Project Completion Report

2013-17

Bhoosamrudhi: Improving Rural Livelihoods through Innovative Scaling-up of Science-led Participatory Research for Development

World Vegetable Center

ICRISAT DEVELOPMENT CENTER

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Contents

1. Title of the project: Bhoosamrudhi: Improving Rural Livelihoods through Innovative Scaling-up of Science-led Participatory Research for Development

2. Districts, area and beneficiary details:

Sl. No	Name of the district	Area covered (ha)	No. of beneficiaries
1	Chikkamagaluru	80,000	12,308
2	Tumakuru	80,000	10,000
3	Raichur	80,000	16,450
4	Vijayapura	80,000	18,500

3. Implementing departments and other collaborating institutions

I. Implementing departments

a) Department of Agriculture, Government of Karnataka (DoA)
b) Watershed Development Department, Government of Karnataka (WDD)
c) Department of Animal Husbandry and Veterinary Services, Government of Karnataka (DoAH)
d) Department of Horticulture, Government of Karnataka (DoH)

II. Other collaborating institutions

A. National and International Research Organizations

a) International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
b) International Water Management Institute (IWMI)
c) International Livestock Research Institute (ILRI)
d) International Rice Research Institute (IRRI)
e) International Maize and Wheat Improvement Center (CIMMYT)
f) International Food Policy Research Institute (IFPRI)
g) International Center for Agricultural Research in the Dry Areas (ICARDA)
h) World Vegetable Center (WorldVeg)
i) Indian Institute of Horticulture Research (IIHR)

B. State Agricultural Universities

a) University of Agricultural Sciences (UAS), Bengaluru, Dharwad, Raichur and Shimoga
b) University of Horticultural Sciences, Bagalkot
c) Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar

C. Line Departments

e) Department of Water Resources
f) Department of Rural Development and Panchayat Raj
g) Karnataka State Seeds Corporation (KSSC)

4. Date of commencement of the project: 2012-13

5. Date of completion of the project: 2016-17

6. Objectives of the project

a) To form a consortium of CGIAR institutions to operationalize an action research scaling-up model in partnership with line departments in the state of Karnataka. The goal is to increase crop yields by 20% and farmers' incomes by 25% in four years;
b) To establish four pilot sites of learning to scale up integrated participatory research for development. This will benefit small and marginal farmers in irrigated and rainfed agriculture areas representing the revenue divisions in the state; and
c) To develop the capacity of agriculture-related development agencies and researchers in the state to enhance the impact of the development programs through science-led support systems.

7. Impact of the new/innovative technologies developed by CGIAR institutes on yield and famers' incomes

Interventions	Center	Coverage	Impact
Mechanization			
Use of Zero-Till multi crop planter	CIMMYT	12 units; 700 ha	Preserved soil moisture (5-8 cm of residue soil moisture from top layer)
Laser leveler	CIMMYT	5 units; 50 ha	Enhanced water use efficiency (WUE) by 15-20%
Relay planter	CIMMYT	5 units; 250 ha	Introduction of relay crop, enhanced WUE, cropping intensity and reduced cost of cultivation
Tractor-drawn seed drill cum Broad Bed and Furrow (BBF) maker	ICRISAT	20 units; 1,000 ha	Enhanced WUE by 10-15%, protection from dry spells and safe disposal of excess runoff
Shredder	ICRISAT	7 units	500 tons aerobic compost prepared
Power weeder	IRRI	6 units; 50 ha	Reduced cost of cultivation on weeding by `4,000-5,000 ha^{-1} in sugarcane and cotton
Easy planter	ICRISAT/DoH	136 units; 50 ha	Reduced cost of manual planting by `3,000- 4,000 ha^{-1}
Nipping machine	DoA/ICRISAT	25 units; 300 ha	Increased yield by 7-8% in pigeonpea
Solar pest trap	DoA/ICRISAT	10 units; 50 ha	No. of pesticide spray reduced by one-fourth; improved quality of produce
Magnetic water conditioner (MWC)	DoA/ICRISAT	2 units; 5 ha	Increased efficiency of drip system and crop yield (brinjal 9 kg/plant in MWC treated vs 7 kg/ plant in control)
Polypropylene sheet for pomegranate orchards	ICRISAT/DoH	5 ha	Reduced damage of fruits by birds and pests by 50%; uniform color of fruits
Crop intensification and diversification			
Fallow management (e.g. Rice and maize fallows)	ICRISAT/WorldVeg/ ICARDA/CIMMYT	1,100 ha	Additional crop yield obtained through pre-*kharif* mung bean (350 kg ha^{-1}) and vegetable cowpea (850 kg ha^{-1}). Additional income of `8,000-10,000 ha^{-1}
Farmers' participatory varietal evaluation of promising cultivars	ICRISAT/CIMMYT/ IRRI/ ILRI/AVRDC	750 ha	Crop yield increased from 22% to 59% in different crops in Raichur; 12-30% in Vijayapura, 15-39% in Chikkamagaluru, 15-40% in Tumkur
			The yield of improved rice cultivars was between 5.7 t ha^{-1} and 7.7 t ha^{-1} in Raichur, 4.5 t ha^{-1} to 7.5 t ha^{-1} in Chikkamagaluru
			Additional benefits of Rs. 4,000 to Rs. 12,000 ha^{-1} was obtained from improved cultivars
Water management			
Direct Seeded Rice (DSR)	CIMMYT/IRRI/UAS/ ICRISAT	22,500 ha	Enhanced WUE by 46%; reduced cost of cultivation by Rs. 8,000-10,000 ha^{-1}

Interventions	**Center**	**Coverage**	**Impact**
Surface and subsurface drip irrigation in DSR	CIMMYT/ICRISAT/ IRRI/IWMI	13 farmers; 5 ha	Water saving by 70% over Transplanted Rice (TPR) and 40% over DSR
Capacity building in micro irrigation and maintenance of drip system	IWMI/ICRISAT	300 farmers	Enhanced WUE by 20-25%
Safe use of domestic waste water in agriculture	ICRISAT	5 units functioning	Improved sanitation
Integrated weed management	IRRI/CIMMYT/ ICRISAT	21,000 ha	Reduced cost on manual weeding by `3,000-4,000 ha^{-1}
Nutrient management			
Soil health mapping	ICRISAT	5,800 samples	Crop-specific soil test-based fertilizer recommendations provided; increased crop productivity by 11 to 35%
Site-specific balanced nutrient application in maize	CIMMYT	50 ha	Enhanced crop yield by 27-47%
Plant growth promoter (Aquasap - sea-weed extract)	ICRISAT	325 ha	Improved crop yield by 7-30%
Gliricidia on field bunds	ICRISAT/WDD	20 ha	
Enhancing organic matter through aerobic composting	ICRISAT	500 tons	Increased organic matter availability in soil
Feed and fodder management			
Introduction of dual-purpose, multi-cut crop cultivars	ILRI/ICRISAT	350 ha	Multi-cut sorghum recorded yield of 65-70 t ha^{-1} and quality maize fodder available from dual purpose cultivars (fodder yield: 7-8 t ha^{-1}; grain yield: 5-6 t ha^{-1})
Introduction of FEAST and TECHFIT tools	ILRI		Feed assessment for fodder quality improvement
Introduction of thornless cactus	ICARDA	10,000 cladodes	Increased availability of quality feed;
Vegetable production technologies			
Introduction of high-value vegetable crops and cultivars	AVRDC	785 ha	3,402 beneficiaries covered; 20-30% more yield
Promotion of protected vegetable cultivation	AVRDC	20 units	3-4 fold higher yield; Less labor (mulching); moisture conservation; healthy produce
Postharvest processing (solar dryer)	AVRDC	4 units	Reduced postharvest losses
Promotion of best management practices	AVRDC	1,000 ha	Reduced pesticide residues in produces; improved quality
Promotion of vegetable/fruit crop special mixtures	IIHR/AVRDC		Increased productivity by 10-15 % along with improved quality

8. Capacity building details/ workforce trained under the project

District	No. of trainings	No. of participants
Chikkamagaluru	50	1,070
Tumkur	45	1,015
Raichur	240	7,231
Vijayapura	150	1,955
All districts	485	11,271

Note: This figure does not include team building and work plan meetings.

9. Detailed project report

9.1. Process of Project Implementation

9.1.1 Stakeholder Consultation

For Bhoosamrudhi a rigorous process for identifying representative benchmark locations in four revenue divisions of Karnataka was adopted. Number of consultations with the department officials and GoK senior officials were held, followed by workshops with officials from all the four benchmark locations. Visits by multi-disciplinary and multi-institutional teams were undertaken to identify the benchmark locations and prepare work plans for each location.

Considerations for Selection of Pilot Sites

The Bhoosamrudhi initiative was for creating an innovation platform to develop a “Proof of Concept” to demonstrate how science-led participatory Research for Development (PR4D) can enhance the impact and trigger sustainable agriculture development that can be scaled up. With this objective in mind the pilots were planned with the following considerations:

- Benchmark pilot districts were selected for each of the four revenue divisions in Karnataka.
- Villages were selected to form a cluster of 10,000 ha in each district during first year to test, refine and validate the improved technologies as well as understand the acceptability of the interventions and enabling conditions for scaling-up.
- A systems approach was piloted where several line departments and multi-disciplinary scientists worked together. Convergence on ground in thinking and actions and strong political will was needed.
- Once the benefit of the refined technologies were proved, plans for area expansion were made from the second year onwards to reach 80,000 ha by the fourth year in each district.
- Even a simple intervention like popularizing seeds of improved new cultivars was difficult as a number of steps were involved in multiplying the seeds. The process also took its own time as the activities are season-based and are also sensitive to various biotic and abiotic factors.
- Instead of target-based approach the participatory approach was adopted to facilitate adoption and sustainability of the innovations introduced.

- For scaling up the interventions, forward and backward market linkages were developed to ensure success, sustainability and profitability for the farmers and quality supply of inputs.
- The pilot projects also focused on educating administrators, policy makers and opinion leaders to smoothen and accelerate implementation on the pilot sites.

Stakeholders' Consultations

The preliminary visits were made by the consortium team to select four pilot sites and interacted with stakeholders (Figure 1). The teams identified the constraints across the four pilot sites:

- Water scarcity, labor scarcity, lack of access to markets, acute power shortage, high cost of cultivation
- Low resource-use efficiency
- Lack of storage facility and narrow window of procurement
- Postharvest losses, lack of processing units and minimum support price
- Fodder scarcity and poor mechanization
- Lack of access to real-time information,
- Lack of convergence of schemes
- Mono-cropping with subsistence

Figure 1: Interaction of multi-disciplinary team of scientists with stakeholders in selected districts.

Consultation with State and District Level Line Departments

After obtaining firsthand information from grassroot level stakeholder's i.e. farmers, women, landless and rural youths, several meetings and discussions were held with state and district line department staff (Figure 2). A two-day stakeholder consultation was held at Bengaluru with Mr Kaushik Mukherjee (then Additional Chief Secretary & Development Commissioner) to draw a road map for implementing the initiative. The discussion had high-profile policy makers and bureaucrats attending and contributing. Stakeholders deliberated and identified district-wise constraints and suggested different strategies to tackle the problems.

Figure 2: Consultation meeting with state and district line departments staff at Bengaluru.

