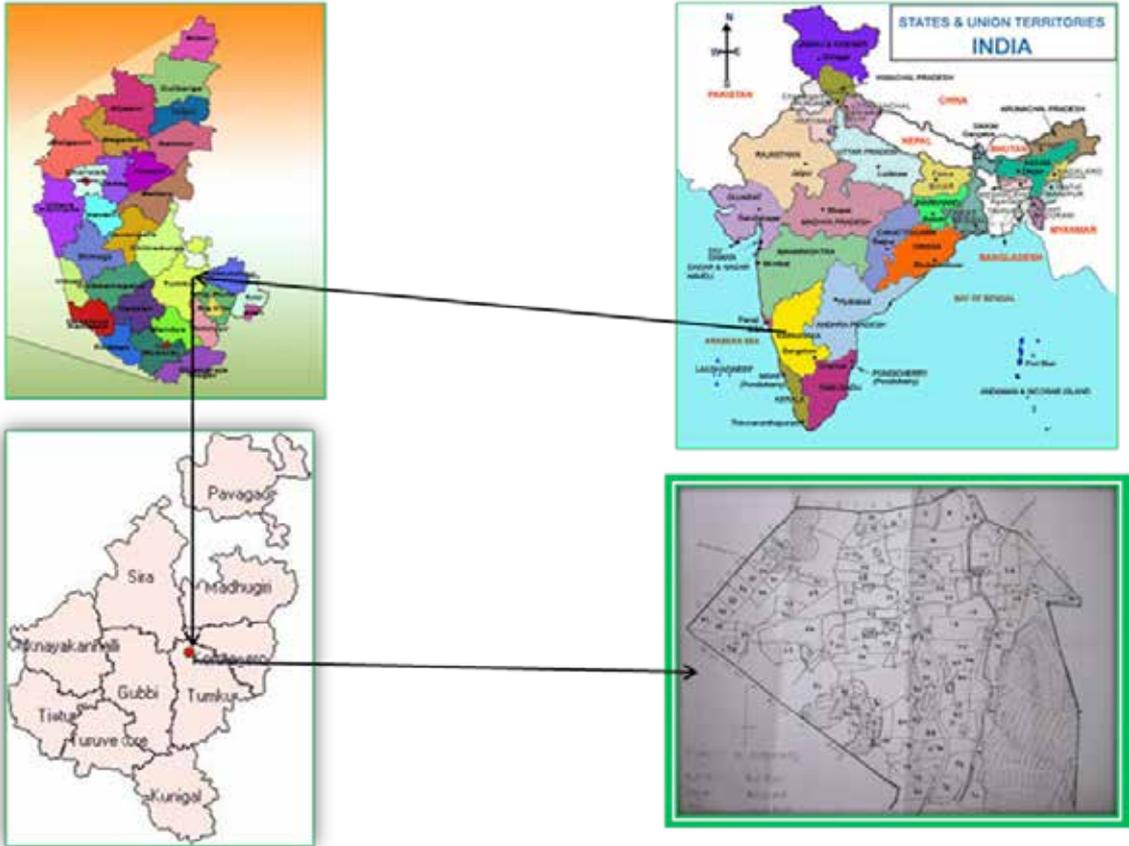
Basic information about NICRA cluster

District: Tumakuru

Item	Existing NICRA village	Additional village selected in the programme
Village & Location	D.Nagenahalli Anupanahalli Post Koratagere Taluk	Tanganahalli Anupanahalli Post Koratagere Taluk
Total area (ha)	378	366
No. of households	269	186
Extent of rainfed area (ha)	174	350



Soil map of D.Nagenahalli



Map of D.Nagenahalli

Climate Variability

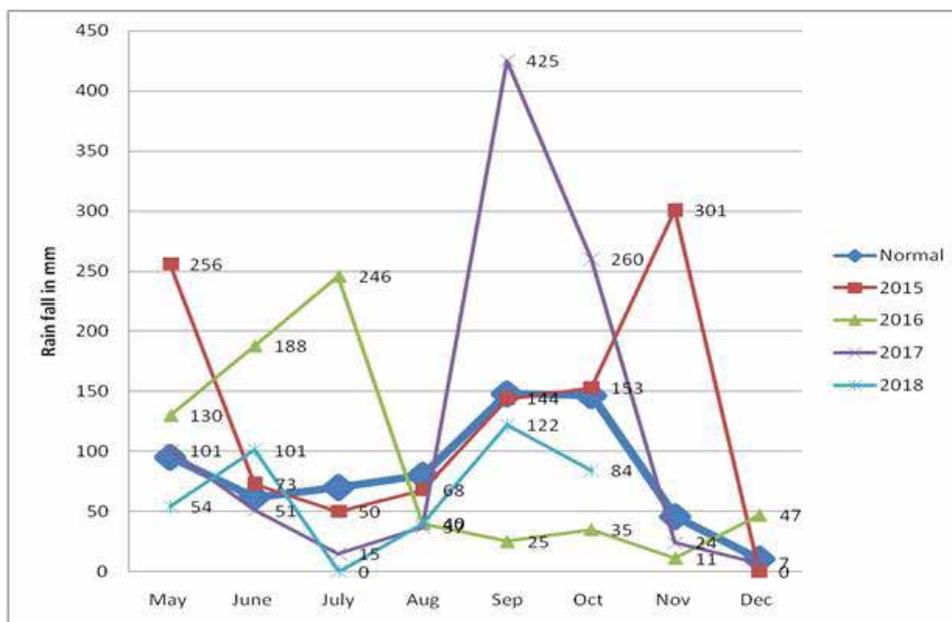
Significant change in the number of rainy days was observed in this area over a period. An average of 56 rainy days were experienced during the 80's, but over the past three decades, this has been reduced to 49 days, thereby increasing the number of dry spells during the monsoon. On the contrary, the numbers of intensive rain spells have increased. These changes in rainfall pattern are adversely influencing the crop production activities in the area and increased the risks in farming.

The village has acute shortage of water, preponderance of waste and common land and falls under Central Dry Agro climatic zone of Karnataka, with an average rainfall of 690 mm per year. The land degradation and water scarcity have emerged as serious problems. Almost all cultivated areas are facing various degrees of degradation, particularly soil erosion and water erosion.

The rainfall received and dry spells experienced during the project period in the NICRA village is presented in Table 8 & Table 9.

Table 8: Year & month wise rainfall, percentage of deviation and dry spells experienced during the project period (2015- 2018) in the village

Month	Normal (mm)	2015		2016		2017		2018	
		Actual (mm)	% deviation	Actual (mm)	% deviation	Actual (mm)	% deviation	Actual (mm)	% deviation
January	0	3	-	0	-	0	-	0	-
February	0	0	-	0	-	0	-	0	-
March	0	17	-	0	-	0	-	0	-
April	0	61	-	0	-	8	-	0	-
May	95.2	256	168.9	130	36.5	101	6.1	54	-43.3
June	61.7	73	18.31	188	204.70	51	-17.34	101	63.7
July	69.9	50	-28.47	246	251.93	15	-78.54	0	-100
August	80.1	68	-17.79	40	-50.6	37	-53.81	40	-50.1
September	148.1	144	-0.03	25	-83.1	425	186.98	122	-17.6
October	146.6	153	4.37	35	-76.13	260	77.35	84	-42.7
November	45.5	301	561.54	11	-75.8	24	-47.2	-	-34.1
December	10.1	0	-100.0	47	365.3	7	-30.69	-	-100
		Year 2015		Year 2016		Year 2017		Year 2018	
Dry spells experienced		1)From 23.06.2015 to 17.07.2015, (26 days) 2)From 13.10.2015 to 28.10.2015, (16 days)		1)From: 12.08.2016 to 30.08.2016: (13 days) 2) From 8.09.2016 to 28.09.2016,(20 days) 3) From 30.09.2017 to 11.10.2017 (12 days) 4) From 14.10.2017 to 01.11.2017 (19 days)		1) From: 22.06.2017 to 6.07.2017. (25 days) 2) From: 18.07.2017 to 30.07.2017. (13 days) 3) From: 11.08.2017 to 4.08.2017. (14 days) 4)From: 16.10.2017 to 5.11.2017 (20 days)		1)From: 12.06.2018to: 12.08.2018 (60 days) 2)From: 16.08.2018 To: 12.09.2018 (27 days) 3)From: 20.10.2018 to 02.11.2018 (14 days)	



Variability map of rainfall received in the NICRA village (2015 to 2018)

Table 9. Weather parameters collected from the Small Weather Station at NICRA village:

Parameter	2015	2016	2017	2018
Avg. Min. Temperature (°C)	19.5	19.7	19.6	19.16
Avg. Max. Temperature (°C)	30.1	31.9	32.2	30.6
Annual rainfall (mm)	1132	729	939	457
No. of rainy days	70	38	41	22
No of dry spells (<i>Kharif</i>)				
>10 days	-	-	1	-
>15 days	-	-	-	-
>20 days	1	2	2	2
Intensive rainfall >60 mm	3	2	3	1

Module I: Natural Resource Management

1. On -farm rainwater management

Considering the potential for farm ponds in the village, 96 new farm ponds were created in the village. The total rainwater harvesting capacity of the farm ponds dug and renovated farm ponds during the project implementation is 77,700 m³ which has benefited over 121

farmers. The total water harvesting capacity of the newly constructed 5 check dams is 33,750 m³. The rain water storage capacity of the 13 percolation ponds for underground recharge is 1750 m³, 7 cement/stone slab/plastic /gunny bags lined storage structures have storage capacity of 6,4100 m³. 14 renovated check dams harvest 85,820 m³ and 3 renovated community tanks harvest 1,56,550

m³ of water. The overall storage capacity of water harvesting structures in the village is 3,61,980 m³. 25 out of 32 open wells and 21 out of 29 bore wells were recharged due to creation of water harvesting structures during

project period. The water storage capacity of the various water harvesting structures is shown in Table 10 and its impact on increasing the protective irrigated area and a cropping intensity is shown in Table 11.

Table 10. Details of rainwater harvesting structures and potential capacity created

Name of the Intervention	Units (No.)	Farmers (No.)	Volume of water harvested (m ³)	Protective irrigation potential created (ha)
Farm pond (constructed and renovated)	96	121	77,700	36.8
Percolation pond	13	13	1,750	-
New check dam	05	8	33,750	2.5
Water storage structure (concrete/stone slab/polythene lining/gunny bags lining)	07	07	6,410	9.6
Renovated check dam	14	34	85,820	16
Renovated community tank	03	54	1,56,550	11
Drainage channel for rain water harvesting to village lake (2100 m)	3	107	-	-
Total			3,61,980	75.9

Table 11. Increase in irrigated area & cropping intensity in the village

Particulars	Before	After	% increase
Protective irrigated area (ha)	15.6	60.5	252
Area cultivated in <i>Kharif</i> (ha)	185.0	199.3	7.72
Area cultivated in <i>Rabi</i> (ha)	7.5	22.5	300

2. Construction of new rainwater harvesting structures

i. Farm ponds

Farm ponds were constructed with twin objectives; help farmers to provide supplemental irrigation to crops at critical growth stages and allow maximum seepage of water into the ground. Altogether, 96 farm

ponds of various capacities were developed in the village under the project fully tapping the undulated topography. The total storage capacity of these farm ponds is estimated at about 77,700m³. The farm ponds helped in conserving the rainwater efficiently, irrespective of their sizes. Details of farm ponds-harvested water utilised groundnut crop cultivation are provided in Table 12.

**Table 12. Groundnut crop yield obtained under protective irrigation**

Treatment	Seed yield (q/ha)	% increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice (Two to three protective irrigation)	15.1	51.7	24,160	60,400	36,240	2.5
Farmer's practice (Rainfed condition)	9.95		22,550	39,800	17,250	1.8

Impact

The 96 farm ponds and 5 check dams of various capacities have benefitted about 126 farmers. The total storage capacity of check dams has been estimated at 33,750 cubic meters. Using the stored water in these structures, about 45 ha area was brought under critical irrigation, resulting in doubled cropping intensity. Farmers are growing vegetables and flower

crops in addition to the existing field crops. During 2017, village faced dry spells in the months of June, July, and August. During dry spells, farmers provided three protective irrigations to groundnut crop at germination, pod initiation, and maturity stages. There was 51.70 % increased yield of groundnut under protective irrigation as compared to rainfed condition (Table 12).



ii. Construction of check dam across a narrow drainage line

Sri Lakshmikanth is a small farmer of D.Nagenahalli village. He has 3 acres of dryland with slight slope. The land is low in fertility where he normally cultivates one crop during kharif season. Due to high variability in southwest monsoon, he had difficulty in meeting his family requirements. Under NICRA interventions, a farm pond measuring



20 m x 12 m x 2 m was dug out to harvest the runoff water. His cropping intensity has now tripled, as he is able to take 3 crops by utilizing the harvested rainwater from his 480 m³ dug out pond. One open well got recharged from the farm pond. He uses portable one HP motor with sprinkler to irrigate the crop. He produced 6 quintal groundnut crop from one acre and earned ₹ 20,000 besides ₹ 12,000 earned by producing 10 quintal of paddy in

one acre. He also cultivated chrysanthemum in 0.25 acre and earned ₹ 20,000. During summer he cultivated groundnut in 0.75 acre, chrysanthemum in 0.5 acre and fodder maize in 0.5 acre and earned ₹ 45,000 in total. He also grows tomato, brinjal and aster. His income got doubled after farm pond construction.



iii. Percolation ponds

Percolation ponds were dug to reduce the velocity of runoff from the fields and to recharge the groundwater. Thirteen percolation ponds were dug across the village in scientifically selected spots to ensure filling. The rainwater storage capacity of these ponds was estimated at 1750 cu m which benefitted 20 farmers through recharging of wells.



iv. Recharge of bore wells

Recharge of bore wells was undertaken by farmers by diverting runoff water into less yielding bore wells. The water flowing in the channel was made to pass through a filter media before entering into recharge structure to avoid accumulation of silt. Study of bore wells at the beginning of the project indicated water table at 700-800 ft. Continuous drought over the years

had rendered many of the bore wells go dry or discharge low output. Due to this reason even farmers with irrigation facilities were forced to reduce the cropping area especially during summer. Recharging interventions combined with conservation activities in the village rejuvenated the bore wells. Good amount of water encouraged sustainable intensification of cropping to improve income and livelihood of farmers.





v. Construction of check dams

Check dams were erected in participatory mode across small nalahs in order to break flow of water during the monsoon and allow it to seep into the soil to augment ground water

recharge of the area. Recharged water helped in raising the water table in the adjoining wells. Five check dams contributed to the water storage capacity estimated at 33,750 cu m (Table 13). Eleven farmers benefited due to this intervention.



Table 13. Details of check dams

Sl.No.	Beneficiary	Survey No.	Year of construction	Dimension of the structure (l m x b m x d m)	Storage capacity (Cu m)
1	Chikkamuddaiah	16	2012	30 x 8 x 1.5	360
2	Chandrashekhariah	56	2012	20 x 6 x 1.5	180
3	Narasimhamurthy K	64	2012	20 x 8 x 1	160
4	Chandranna	23	2012	40 x 50 x 3	6000
5	Kemparaju	36	2012	15 x 3 x 1	45
Total					6745

One of the success stories emanating from the project interventions is the case of farmer Sri Chandranna. A check dam of size 40 m x 50 m x 3 m was taken up. He earlier used to cultivate only one crop (finger millet) in one acre farm during monsoon season. In 2013-14, he was

able to grow vegetables in 0.75 acre land using harvested water from the check dam (6000 cu m capacity) for supplemental irrigation. The yield of tomato was 50 q, which provided an additional income of ₹ 43000 (Table 14).

Table 14. Details of impact of check dam constructed in Sri Chandranna's farm

Crop	Area (in acre)	Yield (q)	Cost (₹/ha)	Gross benefit (₹/ha)	Net benefit (₹/ha)
Before intervention (2012-13)					
Finger millet	1.0	6	2100	7500	5400
After intervention (2013-14)					
Tomato	0.75	50	7500	50500	43000

3. Trench cum bunding

In-situ conservation measures such as trench cum bunding (TCB) was demonstrated in D.Nagenahalli village of Tumakuru. The practice was taken up in an area of 129 ha in the village benefitting 227 farmers. Much of the area is under rainfed with steep slopes and were treated with the trench cum bunding in the village as part of NICRA project.

The village has received 5 intensive rainfalls of more than 50 mm, in October and November months in 2015. The soil erosion was reduced and the high runoff was controlled by trench cum bunding intervention. The yield of groundnut with trench cum bunding was 13 q/ha compared to without trench cum bunding (11 q/ha). The increase in yield was 18% and the additional income was ₹ 4000.

The trench cum bunding technology adopted in the project served dual purpose, arrested soil erosion and served as water conservation pits that kept soil moisture intact for longer duration. About 134 ha area was treated with trench cum bund benefitting 185 farmers. The groundnut crop was sown during 2nd week of June 2017, faced dry spells in July, August, and October. The dry spells-created moisture stress during vegetative, pod initiation and maturation stage. The constructed trench cum bund conserved the harvested rain water during June-August that increased the surrounding soil moisture content and kept the moisture for longer duration. This increased the yield of the groundnut by 27.5 % which was not possible without trench cum bunding.

Table 15. Effect of trench cum bunding on groundnut at Tumakuru district

Treatment	Seed yield (q/ha)	Percentage increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice (Trench cum bunding)	15.3	27.5	25,890	59,670	33,780	2.3
Farmer's practice (Without trench cum bunding)	12.0		24,625	46,800	22,175	1.9

The extent of yield improvement due to trench cum bunding was 7.3 q/ha in case of ragi during the year 2017. The average yields obtained due to trench cum bunding was to

tune of 1530 kg which is about 330 kg higher over the farmers practice of without bunding resulting in an additional income of ₹ 12380/ha in case of groundnut crop (Table 15).



Runoff water harvested in trenches



Trench cum bunding



Groundnut crop grown with protective irrigation.

4. Water storage structures

Farmers in D.Nagenahalli village pumped

water from bore/open well to storage structures constructed at a higher elevation as and when power supply was available so as to irrigate cropped area using gravitational force. There was significant loss of water in the form of seepage and transportation. Lining of these storage structures through cement / stone slab / plastic lining and gunny bags was attempted to prevent seepage losses (Table 16). Three water storage tanks were lined with cement-solution dipped gunny bags and three farm ponds with plastic sheets. This improved the water use efficiency thereby extending the area under irrigation by 1.5 ha (Table 16).

Table 16. Performance of cemented or stone slablined water storage structures

Sl. No.	Beneficiary	Year of construction	Dimension (lmxbxm)	Storage capacity (Cum)	Increase in area under irrigation (ha)
1	Dwarakanath.L.P	2012	18 x 6 x 2.5	270	0.5
2	Lokesh S/o Venktaramaiah	2013	12 x 11 x 2	264	0.5
3	Ranganath S/o Shrirangappa	2013	15 x 6 x 2	180	0.5
Total				762	1.5

Table 17. Performance of plastic film lined water storage structures

Intervention	Total area irrigated (ha)	Red Sandy soil	Drop in depth per day (cm)		
			Percent reduction in water loss	Red clay soil	Percent reduction in water loss
Lining with plastic film	4.0	10.2	70.85	9.4	38.2
Without lining	1.8	35.0		15.2	

Impact of water storage structures :

- Reduction in water losses through percolation and seepage to the maximum extent.
- Lining with plastic film was more effective in red sandy soils (70.85 %) compared to red clay soil (38 %).
- Stored water was encouraged for fish culture and to provide supplementary irrigation during critical crop growth stages.



Promotion of water saving techniques

Farmers were encouraged to take up drip irrigation and sprinkler irrigation for various crops. 15 farmers have adopted micro irrigation in 4 ha.





Sprinkler irrigation ensures judicious use of water on undulated and shallow soils. Overall irrigation efficiency was 80-82 % in comparison to 30-50 % in surface irrigation. Sprinkler irrigation was taken up by farmers for flower crops (0.4 ha) and vegetables crops (0.6 ha). Sprinkler irrigated vegetables and

flower crops gave higher yields and good quality produce with higher water productivity in the red sandy soils. Sprinkler irrigation could enhance the income of farmers by enabling them to take up high value crops in smaller plots with optimum use of scarce water (Table 18).

Table 18. Knol-khol crop grown using sprinkler irrigation

Crop	Yield (kg/ha)	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Knolkhol	12,500	42,960	1,37,500	94,540	3.2



Sprinkler irrigation in groundnut

Farmers also cultivated groundnut crop under sprinkler irrigation utilizing the harvested water and realized almost double the income (Table 19).



Table 19. Sprinkler irrigation in groundnut

Treatment	Crop	Farmers (No.)	Area -critical irrigation (ha)	Yield (kg/ha)	Cross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice	groundnut	03	1	1800	27000	88200	61200	3.3
Farmer's practice	groundnut	02	1	1200	25500	58800	33300	2.3

5. *In situ* resource conservation technologies

i. Levelling and formation of compartments

Levelling combined with bunding helps in reducing soil erosion as well as run off to an appreciable extent by enhancing infiltration

of water into the soil (Table 20). Around 15 ha land belonging to 39 farmers formed compartments. The practice conserved rainwater for successful cropping of paddy and finger millet and increased productivity by 15-20% compared to check plots.



Crop cultivated in levelled field.



Leveling and Compartment formation

Table 20. Effect of levelling and formation of compartments on soil moisture storage

Details	Water storage profile (cm /180cm depth)	% increase in water storage profile
Without leveling and formation of compartments	21.5	23.2
Leveled and formation of compartments (after intervention)	26.5	



ii. Tank silt application in finger millet

Tank silt application helped to build soil fertility and increased water holding capacity. Around 500 tonnes of tank silt was applied in 69 ha of farmers' fields which benefited 113 farmers and yield of rainfed finger millet on an average increased by 32.6% (Table 21), compared to control plot. During July 2015, 26 days dry spell was witnessed in the village,

which affected the moisture availability to finger millet at vegetative stage. However, the application of tank silt to the farm increased the soil fertility and moisture holding capacity and helped finger millet crop to escape the dry spell as evident from the increased yield to the extent of 32.6 % in the silt applied fields over the control plots.

Table 21. Effect of tank silt application on finger millet yield.