9.1.2 Baseline characterization

Analysis of the baseline data for the four study sites of the Bhoosamrudhi program suggests the following:

1. Cultivation was the primary occupation for most of the household members, across the four districts. However, there is evidence of some dissimilarity in the socio-economic profile of the farmers in these districts;

2. Chikkamagalur and Tumkur reported comparatively high proportion of Below Poverty line (BPL) card holders and low proportion of Above Poverty Line (APL) card holders. On the other hand, the proportion of BPL card holders was low in Bijapur and Raichur;

3. Most of the farmers in Bijapur, Chikkamagalur and Raichur had land holdings greater than one hectare, whereas, the proportion of farmers having land holdings less than one hectare was higher in Tumkur;

4. Farmers in Bijapur and Raichur were able to bring more land under cultivation in the rainy season 2012-13 and postrainy season 2012, as compared to those in Chikkamagalur and Raichur. However, cultivation in the postrainy season and summer seasons remained scarce across the four districts with most of the land being left fallow. Cropping intensities of 135% and 129% were recorded in Bijapur and Raichur, respectively. Chikkamagalur and Tumkur recorded even lower cropping intensities of 116% and 107% respectively;

5. The recorded yields of crops such as rainy season groundnut, rainy season pearl millet, postrainy season wheat, grown in the year 2012-13, were found to be lower than the national average in Bijapur. In Chikkamagalur the recorded yield of postrainy season maize was lower than the national average, and in Raichur the recorded yield of postrainy season groundnut was lower than the national average;

6. About 50% of the farmers in Bijapur owned at least one water source. In other districts, the corresponding figure ranged between 11-40%. As the role of water markets was found to be negligible, access to water appears to be a major challenge for the farmers in these districts;

7. Fertilizer usage per hectare, was reported to be considerably high in Chikkamagalur and Raichur, and least in Bijapur. Further, the proportion of farmers using micronutrients such as boron, sulphur and gypsum was also found to be highest in Bijapur and the least in Tumkur;

8. Incidentally, the baseline data also indicates that Tumkur and Chikkamagalur are also the districts with the greatest proportion of farmers with land holdings less than one hectare, and the least proportion of medium and large farmers.

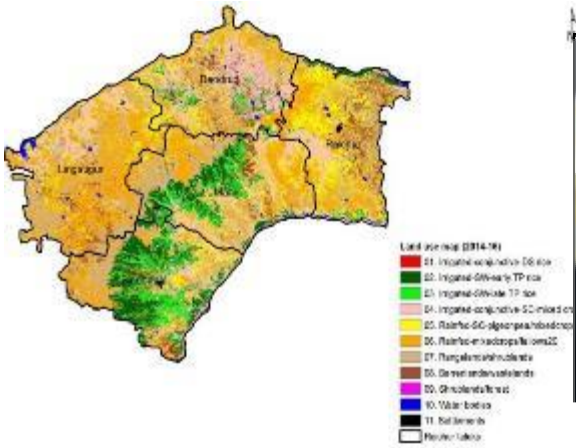
Land Use and Land Cover Mapping

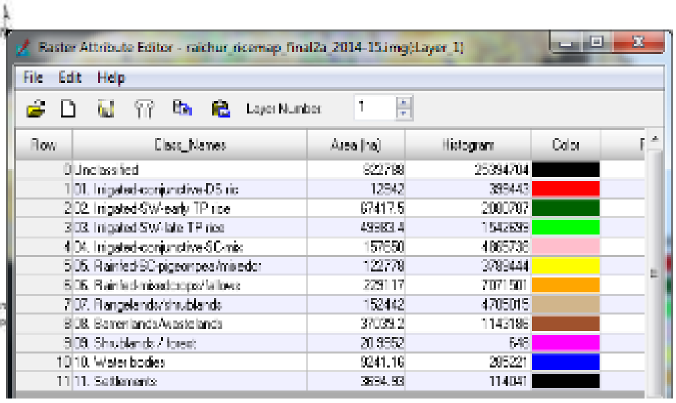
At the start of the program, land use and land cover of benchmark districts were mapped using GIS and remote sensing tools.

Raichur District

Raichur is one of the dry districts of Karnataka, lying on the eastern side bordering Andhra Pradesh; it is bound in the north and south by Rivers Krishna and Tungabhadra. Also, Raichur lies in the Deccan Plateau, a hot semi-arid eco-subregion (6.1, 6.2). Agro-climatically it is in the Northeast Dry Zone (KA 2, KA 3) of Karnataka. Over four rainfall seasons, it has an average rainfall of just above 600 mm. The total geographical area is 835,843 ha with gross cropped area being 695,000 ha. The rainfed area occupies 405,000 ha. All the five *talukas* (counties) in the district are well irrigated with water from the Tungabhadra Dam on the Tungabhadra River and Narayanpura Dam on the Krishna River. The total irrigated area from different sources of irrigation is 185,000 ha, of which 72.2% is irrigated by the canals. Important crops grown here are paddy, sorghum, groundnut, sunflower, cotton and pulses (chickpea and pigeonpea). Major soils in the district are deep black clayey soil spread around 47% of the area and red soils over 34% of the area.

A land use study was conducted in Raichur district to understand the cropping patterns and the importance of DSR in terms of water use efficiency and water productivity. Normalized difference vegetation index (NDVI), a signature based spectral matching technique, coupled with extensive ground truthing was used to map land use/cover. This district is bound by two major rivers in the north and south which feed the irrigation system. Large-scale irrigated rice, grown as a double crop is mostly found in Sindhanur and Manvi *talukas* which are irrigated by the Tungabhadra and its tributaries, mainly the left bank canal. The total area under double crop rice is 124,290 ha. Rainfed pigeonpea and chickpea are the two major pulses (District at a glance, 2012-13). Remote sensing information delineates rainfed pigeonpea and mixed crops under a total area of 130,230 ha. The two other major cereals, sorghum and maize, also are grown under significant area in rainfed conditions (Figure 3). Oilseeds like groundnut and sunflower also play an important role in intercropping with pigeonpea and maize, and also in many places with sorghum. Cotton is a very important cash crop in many parts of Raichur.





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Row	Class_Names	Area (ha)	Histogram	Color
0	Unclassified	922788	25394704	
1	01. Irrigated-conjunctive-DS ric	12942	389443	
2	02. Irrigated-SW-early TP rice	67417.5	2000707	
3	03. Irrigated-SW-late TP rice	49983.4	1542639	
4	04. Irrigated-conjunctive-SC-mix	157650	4865736	
5	05. Rainfed-SC-pigeonpea/mixedcr	122779	3789444	
6	06. Rainfed-mixedcrops/fallows	229117	7071501	
7	07. Rangelands/shrublands	152442	4705015	
8	08. Barrenlands/Wastelands	37039.2	1143186	
9	09. Shrublands / forest	20.9952	648	
10	10. Water bodies	9241.16	285221	
11	11. Settlements	3694.93	114041	

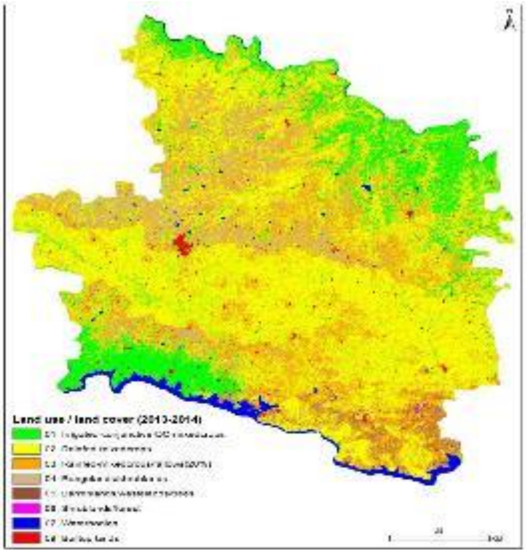
DS rice = Direct seeded rice; TP rice= Transplanted rice

Figure 3: Land use/cover in Raichur district, 2013-14.

Bijapur District

Bijapur district lies in the North Karnataka region of the Deccan Plateau. The southern half of the district is located in the arid Karnataka plateau classified as a hot arid eco-subregion (ESR) with deep loamy mixed red and black soil, and low-to-medium water holding capacity (3). The northern part falls in North Karnataka plateau with hot semi-arid ESR with shallow and medium loamy black soils (with deep clayey black soil inclusions) with medium to high available water capacity (AWC). With a total geographical area of 1.05 million ha, it has a normal annual rainfall of 632 mm. Bijapur has more rainfall during the winter than in the summer. The warmest month is May (30.8°C) and the coolest month is December with an average temperature of 22°C. About 99% of the soils are black (medium 40%, shallow 26%, deep 23%), and the rest (11%) is red soils (sandy, loamy and mixed soils). The major crops grown in Bijapur are sorghum, groundnut, sunflower, pearl millet, maize, wheat, chickpea and pigeonpea. Rivers Krishna and Bhima flow along the southern and northern borders and River Don passes through the district cutting it into half horizontally.

Agro-climatically Bijapur is a dry zone. With a gross cropped area of 1,065,000 ha, the gross irrigated area is 294,000 ha and the rainfed area is 635,000 ha. About 51% of the irrigated area is under wells and 26% under canals (Bijapur district at a glance, 2012-13). The agricultural land use in Bijapur is illustrated in Figure 4. The remote sensing-based analysis clearly shows that the major agriculture area of the district is rainfed whereas irrigation is conjunctive. The major rainfed crops are sorghum, pearl millet, finger millet, groundnut, chickpea and pigeonpea along with cotton. Sugarcane is the major irrigated crop after maize and horticultural crops. The total area under rainfed crops is estimated to be 706,891 ha and gross irrigated area is 163,889 ha. About 84,475 ha of rangelands and shrub lands form potential areas for agricultural development and livelihood improvement.

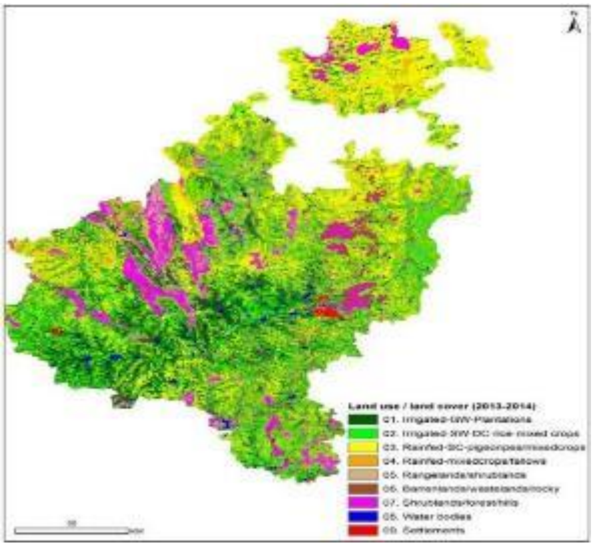


Land use/cover	Area (ha)
01. Irrigated-conjunctive-double crop-mixed crops (18%)	163,889
02. Rainfed-mixed crops (60%)	527,717
03. Rainfed-mixed crops/fallow (25%)	223,968
04. Rangelands/shrub lands	84,475
05. Barren lands/wastelands/trees	15,373
06. Shrub lands/forest	1,532
07. Water bodies	23,118
09. Built-up lands	8,832
Total geographical area	1,048,903
Net sown area	870,780
Area sown more than once	163,889
Gross cropped area	1,034,669

Figure 4: Land use/cover in Bijapur district, 2013-14.

Tumkur District

Tumkur, a southeastern district of Karnataka, shares borders with southern Andhra Pradesh. With 10 *taluks* in the district. It has an annual average rainfall of 687 mm with 50% of it received in the southwest monsoon period and the rest in later months.



Land use/cover	Area (ha)
01. Irrigated-groundwater-plantations/orchards	200,451
02. Irrigated-surface water-double crop-rice-mixed crops	240,110
03. Rainfed-second crop-pigeonpea/mixed crops	313,900
04. Rainfed-mixed crops/fallows 20%	84,271
05. Rangeland/ shrub land	83,247
06. Barren land/wasteland/rocks	20,660
07. Shrub land/forest/hills	88,230
08. Water bodies	12,013
09. Settlements	9,010
Total geographical area	1051,890
Net sown area	554,010
Area sown more than once	240,110
Gross cropped area	794,120
Satellite images used: Landsat 8	

Figure 5: Land use/land cover in Tumkur district, 2013-14.