Finger millet	Yield (q/ha)	Increase (%)	Economics of demonstration (₹/ha)			
			Gross Cost	Gross Return	Net Return	BCR
Tank silt applied @ 15 tonnes/ha	25.6	32.6	22,730	38,400	15,670	1.7
Without tank silt	19.3		21,050	28,950	7,900	1.4



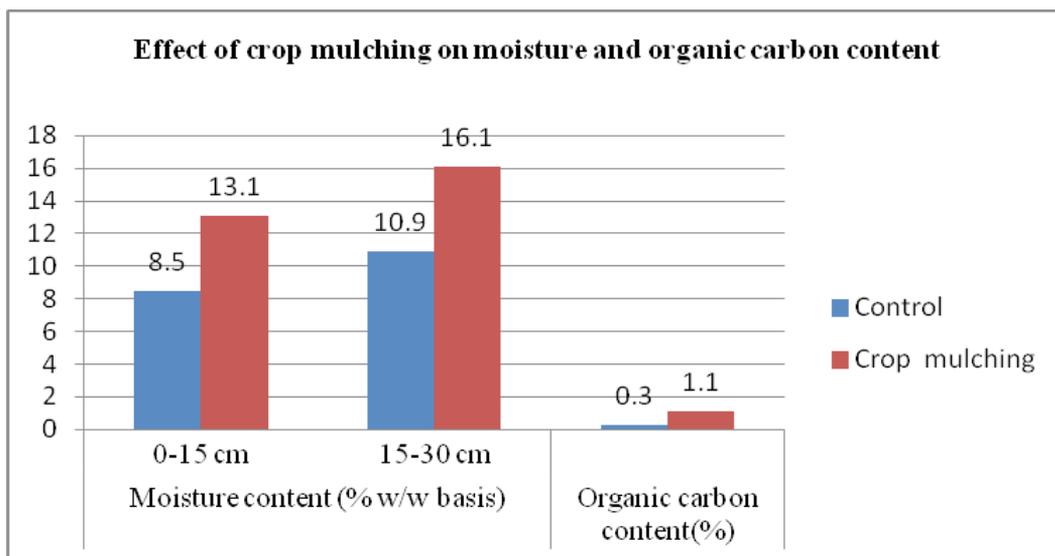
iii. Cover cropping and mulching

Horsegram was sown during *kharif* season in the interspaces of orchard/ plantation crops as a legume cover crop; it conserves soil moisture and improves soil health through the incorporation of crop residues. For the first time in the village, 123 farmers adopted the practice in 25 ha area and realized the benefits of the practice (Table 22).



Table 22. Effect of cover cropping & mulching on soil moisture and organic carbon content

Intervention	Moisture content (% w/w basis)		Organic carbon content (%)	Yield of finger millet (q/ha)
	0-15 cm	15-30 cm		
Control	8.5	10.9	0.3	17.3
Horsegram cover crop & mulch	13.1	16.1	1.1	22.5



Module II: Crop Production Interventions

1. Finger millet var. ML-365 : To cope with early season drought

Situation analysis: Finger millet (*Eleusine coracana*) is the main staple food in Southern Karnataka, grown as rainfed as well as irrigated crop. Farmers in Tumakuru are getting comparatively low yield in finger millet, due to delayed onset of monsoon, low and erratic rainfall, long dry spells, high temperature, and non-availability and non-adoption of high yielding varieties. Hence finger millet variety ML-365 released by University of Agricultural Science, GKVK, Bengaluru was demonstrated

in the NICRA project village.

The specific characteristics of the variety are:

- Short duration (about 105 days)
- Medium plant height
- High grain and fodder yield
- Resistant to leaf spot, neck blast disease and lodging
- Good cooking quality
- Suitable for dryland agriculture and late sowing



Performance of the variety ML-365 was significantly superior over its local Gutte variety (Table 23). The variety ML365 and local Gutte finger millet were sown during July 3rd week of 2015 in D. Nagenahalli. ML365 which is a short duration variety (105 days) was harvested in the last week of October and local Gutte finger millet which is long duration crop (125 days) was destroyed by heavy rainfall (301 mm) in November 2015. Finger

millet ML-365 also withstood 15 day dryspell during July and August. Around 217 farmers adopted the practice in 82 ha area and realized the benefits of the practice.

The results showed an increase of 32.4 % over the yield of local Gutte finger millet and additional income increased by 90.98 %. The percentage of leaf spot and neck blast diseases also reduced.

Table 23. Impact of Economics on drought tolerant Finger millet

Treatment	Seed yield (q/ha)	Percentage increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice Finger millet ML-365	26.8	32.4	22,540	56,350	33,810	2.5
Farmer's practice Gutte Finger millet Local	19.5		22,130	39,834	17,704	1.8



Finger millet ML-365



Local Gutte finger millet

2. Pigeonpea (var. BRG 2) : to cope with delayed monsoon

BRG-2 is a short duration (about 125 days) and high yielding pigeonpea variety released by UAS, GKVK, Bengaluru. It is suitable for dryland agriculture, late sowing and is found to be resistant to pod borer. The performance of the variety is excellent compared to local variety,

which is a long duration variety (about 150 days). BRG-2 can also be used for intercropping in finger millet, groundnut and maize crops. 150 farmers adopted the practice in 45 ha area and realized the benefits of the practice.

The results showed an increase of 28.42 % over the yield of local variety and additional net income realized was ₹ 10,170/ha (Table

24). It can be up scaled through involving State Agriculture Department, FPOs, and NGOs.

Table 24. Impact of Economics

Treatment	Seed yield (q/ha)	Percentage increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice Pigeonpea BRG-2	12.2	28.42	22,500	50,020	27,520	2.2
Farmer's practice Pigeonpea local	9.5		21,600	38,950	17,350	1.8



Pigeonpea variety BRG 2

3. Aerobic Paddy MAS-26 : A water saving technology

Rice (*Oryza sativa* L.) is the most important cereal crop of India. In Karnataka, about 40-45 % of the rice is grown under puddled condition with large quantities of water and is

labour intensive. Hence, cultivation of aerobic paddy variety MAS-26 was promoted through demonstration in the village which requires less water. The advantages of the drought tolerant aerobic paddy MAS-26 are possibility of direct sowing, no need for puddling, resistance to pests and diseases, reduction in pollution, medium duration, more tillers and 50% water saving along with 80% seed saving. This has been promoted and demonstrated in D.Nagenahalli village under NICRA Project from 2013 to 2018 in 12 ha and benefited 52 farmers.

The results showed an increase of 30.7 % over the yield of local paddy and additional income increased by ₹ 16550/ha (Table 25).

Table 25. Impact of Economics in Aerobic paddy

Treatment	Seed yield (q/ha)	Percentage increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice: Aerobic paddy MAS-26	32	30.7	19,150	38,400	19,250	2.0
Farmer's practice: Aerobic paddy local variety	26		18,500	31,200	12,700	1.7



Aerobic Paddy MAS-26

4. Promotion of resilient cropping systems

Resilient cropping systems were introduced in the village for risk insurance in the event of aberrant rainfall conditions. These cropping systems best utilize the natural resources like soil, rainwater and insure the crop against weather aberrations. Intercropping systems helped farmers to harvest higher yields and higher net income per unit area as compared to sole cropping. Crop combinations of finger millet with pigeonpea and field bean, maize and groundnut with pigeonpea were introduced in the village as detailed below:

Inter cropping system	No. of farmers	Area covered (ha)
Finger millet + Pigeonpea (4:1)	115	41
Maize + Pigeonpea (2:1)	35	12
Groundnut + Pigeonpea (3:1)	64	16
Finger millet + Dolichos (3:1)	21	4

Finger millet + pigeonpea intercropping system

Finger millet and groundnut are staple food and cash crops cultivated during *Kharif* season. Crops suffer from moisture stress because of low rainfall, dry spells, and uneven distribution-leading to low yield and income. To minimize the yield loss risk in the sole crop of finger millet, intercropping of pigeonpea

was introduced in the village during 2011 to 2018.

Impact

The intercropping doubled the benefits as it resulted in higher yields in finger millet besides additional yield of pigeonpea, resulting in increased farmers' income (Table 26). Intercropping system in finger millet is adopted by 115 farmers in 41 ha.

Table 26. Performance of finger millet as a sole crop and finger millet +pigeonpea intercropping

Treatment	Yield (q/ha)	Gross Cost (₹/ ha)	Gross return (₹/ ha)	Net return (₹/ ha)	B:C
Finger millet ML-365 as sole crop	26.8	23,270	60,210	36,940	2.6
Demo (Finger millet ML-365+Pigeonpea BRG-2)	27.1+ 1.1 (Pigeonpea)	22,540	56,350	33,810	2.5



Finger millet +Pigeonpea intercropping

Groundnut + Pigeonpea (4:1) intercropping system

Similarly, to minimize the low yield in the sole crop of groundnut, cropping system of groundnut+ pigeonpea has been introduced in

the project village from 2011 to 2018. The intercropping of pigeonpea in groundnut resulted in higher yields of groundnut with additional yield of pigeonpea, thus increasing the farmers income (Table 27). Intercropping system in groundnut was adopted by 64 farmers in 16 ha.

Table 27. Performance of groundnut as a sole crop and groundnut+pigeonpea intercropping

Treatment	Yield (q/ha)	Gross cost (₹/ ha)	Gross return (₹/ ha)	Net return (₹/ ha)	B:C
Groundnut as sole crop	13	18,000	34,500	16,500	1.92
Groundnut +Pigeonpea BRG-2 intercropping	14 (Groundnut)	17,600	26,000	8,100	1.5
	1.3 (Pigeonpea)				

Impact

The cropping system best utilizes the natural resources like soil, rain water and serves as a crop insurance against weather aberrations. These intercropping systems helped the farmers in the village to harvest higher yields per unit area besides higher net returns per unit area as compared to solo cropping.





7. Tree based farming system

i. Dry land horticulture to cope up with climatic vulnerabilities

Tree planting was taken up on degraded ridge lands in the village. In order to ensure better survival rate, the planting was done on the bunds after digging the trenches in the entire area. Nearly 80 % area was brought under the cover of plants with the participation of 100 farmers. Block plantation of *Melia dubia* and *Acacia auruculiformis* was established. A total of 32,000 plants belonging to different fruits and forest species were planted. Nearly 60-70 % plants survived despite poor rainfall. The exercise has created great awareness

among the farmers about the role of trees in improving soil and water conservation besides helping in improving micro climate and carbon sequestration in the long run. Tree fodder species (*Melia* and *Acacia*) could supply fodder to small ruminants (goat and sheep) during the lean season (summer).

Impact

An agri-horti system of mango/ tamarind/aonla with finger millet resulted in higher system productivity. Finger millet yield was higher in agri-horti system (23.8 q/ha) compared to sole finger millet grain yield (17.0 q/ha) during the three years.



Melia dubia



Acacia auriculiformis

Impact of dry land horticultural crops

- Tamarind, amla, cashew, and mango seedlings were planted in about 15 ha area from 2011 to 2016 combat climatic vulnerabilities like dry spells, drought, high temperature, low rainfall and erratic rainfall.
- Amla and tamarind seedlings, which were planted during previous years, have started giving yields.
- Farmer, Shri Nagarajaiah has planted amla saplings in one ha in 2011 which have started giving yields from 2015 onwards. About 1,700 kg amla fruits were harvested in 2017 and sold for ₹ 27,900.
- Farmer, Shri. Ramanjineya has planted 65 tamarind saplings in 0.8 ha in 2011 and saplings were well established and started giving yield during 2017. About 260 kg tamarind was harvested in 2017 and sold for ₹ 23,400 at ₹ 90 per kg.

- Farmers are earning higher income from horticulture crops along with field crops.



Amla



Mango



Tamarind



Cashew

Module III : Livestock Activities

Multi cut fodder Sorghum CoFS-29

Availability of green fodder is very important for sustainable dairy farming. Many farmers having dairy animals were not cultivating green fodder in D.Nagenahalli. Demonstrated fodder sorghum var. CoFS-29 a hybrid fodder and has the ability to withstand drought conditions. It has fewer incidences of leaf spot and leaf

blight. It has protein content of approximately 8 %. The first cutting can be done after 60 days and subsequent cuttings at 40 days intervals. About 7.5 kg seeds are required per acre.

Impact

Availability of green fodder was ensured for several months and feeding to milch animals led to increased milk yield from 0.5 to 1.5 litres /animal/day.





2.3 Gadag, Karnataka

(L. G. Hiregoudar and N. H. Bhandi)
ICAR-KVK Hulkoṭi, Gadag (Dist), Karnataka

Gadag district is located in the Western part of Northern Karnataka. It is surrounded by Bagalkot district on the North, Koppal district on the East, Bellary district on the South East and Haveri district in the South West. There are five taluks in the district namely Naragunda, Rona, Gadag, Shirahatti and Mundargi. Presence of 2 agro climatic zones - North dry zone and North transitional zone and presence of both black and red sandy soil, provides scope for cultivation of large variety of crops. Moderate rainfall pattern encourages the growth of short/long duration crops and for adopting mixed and inter-cropping systems.

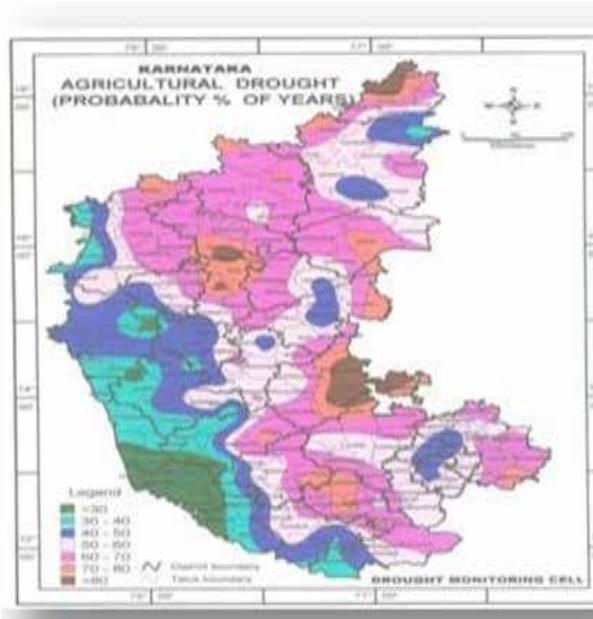
2.3.1 Information about NICRA village

The NICRA project was implemented by ICAR KVK Gadag from June, 2015 in Mahalingapur village of Gadag district for addressing climatic variability of drought. The climate of the village is semi-arid and annual rainfall is 641 mm. Rainfall is usually erratic and the probability of agricultural drought is to the extent of 70% of the years. Long dry spells between two rains during June to September period affects the crop yield and thereby the livelihood of the farmers.



Basic information about NICRA cluster

Item	Existing NICRA village	Additional villages selected in the programme	
		Village 1	Village 2
Village name	Mahalingpaur	Nabhapur	Kabalayatakatti
Name of Mandal/Block	Gadag	Gadag	Gadag
Total area (ha)	466	530	480
No. of house holds	249	215	230
Extent of rainfed area (ha)	438	485	456



Satellite image of Gadag district

Climatic variability:

The rainfall received, dry spells experienced, and temperatures recorded in the project village from June, 2015 to December, 2018 are given in the table 28 and Fig. below.

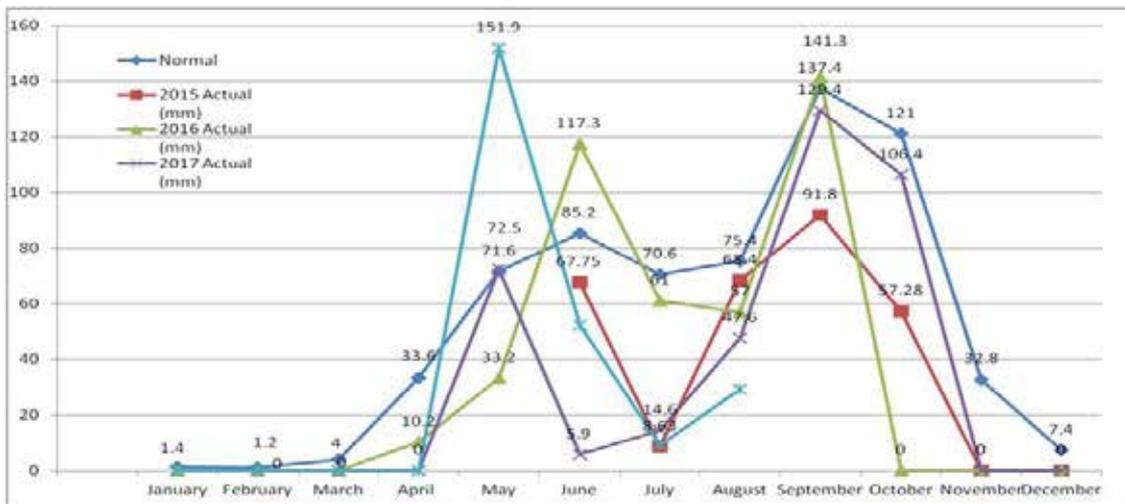


Fig: Year and monthwise variability map of rainfall received in the NICRA village (2015 to 2018)



Table 28. Yearwise & month wise rainfall, percentage of deviation and dry spells experienced for the years 2015-2018 in the project village

Month	Normal (mm)	2015		2016		2017		2018	
		Actual (mm)	% of deviation	Actual (mm)	% of deviation	Actual (mm)	% of deviation	Actual (mm)	% of deviation
January	1.40	-	-	0.00	-100.00	0	-100.00	0.00	-100
February	1.20	-	-	0.00	-100.00	0	-100.00	0.00	-100
March	4.00	-	-	0.00	-100.00	0	-100.00	0.00	-100
April	33.60	-	-	10.20	-69.64	0	-100.00	0.00	-100
May	71.60	-	-	33.20	-53.63	72.50	1.25	151.90	112.15
June	85.20	67.75	-20.48	117.3	37.68	5.90	-93.08	52.40	-38.49
July	70.60	8.63	-87.78	61.00	-13.60	14.60	-79.32	9.30	-86.82
August	75.40	68.40	-9.28	57.00	-24.40	47.60	-36.87	29.30	-61.14
September	137.40	91.80	-33.19	141.30	2.84	129.40	-5.82	27.70	-79.83
October	121.00	57.28	-52.66	0.00	-100.00	106.40	-12.07	49.20	-59.33
November	32.80	0.00	-100.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
December	7.40	0.00	-100.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Dry spells experienced		Year 2015		Year 2016		Year 2017		Year 2018	
		1) 03-07-2015 to 12-08-2015 (41 days)		1) 01-01-2016 to 06-04-2016 (97 days)		1) 01-01-2017 to 08-05-2017 (127 days)		1) 01-01-2018 to 11-05-2018 (131 days)	
		2) 13-10-2015 to 31-12-2015 (80 days)		2) 08-04-2016 to 17-05-2016 (40 days)		2) 15-05-2017 to 15-07-2017 (62 days)		2) 12-06-2018 to 10-08-2018 (60 days)	
				3) 22-05-2016 to 03-06-2016 (13 days)		3) 21-07-2017 to 15-08-2017 (26 days)		3) 23-08-2019 to 16-09-2018 (25 days)	
				4) 10-07-2016 to 19-07-2016 (10 days)		4) 20-08-2017 to 05-09-2017 (17 days)		4) 30-09-2018 to 15-10-2018 (16 days)	
				5) 06-08-2016 to 13-08-2016 (8 days)		5) 24-10-2017 to 31-12-2017 (69 days))		5) 18-10-2018 to 31-12-2018 (75 days)	
				6) 17-08-2016 to 26-08-2016 (10 days)					
				7) 01-09-2016 to 12-09-2016 (12 days)					
				8) 01-10-2016 to 31-12-2016 (92 days)					

Table 29. Year wise and month wise average temperature recorded in the project village for the years 2015-2018

Year	January	February	March	April	May	June	July	August	September	October	November	December
Normal	23.4	25.7	28.3	29.7	29.3	26.30	24.80	24.70	24.90	25.20	23.80	22.70
2015	-	-	-	-	-	26.03	26.32	26.42	27.03	26.77	25.58	24.45
2016	23.87	27.13	29.96	31.35	29.95	26.03	25.23	25.27	25.11	29.03	29.06	22.91
2017	22.16	24.55	27.96	31.05	30.58	27.18	26.61	26.53	25.90	27.34	23.33	22.06
2018	22.37	23.78	27.49	30.27	29.9	27.04	26.27	25.83	26.43	27.32	26.61	25.97

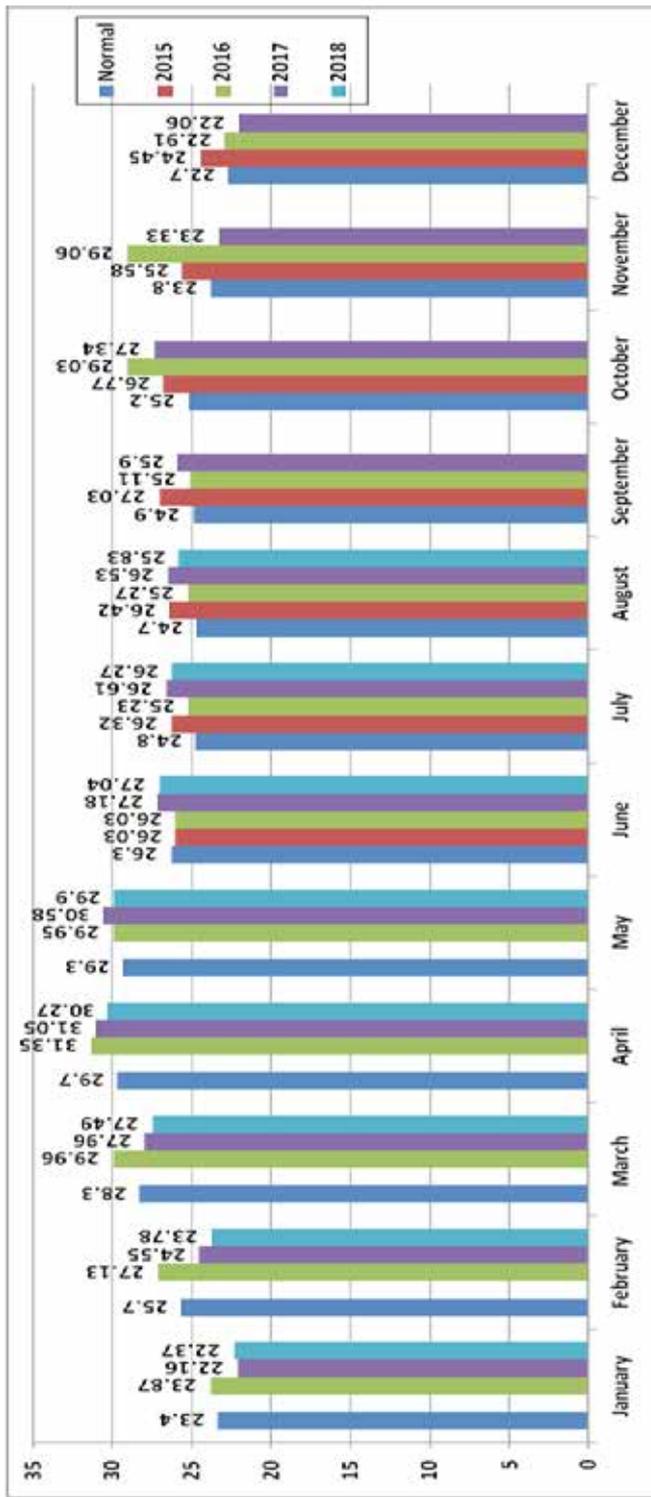


Fig: Year and month wise variability map of temperature recorded in NICRA village



Module I: Natural Resource Management

1. De-silting of rainwater harvesting structures

De-silting of community pond of size 90m x 12m x 2m (2160m³) and check dam of size 100m X 10m X 1m (1000m³) were carried out during 2015 and 2016 for harvesting the rainwater. After de-silting of water harvesting structures in 2016, the village was fortunate to receive good rains in the month of June (37.8 % more than normal) as indicated in Table 28 and Fig. Approximately 63.2 lakh litres of water was harvested by two fillings of these water harvesting structures. This resulted in recharging of ground water in 9 bore-wells in the vicinity of rainwater harvesting

structures and the recharged bore-wells were able to provide water for protective irrigation in an area of 15.2 ha where maize crop was sown during 3rd week of June. After sowing, the crop suffered from moisture stress during vegetative, tasseling and silking stages (-13% during July and -24.4 % during August against normal). But, 12 farmers owning these recharged bore-wells provided one protective irrigation to their maize crop during critical stage (35- 45 DAS) in an area of 15.2 ha. The protective irrigation supported maize crop recovered from moisture stress and gave 37.44 % increased yield compared to rainfed crops of other farmers. The results are given in the Table-30.



Table 30. Maize crop yield under protective irrigation.

Treatment	Seed yield (q/ha)	Percentage increase in yield	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice (Two protective irrigation given)	24.19	37.44	20496	29025	8529	1.41
Farmer's practice (Rainfed condition)	17.60		18372	22969	4597	1.25

Impact: The result shows that desilting of existing rain water harvesting structures has enhanced the ground water table which in-turn helped the farmers to provide one protective irrigation to crop during long dry spells and thus enabled farmers to increase their income.

2. Recharging of groundwater through construction of bore well recharging structures

Recharging of ground water through construction of bore well recharging structures was demonstrated in 12 units during 2017 and 5 units during 2018. The main purposes were (i) efficient rain water harvesting; (ii) to increase ground water table; and (iii) to ensure water availability in the bore wells throughout the year. The village received good pre-

monsoon & initial monsoon rains in the month of May to 2nd week of June, 2018 (Table 28 & Figure). Rainwater collected in the recharged structures contributed in recharging bore wells with nearly 2 to 2.5 lakh litres of water per unit during this period. In *Kharif* 2018, most of the farmers (60 to 70%) in the village sown the greengram in 1st and 2nd week of June. After sowing, the village experienced long dry spell during 15th June to 10th August, 2018 (56 days). The moisture stress affected the vegetative, flowering and pod formation stages (60 DAS) in greengram. Farmers owning the recharged bore wells utilized the groundwater for protective irrigation during these critical stages i.e. 30-35 days after sowing (DAS) for greengram crop. This resulted in increase of crop yield. The results are given in Table-31.

Table 31. Green gram crop yield due to providing of protective irrigation

Treatment	Seed yield (q/ha)	% increase in yield	Gross cost	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice (Two protective irrigation given)	8.3	80.43	19480	53950	34470	2.76
Farmer's practice (Rainfed condition)	4.6		18360	29900	11540	1.62



Impact: There was 80.43 % increase in yield in protective irrigation over non-irrigated greengram crop. Hence, the recharging of groundwater through construction of

recharging structures for bore wells is very much essential in drylands to ensure water yield especially during long dry spells.



Bore-well before construction of ground water recharging structure



Visit of ZMC members to bore-well recharging structure



Green gram crop after protective irrigation



Completion of bore-well recharging structure

Module II: Crop Production

1. Maize + Pigeonpea intercropping system

Maize is an important cereal crop cultivated in *Kharif* season covering 40-50% of the cultivated area in the district. This crop suffers from moisture stress due to long dry

spells during June to August leading to low productivity and loss to the farmers under variable climatic condition. To address this problem, maize + pigeonpea intercropping system was demonstrated under the project during 2015-16 to 2017-18. Sowing dates and harvesting periods of the crop are as follows:

	2015-16	2016-17	2017-18
Sowing window	1 st week of July	3 rd week of June	3 rd week of July
Harvesting window of Maize crop	2 nd week of November	1 st week of November	1 st week of December
Harvesting window of Pigeonpea crop	3 rd week of December	1 st week of December	2 nd week of January

The following technologies were adopted while implementing the demonstrations

- i. Introduction of pigeonpea as an intercrop in maize as pigeonpea can sustain early and mid-season drought during *Kharif* season.
- ii. Demonstration of medium duration TS-3R variety in pigeonpea
- iii. Seed priming with calcium chloride @ 2 %
- iv. Seed treatment with Bio-fertilizers (PSB & *Rhizobium*)
- v. Opening of conservation furrows at every 25-30 feet interval at 20-25 DAS.
- vi. Foliar spray of pulse magic @ 1 % during flowering stage
- vii. Biological control of pests in Pigeonpea



Situation Analysis

During the crop demonstration of maize+ pigeonpea intercropping system, rainfall data (Table 28 and Fig) indicates that maize crop suffered from moisture stress during vegetative stage (45-50 DAS) and hence the crop could not recover fully as half of the crop duration was under moisture stress. Although pigeonpea crop also suffered due to moisture stress during early vegetative stage (45-50 DAS), sufficient moisture received during grand growth period and flowering stage helped the crop to recover. It proved that pigeonpea crop could withstand climatic variability in terms of long dry spells whereas maize could not withstand.

Impact

The results obtained from farmers practice (maize as a sole crop) and from demonstration (maize + pigeonpea intercropping system) are given in below Table-32.



Table 32. Performance of maize as a sole crop and maize + pigeonpea intercropping system

Year	Area (ha)	No. of demo	Crop	Yield (q/ha)	Gross cost (₹/ha)	Gross return (₹/ha)	Net Returns (₹/ha)	B:C	Crop Equivalent Yield (CEY)
2015-16	8	20	Maize sole crop	21.95	25628	26340	712	1.02	36.96
			Maize+Pigeonpea	18.40(Maize) + 4.95 (Pigeonpea)	32980	44355	11374	1.34	
2016-17	30	75	Maize sole crop	17.9	18592	23270	4678	1.25	33.83
			Maize+Pigeonpea Intercrop	14.46(Maize) + 5.60 (Pigeonpea)	30338	43991	13653	1.45	
2017-18	16	40	Maize sole crop	24.50	25812	28175	2363	1.09	42.50
			Maize+Pigeonpea intercrop	20.0 (Maize)+ 5.75 (Pigeonpea)	35500	48875	13375	1.37	

Impact

The results reveals that maize as a sole crop gave low income and hence less profitability, whereas maize + pigeonpea intercropping system gave more income and more profitability even under climatic variability in terms of long dry spells especially during June, July and August months. Hence, maize

+ pigeonpea intercropping system was found to be more suitable for dryland conditions as compared to maize as sole crop. Realizing these facts through demonstrations, farmers now invariably follow the maize + pigeonpea intercropping. The extent of adoption by farmers in and around NICRA village is to the tune of 60-70%.



Foliar spray of pulse magic in pigeonpea crop



Celebration of field day Maize+Pigeonpea intercropping system

2. Greengram + Pigeonpea intercropping system

Greengram is cultivated in *Kharif* season in nearly 40-45% of the cultivated area in the district. But after sowing the crop, it normally suffers from moisture stress during vegetative, flowering and pod development stages during June-August months due to long

dry spells. Hence, it results in low income and less profitability to the farmers. Therefore, to address this problem, greengram + pigeonpea intercropping system was demonstrated in NICRA project during 2016- 17, in an area of 8 ha covering 20 farmers. Sowing dates and harvesting stage periods of the crops are as follows:

Particulars	2016-17
Sowing dates	2 nd week of June
Harvesting window of greengram	4 th week of August
Harvesting window of pigeonpea crop	4 th week of November



The following technologies were adopted while implementing the demonstrations

- Demonstration of non-shattering and high yielding variety DGGV-2 in greengram crop
- Demonstration of medium duration TS-3R variety in pigeonpea
- Compartment bunding
- Seed priming with calcium chloride @ 2%
- Seed treatment with Bio-fertilizers (PSB & *Rhizobium*)
- Opening of conservation furrows at every 25-30 feet interval at 20-25 DAS
- Contour cultivation
- Foliar spray of pulse magic @ 1 % during flowering stage

- Biological control of pests in pigeonpea crop

Situation analysis

Rainfall data (Table 28 and Fig) indicates that greengram crop suffered from moisture stress during vegetative and flowering stages (45-50 DAS) and the crop could not recover fully as 70% of the crop duration was under moisture stress. Pigeonpea crop also suffered due to moisture stress during early vegetative stage (45-50 DAS), but the late rains during grand growth period and flowering stage helped the crop to recover from the early moisture stress. The results obtained from farmers' practice (greengram as a sole crop) and from demonstration (greengram + pigeonpea intercropping system) are given in Table 33.

Table 33. Performance of greengram as a sole crop and Green gram+Pigeonpea intercropping system

Particulars	Yield (q/ha)	Gross Cost (₹/ ha)	Gross return (₹/ ha)	Net return (₹/ ha)	B:C	CEY
Local (Green gram as a sole crop)	7.85	29363	40820	11457	1.39	-
Demo (Green gram + Pigeonpea intercropping)	Green gram 7.06 + pigeonpea 5.86	39335	63187	23852	1.60	12.15



The results show that, greengram as a sole crop gave low income and hence less profitability, whereas greengram + pigeonpea intercropping system gave more income and more profitability even during climatic variability in terms of long dry spells especially during June and July months. Therefore, greengram+ pigeonpea intercropping system was found to be more suitable as compared to greengram as sole crop under dryland condition. Realizing these advantages through demonstrations, more farmers are now following greengram+ pigeonpea intercropping. The extent of

adoption by farmers in and around NICRA village is to the tune of 45-50 % in the span of just 2 years.

3. Drought tolerant foxtail millet

Drought tolerant, high yielding and good fodder quality foxtail millet variety DHFt-109-3 was introduced through demonstrations in the project area in order to enable farmers to grow the crop successfully under variable climate characterized by long dry spells. Sowing period and harvesting stage of the crop is as follows:

Year	2015- 16	2016- 17
Sowing window	3 rd week of July	3 rd week of June
Harvesting window	1 st week of November	1 st week of October

Problem Analysis

Foxtail millet crop suffered from moisture stress in early stages but recovered after receiving good rains especially during later stages. Variety DHFt-109-3 could give good yield as the variety is drought tolerant in nature

and withstands the drought situation during its early stages compared to local Halanavane.

The results obtained from farmers' practice (Halanavane) and from demonstration (DHFt-109-3) are given in Table 34.

Table 34. Performance of demonstration on foxtail millet

Year	Area (ha)	No. of demo	Crop	Yield (q/ha)	% increase in yield over control	Gross cost (₹/ha)	Gross return (₹/ha)	Net Returns	B:C
2015-16	2	5	Local (Halanavane variety)	13.5	24.44	19182	29700	10518	1.54
			Demonstration (DHFt-109-3 variety)	16.8		19811	36960	17149	1.86
2016-17	16	40	Local (Halanavane variety)	10.64	24.43	14476	19152	4676	1.32
			Demonstration (DHFt-109-3 variety)	13.24		15571	23832	8261	1.53



Impact

Cultivation of DHFt-109-3 variety of foxtail millet crop is profitable even during climatic variability in terms of long dry spells especially during June and July months. The farmers

in NICRA village realised the importance of cultivation of this variety under dry land situation through this demonstration. The extent of adoption of DHFt-109-3 variety by farmers in and around NICRA village is to the tune of 20-25 %.



Demonstration on DHFt-109-3 variety of foxtail millet crop



Celebration of field day in foxtail millet crop

4. Integrated crop management (ICM) in *rabi* sorghum

In *rabi* season, sorghum is the major crop. This crop is being cultivated in 30-40% of the area in the district. The receding soil moisture during *rabi* season causes low productivity

in *rabi* sorghum crop (6-7q/ha). Hence to overcome the moisture stress problem and to get enhanced productivity, ICM on *rabi* sorghum was carried out during 2015 to 2017 under NICRA project. Sowing window and harvesting period of the crop are as follows:

Particulars	2015-16	2016-17	2017-18
Sowing window	1 st week of October, 2015	3 rd week of September, 2016	2 nd week of September, 2017
Harvesting window of <i>rabi</i> sorghum crop	1 st week of February, 2016	3 rd week of January, 2017	2 nd week of January, 2018

The following technologies were adopted as a part of ICM

1. Compartment bunding for harvesting rain water and enhancing the moisture availability in the soil during *rabi* season.
2. Seed priming with calcium chloride @ 2% to enhance germination percentage, to improve the crop vigour and to induce drought tolerance to the crop.
3. Seed treatment with *Azospirillum* & phosphate solubilizing bacteria (PSB).

4. Repeated inter cultivation to conserve the residual soil moisture During the *rabi* season, when crop did not receive sufficient rains in its different growth and development stages (Table-1).

In the demonstrated fields, the compartment bunds made for *in-situ* soil moisture conservation before sowing of the crop helped in enhancing the moisture availability to the crop. It was followed by repeated inter cultivation operations to prevent evaporation losses and for maintaining the sub-surface soil moisture. Seed priming with calcium chloride @ 2% helped the crop to withstand drought.



The results obtained from demonstration of ICM on *rabi* sorghum against farmers practice is given in Table-35.

Table35. Performance of ICM on *rabi* sorghum against farmers practice

Year	Area (ha)	No. of demos.	Yield (q/ha)		% increase in yield	Gross Cost (₹/ha)		Gross Returns (₹/ha)		Net Returns (₹/ha)		BC Ratio	
			Demo	Local		Demo	Local	Demo	Local	Demo	Local	Demo	Local
2015-16	10.0	25	11.2	9.30	20.43	18538	18016	28000	23250	9462	5234	1.51	1.29
2016-17	6.0	15	7.62	5.60	36.07	18755	17821	32352	23636	13597	5815	1.73	1.33
2017-18	32.0	80	11.50	9.0	27.77	20520	17580	32200	25200	11679	7620	1.57	1.44

Impact

In-situ soil moisture conservation technologies like compartment bunding, repeated inter cultivation and drought inducing measures like seed treatment with calcium chloride and

bio-fertilizers were effective in mitigating the drought-like situations. The income realized by farmers under demonstrations were 1.5 to 2 times more than the local checks.





5. Dry land horticulture for drought proofing

During 2015 to 2018, promotion of dryland horticulture for drought proofing and income security even under climatic variability in terms of long dry spells was demonstrated in an area of 28.5 ha covering 50 farmers. Farmers were encouraged to plant mango, cashew, tamarind, custard apple, drumstick, curry leaf, and other minor horticulture fruit crops that are drought tolerant and suitable for dryland conditions. During these 4 years of demonstrations (June, 2015 to August 2018) village received good

rains only during June and September, 2016 and May 2018. In all the remaining months the village experienced deficit rainfall (Table - 28). Increase in maximum temperature was recorded during March to May (1.28 °C to 1.66 °C) followed by June to November months (0.88 °C to 5.26 °C) (Table and Fig. 29). Even during these climatic variability years, dryland horticulture crops performed better with a survival rate of 60-70 %. In the coming 2-3 years, farmers are expecting good and assured returns from the dryland horticulture components.



Module III: Livestock Activities

1. Upgradation of local goats with Jamnapari buck

Problem Analysis: The farmers who are practicing goat farming in dryland area are facing the problem of low income in view of prevailing high temperatures, less body weight gain, low milk yield, and long gestation period. So to overcome these problems, Jamnapari buck was introduced in the project area during

2016-17. The purpose of demonstration was to enhance body weight, milk yield and to attain early maturity even under higher temperature conditions as this breed of Jamunapari buck is tolerant to high temperatures. Jamunapari bucks provided during January, 2017 performed better even under increased temperature during April-May and June-October (Table and Fig. 29). Number of upgraded kids and income from sale of male upgraded kids is given in Table 36.

Table 36. Number of upgraded kids & income from sale of male kids

Particulars	Number of animals at the beginning of demo	Number of upgraded kids from Feb, 2017 to Mar, 2018				Income generated from sale of 6-8 months male kids (₹)
		Total	Male kids	Female kids	Mortality kids	
Local	10+1 local buck	21	11	6	4	44000
Demo	10+1 Jamunapari buck	32	17	12	3	102000

Impact: The above intervention clearly shows that introduction of Jamunapari buck fetched high income over local even under climate variability.



Upgradation of local goats with Jamnapari buck

2. Backyard poultry management under cage system

Backyard poultry is one of the income generating activities for small and marginal farmers under rainfed conditions. Local poultry birds have less growth rate, less egg laying capacity and low survival percentage due to predators especially during summer. Therefore, demonstration on improved breed Swarnadhara backyard poultry under cage system was conducted in NICRA village

during 2016 through 10 demonstrations. The objective was to provide (i) Proper shelter to the birds (ii) Efficient utilization of space to facilitate gaining of more body weight, and (iii) Increase in eggs production even under variability of temperature and rainfall. The demonstrated Swarnadhara poultry birds maintained in cages performed better when compared to local practice in terms of egg production and net income as shown in Table 37.



Table 37. Egg production and economics of demonstration and farmers' practice

	Sale of eggs/unit/year	Percentage increase in no. /unit/year	Sale of cocks /unit/year	Gross returns (₹/unit/year)	Cost of cultivation (₹/unit/year)	Net returns (₹/unit/year)	BCR
Demo (Swarnadhara birds under cage system)	1776	67.86	4	15508	6100	9408	2.54
Local (Farmers' practice with local birds)	1058		4	9758	6580	3178	1.48

Impact

Performance of improved breed Swarnadhara poultry birds under cage system gave more

income to small and marginal farmers under variable climatic conditions as compared to local breed.



Demonstration of backyard poultry (Swarnadhara birds) management under cage system

2.4 Belagavi, Karnataka

(D. C. Chougala and M. N. Malawadi)

ICAR-KVK, Tukkanatti-Belagavi I, Gokak (Taluk) Belagavi (Dist), Karnataka

The district of Belagavi is located East of the Western Ghats and is situated in the Northwestern part of Karnataka state. It is bordered by the state of Goa on its Southwest and Maharashtra state towards its West and North. The districts of Bijapur and Bagalkot of Karnataka state lie towards its Northeast and East respectively whereas; the districts of Dharwad and Uttar Kanara lie towards its South and Southwest, respectively. Belagavi district comes under the Agro-Climatic Zone of Northern Transitional Zone-8 in Karnataka state. The district has semi-arid climate with annual rainfall of 772.5 mm. Rainfall is usually erratic and probability of agricultural drought is to the extent of 70 % of the years. Recurrent drought (early and mid-season), uncertain

rainfall and long dry spells between two rains during June to September period affects the crop yield and thereby the livelihood of the farmers.

2.4.1 Information about the NICRA village

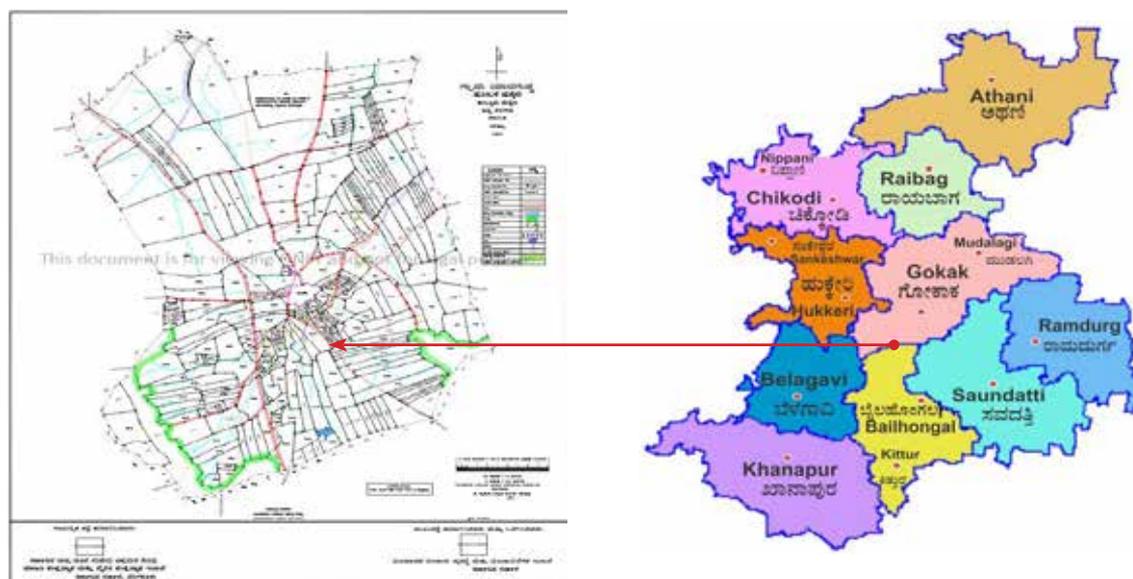
NICRA project is implemented by KVK Belagavi in Yadagud village of Hukkeri taluk since 2014-15. Yadagud village is prone for vulnerabilities such as recurrent droughts (early, mid-season, terminal) uncertain, intermittent rainfall and dry spells, water logging in low lands (poor drainage), soil erosion in uneven lands, low productivity of soil and in livestock fodder scarcity and low productivity of animals due to poor genetic potential.





Basic information of the village:

Name of the Village	Yadagud
Name of Gram Panchayat	Yadagud
Name of taluk	Hukkeri
Distance	36 km from KVK
Geographical area of the village (ha)	1277.6
Total cultivated area (ha)	1157.6
Area under rainfed cultivation (ha)	998
Major soil type	Red soil (75%) and Black soil (25%)
Population	4469
No. of households	2250
Annual Rainfall	Actual rain fall 456.9 mm (2017), Normal 772.5 mm
Major growing crops	Jowar, groundnut, soybean, maize, pigeonpea, wheat & Chickpea.