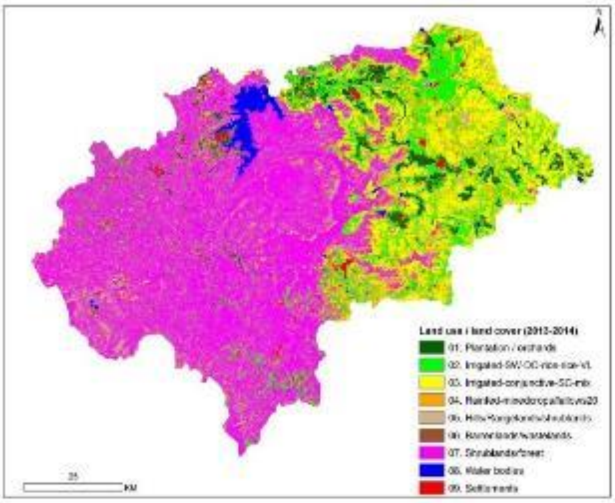
It also has three important rivers Shimsa, Jayamangali, Suvarnamukhi passing through it and many streams join these at different points in the district. As seen in Figure 5, the northern part of the district is largely rainfed and southern parts are irrigated. Tumkur has a large rainfed agricultural land area of around 0.38 million ha with finger millet dominating.

Groundnut and pigeonpea take second place. Maize is another important crop in Tumkur. Important crops like paddy, areca nut, coconut are grown under borewell and open well irrigation. Coconut plantations occupy around 122,500 ha in Tumkur. Red soils dominate the district with a total area of 386,531 ha and sandy loams are spread out in the district over 209,743 ha. Black soils occupy small patches along with sandy soils (Figure 5).

Chikkamagaluru District

Chikkamagaluru district is in the south-western part of Karnataka. It is also called the heart of the 'Malnad' region. It is bound by Hassan in the south, Shivamogga in the north, Udupi and Mangalore in the west and Chitradurga in the east. The Western Ghats separate it from Dakshina Kannada district. It is a largely hilly area with heavy rainfall of more than 2,500 mm annually. It is also famous for its coffee plantations and the Central Coffee Research Institute (CCRI) is situated here at Balehonnur.

With a total geographical area of 722,075 ha, agricultural land use amounts to a total of 246,912.5 ha, which includes rainfed mixed crops and large irrigated land under surface water (Figure 6). Finger millet, paddy, maize and sorghum are the major cereals. Horse gram and Bengal gram are two important pulses. Sesame, groundnut and sunflower are the important oil seeds. The largest chunk of land is under the land cover shrub lands/forest associated with hills/rangelands/shrub lands totaling to 423,785 ha in the district.



Land use/land cover	**Area (ha)**
01.Plantation/orchards	23,336.20
02. Irrigated-surface water-double crop-rice-rice-very large scale	79,054.30
03. Irrigated-conjunctive-second crop-mix	111,340.00
04. Rainfed-mixed crops/fallow	56,518.20
05.Hills/rangelands/shrub lands	116,153.00
06. Barren lands/wastelands	1,653.55
07. Shrub lands/forest	307,632.00
08. Water bodies	14,101.90
09. Settlements	6,574.18
Total geographical area	**716,363.33**
Net sown area	190,394.3
Area sown more than once	79,054.3
Gross cropped area	269,448.6
Satellite Images used: Landsat 8	

Figure 6: Land use/cover in Chikkamagaluru district, 2013-14.

9.1.3 Soil fertility assessment

ICRISAT along with DoA staff collected soil samples in selected villages by adopting the stratified soil sampling method. Analysis of soil samples has been done and the results are shared with the farmers (Table 1 & Figure 7).

Table 1. District-wise area covered for soil sampling and number of soil samples analyzed.				
District	Area covered (ha)	No. of taluks	No. of villages	Samples analyzed
Bijapur	80,000	4	9	898
Chikkamagaluru	80,000	4	40	606
Raichur	80,000	4	23	680
Tumkur	80,000	10	101	1,010

Figure 7: Demonstrating soil sample collection in farmers' fields.

9.2. Scaling-up of science-led interventions

During the project period, number of interventions were undertaken in target districts by consortium partners which impacted on crop productivity and income the pilot districts (Refer section 7 in the summary).

9.2.1 Nutrient management

ICRISAT initiated collection of soil samples from pilot villages across all Bhoosamrudhi districts. ICRISAT along with DoA staff collected soil samples in selected villages by adopting stratified soil sampling method. Ten representative samples from each village was collected. The focus was given to promote balanced fertilizer application comprising application of deficient secondary and micro nutrients. The results of soil samples collected from farmers' fields were analyzed and results were shared with all the stakeholders.

Soil analysis results of Bijapur district clearly indicate that nearly 53% of the fields are deficient in organic carbon, 88% in Av. zinc, 76% in Av. phosphorus, and 61% in Av. sulphur. Boron deficiency was found in 14% fields.

In Raichur district, organic carbon was severely deficient (> 85% fields) in all the villages except in Govindoddi village in Manvi taluk; phosphorus was found deficient in 26% fields, especially in Lingasugur and Devadurga taluks; available sulphur, boron and zinc were found deficient in 55%, 47% and 87% fields, respectively; boron is largely deficient in Pucchaldinni, Kurukunda, Patakamdoddi and Buddinni villages in Raichur district.

In Chikkamagaluru district, 62% fields are deficient in organic carbon, 56% in Av. sulphur, 69% in Av. zinc and 36% in Av. boron in selected villages.

Soil test results for Tumkur district showed that 84% fields are deficient in soil organic carbon, 81% in Av sulphur, 75% in Av. zinc and 75% in Av. Boron in pilot villages of Bhoosamrudhi project.

Potassium deficiency was found in less than 10% fields in all the four districts which indicated scope for reduction of potassium fertilizer in the pilot sites. For detailed analysis refer Appendix 1.

9.2.2 Aerobic composting

The conventional method of preparing compost from agriculture waste involved dumping the waste in a particular place for decomposition. This method was not only time consuming, but also resulted in loss of plant nutrients and caused environmental pollution. The aerobic composting methodology was introduced to the farmers to overcome the said problems. Live demonstrations and training programs were held in the pilot villages (Figure 8).

Farmers were shown how to use the mechanical shredder to chop up the waste and add a microbial inoculant to accelerate the process of decomposition. The resultant compost was also organically richer. For aerobic composting, the recommended dose of inoculant is 1 kg for 1 ton of organic waste. If the waste is dry, a slurry is prepared with 30 liters of water for 1 kg of inoculant and sprayed onto it. The compost heap is turned over every week for aeration. Under normal conditions, the composting process takes 4-6 weeks.

Earlier, farmers practicing organic farming were using raw cow dung as compost which led to plant infestation. ICRISAT guided the farmers to use inoculants and mix the dung with agriculture biomass to increase soil fertility.

Figure 8: Aerobic composting promoted in pilot villages.

9.2.3 Aquasap foliar spray

Aquasap is an organic extract/fertilizer from sea weed that is applied to crop foliage. It contains macro and micronutrients, essential amino acids and plant growth hormones that boost crop yield by accelerating the metabolic function and enhancing its nutrition uptake capacity. In vegetable crops, Aquasap in addition to foliar application is used for dipping the seedling roots in a 0.3% solution. Aquasap is organic and hazard free. It can be handled with bare hands.

During the *kharif* (rainy) 2015 season participatory on-farm trials were conducted on foliar application of Aquasap for major crops (both improved cultivars and local varieties). In the test plots, 1% Aquasap solution was sprayed thrice during the cropping season – after establishment, pre-flowering and post-flowering stages. About 1 liter Aquasap solution was used for 1 acre (0.4 ha). Similar agronomic practices were followed in the test plots and control plots.

At maturity, crop cutting experiments (CCEs) were conducted in 3 m x 3m area in both the treatment plots. The fresh weights for grain/pod and straw were recorded and about 2 kg subsample (~1 kg grain/pod, ~1 kg straw) was sent to ICRISAT. The subsamples were dried and yields (kg ha$^{-1)}$ were interpolated.

Pearl millet

Studies on the responses to Aquasap spray in pearl millet crop in Vijayapura district showed yield increase in local cultivar as well as improved cultivar. In local cultivar, the grain yield increase recorded was 36% while in improved cultivar it was 14% (Figure 9).

Similar studies in pigeonpea showed yield increase to the tune of 30% in local cultivars and 15% in improved cultivar (Figure 10).

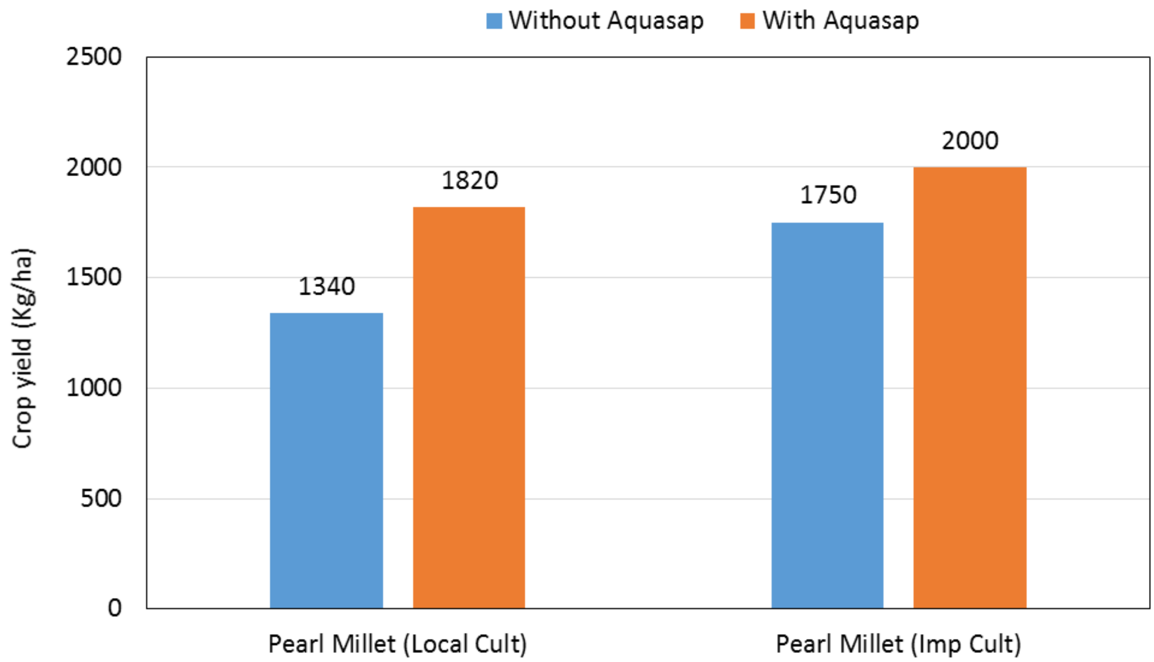


Figure 9: Effect of Aquasap spray on pearl millet grain yield in Vijayapura, Karnataka, **kharif** ***2015.***

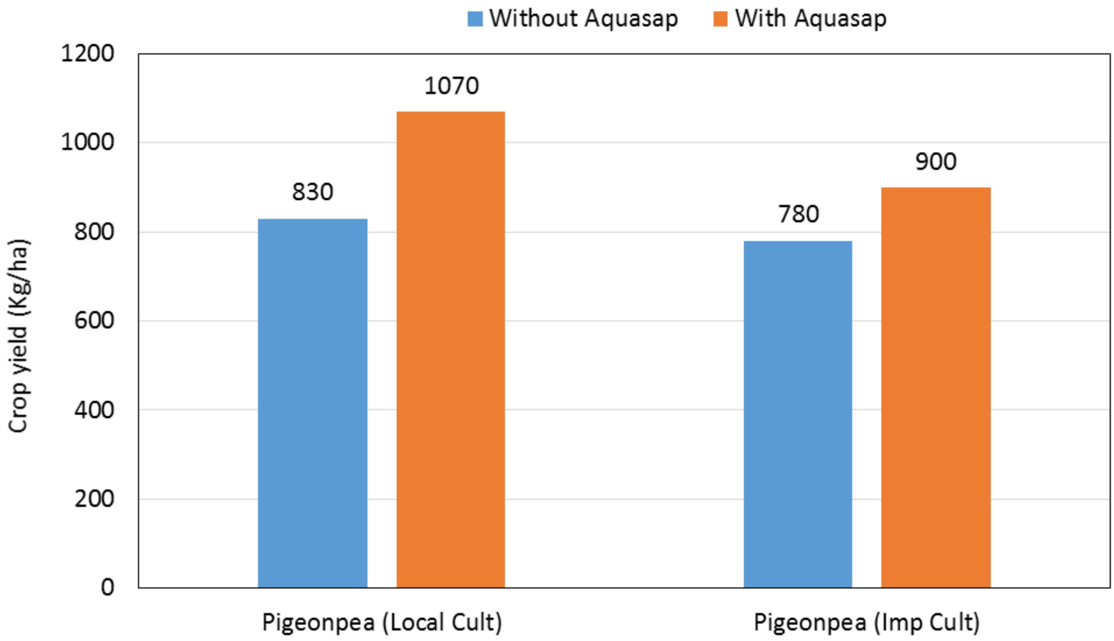


Figure 10: Effect of Aquasap spray on pigeonpea grain yield in Vijayapura, Karnataka,* kharif *2015.