Map of NICRA village

Rainfall data: The rainfall data recorded in the NICRA village Yadagud of Belagavi district is presented in Table 38 and dry spells in Table 39 besides graphically presentation in the Fig. below.

Table 38. Rainfall (mm) data recorded since from 2015-2018

Month	Normal rain fall (mm)	2015			2016			2017			2018		
		Rain (mm)	Deviatio n days	Rainy days	Rain (mm)	Deviatio n days	Rainy days	Rain (mm)	Deviatio n days	Rainy days	Rain (mm)	Deviatio n days	Rainy days
JAN	0.7	0	-100.0	0	0	-100.0	0	0	-100.0	0	0	-100	0
FEB	0.8	0	-100.0	0	0	-100.0	0	0	-100.0	0	0	-100	0
MAR	7.1	13.5	90.1	2	0	-100.0	0	0	90.1	0	0	-100	0
APR	34.4	0	-100.0	0	0	-100.0	0	0	-100.0	0	0	-1	3
MAY	90.2	59.1	-34.5	5	12.5	-86.1	2	28	-34.5	4	3.2	-96	1
JUN	106	111.6	5.3	7	37	-65.1	4	61.2	5.3	8	133.3	26	6
JUL	160.1	0	-100.0	0	140.1	-12.5	16	107.6	-100.0	9	128	-20	13
AUG	96.4	20.5	-78.7	3	63.4	-34.2	9	24.6	-78.7	4	109.1	13	12
SEP	107.4	63.1	-41.2	5	34.2	-68.2	4	170.7	-41.2	11	47.8	-55	05
OCT	129.5	70.6	-45.5	3	10.3	-92.0	2	64.8	-45.5	4	-	-	-
NOV	34.1	5.3	-84.5	1	15.1	-55.7	1	0	-84.5	0	-	-	-
DEC	5.8	0	-100.0	0	0	-100.0	0	0	-100.0	0	0	-	-
Total	772.5	343.7	-	26	312.6	-	38	456.9	-	40	455.3	-	40
Deficit	-	428.8	-	-	459.9	-	-	315.6	-	-	-	-	-

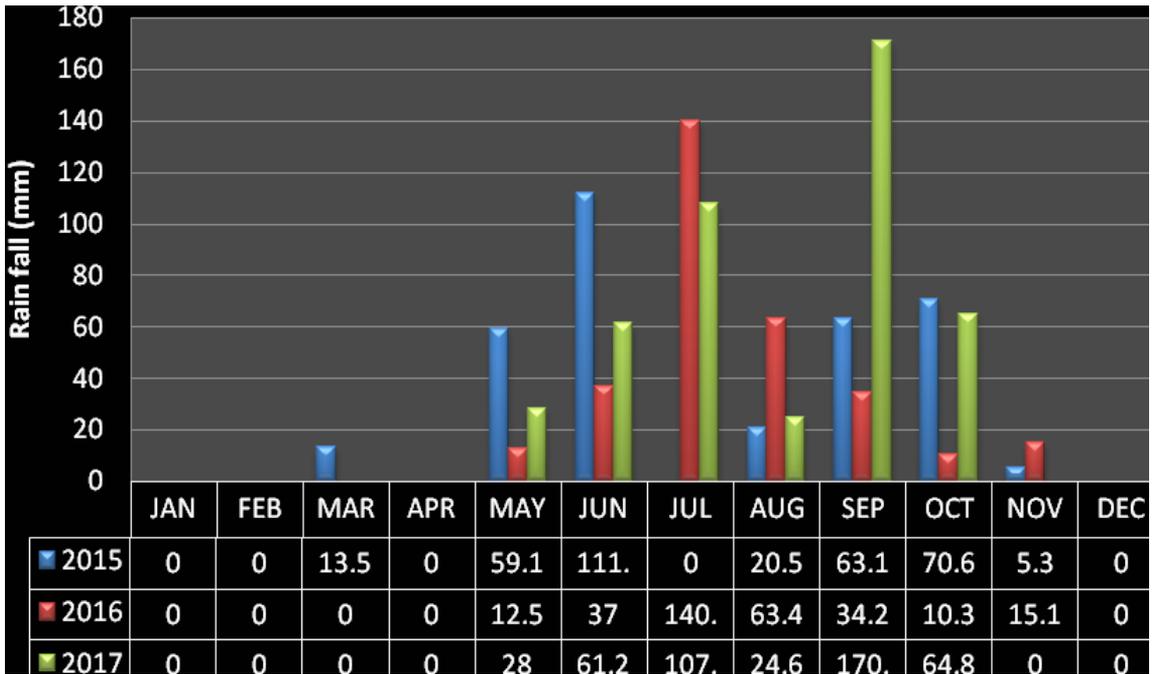


Fig: Rain fall data of NICRA village Yadagud (2015 to 2017)

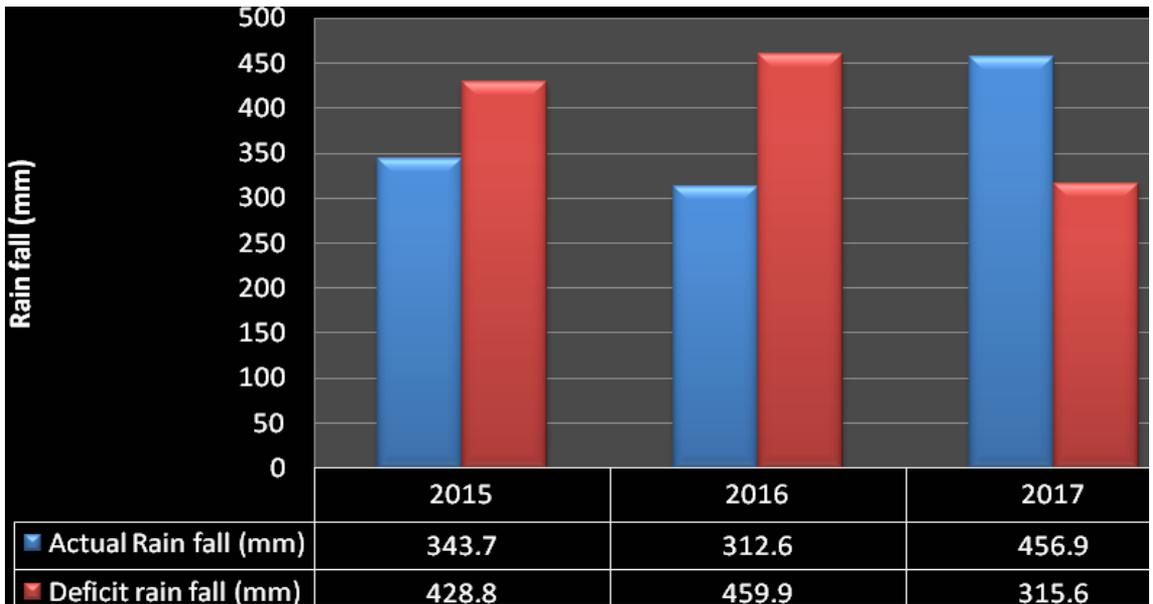


Fig: Comparison of actual and deficit rain fall data of NICRA village Yadagud (2015 to 2017)

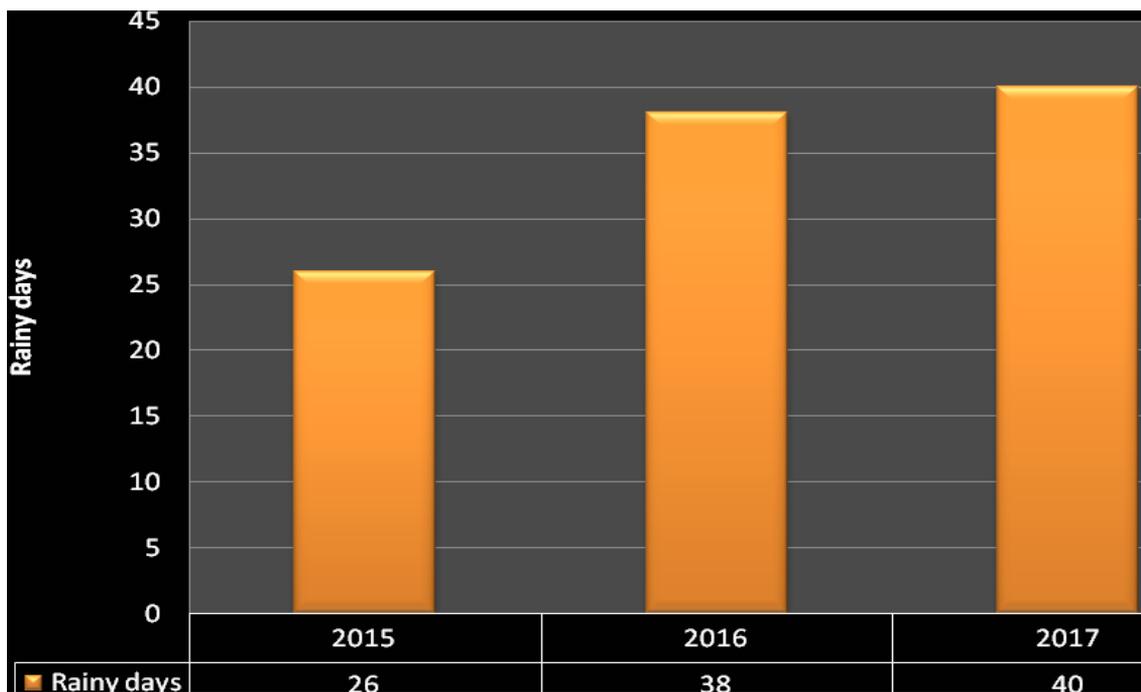


Fig: Rainy days data of NICRA village Yadagud (2015 to 2017)

Table 39. Dry spells recorded at NICRA village Yadagud during 2015-2018

Historical trends in rainfall		Decadal average 2004- 2014	2015	2016	2017	2018
No. of rainy days		40.4	26	38	40	40
No. of dry spells	> 10 days	2.3	3	1	-	1
	> 15 days	1.3	1	-	-	1
	> 20 days	3	4	1	1	-
	> 60 days	1	-	1	1	-

Note: Rainy days and dry spells recorded upto September-2018

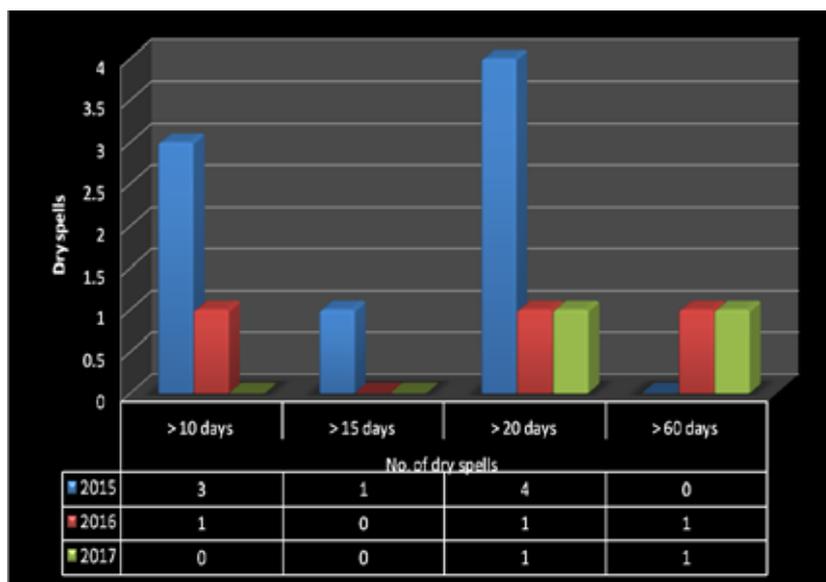


Fig: Dry spells of NICRA village Yadagud (2015 to 2017)

Module I: Natural Resource Management

1. Strengthening of existing bunds

Strengthening of existing bunds was taken up in the year 2014-15 at Yadagud village with an objective of conservation of soil moisture, reducing soil erosion and improving the productivity of farm produce. About 27 ha strengthened with bunds covering 25 farmers. Strengthening of existing bunds minimised the soil erosion and loss of soil moisture. Crop yield increased by 1.33 q/ha, due to uniform

moisture availability and uniform crop growth. The availability of moisture reduced the stress during critical growth period and gave an assured yield in sorghum, soybean, maize and wheat.

Impact

Crop yields increased by 33.3 % and additional net income obtained was upto ₹94,449. Groundwater table also increased and as a result 15 open wells and 7 bore wells got recharged.



A view of strengthened existing bunds and crop growth

2. Compartment bunding

Levelling and compartment bunding technology was adopted with two objectives in mind. First, levelling combined with bunding helps in reduction of soil erosion and secondly, it reduces run off by enhancing infiltration of water into the soil. Lands belonging to ten farmers covering an area of 8.80 ha area was covered under trench-cum-bunding and was supplemented by growing pigeonpea. During 2015-16, village faced dry spells in the month of July, August and October, subjecting the

pigeonpea crop to moisture stress during vegetative, pod initiation and maturity stages. The levelling and compartment bunding technology helped in harvesting the rainwater received during June and September which had increased the moisture content through conserved the soil moisture. Fields treated with levelling and compartment bunding recorded higher crop yield of 10 q/ha when compared to farmers practice with only 7.5 q/ha. This increase was to the extent of 33.30 % which would not have been possible without levelling and compartment bunding (Table 40).

Table 40. Effect of leveling and formation of compartments for soil moisture storage

Details	No. of beneficiary farmers	Area covered (ha)	Water storage profile	Pigeonpea yield (q/ha)	% increase in yield
Improved Technology: Leveled and formation of compartments	10	8.8	-	10	33.3
Control: Without leveling and formation of compartments	10	12.0	-	7.5	--



3. Rainwater harvesting and efficient utilization in soyabean and maize

Desilting of nala: Janamatti nala, Taladappa nala and Donagri nala

Three nalas viz. Janamatti nala, Taladappa nala

and Donagri nalas were desilted under NICRA project during 2014-15 at village Yadagud. Before NICRA interventions, the water storage capacity of those three nalas was 872.81 m³ and after desilting of these nalas the water storage capacity has increased upto 3959.19 m³ and protective irrigation potential was created for an area up to 35.1 ha. Totally 25 farmers were benefitted by the desilting of the nalas. Area under cultivation increased in *Kharif* up to 29.2 ha and *Rabi* up to 23.2 ha.

Impact

After desilting of nalas the water storage capacity increased up to 3959.19 m³. The nalas were filled two times due to rainfall on 20th



July-2017 (28.4 mm/day) and 11th Sept-2017 (35.1 mm). The soybean crop was sown in 2 ha area on 2nd and 3rd week of June-2017. Stored water was used for protective irrigation at two times, first at 55 days after sowing and second

at 75 days after sowing, coinciding critical growth stages of soybean such as flowering and pod formation. After desilting of nalas the area had increased from 5.3 to 12 ha and crop yield increased from 24.54 q/ha to 30.12 q/ha.

Crop sown and date of sowing & Area sown (ha)		Soybean: 2 nd and 3 rd week of June-2017 Area sown :12.0 ha	
No. of irrigations and crop growth	No. of irrigations	1	2
	Days after sowing (DAS) at which irrigation was given	55	75
Area brought under irrigation	Crop growth stage	Flowering stage	Pod formation
	Before Desilting of Nala	35.45	
Method of irrigation (ha)	After Desilting of Nala	44.7	
	Drip	Sprinkler	Furrow
Crop yield (q/ha)	-	-	39.4
	Before Desilting of Nala	24.54	
	After Desilting of Nala	30.12	



The maize crop was sown during 2nd and 3rd week of June-2018 in an area of 70.5 ha. The rainwater harvested and stored in the developed structures was used for irrigation at two times, 50 days and 70 days after sowing. These stages coincided critical growth period of cob

initiation and grain formation in maize. After desilting of nala's the area under protective irrigation increased from 21.75 ha to 70.5 ha, and crop yield increased from 66.51q/ha to 78.92 q/ha (Table 41).

Table 41. Water harvested and utilised for irrigation in maize crop

Crop sown and date of sowing & Area sown (ha)	Maize: 2 nd and 3 rd week of June-2018		Area sown :70.5 ha	
No. of irrigations and crop growth	No. of irrigations	1	2	3
	Days after sowing (DAS) at which irrigation was given	55	75	-
	Crop growth stage	Cob initiation	Grain formation	-
Area brought under irrigation, (ha)	Before Desilting of Nala	21.75		
	After Desilting of Nala	70.5		
Method of irrigation (ha)	Drip 10.0	Sprinkler		Furrow 60.5
Crop yield (q/ha)	Before Desilting of Nala	66.51		
	After Desilting of Nala	78.92		



Maize field visited by KVK Scientists



Protective irrigated maize plot

4. Rainwater Management

A total of 12 nalas were de-silted as a result of which, the water storage capacity has increased from 3885.7 to 14664.3 cu.m. This facilitated supplemental irrigation to crops in both *Kharif*

and *Rabi* season. After de-silting of nalas the water storage capacity has increased by 2-3 times and protective irrigation potential gone up to 125.7 ha (Table 42). Totally 133 farmers benefitted by de-silting of nala's. Before



Table 42. Impact of de-silted nala's at NICRA village (2015-2018)

Sl. No.	Name of structures constructed / repaired	Year of work done	No. of farmers benefited	Water storage capacity (cu.m)		Protective irrigation potential created (ha)	Area under cultivation (ha)				Cropping intensity (%) Rabi		
				Before	After		Before Kharif	Before Rabi	After Kharif	After Rabi		Cropping intensity (%) Kharif	
1	Dongari Nala	2014-15	7	379.62	1419.37	11.4	4.8	1.4	8.4	6.2	173.80	235.48	
2	Thaladappa Nala	2014-15	5	73.85	443.12	7.6	2.4	1.2	6.4	5.6	187.50	214.29	
3	Janamatti	2014-15	13	419.34	2096.70	16.2	6.4	3.6	14.4	11.4	179.16	226.32	
4	Walake Tota	2015-16	9	486.00	1615.0	7.4	2.4	0.8	6.0	4.8	180.00	225.00	
5	Janamatti School Tota	2015-16	5	171.72	629.72	4.4	1.8	0.6	3.2	2.4	175.00	233.33	
6	Aralimatti Nala	2016-17	6	69.35	403.0	9.5	3.2	1.2	6.7	5.9	188.05	213.56	
7	Yamagami Nala	2016-17	8	315	994.14	12.5	4.6	1.5	9.1	6.1	167.03	249.18	
8	Badiger tota Nala	2016-17	10	402.20	1239.39	14.	5.2	2.6	12.2	8.3	168.03	246.99	
9	Magenni tota Nala	2016-17	8	276.07	1131	13.2	4.8	1.1	9.3	5.2	156	278.85	
10	Old Janamatti Nala	2016-17	48	782.55	3112.87	17.4	7.1	2.9	14.9	8.9	159.7	267.42	
11	Patil Tota-I	2017-18	5	232	728.0	5.4	6.9	1.5	11.2	5.3	178.06	213.06	
12	Patil Tota-II	2017-18	9	278	852.0	6.7	7.6	2.1	13.4	7.3	169.03	236.9	
Total				133.0	3885.7	14664.3	125.7	57.2	20.5	115.2	77.4	173.4	236.7

desilting, there was only one crop per year and after this intervention two crops were grown per year. Now, Yadagud village farmers are growing crops like pigeonpea, groundnut,

jowar, greengram, horse gram, bajra, wheat, chickpea and minor millets by using nala harvested water for the protective irrigation both in kharif and rabi seasons.



Janamatti nala filled with rain water (2018)



Dongari nala filled with rain water (2018)



Aralimatti nala filled with rain water



Recharged open wells at NICRA village

5. Green manuring with unhemp

Green manuring is practiced by growing sun hemp in the *Kharif* season with an objective of *in-situ* green manuring which adds organic matter to soil and increases nutrient levels in the soil. Green manuring crops are incorporated

to soils at flowering stage. It was practiced for low fertile soils in an area of 1.6 ha covering 4 farmers. This green manuring technology in sorghum crop resulted in higher yield of 1162 kg/ha compared to farmers practice of 943 kg/ha (Table 43).

**Table 43. Green manuring**

Inter-vention	No of Demo.	Area (ha)	No. of farmers	Green biomass incorporated (k/ha)	Remarks	Yield of sorghum (kg/ha)	
						Demo.	Farmers practice
Green manuring	4	1.6	4	10.65	Incorporation of sunhemp	1162	943

Impact: Incorporation of sunhemp to the soil has increased sorghum yield by 219 kg/ha and earned additional net returns of ₹4818/ha (Table 43).

**A view of *In-situ* green manuring**

6. *In-situ* moisture conservation

Mulching: Mulching helps in moisture conservation and increases organic carbon content. It was demonstrated in area of 0.4 ha where turmeric and chilli crops were cultivated. Both crops recorded higher crop yield of

23 q/ha and 96 q/ha respectively when compared to farmer's practice. The intervention reduced the irrigation water requirement as the irrigation interval was increased up to 12-15 days in turmeric and 10-12 days in chilli (Table 44).

Table 44. Mulching in horticultural crops with sugarcane trash

Crop	Area (ha)	Irrigation interval (days)		Water saving	Crop yield (q/ha)		Increase in yield (%)	Net return (₹/ha)	
		Demo	Check		Demo	Local		Demo	Check
Turmeric (Dry)	0.2	12-15	8-10	8 no. of irrigations	23.01	21.36	7.17	230115	200256
Chilli (Green)	0.2	10-12	7-8	5 no. of irrigations	96.01	89.62	6.65	288029	269221

Impact

Mulching sugarcane trash as biodegradable waste in chilli and turmeric maintained soil moisture and increased yield up to 7.17 and 6.65 % respectively.



Dry spells experienced and their impact on the crop growth in relation to drought mitigating interventions in comparison to farmers practice in the NICRA village during 2017-18 are presented in Table 45.



Table 45. Dry spells and their impact on the crop growth and interventions performed in relation to the farmers practice

Sl. No	Dry spell (no. of days)	Sowing date	Duration	Crop Variety	Crop stage affected	Intervention taken up	Number of farmers involved	Impact on crop yields (q/ha)		
								Demo	Farmers' practice	Increase over farmers' practice
1	>20days	2 nd and 3 rd week of June-2017	23 rd July-2017 To 25 th August-2017	Blackgram DBGV-5	Flowering stage	1. Inter-cultivation 2. Providing protective irrigation 3. Foliar spray with KNO ₃	32	8.75	7.50	16.67
2.	>20 days	2 nd and 3 rd week of June-2017	23 rd July To 25 th August-2017	Foxtail millet-DHFT-109-3	Ear head initiation stage	1. Drought tolerant variety 2. Inter-cultivation 3. Compartment bunding	60	4.90	3.79	29.8
3	>60days	2 nd and 3 rd week of September-2017	17 th October to 31 st January	Jowar M 35-1	Seedling stage	1. Inter-cultivation 2. Compartment bunding. 3. Digging of conservation furrows	58	Grain: 15.74 Fodder: 7.50 t/ha	Grain 11.98 Fodder 6.32 t/ha	31.38 15.73
4	>60days	2 nd and 3 rd week of September-2017	17 th October to 31 st January 2018	Chickpea JG-11	Seedling stage	1. Inter-cultivation 2. Urea spray (2%)	45	Grain :11.25	9.37	20.06

Module II: Crop Production

1. High yielding blackgram variety : DBGV-5

During *Kharif* season blackgram grown at NICRA village faced more than 20 days dry spell from 23rd July-2017 to 25th August-2017. Blackgram variety DBGV-5 is a medium duration (80-85 days), drought tolerant variety and alternative to maize crop as blackgram is early mature crop compared to maize and

conserves soil and water thereby increases the soil fertility.

Blackgram crop was affected during flowering stage, but yield loss was minimized by adopting inter-cultivation, protective irrigation and foliar spray with KNO₃. The demonstration conducted with 203 farmers recorded higher yield of 10.95 q/ha as compared to 8.15 q/ha in farmer's practice with gross return of ₹ 49275/ha and B:C ratio of 2.99 respectively (Table 46).

Table 46. Impact of varietal demonstration of drought tolerant blackgram DBGV-5.

Crop	Variety	Area (ha)	Crop stage experienced dry spells	Seed yield (q/ha)	Seed yield increase over farmer's practice (q/ha)	Total cost of cultivation (₹/ha)	Total returns (₹/ha)	B:C ratio
Black gram (Demo)	DBGV-5	0.4	Flowering and pod formation stage	10.95	2.80	16440	49275	2.99
Black gram (Farmer practise)	Local	0.4	Flowering and pod formation stage	8.15	-	16145	36675	2.27

Impact

Blackgram variety DBGV-5 recorded 28% higher yield compare to farmers practice. Encouraged by the results, 445 farmers of the project village and several farmers in the adjacent villages have adopted this new variety.





2. Drought tolerant wheat variety : DWR-2006

Problem Analysis:

Wheat is an important crop cultivated in *Rabi* season, but the crop suffers from moisture

stress because of low rainfall, dry spells and uneven rainfall. DWR-2006 wheat variety was found suitable for rainfed situation as it has tolerance to moisture stress and requires only 2-3 irrigations.

Particulars	Before	After
	DWR-162	DWR-2006
Climatic requirement	Suitable for irrigation	Suitable for rainfed
Irrigation interval	Irrigation to 4-5 times	Irrigation to 2-3 times
Tolerance	Not tolerant moisture stress	Tolerant to moisture stress
Yield (q/ha)	8.75	11.5
Net Returns (₹/ha)	₹ 8593	₹ 11071

Impact

The demonstrations carried out during 2014 to 2017 covered an area of 37.80 ha involving 160 farmers. Variety DWR-2006 recorded a

higher yield of 12.0 q/ha when compared to farmer's practice of using a local variety (9.0 q/ha) with BC ratio of 2.2 and 1.8, respectively (Table 47).

Table 47. Performance of wheat (DWR-162 and DWR-2006)

Year	Crop	Variety		Area (ha)	Demo (No's)	Seed yield (q/ha)		B:C ratio	
		Demo	FP			Demo	FP	Demo (B:C ratio)	Farmers practise (B:C ratio)
2014-15	Wheat	DWR-2006	Local	11.8	30	16.25	11.86	1.70	1.38
2015-16	Wheat	DWR-2006	Local	10	50	11.50	8.75	2.93	2.14
2016-17	Wheat	DWR-2006	Local	16	80	8.20	6.40	1.99	1.73
Total				37.8	160	12.0	9.0	2.2	1.8



A view of drought tolerant wheat variety -DWR 2006



ZMC team visited demo plot of wheat var. DWR-2006

3. Pigeonpea variety : TS-3R

Problem Analysis

Earlier farmers used long duration, moisture stress, wilt disease and (*H. Armigera*) prone Gulyal local variety. Under NICRA, introduced medium duration (**150 days**), drought tolerant, wilt disease resistant, less infestation of *H. Armigera* and high yielding pigeonpea variety TS-3R with improved practices.

Particulars	Before	After
Variety	Gulyal variety	TS-3R
Resistance	Susceptible to wilt	Resistant to wilt
Duration	Long durated -180 to 200 days	Medium durated -145 to 150 days
Tolerance	Susceptible to moisture stress	Tolerant to moisture stress
Yield (q/ha)	Yield : 9.0	14.25
Net Returns (₹/ha)	₹ 37800 /ha	₹ 60900 /ha

The performance of pigeonpea TS 3R in relation to Gulyal local is presented in Table 48.

**Table 48. Performance of pigeonpea (TS-3R) in inter cropping system.**

Crop	Variety	Area (ha)	Crop stage experienced dry spells	Yield (q/ha)	Yield increase over farmer's practice (q/ha)	Total cost of cultivation (₹/ha)	Total returns (₹/ha)	B:C Ratio
Pigeon pea	TS-3R	0.2	Pod formation stage	14.5	5.5	18195	60900	23100
Pigeon pea	Gulyal	0.2	Pod formation stage	9	-	17550	37800	-



4. Drought tolerant foxtail millet variety: DHFT-109-3

Moisture stress and erratic rainfall are the major problems to be addressed in the village. Use of existing local and farm saved seeds was the farmer's practice. The foxtail millet variety DHFT-109-3 is drought tolerant, medium

duration and suitable for marginal lands. This variety was demonstrated in NICRA village in an area of 22 ha covering 120 participating farmers. Farmers got remunerative yield of 4.76 q/ha comparing to farmer practice (3.71 q/ha) with B: C ratio of 1.74 and 1.45, respectively (Table 49).

Table 49. Performance of foxtail millet variety DHFT-109-3

Year	Crop	Variety		Area (ha)	Dem-os (No's)	Seed yield (q/ha)		Im-proved practise B:C	Farm-ers practise B:C
		Demo	FP			Demo	FP		
2016-17	Fox tail millet	DHFT-109-3	Local	10	60	4.63	3.63	1.46	1.33
2017-18	Fox tail millet	DHFT-109-3	Local	12	60	4.90	3.79	2.03	1.57
Total				22	120	4.76	3.71	1.74	1.45

Impact: Yield increased up to 1.05 q/ha by use of drought tolerant foxtail millet variety DHFT-109-3.



Module III : Livestock Activities

The problems identified in livestock sector and corrective measures adopted in the NICRA village are as under :

Problem Analysis	Technologies adopted
<ul style="list-style-type: none"> • Poor knowledge on animal health management • Poor knowledge on disease preventive measures. • Low yielding fodder varieties • Lack of scientific information on fodder storage and protection methods 	<ul style="list-style-type: none"> • Organised animal health camps • Preventive measures against outbreak of disease • Introduction of high yielding and climate adaptable fodder variety (COFS-29). • Polythene sheet coverage on fodder heaps • Silage making for quality fodder

1. High yielding and climate adaptable fodder production : CoFS-29

Fodder production was carried out by introduction of new multicut drought tolerant variety CoFS-29 during 2016-17. Fodder sorghum variety CoFS-29 was grown in an area of 3.1 ha and harvested green fodder yield of 32 t/ha /season. Feeding of green fodder of

CoFS 29 led to an increased milk production (4.0 liters/day) as compared to local fodder (3.57 liters/day). In 2017-18, lucerene (RL-88) was grown in an area of 0.34 ha and farmers recorded green fodder yield of 1.36 t/ha/season. Milk yield increased up to 4.25 liters/day by lucerne feeding compare to local fodder 4.0 liters/day (Table 50).



Table 50. High yielding and Climate Adaptable fodder variety (Sorghum CoFS -29)

Year	Treatment	Fodder crop	Variety	Area (ha)	Fodder yield (t/ha/season)	Milk yield (liters/day) With intervention
2016-17	Farmer's practice	Dry Fodder	Local Jowar	3.1	24.5	3.57
	Improved practice	Sorghum	COFS-29	3.1	32	4.00
2017-18	Farmer's practice	Dry Fodder	Local	-	-	4.00
	Improved practice	Lucerene	RL-88	0.34	1.36	4.25

Impact: Fodder variety sorghum (CoFS-29) and lucerne (RL-88) increased the milk production on an average 0.42 liters/day.



Fodder variety (CoFS-29)

2. Supplementation of mineral mixture for livestock

Supplementation of protein and energy along with minerals through urea and molasses is very effective and economical in low and medium productivity animals during lean period. About

100 farmers adopted this technology in 2015-16 and achieved 5.3 % increased milk production. Similarly in 2017-18, 115 farmers adopted this practice and increased milk production by 5.9 % over farmers practice of feeding dry fodder and concentrate feed or rice bran (Table 51).

Table 51. Performance of mineral mixture on milk yield

Year	Technology demonstrated	No. of farmers benefitted	Type of animals	Milk yield (liters/day)		Economic impacts
				Demo	Local	
2015-16	Mineral mixture	100	Cattle	4.12	3.9	5.3 % increase in milk production
2017-18	Mineral mixture	115		4.25	4.0	5.9 % increase in milk production
2018-19	Mineral mixture	150		4.20	3.95	6.33 % increase in milk production

Impact: An average milk production increased up to 5.6 % in the village.

3. Conservation of green fodder as silage for lean season supplementation

Silage bag technology was demonstrated in 2016-17 for maize and fodder grass covering

10 farmers. Use of silage for the milch animals has led to increased milk production to the extent of 4.05 liters/day from 3.70 liters/day. Similarly in 2017-18, 5 farmers adopted feeding of silage and achieved milk production of 4.2 liters/day as compared to 3.85 liters/day in farmers practice (Table 52).

Table 52. The results of the demonstration on silage making.

Year	Fodder (q)	No. of farmers are benefitted	Name of the fodder crop	Quantity of storage (q)	Period of use (months)	Type of animal being fed (Cow/buffalo/Bullock etc) No. of days	Improvement in milk yield (liters/day)	
							With intervention	Without intervention
2016-17	2.8	10	Maize and Fodder grass	2.8	4.0	120 (Buffalo)	4.05	3.70
2017-18	2.5	05	Maize and Fodder grass	2.5	4.0	125 (Buffalo)	4.21	3.85
Total	2.6	15	-	2.6	4.0	-	4.13	3.77



Silage demonstration outcome

1. Availability of green fodder at the time of drought period
2. Supply of required nutrients to animals.
3. Improving the milk production (300ml/ animal/day)
4. The animals will overcome severe drought and sickness during non-availability of green fodder
5. Efficient utilization of green fodder



Demonstration of silage at Yadagud village

Module IV: Custom Hiring Centre

Cycle weeder

Cycle weeder is an efficient tool for drudgery reduction in weeding. It is handy tool for small farmer. This tool is recently introduced for weeding and pulverization of soil in the custom hiring centre at NICRA village. It is easy to operate and priced at an affordable rate. It is suitable to all crops like blackgram, pigeonpea, maize, soybean jowar and wheat



etc. This small implemented has simplified the weeding operation besides reduced drudgery.

Advantages of cycle weeder:

- ✓ Easy to handle
- ✓ It saves time and energy
- ✓ Increases weeding efficiency
- ✓ It avoids bending posture, which reduces drudgery
- ✓ Suitable for all crop
- ✓ It helps in moisture conservation



2.5 Chikkaballapura, Karnataka

(R. Manjunath and Devaraja)

ICAR-KVK, Chikkaballapur, Chintamani, Chikkaballapur (Dist), Karnataka

The Chikkaballapura district is agro-climatically located in the Eastern Dry Zone of Karnataka. The district has a semi-arid climate with an annual rainfall of 750 mm. Rainfall is usually erratic and the probability of agricultural drought is to the extent of 75 % over the years. Long dry spells between two rains during June to September period affects the crop yield and thereby the livelihood of the farmers.

2.5.1. About the NICRA village

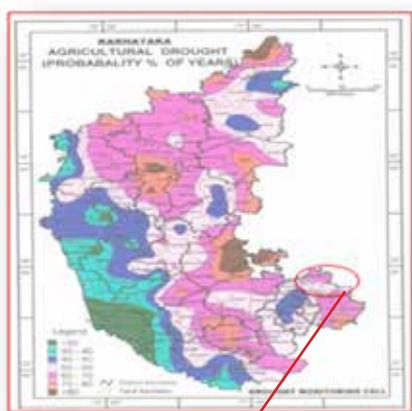
The NICRA project is being implemented by KVK Chikkaballapur since November 2011 in S. Raguttahalli village of Munganahalli block, Chintamani taluk, Chikkaballapura district, where the annual average rainfall is 590 mm. Uncertain rainfall pattern resulting in longer dry spells and recurrent droughts are common climatic variabilities leading to lower crop yields, crop failures and low fodder availability for the livestock.



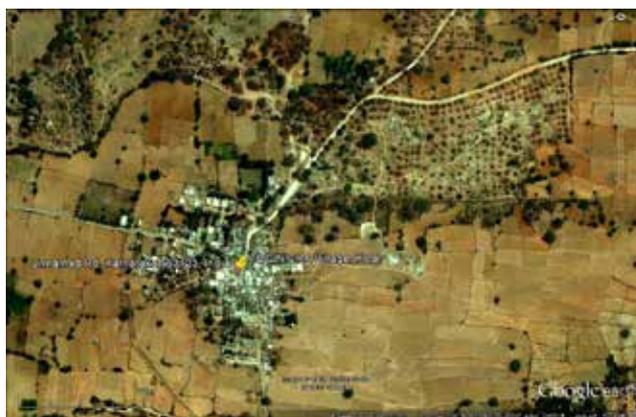


Basic information of the NICRA village:

Item	NICRA village	Additional villages selected in the programme
Village name	S Raguttahalli	Madamangala
Name of mandal /Block	Munganahalli	Munganahalli
Total area (ha)	154.27	110.50
No. of house holds	251.00	130.0
Extent of rainfed area (ha)	127.25	80.30



Chikkaballapura District



GPS image of S. Raguttahalli

Climatic Variability: The rainfall and dry spells recorded in the NICRA village S. Raguttahalli from Jan, 2015 to October, 2018 are given in the following Table-53 and 54.

Table 53. Year wise & month wise Rainfall, percentage of deviation for the years 2015-2018 in the S. Raguttahalli NICRA village

Month	Normal rain fall (mm)	2015			2016			2017			2018		
		Actual rain (mm)	Rainy days	% of deviation	Actual rain (mm)	Rainy days	% of deviation	Actual rain (mm)	Rainy days	% of deviation	Actual rain (mm)	Rainy days	% of deviation
Jan	2.17	18	1	729.49	0	0	-100.00	0	0	-100.00	0	0	-100
Feb	6.52	0	0	-100.00	0	0	-100.00	0	0	-100.00	0	0	-100
Mar	12.93	69	2	433.64	0	0	-100.00	42	2	224.83	60	2	364.0371
Apr	26.93	74	4	174.79	0	0	-100.00	0	0	-100.00	18	1	-33.16
May	67.13	29	2	-56.80	114	4	69.82	80	3	19.17	44	4	-34.4555
Jun	63.39	90	2	41.98	86	5	35.67	102	1	60.91	33	2	-47.9413
Jul	75.19	59	2	-21.53	178	9	136.73	25	1	-66.75	0	0	-100
Aug	95.09	92	4	-3.25	5	1	-94.74	142	7	49.33	15	1	-84.2255
Sep	155.64	218	9	40.07	0	0	-100.00	244	9	56.77	-	-	-
Oct	121.26	40	3	-67.01	8	1	-93.40	207	9	70.71	-	-	-
Nov	60.08	468	16	678.96	10	1	-83.36	25	1	-58.39	-	-	-
Dec	16.98	06	1	-64.66	60	2	253.36	0	0	-100.00	-	-	-



Table 54. Dry spells experienced from the years 2015-2018 in the S. Raguttahalli

Historical trends in rainfall	Year 2015	Year 2016	Year 2017	Year 2018
Dry spells experienced	1) 2-06-2015 to 18-07-2015 (38 days) 2) 5-7-2015 to 18-8-2015 (23 days)	1) 1-07-2016 to 30-8-2016 (30 days) 2) 01-09-2016 to 9-10-2016 (39 days) 3) 11-10-2016 to 31-10-2016 (20 days)	1) 7-6-2017 to 27-07-2017 (50 days) 2) 15-05-2017 to 15-07-2017 (62 days)	1) 2-6-18 to 12-8-18; (71 days) 2) 16-8-18 to 8-9-18 (23 days) 3) 27-9-18 to: 15-10-18 (19 days)

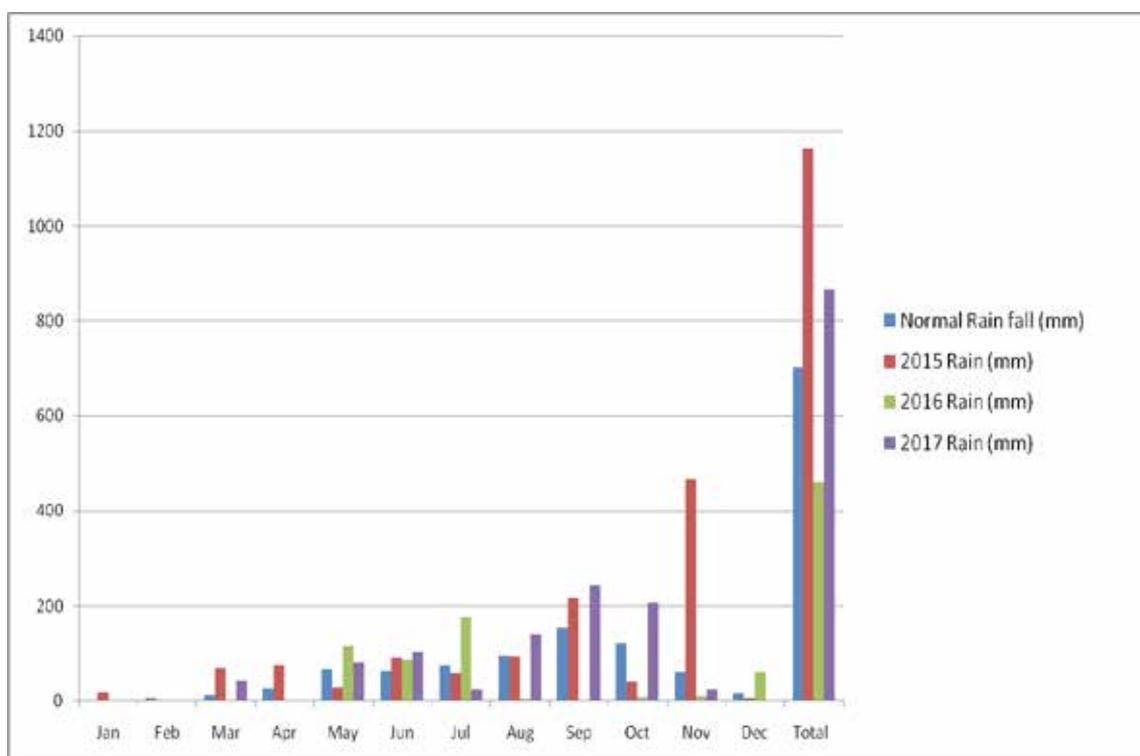


Fig. Variability map of rainfall data of NICRA village S. Raguttahalli (2015 to 2017)

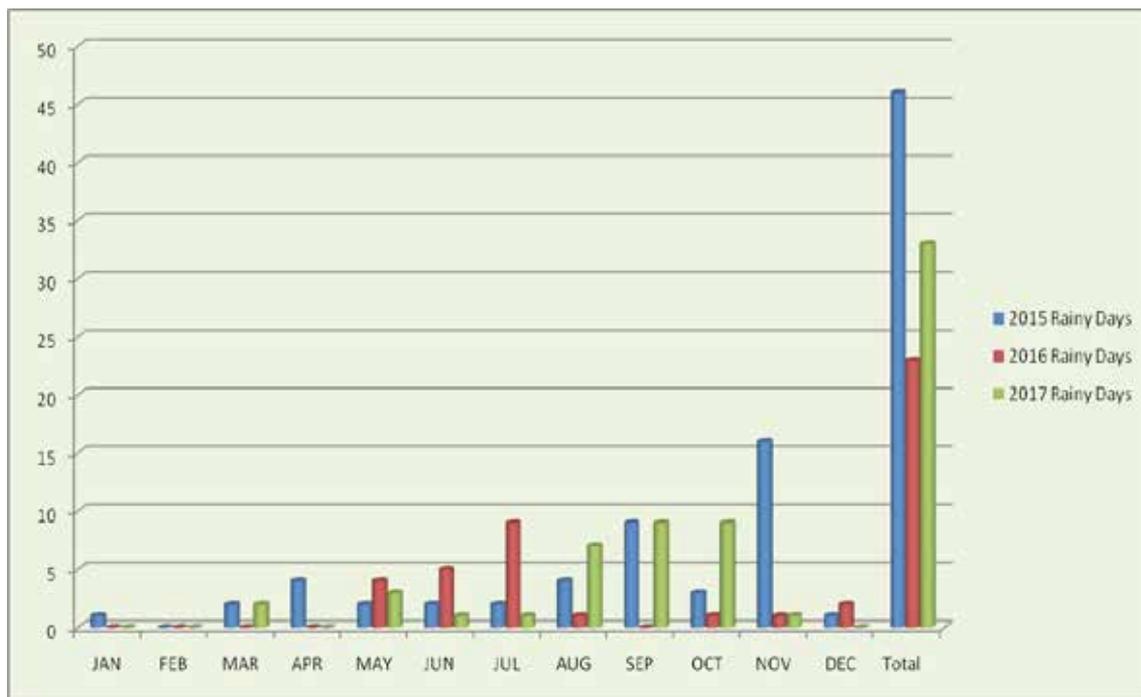


Fig. Variation in rainy days from 2015 to 2017 at NICRA village

Module I: Natural Resource Management

1. *In-situ* moisture conservation:

In-situ water harvesting using simple technologies enables higher amount of water infiltration, temporarily impounds water on the surface of the soil to increase the opportunity time for infiltration that prolongs the availability of moisture to the crop and also enable crop to survive under variable rainfall conditions. A good *in-situ* soil and water conservation practice improves soil porosity, increase infiltration and soil hydraulic conductivity and consequently increase soil water storage and promote crop growth. Emphasis was given to *in-situ* measures such as conservation furrows, bunding, land levelling, compartmental bunding, sowing across the slope, ridge and

furrow, trench cum bunding, contour farming, etc. Selection of appropriate soil and water conservation measures for a location depends on the amount and distribution of rainfall, slope and soil type, depth and texture, especially the clay content and clay type, which greatly influence water holding capacity and hydraulic conductivity impacting runoff and soil erosion. The demonstration taken up on various *in-situ* measures and their impact is discussed below:

Trench cum bunds are the important works taken up under Natural Resource Management component which serves the twin objectives of conserving soil moisture and reducing soil erosion. An area of 65 ha was treated with trench cum bunds in the year 2015-2017 benefiting 99 farmers.