Maize and chickpea crops

In maize, one of the important crops in the region. Usage of Aquasap spray showed a yield benefit of 9% in Chikkamagalur and 14% in Tumkur (Figure 11).

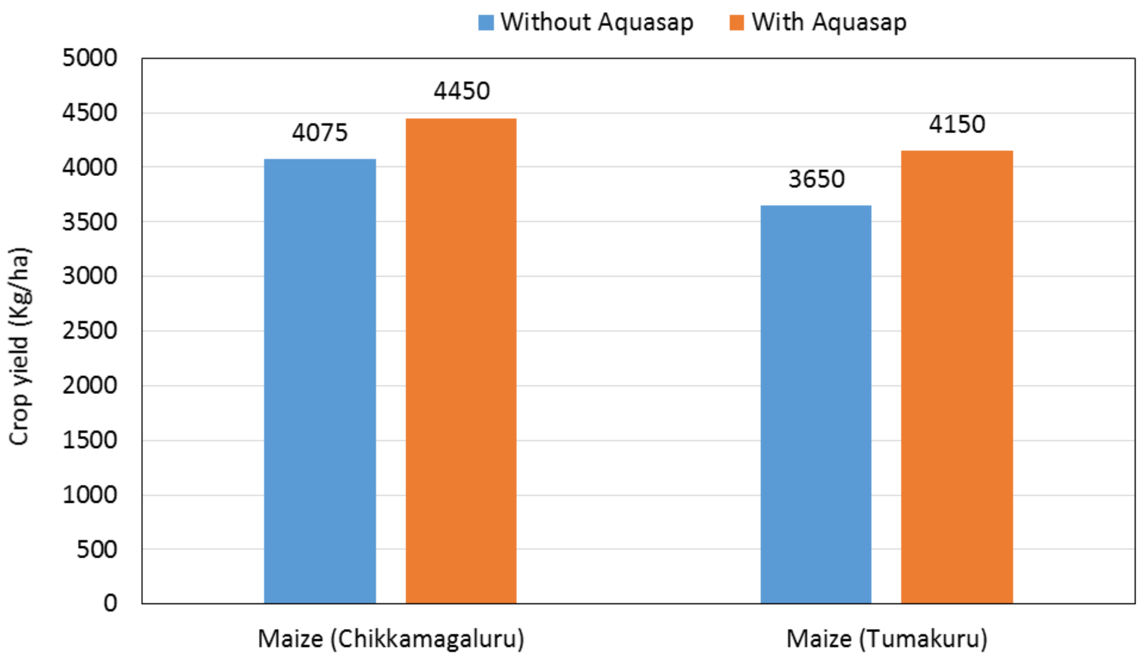


Figure 11: Effect of Aquasap spray on maize (in Chikkamagalur and Tumkur districts) yield in Karnataka,* kharif *2015.

A detailed analysis of the impact of Aquasap foliar spray on maize yield revealed that different hybrids have responded differently but positively to the Aquasap spray and the yield increased between 9-12% over farmers' practice (Figure 12).

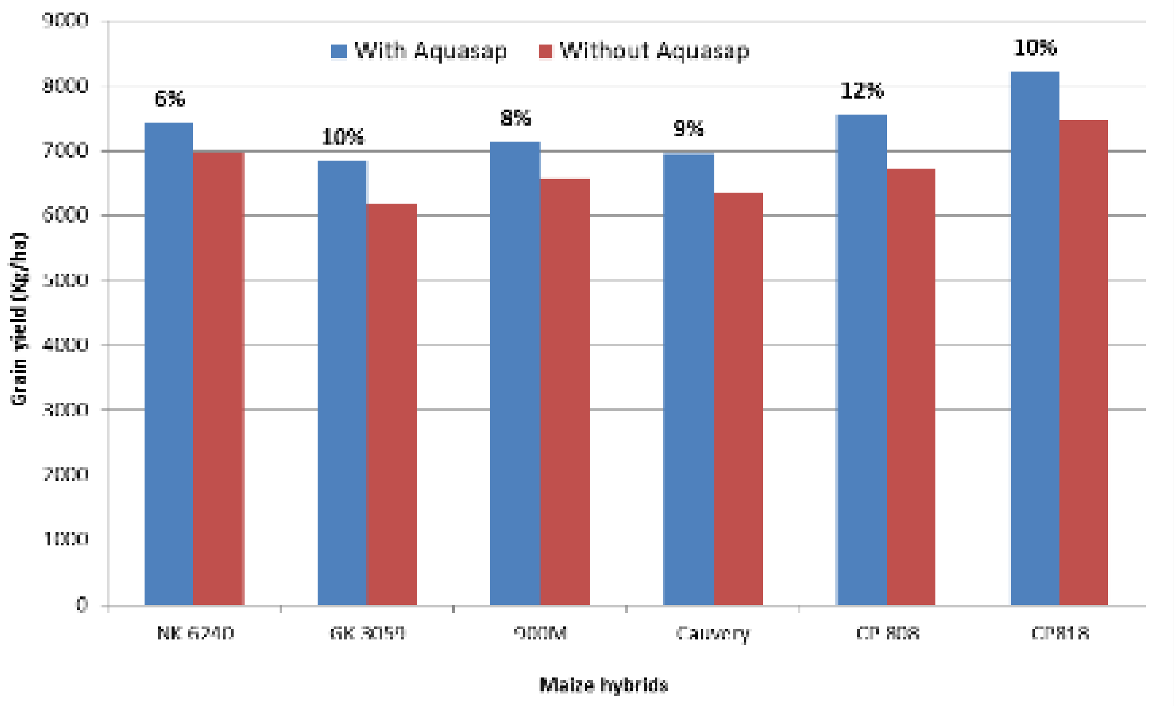


Figure 12: Maize yield increase due to Aquasap foliar spray in Chikkamagaluru district.

Vegetables

Most of the farmers in Karnataka are engaged in vegetable cultivation. Trials with Aquasap spray in vegetables showed significant yield benefits and thereby an opportunity to enhance farmers' incomes. The yield increase recorded was between 11-13% in crops like tomato, chilies and beans (Figure 13).

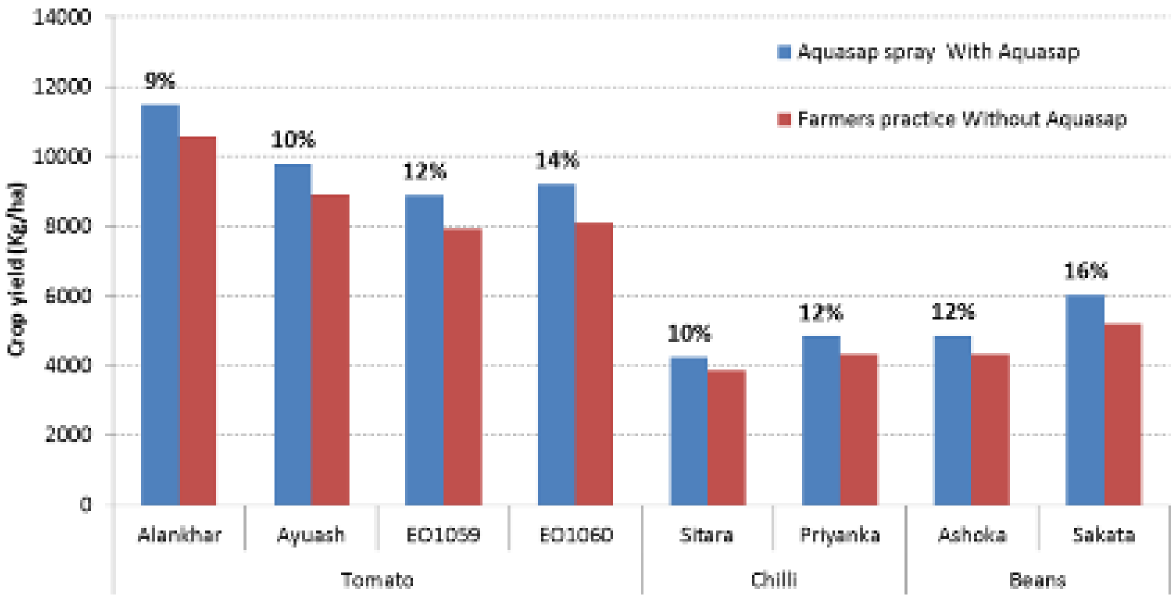


Figure 13: Effect of Aquasap spray on vegetables yield in Chikkamagaluru district.

9.2.4 Water management

9.2.4.1 Analyzing the impact of watershed intervention on surface runoff

Despite number of challenges in drylands, Integrated Watershed Management approach has proved to be the suitable adaptation strategy to cope up with the changing climatic situation and for achieving holistic development (Wani et al. 2003). Integrated watershed development program (IWMP) reduce water related risks by improving green and blue water availability, reduce land degradation and strengthen various ecosystem services (such as reduced soil loss, increased base flow, carbon sequestration, etc.). IWMP is a national-scale program that has spent more than USD6 billion for the welfare of society since inception. IWMP has made significant contribution in terms of enhancing water resources and cropping intensity, crop and livestock productivity and livelihoods. Despite the huge investment made on IWMP, there is no clear understanding of its impact on hydrology and the ecosystem services generated for different rainfall and agro-ecological regions.

Hydrological data at meso-scale watersheds of 100-1,000 ha are rarely available and most of the inflow calculations for designing water harvesting structures (check dam at meso-scale watershed and farm pond at field) are either based on thumb rules or by empirical equations. In the absence of real field or watershed scale monitoring, designing water harvesting protocol for specific sites resulted in over designing of structures or underutilization of the available water resources. Under this study, we have selected two (almost) identical watersheds of similar land use and topography in the selected three districts (Tumkur, Chikkamagaluru and Bijapur) of Karnataka. Surface runoff generated at watershed outlet along with rainfall is estimated and compared for treated and control watersheds. Specific objectives of the current hydrological study is:

i) Establishing rainfall-runoff relationships
ii) Understanding impact of various Agriculture Water Management (AWM) interventions and change in land use on water balance components

Identification of meso-scale watersheds for hydrological monitoring
Field visits were undertaken to benchmark locations to identify suitable sites for establishing hydrological monitoring stations (automatic runoff recorder and automatic weather stations) with the help of the Department of Agriculture. Micro-scale watersheds ranging between 200 and 2,000 ha were identified at Tumkur, Bijapur and Chikkamagaluru districts. With the help of Google earth, IWMP watersheds and stream networks were identified in selected Bhoosamrudhi villages and verified through ground-truthing (Figure 14 shown for Tumkur). The entire stream network was tracked and the positions and capacity of various water-harvesting structures (e.g., check dams and tanks) were recorded. Topographical and land use (plantation crops, agriculture land, etc) details were collected during ground-truthing and local farmers were interviewed regarding their land and water management practices and challenges. Criteria for selecting pilot watersheds for hydrological monitoring was as below:

- Rainfed agriculture zones (surface water irrigated zones were avoided)
- Located within first and second stream order network

- Pilot watersheds area was between 200-1,000 ha
- Two identical pilot watersheds (treated and control) with similar biophysical factors

A total of eight sites were identified for installing runoff recorders and three sites for weather stations (Table 3). Two runoff stations were installed at Tumkur, three at Chikkamagaluru and two at Bijapur. Automatic runoff recorder (DIVER) along with BARO (barometric measurement device) were installed at the outlet of the selected watershed. DIVER has pressure transducers which precisely measure the pressure head at defined intervals (programmed at 15 min interval in current case). Runoff was monitored from year 2014 onwards.