After trench cum bund



Water stored in trenches



Groundnut crop

The results showed that trench cum bund structure has conserved the soil and water *in-situ* and enhanced the ground water table which in-turn helped the crops during long

dry spells and thus enabled farmers to increase their income. Groundnut crop was cultivated on these fields realised higher crop yields when compared to farmer's practice (Table 55).

Table 55. Yields of groundnut due to construction of trench cum bunds at S. Raguttahalli

Demonstration	Yields (q/ha)	Gross cost	Economics (₹/ha)		
			Gross return	Net return	BCR
Groundnut with Trench cum bund	12.3	21,250	55,350	34,100	2.60
Groundnut without Trench cum bund	10.2	21,250	45,900	24,650	2.16

Impact of trench cum bund in crop cultivation

Trench cum bunding arrested soil erosion and served as water reservoir pits that keeps soil moisture intact for longer duration. Moisture is held for 10-15 days nearer to the bunds (1-1.5 m width area) and facilitates availability of soil moisture to the crop.

2. Desilting of rainwater harvesting structures

Desilting of community ponds and check dams was carried from 2011 to 2016. During the year 2015 observed heavy rainfall of 1163 mm. The desilted farm ponds and check dams

were completely filled with water and desilted, fertile soil was applied to unfertile lands, which enhanced the water holding capacity of soil and soil fertility.

Impact

During the long dry spells of June to September, the stored water in the farm ponds and check dams was used for protective irrigation to pigeonpea during critical stages of crop growth and got higher yields. The results show that 39.42 % of yield increased due to protective irrigation over the farmers practice (Table 56).



Before desilting



Desilted of tank



Mixing of fertile soil to crop fields



Water filled desilted tank



Pigeonpea with protective irrigation



Table 56. Higher yields of pigeonpea due to protective irrigation

Treatment	Seed yield (q/ha)	% increase in productivity	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Pigeonpea var. BRG-1 (protective irrigation given)	14.50	39.42	11,250	65250	54000	5.80
Farmer's practice (Rainfed condition)	10.40		11,050	46800	35750	4.20

3. Construction of rainwater harvesting structures

Under Natural Resource Management module construction of 8 farm ponds, 13 percolation tanks, 2 check dams and 2 nala bunds were taken up in the farmers' fields of S. Ragutthalli.

Rainwater harvested *in-situ* in the fields, maintained soil fertility by reducing soil and water runoff, which gradually increased the underground water as evidenced recharging of open wells and bore wells near vicinity of the rain water harvesting structures.



Impact:

The water storage capacity is increased by constructing farm ponds, percolation tanks, check dams and nala bunds. In turn helped recharge of surrounding open and bore wells. The harvested water can be used for supplemental irrigation.

check dams and nala bunds. In turn helped recharge of surrounding open and bore wells. The harvested water can be used for supplemental irrigation.



Farm pond completely filled



Percolation tanks to recharge underground water



Check dam filled by rain water



Nala bund filled by rain water

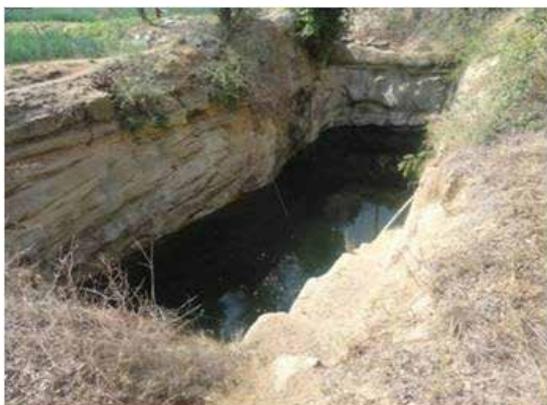
4. Recharging of open wells

The open wells in the NICRA village have got recharged due to various water harvesting

and rain water conservation technologies implemented during 2011-2018. The details are given in the table 57.

Table 57. Raise of water level in bore wells due to various NRM activities at S. Raguttahalli

Sl.No	Farmer name	Bore well Depth (ft)	Water level (ft)		
			2014-15	2015-16	2016-17
1	Munireddy R.V.	300	180	268	39
2	Venkatareddy R.E.	180	160	170	42
3	Lakshmi Narayanappa	650	350	420	68
4	Sriramareddy R.V.	780	600	712	65
5	G.R. Nagaraju	700	556	610	312
6	Keshavareddy R.K.	300	110	150	27
7	Srinath	900	620	750	118
8	MuniVenkatareddy R.V.	500	280	400	56
9	Sharadamma	900	680	754	153
10	Venkataravanappa	930	567	700	418



Open well of Shri Keshava Reddy



Open Well of Shri Shiva Reddy



Open well of Shri Venkataravanappa



Evaluation of recharged bore wells



Module II: Crop Production

1. Finger millet variety ML-365 for early maturity and drought tolerance

Finger millet is the main staple food consumed by majority of the people in Chikkaballapura and Kolar districts. Finger millet is grown as rainfed as well as irrigated crop, mostly cultivated by poor and marginal farmers. Farmers in Chikkaballapura district getting comparatively low yield. The main reasons for low productivity are delayed on set of monsoon, low rain fall, erratic rain fall, dry spells, high temperature and non-availability and non-adoption of high yielding variety. Hence short duration variety of finger millet ML-365 was demonstrated in the village.



Finger millet ML-365

The specific characteristics of the variety are:

- Short duration (about 105-110 days)
- High grain and fodder yield
- Resistant to leaf spot, neck blast disease and lodging
- Good cooking quality
- Suitable for dryland agriculture and late sowing

Impact

Finger millet ML-365 variety demonstrated in S.Raguttahalli village under NICRA project from 2011 to 2018 in 200 ha area has performed significantly superior over local varieties and recorded 25 % higher yield compared to the local variety used by the farmers (Table 58).



Field day celebration

Table 58. Impact of increasing yield levels of ML-365 over local variety.

Treatment	Seed yield (q/ha)	Per cent increase in productivity	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Finger millet var. ML-365	20	25	21,300	50,000	34,900	2.3
Finger millet local variety	16		22100	42,500	28150	1.9

2. Finger millet var. GPU-48 (105 days) for very early maturity and drought tolerance

Finger millet var. GPU- 48 was introduced in monsoon season of 2017 to cope up with long dry spells, blast resistance and short duration (105 days only). Also given protective irrigation in critical stages of crop by using

farm ponds and other irrigation sources.

Impact:

Cultivation of GPU-48 variety of finger millet showed increased yield of 22.50 % over conventional variety and added net income of ₹ 26,300 per ha compared to farmer practice (₹ 19600/ha).



Line sowing by bullocks



Finger millet var GPU- 48

Table 59. Yield levels of GPU-48 over local varieties at NICRA village

Treatment	Seed yield (q/ha)	Per cent increase in productivity	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Finger millet var. GPU-48 (protective irrigation)	19	22.50	20,200	48,500	26,300	2.40
Finger millet local variety	15.5		21,100	41,300	19,900	1.95

3. Pigeonpea var. BRG-5 for wilt tolerance and higher yields

Pigeonpea (*Cajanus cajan*) is predominantly a crop of tropical areas mainly cultivated in semi-arid regions of Karnataka and India. Pigeonpea can be grown between 14°N and 28°N latitude, with a temperature ranging from 26° to 30°C in the rainy season (June to October) and 17° to 22°C in the post rainy

(November to March) season. Pigeonpea var. BRG-5 was demonstrated in NICRA village of Chikkaballapura district because of its wilt tolerance and higher yields compared to other varieties of pigeonpea which suffers from wilt disease.

Technologies demonstrated along with variety BRG-5

- Deep ploughing



- Line sowing
- Bio fertilizer application along with FYM
- Use of CHC- Seed drill & Cycle weeder
- Integrated nutrient management
- Stress stage-thinning & KCl 2% spray
- Lifesaving irrigation given by using farm pond/ other sources when dry spell occurred
- Foliar spray of pulse magic (mixture

of micro nutrients) @ 1 % during 50 % flowering and pod formation stage.

Impact

The new variety BRG-5 recorded higher seed yield of 13.60 q/ha and gave higher income against farmers practice and showed superiority to overcome wilt and pigeonpea sterility (Table 60).



Pigeonpea var. BRG-5



Celebration of Field day

Table 60. increasing yield levels of Pigeonpea var. BRG-5 over local variety

Treatment	Seed yield (q/ha)	Per cent increase in productivity	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Pigeonpea var. BRG-5	13.60	26.16	21500	81600	69100	3.79
Pigeonpea local variety	10.78		24453	64650	47678	2.64

4. Foxtail millet under recurrence of drought years

The foxtail millet is very hardy, drought tolerant and has disease resistance characteristics.

Hence foxtail millet was introduced in NICRA village to cope up with drought and to improve health and nutritional status of villagers.

Technology demonstrated:

- Deep ploughing
- Bio fertilizer application with FYM
- Soil test based nutrient recommendation
- Use of CHC-Cycle weeder
- Market linkage for better price
- Lifesaving irrigation given by using

farm pond/ other sources when dry spell occurred.

higher yields and B: C ratio than finger millet (Table 61). The early harvest avoided damage by heavy downpour during November. This foxtail millet has high demand for the value addition.

Impact

The demonstration of foxtail millet resulted in



Creating awareness about foxtail millet



Foxtail millet crop



Celebration of field day

Table 61. Yield comparison of foxtail millet demo with finger millet

Particulars	Demo Foxtail millet	Farmers practice Finger millet
Grain (q/ha)	10.97	15.65
Fodder (q/ha)	19.90	51.50
Gross Cost (₹/ha)	20000	28865
Gross Return (₹/ha)	88208	42510
Net Return (₹/ha)	68208	13645
BCR		

5. Finger millet + Pigeonpea (10:2) intercropping system

To make good use of late rains, intercropping of finger millet + pigeonpea (10:2) was introduced in S.Raguttahalli in the monsoon of 2017 besides to creating awareness about benefits of intercropping system and to reduce fertilizer application in finger millet.

Technology demonstrated:

- Deep ploughing & seed treatment
- Bio fertilizer application with FYM
- Use of CHC-Cycle weeder/Roto weeder/

Seed drill

- Nipping @45 and 80-90 DAS in Pigeonpea
- Soil test based INM
- Need based plant protection application

Impact:

Farmers realized clearly the benefits of intercropping of finger millet + pigeonpea (10:2) over check in terms of low cost of cultivation, LER (land equivalent ratio) and high B: C ratio (Table 62).



Intercropping of finger millet + pigeonpea (10:2) in farmer's field.

Table 62. Yield comparison with improved technologies in finger millet + pigeonpea intercropping

Crop	Yield (q/ha)		LER		Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	BCR	
	Grain	fodder	Single crop	Mixed crop					
Demo	Finger millet + Pigeon-pea	20.71 3.61	47.40	0.83 0.29	1.12	21500	69607	48,107	3.24
Check	Finger millet + (Sole crop)	16.25	45.25	0.65	0.83	22806	54701	31,903	2.40

Module III: Livestock Activities

1. Upgradation of sheep breed

Farmers who were practicing sheep farming in dryland area are facing the problem of low income with local sheep due to prevailing high temperatures, less body weight gain and long gestation period. To overcome these problems, Nari suvarna twin breed was introduced through NICRA project during 2011-12. Demonstration on twin breed Nari suvarna was taken for upgradation of local sheep as it performed better even under variations

in temperature and help doubling the sheep production within short period.

Ideal characteristics of Nari Suvarna

- Twin breed
- Higher body weight compared to local breed
- Disease resistance compared to local breed
- Higher wool quality
- Tasty meat

Impact

Twining in sheep and improved grazing efficiency was achieved and high income generated due to twin breed of Nari Suvarna

over local breeds. Three farmers of the village involved in the production of Nari Suvarna as it is giving more number off springs (Table 63 and 64).

Table 63. Naari Suvarna production status

Sl. No	Name of the farmer	2014-15			2015-16			2016-17			2017-18		
		Pairs	M	F	Pairs	M	F	Pairs	M	F	Pairs	M	F
1	Manjunathreddy	11	14	8	14	14	14	18	8	28	12	10	14
		-	-	-	2	2	2	-	-	-	-	-	-
2	Sriramareddy	-	-	-	4	4	4	-	-	-	-	-	-
3	Venkataramanappa	-	-	-	3	3	3	-	-	-	-	-	-
Total		11	14	8	23	23	23	18	8	28	12	10	14



Naari Suvarna Ewes



Naari Suvarna Ram

Table 64. Number of upgraded kids & economic status of Nari Suvarna

Particulars	Number of pairs during 2016-17	Total	Male kids	Female kids	Number of upgraded (October -2018)			Income generated from sale of rams (₹)	
					Total	Male kids	Female kids		Mortality kids
Demo (Nari Suvarna)	12 pairs	24	10	14	52	28	24	0	1,15,000
Local	12 pairs	24	10	14	38	22	16	2	85,500

2. Backyard poultry management under cage system with improved manual feeders and drinkers

Backyard poultry is one of the best income

generating activities. The farmers of village were not aware of scientific method of rearing and the poultry is prone to predators. To overcome this, demonstration of poultry cages and improved manual drinkers were introduced



to the farmers.

The objective of cage system with improved manual feeders and drinkers

- Protection from natural enemies
- Reduce poultry feed wastage
- provide proper shelter

- Efficient utilization of space in order to facilitate gaining of more body weight
- To maintain hygienic conditions

This intervention has helped the farmers in the NICRA village to earn additional income from the backyard poultry.



Low cost cages for backyard poultry



Distribution of feeders and manual drinkers

2.6 Kalaburagi, Karnataka

(Raju G. Teggeli and Jaheer Ahmed)

ICAR-KVK, Kalaburgi-I, Aland Road, Kalaburagi (Dist), Karnataka

‘Kalaburagi’ means stony land in Kannada. Kalaburagi district is situated in the Northern part of Karnataka State. The Kalaburagi district has 7 taluks viz., Aland, Afzalpur, Kalaburagi, Chincholi, Chittapur, Sedam, Jewargi. The rivers Krishna and Bhima flow in the district. The predominant type of soil in the district is black soil. The district has a large number of tanks which in addition to the rivers, irrigates the land. The upper Krishna project is major irrigational venture in the district. The main crops of the districts are sorghum, groundnut, paddy and pulses.

2.6.1. About the NICRA Village

The NICRA project is implemented by KVK Kalaburagi in Melakunda village which falls under North Eastern dry zone of Karnataka.

The village is located with Latitude $17^{\circ}19.895$ N and Longitude $76^{\circ}39.650$ E. The village has 1520 ha total cropped area with 750 households. Shallow to medium black soil and clay loam soils are the major soil types in this village. The predominant crops grown in these villages are pigeonpea, greengram, sunflower, cotton, pear millet in *Kharif* season and chickpea, sorghum, wheat, watermelon, and onion during *Rabi* season. Horticulture crops (Mango, citrus, tamarind, ber and vegetables) are grown under irrigation. Open well, bore well, farm pond and lake are the major source of irrigation. Livestock is the important component in the village. Mortality and morbidity losses due to biotic and abiotic stress and fodder scarcity are the major causes for low productivity of livestock.





Basic information about NICRA Village:

Item	NICRA village	Additional villages selected in the II phase programme	
		Village 1	Village 2
Village name	Melakunda (B)	Melakunda (K)	Hadagil Haruti
Name of mandal/block	Melakunda (B)	Melakunda (B)	Sharana Sirasagi
Total area (ha)	1633	807	1103
No. of house holds	750	326	467
Extent of rainfed area (ha)	1520	727	978

Climatic Vulnerability

NICRA village receives average annual rainfall of 750 mm. Distribution of rainfall is erratic. Late onset of monsoon, mid and terminal dry spell and poor soil health are the most common climatic vulnerabilities of the village. Most of the crops are affected by late onset of monsoon followed by dry spell during critical crop growth periods, which in turn is severely

affecting the yield of crops. Water scarcity, poor soil health, frequent drought and losses due to pest and diseases are major climatic vulnerability faced by farming community. Low seed replacement rate, poor access to quality seeds and farm machinery, poor livestock services etc. are major institutional limitations for improved livelihoods in this village.



Climatic Variability: The actual climatic variability expressed in the village from 2015 to 2018 is presented in table 65 and figure below:

Table 65. Rainfall received, dry spells experienced and temperatures recorded are given below

Months	Normal rainfall (mm)	2015-16		2016-17		2017-18	
		Actual	Deviation	Actual	Deviation	Actual	Deviation
April	23.34	0.00	-23.34	20.6	-2.74	0.00	-23.34
May	35.44	0.00	35.44	43.8	8.36	7.00	-28.44
June	96.57	35.4	-61.17	182.3	85.73	239.20	142.63
July	130.9	86.7	-44.2	226.8	95.9	85.80	-45.1
August	148.1	158.4	10.3	38.6	-109.5	100.9	-47.2
September	162.5	209.2	46.7	355.0	192.5	357.0	194.5
October	104.5	47.3	-57.2	30.4	-74.1	124.0	19.5
November	18.40	0.0	-18.40	0.0	-18.40	0.00	-18.40
December	4.70	0.0	-4.70	0.0	-4.70	0.00	-4.70
Dry spell experienced		Date: 12/06/2015 to 23/06/2015 (12 days)		Date: 8-06-2016 to 21-06-2016 (13 days)		Date: 10/06/2017 to 21/06/2017 (12 days)	
		Date: 05/08/2015 to 21/08/2015 (17 days)		Date: 7-07-2016 to 20-07-2016 (13 days)		Date: 2/09/2017 to 15/9/2017 (14 days)	
				Date: 19-08-2016 to 30-08-2016 (12 days)		Date: 20/10/2017 to 30/10/2017 (11 days)	

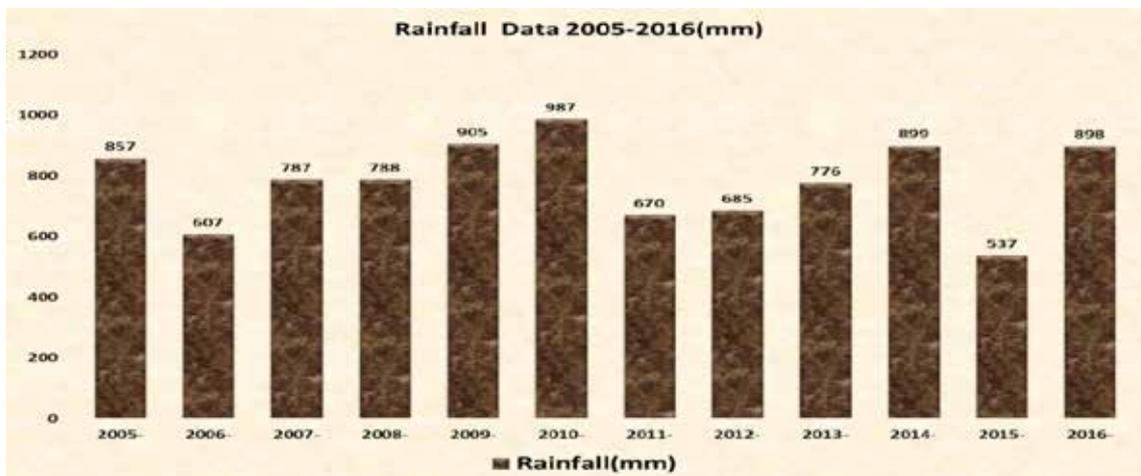


Fig. : Variability map of rain fall data of NICRA village Melakunda (B) (2005 to 2016)

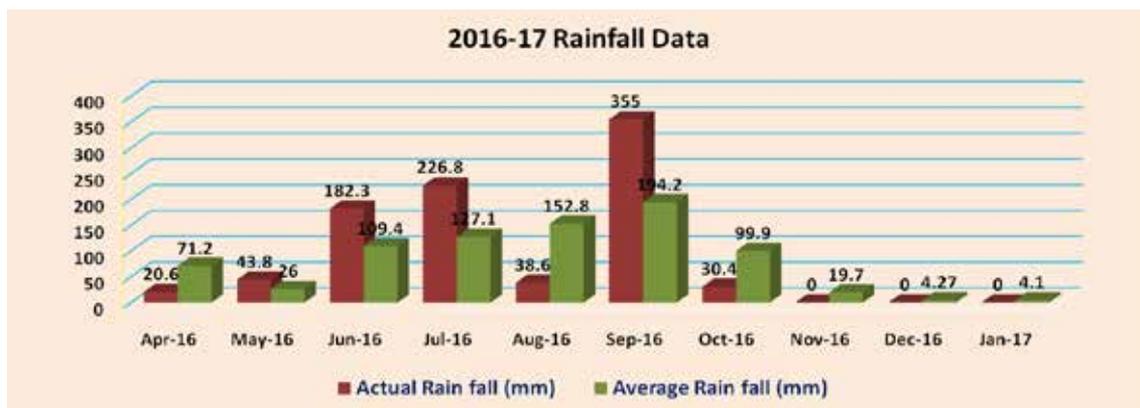


Fig. : Variability map of rainfall data of NICRA village Melakunda (B) (2016-17)

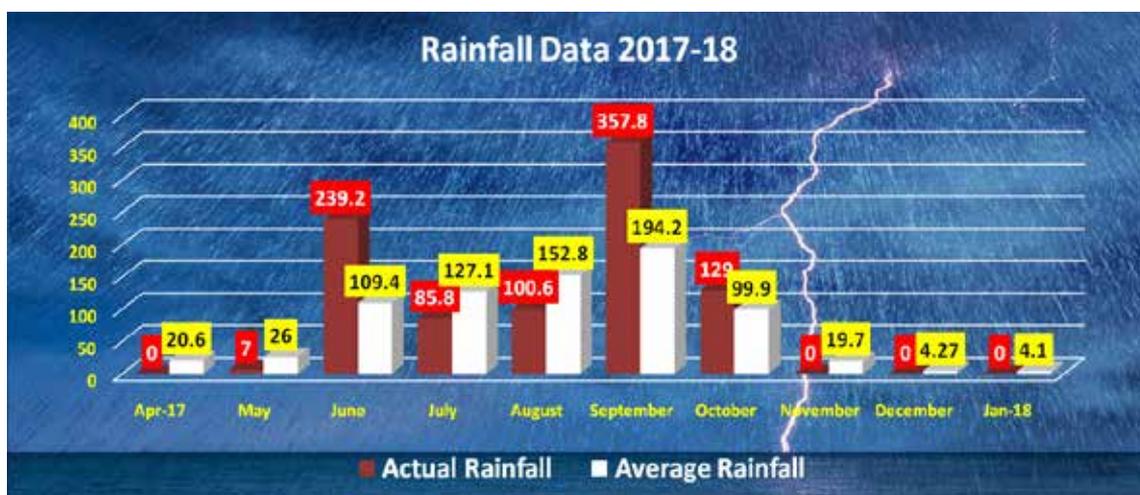


Fig.: Variability map of rain fall data of NICRA village Melakunda (B) (2017-2018)

Module I: Natural Resource Management

1. Desilting of nalas

Under natural resource management module, desilting nala of size 200m x 12m x 1m (2400 m³) was carried out in NICRA village during 2015 for rainwater harvesting. After desilting of nala, village has received good rain in the month of June 2016. Approximate quantity of water stored in nala was 2400 m³; nala has filled 4 times i.e 2400 X 4 = 9600 m³. This resulted in recharging of 12 bore

wells belonging to 7 farmers which were defunct from last two years. Recharged borewells were able to provide critical irrigation to mulberry and banana. Apart from this, recharged water utilised for moisture stressed pigeonpea thereby getting 15-20 % higher yield under rainfed condition compared to no irrigation. This technology also helped in increasing the cropping area in mulberry, vegetables (cucumber, bhendi, methi, and palak & coriander), banana (G-9), water melon and pigeonpea. An average of 25 ha area was

brought under cultivation by desilting nala as given in Table 66.