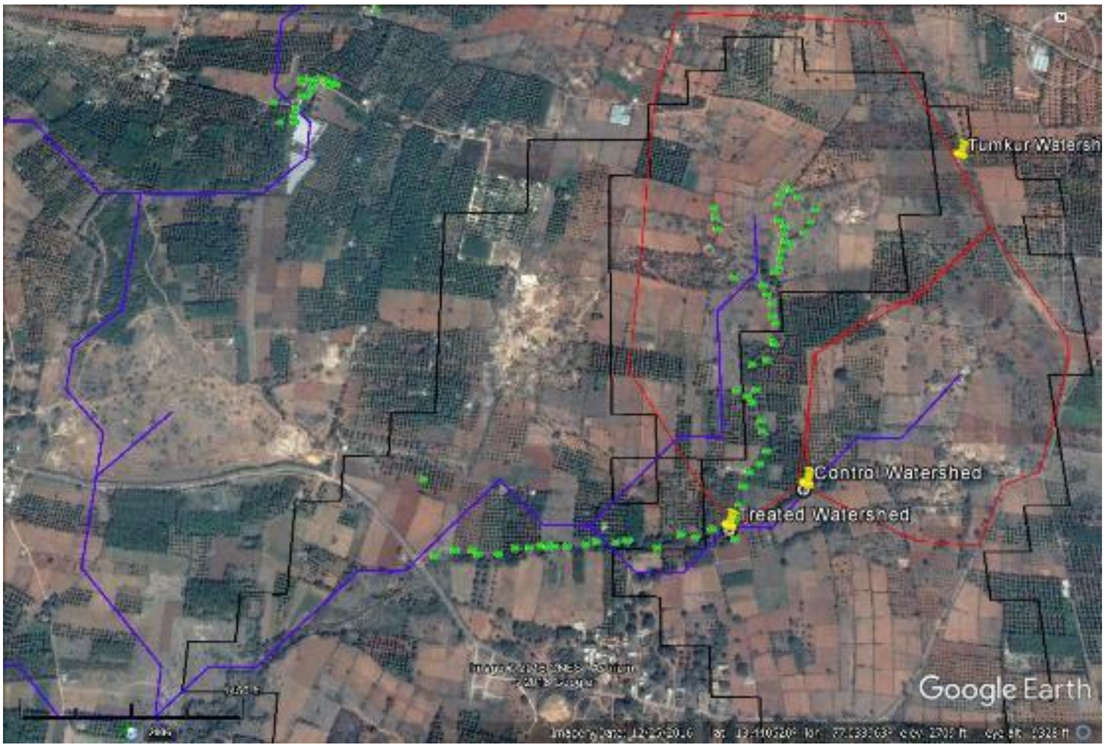


Figure 14: Location of hydrological monitoring stations at Herelkette village, Tumkur, Karnataka.

Figure 15 a): Runoff setup at Haralakatte village in Tumkur; downloading DIVER data; automatic weather station.

Figure 15 b): Hydrological monitoring station installed at Lakumanahalli village, Chikkamagaluru.

Table 3. Location of hydrological monitoring set up in Bhoosamrudhi Plus villages.				
District	Rainfall	Village	Scenario	Scale
Chikkamagaluru	850 mm	Kunnalu	i) Land use: Agriculture vs Plantation	500 ha
		Lakumanahalli	ii) Check dam vs No check dam	200-500 ha
Tumkur	600 mm	Haralakatte	i) Check dam vs No check dam	30-50 ha
Bijapur	600 mm	Sivangi and Niwalkhed	Field bunding vs No bunding	1,000 ha

Water balance components

The movement of rainwater on earth and subsurfaces and then into the atmosphere is known as hydrologic cycle. Figure 16 shows a conceptual representation of the hydrological cycle at watershed scale. Rainfall is partitioned into various hydrological components as defined by mass balance equation such as:

Rainfall = Runoff from the watershed boundary + groundwater recharge + Evapotranspiration (Evaporation + Transpiration) + Change in soil moisture storages+ Change in reservoir storages --Eq.1

In the below equation (Figure 16), a fraction of rainfall stored in terms of soil moisture is known as green water; and the amount of water partitioned in terms of surface runoff, groundwater recharge, and water stored in water harvesting structures is known as blue water (Falkenmark 1995).

Figure 17, Figure 18 and Figure 19 showed the hydrograph obtained from Tumkur, Bijapur and Chikkamagaluru in 2014-15, respectively. These lines shows the amount of water leaving from the watershed outlet in response to rainfall. Table 4, Table 5 and Table 6 further summarize the rainfall-runoff relationship for pilot locations. Tumkur district which is in general characterized by a dry ecology in terms of total rainfall, experienced excess rainfall in 2014-15. Total rainfall received at pilot village was 1,250 mm in 2014-15; out of that nearly 800 mm was received between August and October; whereas June and July month were almost dry. Data further showed that heavy rainfall was also received in the months of April and May 2015. A good amount of surface runoff is found to be generated in wet years as soils in the Tumkur are characterized by shallow soil depth (45-60 cm), poor water holding capacity and low organic carbon. Water balance analysis for the study area showed that nearly 16% of surface runoff is generated from the control watershed compared to 11% in the test watershed in an average year.

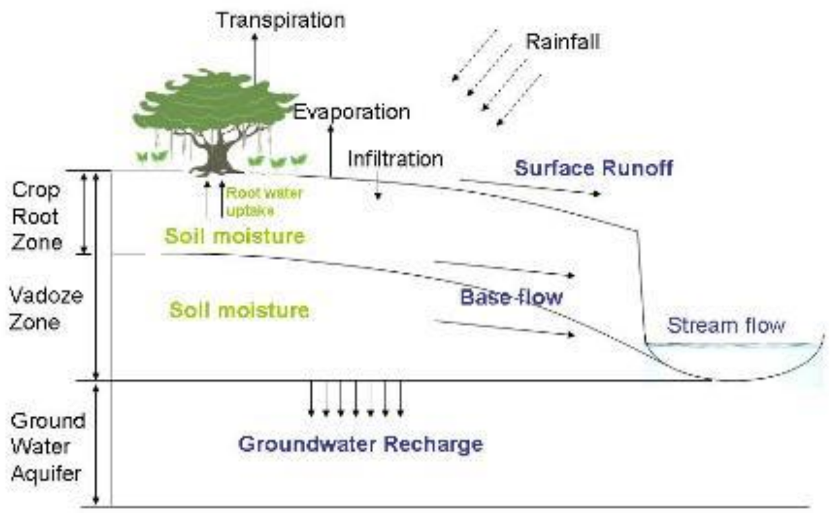


Figure 16: Schematic diagram of water balance components.

Water balance analysis of Bijapur indicates 10% runoff coefficient from control watershed in 2014-15. Hydrological analysis could not be undertaken further as hydrological device (DIVER) was repeatedly missing from the monitoring location. Chikkamagaluru experienced chronic drought situation continuously from 2015-16 and 2016-17. A mere 385 mm rainfall was recorded at the monitoring site in 2015-16 against 700-800 mm average rainfall indicating a 50% deficit of rainfall compared to a normal year. Except November 2015, the runoff generated in most of the months was negligible. The test watershed further harvested most of the runoff and water at the outlet was reduced significantly.

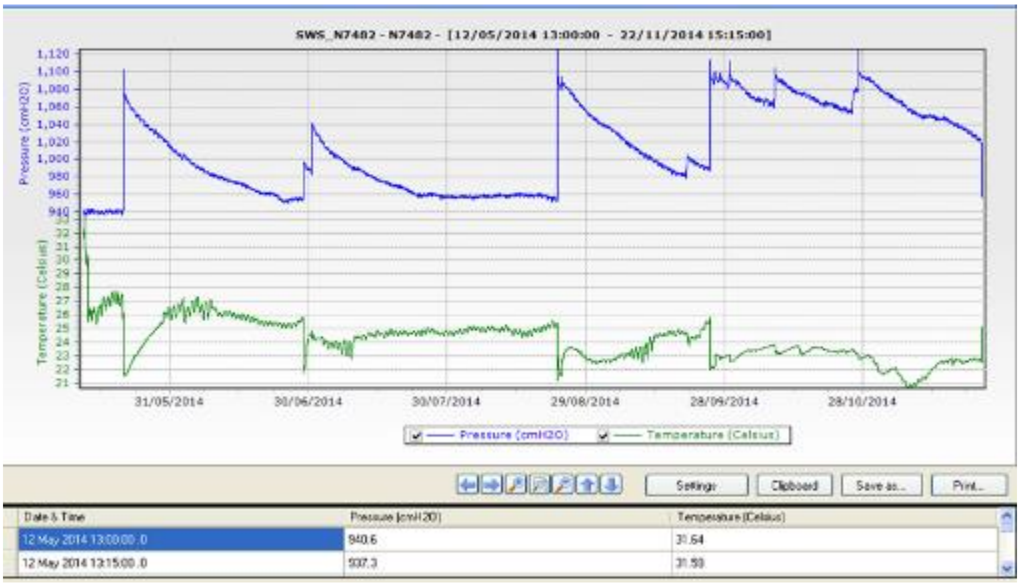


Figure 17: Hydrograph obtained against the rainfall received in 2014 at Tumkur district.

Table 4: Rainfall-runoff relationship obtained for control and test watershed at Tumkur in 2014-15; which is further compared with an average year.						
	2014-15 (wet year)			Average year		
Month	Rainfall (mm)	Runoff in control watershed (mm)	Runoff in test watershed (mm)	Rainfall (mm)	Runoff in control watershed (mm)	Runoff in test watershed (mm)
Jun	33.8	0	0	64	5.6	0
Jul	69	10	6	60	9.8	7
Aug	268.2	59	38	102	17.5	21
Sep	292	107.1	88.9	311	58.1	35.7
Oct	247.2	98	85.4	42	9.8	7
Nov	21.6	12.6	11.2	4	0.7	0
Dec	8.4	5.6	2.1	10	1.4	2.1
Jan	0	0	0	0	0	0
Feb	3.2	0	0	0	0	0
Mar	52.6	12	12	8	1.4	0
Apr	135.6	45	38	42	2.8	2.8
May	117.6	55	36.4	107	14.7	9.8

Table 5. Rainfall-runoff coefficient obtained from control watershed in Bijapur during 2014.				
Station	Rainfall (mm)	Runoff (mm)	GW recharge (mm)	ET (mm)
Shivanagi (control)	625	61	33	531
Niwalkhed (test)	Logger lost			

Table 6. Rainfall-runoff relationship obtained for control and treated watershed at Chikkamagaluru in 2015-16 (i.e. dry year); data is compared with an average year.						
	2015-16 (Dry year)			Average year		
Month	Rainfall (mm)	Runoff in control watershed (mm)	Runoff in test watershed (mm)	Rainfall (mm)	Runoff in control watershed (mm)	Runoff in test watershed (mm)
Jun	17	5	0	85	22	12
Jul	5	0	0	205	29	20
Aug	17	0	0	55	7	2
Sep	26	5	3	97	22	4
Oct	30	16	5	25	7	5
Nov	170	36	20	13	0	0
Dec	9	3	2	17	0	0
Jan	1	0	0	0	0	0
Feb	0	0	0	0	0	0
Mar	0	0	0	5	1	0
Apr	3	1	0	70	10	5
May	107	14	0	230	33	11