Table 66. Cropping area increased by nala shaping technology at NICRA Village

Sl. No	Crop	Area (ha)	Farmers (No.)	No. of irrigation
1)	Mulberry	12	8	3
2)	Vegetables (Cucumber, Bhendi, Methi, Palak & Coriander)	4	5	2
3)	Banana (G-9)	1	4	48
4)	Pigeonpea (TS-3R)	8	12	1



Before Nala shaping



After Nala shaping:

2. Dibbling in ridges and furrows in pigeonpea v/s normal sowing.

The pigeonpea crop suffers from severe moisture stress in most of the years. To overcome this problem, adopted a climate resilient technology by sowing pigeonpea on ridges and furrow method which helped in *in-situ* conservation of rainwater in furrows, better drainage of excess water and proper aeration in the seedbed and root zone compared to normal sowing.

Field demonstration was carried out in NICRA village from 2015-16 to 2017-18 to compare normal sowing v/s ridges and furrows method of dibbling in pigeonpea under drought condition. In the month of June, pigeonpea

crop experienced early season drought from 12/06/2015 to 23/06/2015 i.e. 12 days dry spell in the NICRA village.

Impact

The results of the technology indicated higher plant height (187.2cm), root length (16.4cm), depth of moisture (13.7cm), more number of pods / plant (263), number of seed / pod (4.1), 100 seed weight (10.4g), field emergence (92%) and seed yield (13.2 q/ha) compared to normal sowing. Apart from this, technology also helped in increasing water use efficiency, increasing yield by 15%, less moisture stress during non- rainy days, better weed management and reduction of crop lodging ultimately helped in getting higher crop yield.



The pigeonpea field of Shri. Channasavaiah, a farmer under NICRA project, despite drought the crop was healthy and better due to ridges and furrow method of sowing. During heavy rain, excess water drained out and maintained

moisture in ridges and furrows for a longer period of time during drought period. The seeds were treated with CaCl_2 for drought tolerance (Table 67 and 68).

Table 67. Ridges and furrow method of dibbling as influenced by early season drought in pigeonpea

Particulars	Ridges & Furrows method of dibbling	Farmers practice
1) Plant height (cm)	187.2	175.8
2) Root length (cm)	16.4	9.7
3) Depth of moisture (cm)	13.7	7.3
4) Pods / plant (No.)	263	187
5) Seed / pod (No.)	4.1	3.6
6) 100 Seed weight (g)	10.4	9.1
7) Field emergence (%)	92	83
8) Seed yield (q/ha)	13.2	11.4

Table 68. Economics of ridges and furrow method of dibbling as influenced by early season drought in pigeonpea

Intervention (Ridge and furrow)	Yield (q/ha)	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Ridge and furrow	13.2	22,000	71,280	49,280	3.2
Normal sowing	11.4	20,800	61,560	40,760	2.9



Ridge and furrow



Dibbling of seeds



plant observation by farmer

Module II: Crop Production

1. Influence of seed hardening with CaCl_2 on growth, yield and quality parameters of chickpea

Field demonstration was conducted to study the drought tolerance by seed hardening with CaCl_2 (2%) in chickpea. Growth, yield and quality parameters were studied during 2017-18 under rainfed condition in NICRA village (Melakunda B). The annual rainfall received during the year 2017-18 was 720 mm.

Problem analysis

Chickpea (*Cicer arietinum*.L.) is a major *rabi* season pulse crop in Hyderabad-Karnataka region. It is generally grown on conserved moisture and moisture in the soil profile gradually recedes as the crop grows. As a consequence, plant experiences progressively increasing degree of terminal moisture stress. Thus, soil moisture stress is a major limiting factor for the growth, yield and quality parameters in chickpea.

The pre-sowing seed hardening with CaCl_2 is one of the simple techniques being employed to modify the morpho-physio-biochemical nature of seed, so as to induce the characters that are favorable for drought resistance. Period of dry spell after seed hardening with CaCl_2 on growth, yield and quality parameter of chickpea are presented in Table 70. The improvement in yield and yield parameters in pulse crop has been attributed to the beneficial effects of seed hardening with CaCl_2 such as increased water content, triggering of biosynthesis of nucleic acids, rapid germination and growth of seedlings resulting in increased uptake of nutrients and the ability of the treated seeds to withstand high temperature for prolonged periods under dry condition. The pre sowing seed hardening with CaCl_2 (2%) improved the yield and seed quality parameters of chickpea over control (Table 70). This simple technique may be followed by the famers to realize the potential yield and seed quality parameters under drought conditions.

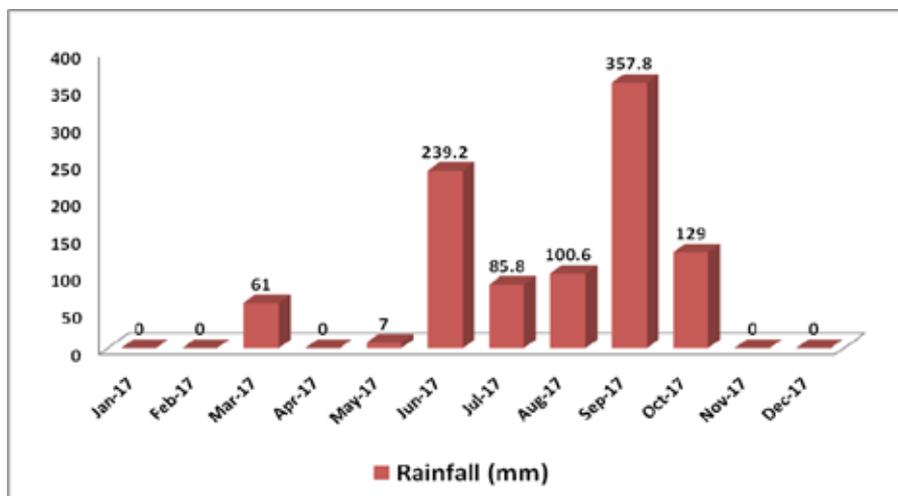


Fig: Period of dry spell after seed hardening with CaCl_2 in chickpea.



Table 69. Period of dry spell after seed hardening with CaCl₂ on growth, yield and quality parameter of chickpea

Rainfall 2017-18	March	April	May	June	July	August	September	October
No. of dry spells >10 days	-	-	1	-	-	-	-	-
during 2017-18 >15 days	2	-	1	-	-	-	-	-
>20 days	-	-	-	-	-	-	-	-
No. of Rainy Days		2	-	1	6	8	12	6
No. Intensive Rain-Spells >60 mm per day (2017)	1	-	-	1	1	1	1	1

Table 70. Effect of seed hardening with CaCl₂ on yield trait in Chickpea under drought condition

Dry spell period	Particulars	Control	Seed hardening with CaCl ₂
Dry spell from 22/10/2018 to 31/10/2018 (10 days)	1) Plant height (cm)	42.2	43.7
	2) Leaf dry matter (g / plant)	1.78	2.15
	3) Stem dry matter (g / plant)	5.13	7.14
	4) Total dry matter (g / plant)	32.4	36.2
	5) Pods / plant (No.)	43.5	48.7
	6) Seed yield (g / pl)	12.18	15.63
	7) 100 Seed weight (g)	21.46	24.67
	8) Seed germination (%)	86.5	94.7
	9) Root length (cm)	8.9	10.7
	10) Seedling vigour	1376	1564.2
	11) Field emergence (%)	87.4	91.7
	12) Seed yield (q/ha)	12.2	13.7

2. Short duration pigeonpea variety : TS-3R

The Kalaburagi district has medium to deep soil with mild to high slopes and pigeonpea is one of the major crop in the district. *In-situ*

moisture conservation measures viz., ridges and furrows and bunding were followed in pigeonpea. The pigeonpea variety TS-3R is a high yielding, short duration (about 160 days), and wilt resistant, suitable for dry land agriculture released from ARS Kalaburagi

under UAS, Raichure. Ridges and furrows were formed at the time of sowing with the help of ridger instrument. The performance of the variety is excellent compared to local variety (Gulyal). The variety TS-3R has been promoted and demonstrated in Melakunda (B) village under NICRA project from 2015 to 2018 in 80 ha and has benefited around 120 farmers.

Impact

Pigeonpea variety TS-3R performed well even under adverse climatic situation over local variety. The results showed that yield increased from 11.2 to 13.5 q/ha over local variety. (Table 71). It is being up scaled through State Agriculture Department and FPOs. The practice has become popular and is being accepted by the farming community and spreading fast.

Table 71. Economics of short duration pigeonpea TS 3R under drought conditions

Treatment	Seed yield (q/ha)	Gross cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Improved practice & Pigeonpea TS-3R	13.5	21,500	62,100	40,600	2.8
Farmer's practice Pigeonpea local	11.2	20,800	51,520	30,720	2.4



3. Intercropping of pumpkin in pigeonpea (TS-3R)

A field demonstration on intercropping pigeonpea (TS 3R) + pumpkin cropping system was taken up in NICRA village. The results revealed that pigeonpea (TS 3R) sole crop gave low income and hence less profitable,

whereas pigeonpea (TS 3R) + pumpkin intercropping system gave more income and more profitability even during climatic variability in terms of long dry spells especially during rainy season. Hence, pigeonpea (TS 3R) + pumpkin intercropping system was found to be more suitable as compared to



pigeonpea (TS 3R) as sole crop under dryland condition. The farmers in NICRA village realized these facts after demonstrations and are invariably following the pigeonpea (TS 3R) + pumpkin intercropping. More number of farmers in and around NICRA village adopted this intercropping system. The farmer, Shri. Mallanna Gudedmani has cultivated four acres of rocky and barren land with pigeonpea

+ pumpkin intercropping. He harvested 600 pumpkins and sold them at ₹50 per piece at Kalaburagi market and got ₹30,000. Overall he got ₹1 lakh from one acre and minimum yield would be between 5000 to 6000 fruits per acre. The cost of cultivation is negligible as the drought resilient crop requires minimum care and moreover it is a short duration crop of 3 months.



4. Seed hardening with CaCl_2 in pigeonpea

This village did not receive rain in the month of June from 8-06-2016 to 21-06-2016. So pigeonpea crop suffered moisture stress.

To overcome the problem of dry spell in the NICRA village, a climate resilient intervention on seed hardening with CaCl_2 was taken. The results are presented in Table 72.

Table 72. Seed priming with CaCl_2 to mitigate drought in pigeonpea

Particulars	Seed priming with CaCl_2	Farmers practice
1) Germination (%)	97.5	82.0
2) Root length (cm)	12.7	8.40
3) Plant height (cm)	187.4	171.9
4) Pods / plant (No.)	262	210
5) Seed / pod (No.)	4.1	3.2
6) 100 Seed weight (g)	9.8	8.2
7) Seed yield (q/ha)	13.6	11.7

The results revealed that seed hardening with CaCl_2 in pigeonpea increased germination percentage (97.5%), root length (12.7cm), plant height (187.4cm), number of pods / plant (262), number of seed / pod (4.1), 100 seed weight (9.8 g) and seed yield (13.6 q/ha) over farmers practice. This technology improves seed viability and vigour, flowering

2-3 days early, uniform seed set and maturity. Seed priming with CaCl_2 play a vital role in mitigating the adverse effects of drought stress, there by contributing to higher yield in pigeonpea (Table 72). More than 80-85 % of farmers in and around NICRA village adopting this technology.



5. Foliar application of pulse magic: In pigeonpea

During pigeonpea flowering stage, crop experiences prolonged mid-season drought in September month leading to flower drop. To overcome this, foliar spray of pulse magic which contains 10 % of nitrogen, 40 % of phosphorus, 3 % of micronutrients and 20 ppm PGR was demonstrated in NICRA village. 10 g of the nutrient mixture and 0.5 ml of PGR mixed in one-liter water sprayed two times,

first spray during 50 % flowering stage and second spray 15 days after the first helped to overcome both mid-season dry spell and reduced flower drop in pigeonpea. The crop also showed higher plant height (188.4cm), number of branches (17.3), total number of pods/plant (293), number of flowers/plant (873), pod set (33.56%), number of seed/pod (4.7), pod bearing length (47.3 cm), pod per peduncle (5.6), 100 seed weight (10.45g), seed yield (14.7 q/ha) compared to unsprayed plot (Table 73).

Table 73. Effect of pulse magic spray in pigeonpea to overcome mid-season dry spell

Particulars	Pulse magic spray	Control plot
1) Plant height (cm)	188.4	172.6
2) Branches (No.)	17.3	13.8
3) Pods / plant (No.)	293	218
4) Flowers / plant (No.)	873	802
5) Pod set (%)	33.56	27.18
6) Seed / pod (No.)	4.7	3.9
7) Pod bearing length (cm)	47.3	38.9
8) Pod per peduncle	5.6	4.1



9) 100 Seed weight (g)	10.45	9.61
10) Seed yield (g / pl)	142.3	134.7
11) Seed yield (q/ha)	14.7	12.3



Foliar application in pigeonpea

Module III: Livestock Activities

1. Upgradation of local female goats with Sirohi buck

Livestock sector was adversely affected by the detrimental effects of persisting extreme weather conditions. The changes in the environmental factor such as temperature, rainfall, relative humidity, wind speed and solar radiation are directly and indirectly affecting the livestock productivity. Before NICRA project, the farmers practicing goat farming in dryland area were facing the problem of low income from local goat under prevailing

high temperatures, less body weight gain, low milk yield, and long gestation period. So to overcome these problems, Sirohi buck was introduced under NICRA project during 2016-17.

The purpose of demonstration of Sirohi buck is that, these breeds are easily adaptable to hot and dry climatic conditions and are resistant to major goat diseases. These bucks performed better even under high temperature during April-May months. The Sirohi buck performed better even under adverse climatic condition over local goat as shown in the table 74.

Table 74. Performance of upgradation of local female goats with Sirohi buck

Parameters	Farmers Practice	Improved Practice
Birth Weight (kg)	2.0	2.7
1 month body weight (kg)	4.25	4.81
2 month body weight (kg)	6.50	7.40
3 month body weight (kg)	9.50	10.20

Maturity age (Months)	15	12
Pregnancy rate	Due to inbreeding, abortion rate is high	Not there
Mortality rate	High	Low
% increase in body weight	10.63	



2. Area specific mineral mixture for livestock

Feeding area specific mineral mixture 15gm/day/cows as concentrate feed helped in

increased milk production (5.20 litter / day / cow), fat (4.50%), SNF (9.10 %) and early estrus (90-100 days) over local cows under heat stress climatic conditions (Table 75).

Table 75. Effect of Area Specific Mineral Mixture on Deoni cows

Parameters	Local	Demo (Deoni cows)
Milk production (L/day/cow)	4.10	5.20
Fat (%)	4.00	4.50
SNF (%)	8.50	9.10
Estrus symptoms	Previously 150days	Early Estrus (90-100 days)

3. Fodder production

The performance of different fodder crops and varieties introduced in the NICRA village to overcome the fodder shortage during lean period is presented in Table 76.

**Table 76. Performance of fodder crops and varieties in NICRA village**

Intervention	Variety	Quantity	Area Covered (Acre)	No. of Beneficiary	Seed rate /Acre	Yield /Acre
Hybrid napier stem slips	DHN-6	50000 stem slips	5	10	10000 stem slips	35-40 tonnes
Multicut fodder sorghum	CoFS-29	10 kg	5	10	2 kg	14 tonnes
Maize	South African Tall	3 q	10	20	30 kg	7.5 tonnes
Lucerne	Lucerne	20 kg	5	10	4 kg	30 tonnes

4. Silage making technology for livestock

A silage bag was demonstrated using fodder maize covering 15 farmers. This climate resilient technology made availability of green fodder at the time of drought period especially in summer. Supply of required nutrients to animal improved the milk production, there by animals withstand severe drought and sickness during non-availability of green fodder.

Impact

There was an increase in milk production (9.56 litres /day/ animal) with silage intervention when compared to without silage (6.30 litres/day). Similarly in 2017-18, 5 farmers adopted this technology and achieved increase in milk production 10.21litres/day when compared to 7.85 litres /day.



6. Dry land fruit crops for drought proofing

Promotion of dry land horticulture crops under climatic variability of long dry spells was demonstrated in 7.5 ha covering 25 farmers. Farmers planted mango, drumstick,

lime, custard apple, teak and other minor horticulture fruit crops that are drought tolerant and suitable for dryland conditions (Table 77). Farmers used waste land (saline & alkaline soil) for planting dry land fruit crops, which improves soil fertility and soil health. Some of the farmers planted seedling on the bunds

which help in conservation of soil moisture and reducing soil erosion. Even under prolonged drought condition plant survival was around 65-70 % in the NICRA village. Hence, these

dryland horticulture crops are one among climate smart technologies for adoption in climatic variability conditions.

Table 77. Dryland horticulture plantations established in the NICRA village as drought proofing mechanism

Year	Crops and Area	Survival%
2016-17	Hebevu (<i>Melia Dubia</i>), Drumstick, Teak and Lime - 2.5 ha	60-65 %
2017-18	Mango (Dasher), Lime (Local) & Custard apple (Memota) -5.0 ha	





2.7 Davanagere, Karnataka

(T. N. Devaraja and B. O. Mallikarjuna)

ICAR-KVK, Davanagere, Kadalivana, LIC Colony Layout, BIET Road, Davanagere (Dist), Karnataka

Davanagere district carved out of the three districts namely Chitradurga, Shimoga and Ballary derives its name from Devanagari. It is located at the centre of Karnataka, about 262 kms from the state capital Bengaluru and spread across 6 taluks Davanagere, Harihar, Jagalur, Honnali, Channagiri and Harapanahalli. Agriculture is the highest contributor in the economic development of the district. Soil and climatic conditions are favorable for growing horticulture crops.

2.7.1 Information about the NICRA village

Krishi Vigyan Kendra, Davanagere has

adopted the village Siddanuru (Elevation 2134 in MSL; N 14° 25.528; E 76° 02.812) for the implementation of NICRA. The village comes under the Central Dry Zone (Zone-4) of Karnataka with hot climatic conditions during March to May. The major climatic condition of the village is drought. The extent of crop loss under drought ranged from 60-70 % and livestock were sold for minimum prices due to scarcity of fodder during drought years. Climatic variations are quite substantial in the village. The majority of the area is under rainfed.





The basic information of the village is presented below:

Village information:

Name of the village and district	Siddanuru, Davanagere District
Households (No.)	205
Total cultivated area (ha)	357.9
Area under rainfed cultivation (ha)	357.9
Major soil type	Red, Redgravel and Black soil
Climatic vulnerability of the village	The major climatic vulnerability of the village is drought. During the year 2007-08 there was reduced rainfall (around 200 mm) throughout the crop period. But, in the year 2009-10 there was excess rainfall (750 mm) than the annual average rainfall (590 mm).

Rainfall:

The actual rainfall received, dry spells and heavy rainfall events recorded in the NICRA village during the project period are presented in Table 78. The historical events are reported in Table 79.