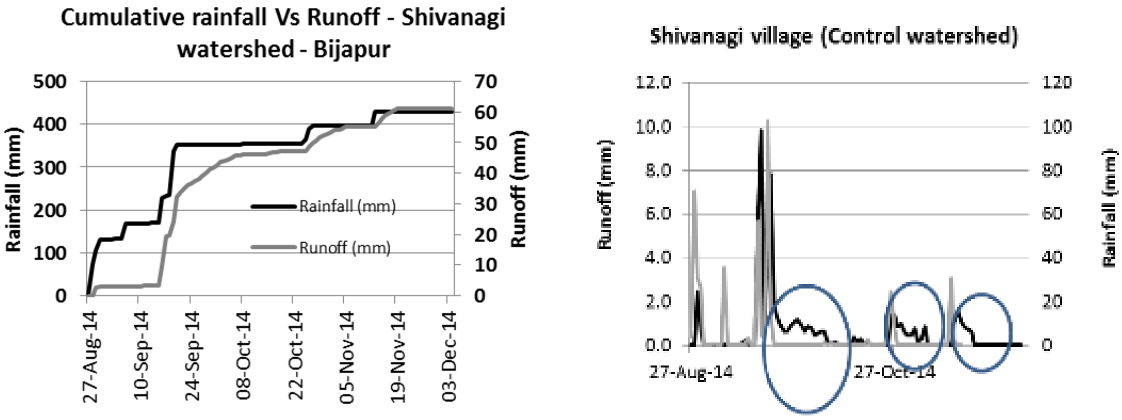
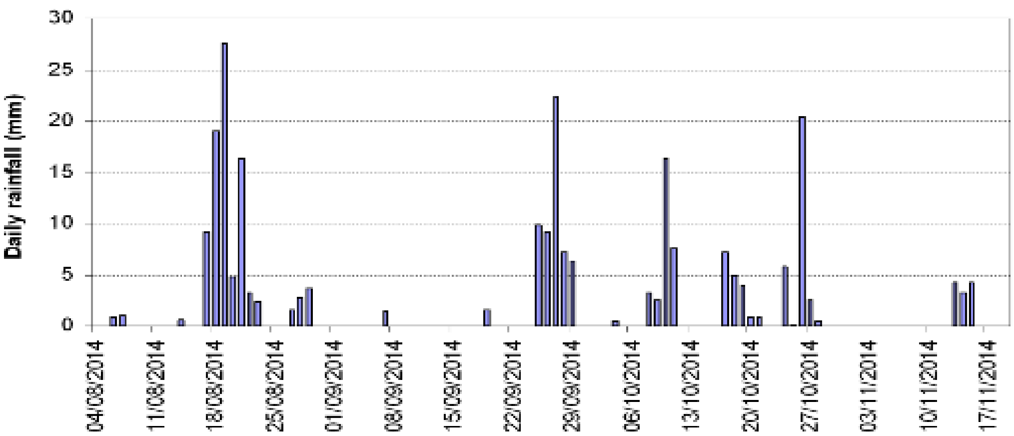


Figure 18: Hydrograph obtained during monsoon 2014 at Bijapur.



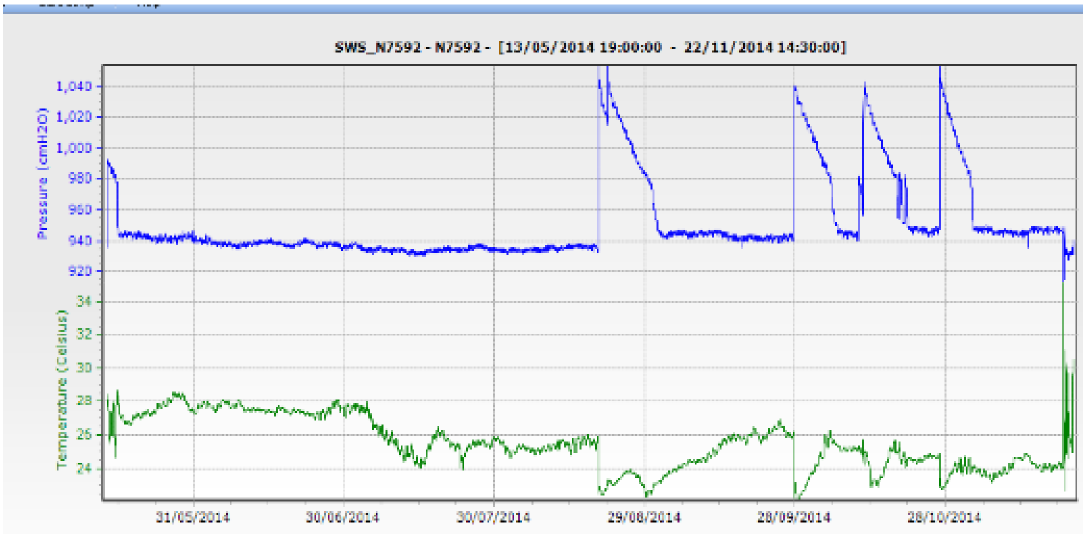


Figure 19: Daily rainfall and hydrograph obtained at Lakkamanahalli, Lakya RSK, Chikkamagaluru.

Observations

- A hydrological study was undertaken to analyze rainfall-runoff relationships in different rainfall zones and soils in three different districts (Tumkur, Chikkamagaluru and Bijapur) since 2014 onwards
- In all, eight monitoring sites ranging from 200-1,000 ha were identified in selected districts and automatic runoff recorders were put in place
- Rainfall and other meteorological parameters were also monitored along with surface runoff
- Tumkur received heavy rainfall during 2014-15 and 2015-16, resulting in heavy runoff (>30%) whereas runoff coefficient from normal year was found at 11-16%. The test watershed recorded 11% surface runoff compared to 16% in control watershed
- At the pilot site in Chikkamagaluru, year 2015-16 experienced severe drought and received rainfall less than 400 mm compared to 700 mm during normal years. This has resulted in drying of streams (except one-two months) during 2015-16 and 2016-17. The test watershed harvested most of surface runoff and negligible amount was received at watershed outlet compared to control watershed.
- At Bijapur, runoff coefficient obtained in 2014-15 was 7-10%. DIVERs (runoff recording devices) were lost in subsequent years repetitively.

9.2.4.2 Magnetic water conditioner

Borewell water used for irrigation in Bijapur district has high salt content leading to salinity of soil. To overcome the problem a magnetic water conditioner was installed in the water line to reduce the salinity and pH of water in Jumanal village (Figure 20). It was observed by a visiting team of government department and ICRISAT officials that the fields irrigated using water conditioner showed reduced salt formation on the soil surface compared to the fields irrigated without water conditioner (Figure 21).

Figure 20: Magnetic water conditioner installed for testing in field at Jumanal village.

Magnetic water treatment devices (MTDs) or magnetic water (MW) conditioners are simple environment-friendly equipment with low installation costs and no energy requirements. MW can be used to increase crop yield, induce seed germination and benefit the health of livestock. MW treatment is currently used in several other countries. MW has been found to be effective in preventing and removing scale deposits in pipes and water containing structures. Magnetized water also can increase the levels of CO_2 and H+ in soils comparable to the addition of fertilizers. Magnetic water treatment works on the principle that as water passes through a magnetic water conditioner, a Lorentz force is exerted on each ion which is in the opposite direction of each other. The redirection of the particles increases the frequency of collisions between ions of opposite sides, combining to form a mineral precipitate or insoluble compound. Calcium carbonate precipitates out of solution as a sludge and can be easily removed from the system since it will not adhere to pipe walls.

Figure 21: Impact of magnetic water conditioner in field.

9.2.4.3 Micro irrigation and water impact calculator

The International Water Management Institute (IWMI) along with ICRISAT had conducted three trainings for 180 farmers in three villages on efficient management of drip and fertigation system and maintenance for enhanced efficiency of equipment (Table 7). These farmers were monitored and advised with appropriate irrigation schedule depending on the crop-water requirement using a water impact calculator.

Table 7. Training on micro irrigation scheduling for farmers in Bhoosamrudhi villages.

Sl. No.	Village	Crop	No. of Participants
1	Nidoni	Grapes, sugarcane and lemon	108
2	Mulasavalagi	Grapes, lemon and mulberry	39
3	Chadchan	Grapes, onion, sugarcane and lemon	33
		Total	180

9.2.4.4 Demonstrations on drip irrigation

IWMI had conducted demonstrations on drip irrigation systems and organized capacity building training programs in different Bhoosamrudhi districts. A manual on drip irrigation system was prepared in Kannada for dissemination to farmers in these districts. IWMI has demonstrated drip irrigation for the following crops in Tumkur district.

- Tissue culture banana at Kora Raitha Samparka Kendra (RSK) of Tumkur
- Tissue culture pomegranate at Dasanakatte, Tiptur
- Drip in china aster (cut flower) at Beladhara
- Capacity building training on-
  - Irrigation scheduling as per water requirement of crops
  - Use of drippers to regulate water discharge instead of micro tubes
  - Use of Venturi injectors for fertigation
  - Fertigation schedule
  - Fertilizer recommendations and water budgeting for farmers based on soil testing

In Chikkamagaluru district, 10 farmers in each village, who already having drip irrigation, have been selected and soil and water samples were collected from these farmers individually to know the water quality and its suitability for irrigation. General farm characteristics like water discharge from borewell, quantity of water irrigated, type of emitters using, discharge rates, fertigation adoption, etc., were recorded from the farmers as well as details of yield and income from individual crops. Five capacity building training sessions on drip and sprinkler irrigation were provided in Hiregouja, Thadabenhalli, Hanchihalli, Gungarahalli and Sarpanahalli (Figure 23).

Figure 22: IWMI scientists assessing the performance of drip irrigation system in Tumkur district.

Figure 23: IWMI scientists monitoring drip irrigation facilities in Chikkamagaluru district.

9.2.5 Crop intensification and diversification

9.2.5.1 Farmer participatory varietal evaluation

The participatory varietal evaluation program works towards increasing farm productivity by facilitating the delivery of high yielding, profitable varieties that are well adapted to a wide range of soil types, environments and farming systems. This is achieved by providing accredited, unbiased information to farmers on better adapted crop varieties, or new and better cultivars, at the earliest opportunity.

In the pilot districts of Bhoosamrudhi, farmers were given choice of improved varieties of preferred dryland crops. Improved cultivars released by State Agricultural Universities (SAUs) and proprietary hybrids of crops were evaluated with an objective to select cultivars having suitable traits for better adaptation to biotic and abiotic stresses. The aim was to enhance/sustain productivity and facilitate scaling up of these varieties to satellite *taluks*. Each demonstration was laid out approximately on half to one acre of farmers' field.

With these trials, farmers were exposed to several improved varieties of each crop grown in their pilot villages (Table 8) and had the option of evaluating the performance of each variety more or less in the same climatic and soil conditions with different levels of input management. Participatory varietal selection trials were confined to two or three main rainfed cropping systems of the district/region during this crop season. During 2013-16, crops evaluated included cereals and millets (sorghum, pearl millet, finger millet and maize), pulses (pigeonpea, chickpea, mungbean and black gram) and oilseed crops (groundnut, soybean, and castor).

Table 8. Participatory varietal evaluation of promising cultivars in different districts of Bhoosamrudhi.

Districts	Major crops targeted	Improved crop cultivars
Raichur	Paddy	RNR 15048, Imp Samba Masuri, G Sona
	Groundnut	ICGV 91114, K 9
	Pigeonpea	ICPH 2740, TS 3R, Maruti
	Vegetables	Grafted capsicum, tomato, vegetable cowpea
Vijayapura	Maize	NK 6240,
	Pigeonpea	TS 3-R, ICPL 161, ICPL 88039
	Pearl millet:	ICTP 8203 Fe, ICMH 1203
	Vegetables	Grafted capsicum, tomato
Tumkur	Paddy	RNR 15048,
	Maize	NK 6240,
	Groundnut	ICGV 91114, K 9
	Finger millet	MR 1
	Vegetables	Grafted capsicum, tomato
Chikkamagaluru	Paddy	IET 21478, IET 21479
	Maize	NK 6240
	Groundnut	ICGV 91114, K 9
	Finger millet	MR 1
	Vegetables	Grafted capsicum, tomato, vegetable cowpea

The activity was promoted through the program with the active involvement of the agriculture department and CGIAR staff. The program collects and delivers the data which, not only assists farmers with their choice of suitable varieties, but also facilitates the registration and commercialization of new cultivars by plant breeders. The experimental protocol, has been established to evaluate the performance of improved varieties under balanced nutrition against a common set of traditional varieties to characterize their yield, quality, disease resistances/tolerances and agronomic characteristics. The information on yield performance of the improved cultivars was collected through crop cutting experiments by CGIAR staff and Farm Facilitators in the presence of agriculture department staff/officials.

Large number of crop cutting studies were undertaken to understand the difference between improved and farmers' practice and their yield benefits. The yield benefits ranging from 7-

39% across different crops in Chikkamagaluru; 5-114% in Raichur; 14-24% in Tumkur and 7-36% in Vijayapura across different crops and seasons (Table 9).

Table 9. Details of crop cutting experiments conducted - improved cultivars and practices.

Sl. No	District	Season	Crop	Crop/variety	Yield data (kg per ha)		% yield increase	Remarks
					Check plot	Experimental plot		
1	Chikkamagaluru	*Kharif*	Castor	Jwala		685	36.9	% increase over RC 8
			Castor	Jyothi		600	27.7	
			Castor	RC-8	430			
			Groundnut	ICGV 91114		2340	39.1	% increase over TMV 2
			Groundnut	ICGV 350		2000	28.8	
			Groundnut	ICGV 0351		1650	13.5	
			Groundnut	K 9		1530	6.9	
			Groundnut	TMV 2	1430			
			Maize	Hybrid	1630	1780	9.2	Aquasap
			Rice	IET 21478		7290		
			Rice	IET 21479		5230		
			Rice	Intan		5360		
			Rice	KHP 10		4080		
			Rice	KHP 2		4800		
			Rice	KHP 5		4970		
			Rice	Sharavathi		5240		
			Rice	Tunga		5460		
		Rabi	Veg Cowpea	Pragathi		930	34.7	% increase over local variety
			Veg Cowpea	KM 5		690	18.4	
			Veg Cowpea	C 152	580			
			Mung bean	Pusa Vishal		395		
			Mung bean	LGG 460		380		
			Mung bean	KKM 2		405		
2	Raichur	*Kharif*	Mung bean	Pusa Vishal		370		
			Mung bean	DGGV2		250		
			Mung bean	BGS 9		300		
			Mung bean	Sipai		810		
			Mung bean	Pusa 3		980		
			Mung bean	BGS 9		880		
			Groundnut	ICGV 91114	320	330	4.7	
			Groundnut	ICGV 91114	1490	2590	73.8	
			Pigeonpea	ICPL 87119	860	1590	85.1	
			Pigeonpea	ICPL 85063	860	1580	83.7	
			Pigeonpea	2671	860	1550	79.7	
			Pigeonpea	2740	860	1840	114.8	
			Sorghum	CSV 23	1545	2880	86.3	
			Pearl millet	ICTP 8203	990	1440	44.9	
			Pearl millet	HHB 671	990	1370	37.9	

Table 9. Details of crop cutting experiments conducted - improved cultivars and practices.								
Sl. No	District	Season	Crop	Crop/variety	Yield data (kg per ha)		% yield increase	Remarks
					Check plot	Experimental plot		
			Sunflower	DRSH 1	810	1580	94.4	
			Castor	DCH 177	1780	2300	28.9	
			Castor	DCH Jyothi	1780	2170	21.9	
		Rabi	Rabi sorghum	CSV 22	1470	2340	59.5	
			Chickpea	JG 11	780	1330	70.4	
			Chickpea	JAKI 9218	780	1470	88.6	
			Chickpea	KAK-2	780	950	21.8	
3	Tumkur	*Kharif*	Mung bean	Pusa Vishal		430		
			Mung bean	LGG 460		420		
			Mung bean	KKM 2		360		
			Groundnut	ICGV 91114	837		23.6	
			Groundnut	TMV 2	677			
			Maize	Hybrid	1460	1660	13.7	Aquasap
4	Vijayapura	*Kharif*	Maize	NK 6240		1000		
			Castor	DCH 177		1600		
			Sorghum	BJV 44		2000		
			Sorghum	M 35-1	643	770	19.0	
			Safflower	PBNS 12	921	1140	23.7	
			Pigeonpea	ICPL 88039	266	300	12.8	
			Pigeonpea	ICPL 161	460	520	13.0	
			Pigeonpea	ICPL 85063	1300	1500	15.4	
			Pearl millet	Dhanasakti	1822	1950	7.0	% increase over Hi-Tech
			Pigeonpea	ICPL 88039	843	930	10.4	% increase over Red-Gulyal
			Pigeonpea	Red-Gulyal	784	903	15.2	
			Pigeonpea	ICPL 88039	827	1070	29.5	
			Pearl Millet	JK 249 Hybrid	1341	1820	35.9	
			Pearl Millet	ICTP 8203	1751	2000	14.4	
		Rabi	Chickpea	KAK 2		1500		
			Chickpea	JG 130		1800		
			Chickpea	JAKI 9218		1900		
			Chickpea	JG 11		1900		
			Chickpea	JAKI 9218	699	740	6.2	% increase over JG 130

9.2.5.2 Evaluation of Improved Cultivars in Raichur

Field trials for groundnut crop with cultivar ICGV 91114 were conducted in Raichur district. The variety is high-yielding, matures in 90-95 days, is tolerant of mid-season and end-of-season drought, has an average shelling percentage of 75%, oil content 48%, and has better digestibility and palatability of haulms for animals. Due to its early and uniform maturity, attractive pod and seed shape and high shelling percentage, ICGV 91114 is becoming popular among farmers of Karnataka. A total of 10 trials were conducted on 5 ha area and the average pod yield was more than 2,540 kg/ha in improved practice compared to the farmers' practice yield of 1,450 kg/ha (Fig. 24). The increase in pod yield with improved management using ICGV 91114 was up to 75% compared to local variety TMV 2.

Similarly, with pigeonpea cultivar evaluation, two hybrids viz. ICPH 2671 and ICPH 2740 were tried with popular ICRISAT varieties Asha and Maruti. These are the first pigeonpea (first of any legume in the world) commercial cytoplasmic-nuclear male-sterility (CMS) based hybrids, and are the results of crop improvement efforts by ICRISAT. These CMS-based medium-duration pigeonpea hybrids were developed by ICRISAT, ICAR and partners under a project supported by Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM), Ministry of Agriculture, Government of India. These hybrids have been found most promising with respect to yield, stability, disease resistance; they are also resistant to shattering and have more root biomass compared to other existing varieties. The special characteristic of the hybrids is the good *dal* quality and was rated by most (80%) respondents as "better than the market sample" in flavor, taste and cooking time.

With hybrid ICPH 2671 (*Pushkal*), four varietal evaluation trials were carried and the hybrid performed quite well under good management conditions and recorded a maximum yield in Raichur (1,550 kg/ha) whereas average yield across the district was 970 kg/ha which is 66% higher than farmers' practice (520 kg/ha). The evaluation of hybrid ICPH 2740 was taken on two farmers' fields and it responded well to good management practices.

The varietal trials on castor were conducted with hybrid DCH 177 to evaluate its performance. This hybrid is high-yielding (1550 to 2130 kg/ha), early-maturing (90 to 100 days) and has oil content of about 49% and is recommended for growing in Karnataka, Tamil Nadu, Maharashtra and Orissa. More importantly, it is tolerant to Fusarium wilt and whitefly insect. Overall, average increase in yield across all the districts over the traditional variety was 28%.

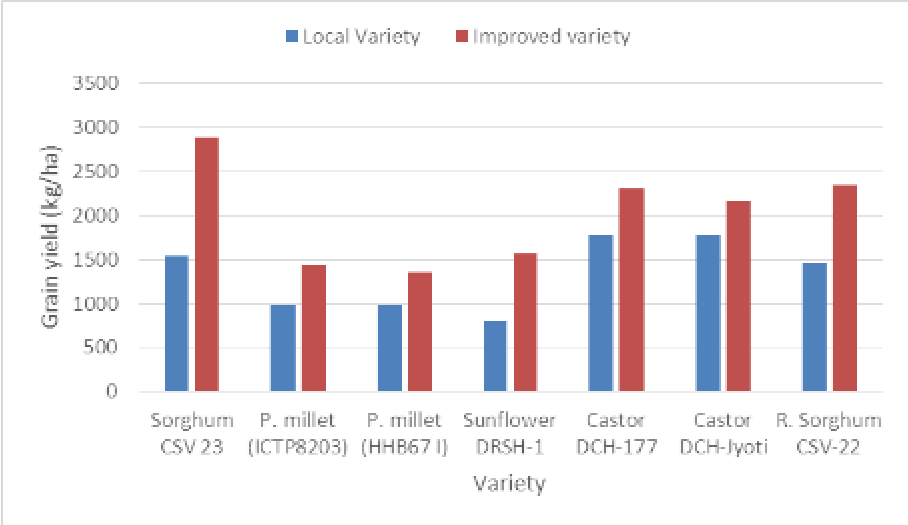


Figure 24: Farmer participatory varietal evaluation of pulses in Raichur district.

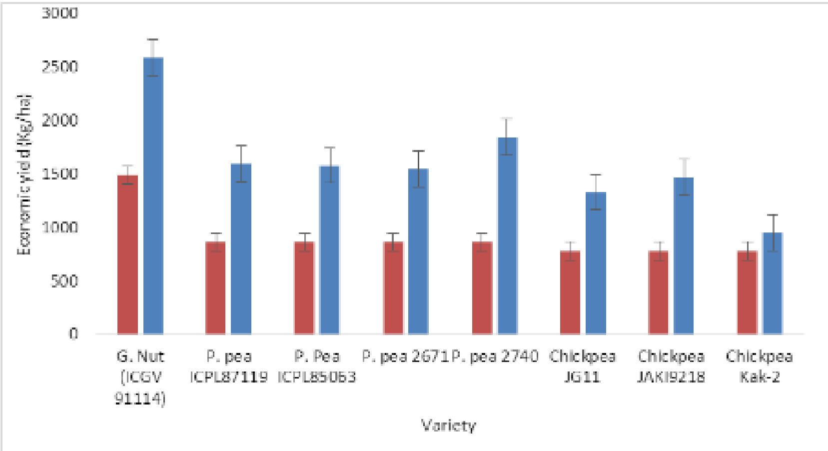


Figure 25: Farmer participatory varietal evaluation of cereals and oilseeds in Raichur district.

9.2.5.3 Evaluation of Improved Cultivars in Tumkur

Finger millet (*Eleusine coracana)* is the most important cereal food crop in Tumkur and farmers continued to be interested in evaluating finger millet *(ragi)* varieties for higher productivity. As part of participatory field evaluations, *ragi* cultivar MR 1 was extensively taken up for demonstrations in Tumkur as against their traditional variety GPU 28. Finger millet is a hardy crop that requires less water, but higher yield can be achieved with supplemental irrigation. The average yield of all the trials was 2,550 kg/ha which is 63% higher than the farmers' practice with traditional variety (Figure 26).

In other evaluations, groundnut variety ICGV 91114 recorded 35-40% increase in yield compared to local existing variety. Farmers like the cultivar because of its ability to sustain in drought situations and yield more in normal situations. The pigeonpea variety ICPL 87119 responded well under low rainfall conditions and yielded 40-45% higher than the existing local variety which is susceptible to sterility mosaic virus disease.

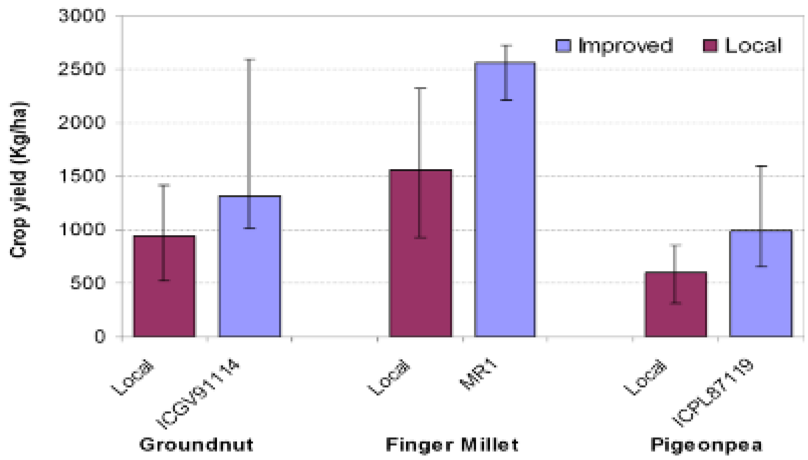


Figure 26: Farmer participatory varietal evaluation in Tumkur district.