Table 78. Rainfall, dry spells and heavy rains recorded at Simple Weather Station at NICRA village

Month	Normal rainfall (mm)	2015			2016			2017			2018		
		Actual	Deviation	Actual	Deviation	Actual	Deviation	Actual	Deviation	Actual	Deviation		
April	38.1	1.5	-36.6	-	-	-	-	-	-	23.2	-14.9		
May	88.1	28.0	-60.1	93.0	04.9	-	-	-	-	140.1	52		
June	75.0	115.0	40	91.0	16.0	22.0	-53	22.0	-53	57.2	-17.8		
July	88.2	42.5	-45.7	107.0	18.8	28.0	-60.2	28.0	-60.2	74.6	-11.8		
August	74.2	74.0	08.3	21.0	-53.2	84.7	10.7	84.7	10.7	50.2	-		
September	112.1	82.5	-29.6	89.0	-23.1	159.1	47.0	159.1	47.0	-	-		
October	117.3	211.0	50.3	-	-	316.7	199.4	316.7	199.4	-	-		
November	38.3	67.0	-	-	-	-	-	-	-	-	-		
December	8.60	33.0	-	-	-	-	-	-	-	-	-		
Total	631.3	654.5	(Rainy days 36)	401	(Rainy day 32)	610.5	(Rainy days-36)	610.5	(Rainy days-36)	610.5	(Rainy days-36)		
Excess rainfall events		06-09-2015 - 65mm		28-06-2016-39 mm		25/9/2017- 91mm		25/9/2017- 91mm		14-05-2018- 41.2 mm			
		10-09-2015 - 78 mm		28-08-2016-41 mm		2/10/2017-130 mm		2/10/2017-130 mm		22-05-2018- 55.0 mm			
Dry spell experienced		From: 26-06-2015 to 12-07-2015 -17 days		From: 06-07-2016 to 19-07-2016 – 14 days		From: 23-06-2017 to 16-07-2017- 23 days		From: 23-06-2017 to 16-07-2017- 23 days		From – 26-06-2018 to 05-07-2018- 10 days			
		From : 11-09-2015 to 25-09-2015- 15 days		From : 5-08-2016 to 30- 08-2016-25 days		From : 24-06-2017 to 03-08-2017- 10 days		From : 24-06-2017 to 03-08-2017- 10 days		From : 23-07-2018 to 12-08-2018- 20 days			
						From: 15-10-2017 to 31-10-2017- 16 days		From: 15-10-2017 to 31-10-2017- 16 days					

Rainfall (mm) received during cropping period in kharif over years (June-Sept)

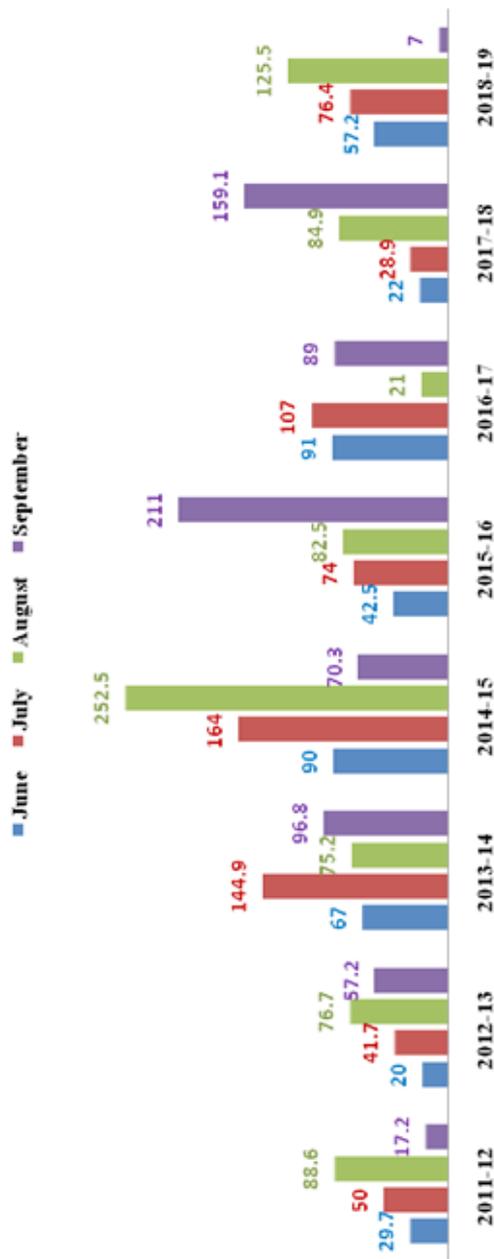


Table 79. Historical trends in rainfall

Historical trends in rainfall	Year (s)									
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2018-19	2018-19
Annual rainfall (mm)	219.2	368.9	702.9	780.8	654.5	401	610.5	456.1	456.1	456.1
June	29.7	20.0	67.0	90.0	42.5	91.0	22.0	57.2	57.2	57.2
July	50.0	41.7	144.9	164.0	74.0	107.0	28.9	76.4	76.4	76.4
August	88.6	76.7	75.2	252.5	82.5	21.0	84.9	125.5	125.5	125.5
September	17.2	57.2	96.8	70.3	211.0	89.0	159.1	7.0	7.0	7.0
Total Kharif rainfall	185.5	195.6	383.9	576.8	410	308	294.9	266.1	266.1	266.1
No. of rainy days (K)	31	34	63	67	36	32	36	43	43	43



Module I: Natural Resource Management

The work under NRM carried out in the NICRA village Siddanuru are cleaning of the channels, deepening of the defunct farm pond and check dams construction.

These water harvesting structures in the village clearly shows that the rainwater harvesting had improved water storage capacity in the

village. Before NICRA (2010), water storage in Siddanuru was 5, 32,000 litres which was increased to 1, 37, 30,400 litres in 2017. In Agansankatte, water harvesting work was done in 2017-18. Before this intervention the water holding capacity of the structures was 69,66,000 liters but during the year 2018-19 the storage capacity enhanced to 2,16,33,000 litres (Table 80).

Table 80. Increased water holding capacity of the NICRA village created during project period

NRM Structures	No.	Area		Water storage (litres)		Village
		Before	After	Before	After	
Farm ponds	39		10x10x3 m ³		1,17,00,000	
Deepening and widening of check dam	01	27x16x1 m ³ 432 m ³	27x16x3 m ³ 1296 m ³	4,32,000	12,96,000	Siddanuru-NICRA 1
Defunct farm pond	01	10x10x1 m ³ 100 m ³	16x15.3x3 m ³ 1296 m ³	1,00,000	7,34,400	
Badappara katte check dam (Desilting and deepening)	01	180 x 9 x ₃ 2 3240 m ³	180 x 9 x ₃ 6.5 10,530 m ³	32,40,000	1,05,30,000	Agasankatte 2 nd village
Agasankatte border check dam (Desilting and deepening)	01	150 x 9 x ₃ 2.0 2700 m ³	150 x 9 x ₃ 4.5 6,075 m ³	27,00,000	60,57,000	
a. Shri Gurappara Sara						
b. Shri Mellekatte Mahadevappa	01	48 x 6 x ₃ 2 576 m ³	48 x 8 x ₃ 4 1,536 m ³	5,76,000	15,36,000	
Community farm pond (Shri Hullumane Gurusiddappanna Katte)	01	20 x 15 x ₃ 1.5 450m ³	30 x 26 x ₃ 4.5 3510 m ³	4,50,000	35,10,000	
				69,66,000	2,16,33,000	

1. Construction of trench cum bunds

The trench cum bund plays a vital role in conserving the rainwater and maintaining the moisture content. Seventy four farmers were benefitted through trench cum bund by growing maize + pigeonpea and finger millet varieties GPU-28 and ML-365. These crops recorded higher yield when compared to farmers practice (Table 81). The planting of

forest saplings on the bund plays an important role in stabilizing the bund. The crop yield recorded clearly indicated that trench cum bunds play an important role in increasing the yield of crops by 32 % over the control plots (Table 81).

Impact: Trench cum bund helped in conserving soil moisture which in turn increased the yield of crops.

Table 81. The performance of crops grown in the trench cum bund treated area

Treatment	Crop	Seed yield (q/ha)	Fodder yield (q/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Farmer's practice	Maize + Pigeonpea (local)	47.02	-	65,828	24,628	1.59
Improved practice (Trench cum bund)	Maize+Pigeonpea(BRG-2)	62.37	-	87,318	44,718	2.04
Number of farmers involved: 20						
Farmer's practice	Finger millet (GPU-28)	1950	39.6	47,950	24,450	2.04
Improved Practice (Trench cum bund)	Finger millet (ML-365)	2450	43.5	60,640	36,540	2.51



2. Construction of farm ponds and protective irrigation to crops

In total, 39 farm pond units with 10x10x3 m³

dimension and water storage capacity of 1, 17, 00,000 liters of water were created. Utilizing this water crops brought under protective irrigation when there will be no rains at critical stages of crops. This intervention can mitigate the climatic vulnerability like drought and dry spells to increase the productivity in dry lands. One study was conducted on the “Assessment of yield in drought tolerant maize hybrids” in collaboration with CIMMYT, Hyderabad in the farm pond area (Table 82). The crop sowing was done in the end of June. There were no rains in the month of June which was very critical for crop growth period. During this period protective irrigation was given from the farm pond constructed in the NICRA



village during 1st week of August *i.e.*, 40 days after sowing during early vegetative stage and second irrigation during end of the August month *i.e.*, after 75 days of sowing, during tasseling and silking stage of crop growth

period. This intervention clearly shows the importance of rainwater harvesting structures to realize the potential yield in crops under uncertain rainfall conditions (Table 83).

Table 82. Protective irrigation through the farm ponds at critical stages in maize crop

Crop	Area (ha)	Yield (q/ha)	Gross cost (₹/ha)	Gross return (₹/ha.)	Net return (₹/ha)	B:C
Hybrid Maize (With protective irrigation)	0.4	28.5	30,000	45,030	15,030	1.51
Hybrid Maize (No protective irrigation)	0.4	60.6	35,000	95,748	60,748	2.73

Table 83. Impact of yield on different crops with farm pond during Khaif.

Sl.No	Crop	Area (ha)	Yield (q/ha)	Gross cost (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C
1	Finger millet (ML-365)	0.4	29.5	24,100	68,050	43,950	2.82
2.	Groundnut (GPBD-4)+ Pigeonpea (BRG-2) (8:1)	0.2	7.2+ 1.8	23,800	40,140	16,340	1.68
3.	Field bean (HA-4)	0.2	12	17,100	28,160	11,060	2.25
		0.8		65,000	1,36,350	71,350	2.09

Impact: The farmer with the farm pond, harvested rain water also have harvested the additional crops in the *rabi* season.

3. Recharging of ground water through deepening and widening of the check dams

Recharging of ground water through deepening and widening of the check dam had improved the water level in the bore wells. The depth of water from bore well has increased

on an average by 197.5 feet. The farmer Mr. Marulusiddappa, whose bore well had stopped from June month, started pumping the water from 120 feet mainly due to water recharging. Many crops were also grown during *rabi* for fodder and vegetables by using the protective irrigation thereby by increasing the cropping intensity. The check dam details are mentioned in table 84.

Table 84. Influence of groundwater in bore well after deepening of the check dam

Name of the Farmer	Depth of the water from borewell (ft)		Crop	Additional crops	Net income (₹)	Cropping intensity (%)
	Before	After				
Marlusiddappa	200	175	Maize+Pigeonpea	Fodder crop and vegetables	55,000	250
A S Veeranna	250	210	Areca nut	Tomato	53,450	150
Netrvatahi	250	210	Areca nut	Tomato	1,25,000	100

Impact

Check dams helped in recharge of groundwater table and water output from the open wells and bore wells in the village have been increased.

Module II: Crop Production

1. Intercropping of drought tolerant pigeonpea (BRG-2) with hybrid maize

The introduction of the new high yielding variety pigeonpea (BRG-2) as intercrop with the maize with paired row technology (5 rows maize + 2 rows pigeonpea) and single row (6 rows maize+ 1 row pigeonpea) were demonstrated in the drought prone fields of NICRA village.

During the initial crop season, received good rain for sowing of seeds and crop stand was good. The crop during grand growth stage and vegetative stage suffered from dry spells in the month of July (6-07-2016 to 19-07-2016) and

August (5-08-2016 to 30-08-2016) for 25 days at silking and cob formation stage. There was drastic reduction in the yield of the maize when grown as sole crop. Reduction in the rains at critical stages had reduced the yield of maize as a sole crop, but the farmers with intercrop have escaped these impacts. Good rains were received during the month of July, farm ponds were filled and harvested water was utilized for providing protective irrigation to maize crop thereby saved crop and got better yield besides additional crop of pigeonpea compared to farmer without farm pond.

Impact

Farmers who had taken intercropping pigeonpea and maize have obtained better yield compared to sole cropping (Table 85). Now the whole village is willing to take intercropping of pigeonpea with maize.

Table 85. Average yield of the Maize + Pigeonpea (6:1) intercropping system

Year	Variety	Yield (q/ha)		Net returns (₹/ha)		Benefit cost ratio	
		Demo	FP*	Demo	FP*	Demo	FP*
2011-12	Maize-NAH-2049	46.10	3.60	42.60	26,600	21,100	2.36
	Pigeonpea-BRG-1						1.98
2011-12	Maize-NAH-2049	47.80	3.80	44.70	28,300	23,200	2.45
	Pigeonpea-BRG-2						2.07
2012-13	Maize-NAH-2049	49.80		40.00	26780	17000	2.05
	Pigeonpea-BRG-2		CEY				1.68



2014-15	Maize-NAH-2049	84.50	44.50	53,931	18,578	2.55	1.66
	Pigeonpea-BRG-2	CEY					
2015-16	Private hybrid+	62.37	47.02	44,718	24,628	2.04	1.59
	BRG-2	CEY					
2016-17	Maize Pvt hyb	43.00	32.50	20200	12000	1.50	1.35
	Pigeonpea (BRG-2)	CEY					
2017-18	Maize Pvt hyb	47.48	35.40	13228	4440	1.33	1.10
	Pigeonpea (BRG-2)	CEY					

*Sole crop maize

2. ICM in drought tolerant finger millet varieties for higher yield

The sowing season affected due to delay in the onset of monsoon and no rains received in the month of May for land preparation. The rainfall shows negative deviation in the month of April and May, whereas rains received in the month of June helped sowing of crops. Dry spell was observed at initial stage of the crop from 26-06-2015 to 12-07-2015 for 17 days and next dry spell for 15 days in the month of September (11 to 25th, Sept 2015). Crops suffered due to dry spells and reduction in the

crop yield of maize and other field crops was observed. Good rain was received in the month of October (211 mm) which was harvested in farm ponds and used for protective irrigation for the *rabi* finger millet crop at critical stages.

Impact

Cultivation of drought tolerant finger millet (GPU-28, ML- 365) in an area of 2.4 ha helped farmers to harvest higher yield over conventional varieties even though the year experienced severe drought (Table 86).

Table 86. Yield results of drought tolerant finger millet

Year	Crop and Technology	Area (ha)	Seed yield (kg/ha)	Fodder yield (kg/ha)	Net returns (₹/ha)	Benefit cost ratio
2011-12	ICM in finger millet (GPU-28)	0.4	2280	3800	23,700	1.75
	Farmer's practice Siddanuru local	0.4	1680	3100	8,300	1.68
2012-13	ICM in short duration finger millet variety (GPU-48)	0.4	2350	3750	24775	1.78
	Farmer's practice (Local variety)	0.4	1780	2740	16350	1.62

2015-16	Finger millet (ML-365) with critical irrigation	0.4	2950	3860	43,950	2.82
	Finger millet (ML-365) with No critical irrigation	0.4	2070	2950	24,310	2.04

Module III: Livestock Activities

1. Enhancement of milk production through mass adoption of dry fodder enrichment

Farming Situation

The Siddanuru village in Davanagere district is mainly depending on the agriculture and livestock rearing for their livelihood. The livestock in the village is mainly depending on the low quality dry roughages viz; maize stovers, maize kadbies, ragi straw and paddy straw during summer season. These feeding stuffs are very low in protein, minerals, vitamin content and are less digestible when fed to animals. Livestock owners are meeting their fodder requirements through a combination of crop residues obtained after crop harvest, grazing on community lands and feeding cultivated forages to a limited extent. At present the village comprises of 115 indigenous cattle, 112 buffalos, 326 crossbred cattle, 58 sheep, and 26 goats. In general the livestock owners have not made any special effort to use the available dry fodders and develop pastures in the village that led to low milk production. Krishi Vigyan Kendra after discussing this matter with the Village Climate Risk Management Committee (VCRMC) members decided to take up method demonstration in farmer's field. Selected 110 livestock owners for the programme and promoted mass adoption of dry fodder enrichment. This method demonstration was conducted on

05-03-2015 in the village to educate farmers about the benefits of dry fodder enrichment. Bio products like Enzymex and Brolyatone at the rate of 5 g / kg and 1 ml / kg of straw, respectively dissolved in 300 ml of water per kg of dry fodder is sprayed uniformly just half an hour before feeding. This method is easy and practicable, when compared to traditional method of urea or salt treatment of dry roughages.

Technology details

Since the poor quality dry crops straw are the stable source of feeding stuffs for livestock in the village supplementing them with deficient nutrients is very crucial especially minerals and vitamins during summer as these nutrients reduces stress on dairy animals. Enzymex powder contains fiber (Cellulose), digesting enzyme, Brolyatone tonic supplies essential minerals & vitamins to the animals whereas urea provide easily available nitrogen for microbes for protein synthesis. Concoction of all these nutrients helps in better microbial growth in the rumen and there by increases the digestibility of dry fodders resulting in better performance among producing animals. Thus prepared solution is sprinkled on dry fodder before feeding to the animals. When the enriched dry fodder was fed to the animals the voluntary intake was increased by more than 80 % with an average increase in milk production by 14.7 %. There was an average reduction in feeding cost by 9 %.



Feed supplements required to enrich the poor quality dry fodders is as under:

Items/ Feed supplements	Quantity (per kg of dry fodder)
Enzymex powder (g)	3-4
Brolyatone tonic (ml)	1-2
Feed grade urea (g)	10
Water (ml)	300

Technology demonstrations were taken up with 110 livestock farmers in the village. The economics of 10 individual farmers is presented in Table 87.



Impact

Farmers perceived that voluntary intake of dry fodder by animals increased and there was no wastage of fodder. Since the dry fodder is costlier, feeding of enriched dry fodder has reduced the feeding cost among dairy animals and reduced the cost on concentrates feeding. This has resulted in increased milk production by 0.5 to 1.0 liters (10-15%) and the quality of the milk is also improved. Overall animal health condition is also improved.

Resilient practice

It is observed during the feeding trial (Technology demonstration) that the voluntary intake of enriched fodder is very high (>90%) and feeding such fodders has increased the milk production by 10-15 %. After seeing the benefits of feeding enriched fodders, many farmers have come forward to use this technology on account of easy adoption and economical to feed.

Table 87. Economics of 10 farmers (per cow basis)

Sl. No.	Name of Farmer	Before				After			
		Gross cost / day (₹)	Milk yield (L/day)	Gross income (₹)	BCR	Gross cost / day (₹)	Milk yield/day (₹)	Gross income (₹)	BCR
1	Ravikumara	80-00	5.5	143.00	1.79	85.40	6.2	161.20	1.88
2	Manjappa S.M.	80-00	5.0	130.00	1.63	85.40	6.0	156.00	1.83
3	K.R. Marulasiddappa	80-00	4.5	117.00	1.46	85.40	5.3	137.80	1.61
4	Yogaraj S.C.	80-00	5.5	143.00	1.79	85.40	6.3	163.80	1.92
5	Chandreshkaraiah S.M.	80-00	7.0	182.00	2.28	85.40	7.2	187.20	2.19
6	Prashulingappa A.S.	80-00	4.5	117.00	1.46	85.40	5.2	135.20	1.58
7	Marulasiddappa A.S.	80-00	4.5	117.00	1.46	85.40	5.3	137.80	1.61
8	Basavarajaiah S.M.	80-00	7.0	182.00	2.28	85.40	8.1	210.60	2.47
9	Chandrashekhappa K.S.	80-00	5.0	130.00	1.63	85.40	5.7	148.20	1.74
10	Thippesh Naik P.	80-00	4.5	117.00	1.46	85.40	5.5	143.00	1.67
Average		80-00	5.3	137.80	1.72	85.40	6.08	158.08	1.85
		Cost of milk production ₹ 15.10/litre				Cost of milk production ₹ 14.00/ litre.			



3. Conclusions and key messages

The impacts of climate change will reduce productivity and lead to greater instability in production in the agricultural sector (crop and livestock production, fisheries and forestry) in communities that already have high levels of environmental degradation and limited options for coping with adverse weather conditions. Addressing climate change impacts on agriculture is special challenge. Changes in weather parameters that affect crop cultivation suitability besides associated loss in agriculture biodiversity, decrease in input use efficiency, and prevalence of pests and diseases are some of the major causes of climate change impacts on agriculture. Agriculture production systems require adaptation to these changes in order to ensure the food and livelihood security of farming communities. There are several potential adaptation options to reduce moderate to severe climatic risks in agriculture. Adaptation options that sustainably increase productivity, enhance resilience to climatic stresses, and reduce greenhouse gas emissions are known as climate-smart agricultural (CSA) technologies.

This publication presents management practices and technologies for climate change adaptation and mitigation in 7 drought prone/flood prone districts located in Karnataka and Kerala under NICRA project. It covers practices with an explicit focus on adaptation to specific climatic stresses, and practices that simultaneously reduce production risks and lower greenhouse gas emissions. This study employed a participatory assessment method

to assess climate smart agricultural practices and technologies in drought prone districts in the state of Karnataka and flood prone district in Kerala.

There are number of factors that influenced the farmers in each location to adopt climate smart technologies for weather aberrations. For instance, farmers in a location with low rainfall and high climatic variability in annual rainfall prefer risk mitigation technologies such as short duration drought tolerant crops and varieties in conjunction with in-situ rainwater conservation and harvesting in storage structures. Many agricultural practices and technologies such as enhancement of soil organic carbon through crop residue recycling, location specific intercropping systems, *in-situ* moisture conservation practices, improved shelter for livestock, custom hiring centres, issuance of weather advisories based on block level weather forecast have improved crop yields, water and nutrient use efficiency and reduced greenhouse gas emissions from agricultural activities. The study also indicate that farmers' preferences and willingness-to-pay are influenced by technologies and their relevance to combat the climatic variability besides cost of implementation and gross returns.

Mainstreaming climate resilient technologies in development programs

In India, several developmental programmes are being implemented by various ministries and some of the developmental programs

have incorporated interventions/actions which contributes towards adaptation to climate change. The focus of these programs is mostly on efficient utilization of natural resources, enhancing the productivity, arresting resource degradation, etc. and adaptation to climate change is a co benefit for these programs. These practices can be further spread as part of the development programs so that they reach large number of farmers in the country and thus contribute to resilience. The proven resilient practices are to be spread and made accessible to the communities so as to minimize the impacts of climate change and to establish climate resilient villages.

Key messages are:

The effective management of agricultural ecosystems contributes to both climate change adaptation and climate change mitigation. In rural environments, approaches for the sustainable crop production that can support climate change adaptation and mitigation include:

- the rainwater conservation measures and sustainable mechanization to maintain healthy soils and manage water efficiently;
- the use of quality seeds of short duration and drought tolerant varieties;
- the cultivation of a diverse crop species and varieties in associations and/or rotations;
- the integrated pest management practices;

and

- the diverse forest and horticultural tree plantations to buffer the climate change impacts in the region

As multiple programs are being piloted by various departments with different guidelines and implementation mechanisms, there is a need for forging convergence of these programs at the village level, so that the farmers can take benefit of these programs depending on the their resource endowments, farming situations and climatic vulnerability. Further, climate change adaptation policies need to emphasize on the crucial role of providing information about these climate smart technologies and creating financial resources to enable farmers to adopt various mitigation technologies that are relevant for their location.

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