9.2.5.4 Evaluation of Improved Crop Cultivars in Chikkamagaluru

Trials for pigeonpea with six improved cultivars were conducted in Chikkamagaluru with local check. The pigeonpea hybrids were found to perform better compared to the local variety and other ICRISAT varieties were also found to be the better option in the targeted sites in the district. All these varieties and hybrids recorded 15-20% increase in yield over local check (Figure 27).

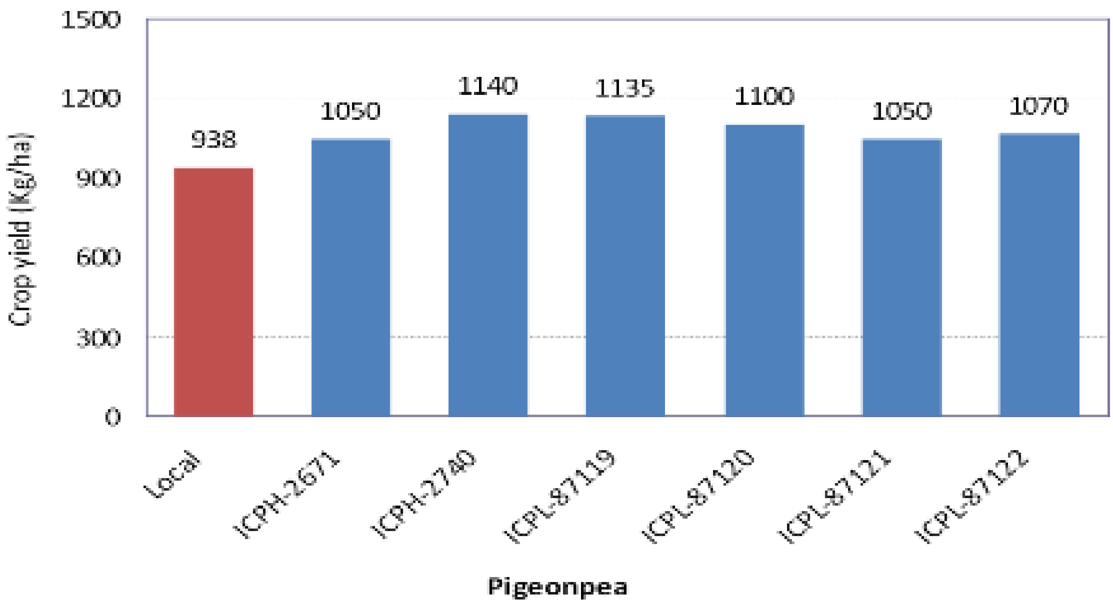


Figure 27: Farmer participatory varietal evaluation of pigeonpea cultivars in Chikkamagaluru district.

For *ragi*, the variety evaluated MR 1 was found to have 15-25% higher yield compared to local variety GPU 28. In groundnut, the cultivars ICGV 91114, ICGV 00308, ICGV 44 were used for varietal evaluation. These varieties are high-yielding, mature in 90 to 95 days, are tolerant of mid-season and end-of-season drought, have average shelling turnover of 75%, oil content 48%, and have better digestibility and palatability of haulms. Due to its early and uniform maturity, attractive pod and seed shape and high shelling turnover, ICGV 91114 is becoming popular among farmers of Karnataka. The average pod yield was a maximum 2,790 kg/ha for ICGV 91114 while the local variety yielded 1,120 kg/ha. The increase in pod yield with improved management for these three varieties ranged from 120-150% compared to local variety TMV 2 (Figure 28).

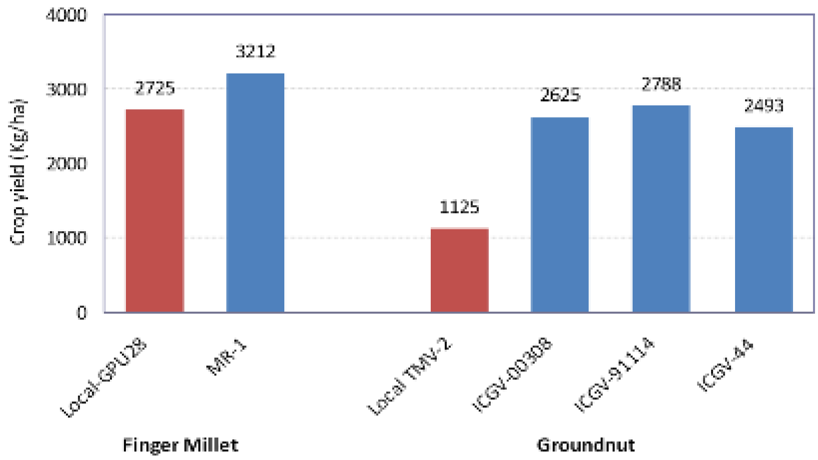


Figure 28: Farmer participatory varietal evaluation in Chikkamagaluru district.

9.2.5.5 Evaluation of Improved Crop Cultivars in Vijayapura

Evaluation of pearl millet with two hybrid cultivars ICTP 8203 and HHB 67 (improved) were conducted in Vijayapura. Hybrid ICTP 8203 is of medium duration variety (75-80 days) with medium height (1.5-1.6 m) and has good resistance to downy mildew and tolerance to drought. Hybrid HHB 67 performed quite well and recorded 29% higher yield compared to the traditional variety.

The hybrid HHB 67-2 (improved) is the first product of marker-assisted breeding to reach cereal farmers in India. It is an improved, downy mildew-tolerant version of HHB 67, a single-cross grain hybrid developed at Chaudhary Charan Singh Haryana Agricultural University, Hisar, in collaboration with ICRISAT. Like HHB 67, it is early maturing, has high-tillering, extra-early maturity (64-65 days) and medium-tall height (170-200 cm). The hybrid has really performed well and has recorded 46% higher yield over the traditional variety.

For pigeonpea, the variety Asha performed well compared to the mosaic-susceptible local variety and has recorded 12% higher yield over the local.

Farmer participatory varietal evaluations of two chickpea cultivars viz. JG 11 and JAKI 9218 were conducted. JG 11 (ICCV 93954) is a *desi* chickpea variety developed by ICRISAT in partnership with Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh, India. It was released by the Central Variety Release Committee of India for southern India. JG 11 has spread rapidly in southern India during the past five years. It is gradually replacing the variety 'Annigeri' that has been holding sway here for over four decades. Farmers prefer JG 11 because of its early maturity (95-100 days), high yield (up to 2.5 t/ha in rainfed condition and up to 3.5 t/ha under irrigated conditions), attractive large seed (22 g/100 seed) and most importantly, high tolerance to Fusarium wilt (<10% mortality). The average recorded yield in the district was 55% higher than farmers' preferred traditional variety.

The variety JAKI 9218 is semi-spreading, profuse branching and bold seeded with excellent seedling vigor and golden yellow grain color. The variety has recorded 45% higher grain yield than farmers' practice with local variety (Figure 29).

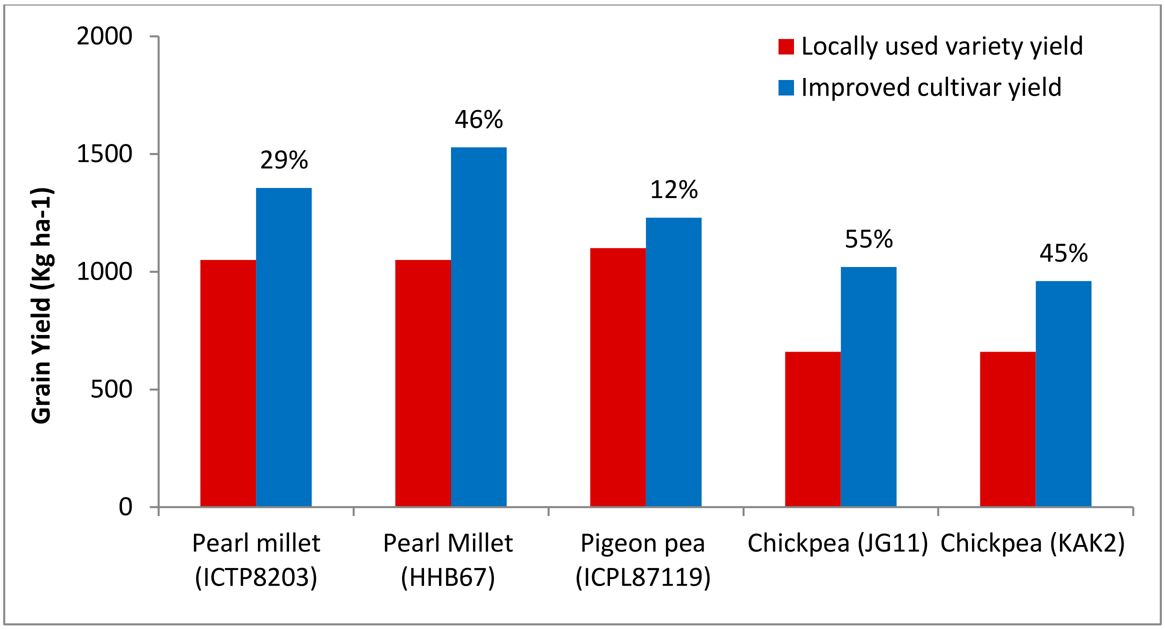


Figure 29: Farmer participatory varietal evaluation in Vijayapura district.

Fallow management

Introduction of vegetable cowpea and vegetable mung bean

In Chikkamagaluru district most of the farmers are practicing rice-fallow system after the harvest of *kharif* rice. Climatic conditions of rice fallow lands in many areas are suitable for growing vegetable cowpea and mung bean. The residual moisture left in the soil at the time of rice harvest is often sufficient to raise short-season crops. Further, the introduction of short-duration rice ensures that fields lie vacant by October. During 2015, efforts were made by AVRDC to introduce vegetable cowpea and mung bean in 25 ha in order to intensify the rice cropping system in Chikkamagaluru district. The yields obtained from these fields were encouraging and efforts are on to scale out the area under these crops in this region. The improved varieties such as Pragathi and KM 5 performed better compared to the local variety i.e., C 152. The yield data showed that nearly 35% higher yield was achieved in case of Pragathi and 18.4% in the case of KM 5 compared to C 152 variety (Table 10).

Table 10. Vegetable cowpea yield in Koppa *taluk*, Chikkamagaluru district

Cultivars	Yield (kg/ha)	% increase over local variety
Pragathi	930	34.7
KM 5	690	18.4
C 152	580	-

Promotion of mung bean (green gram)

Improved varieties of mung bean seeds have been supplied and encouraged farmers to cultivate the fallow land during pre-*kharif* season to maximize the land utilization as well as earn additional income with available soil moisture. Mung bean is the third most important pulse crop cultivated in India covering an area of 3.43 m ha, with production of 1.71 tons and an average productivity of 498 kg ha^{-1} (Anon, 2012). Important mung bean growing states in India are Rajasthan, Odisha, Andhra Pradesh, Maharashtra, Karnataka and Bihar among which Rajasthan occupies larger area and production. Uttar Pradesh leads first in productivity with an average yield of 690 kg ha^{-1}. In Karnataka, it occupies an area of 293,000 ha with a total production of 73,000 tons and an average productivity of only 250 kg ha^{-1} (Anon., 2012). This accounts for less than half of the national productivity thereby indicating the scope to improve its productivity. The production and productivity of mung bean is reported to be low in Karnataka due to non-availability of suitable mung bean varieties. The yield ability of mung bean is mainly dependent on date of sowing. Hence new varieties *viz.,* Pusa vishal, KKM 2, DGGV 2 and BGS 9 were adopted in three districts during pre-*kharif* 2015.

Mung bean cultivars identified by researchers and farmers for higher seed yields

Varieties with specific and general adaptation were identified and recommended for specific growing sites. Seeds of selected varieties are safely stored. During pre-*kharif* 2015, ICARDA introduced new varieties of mung bean in selected Bhoosamrudhi *taluks*/villages in 12 acres. Field interactions on soil health, soil profiling, and selection were done in collaboration with the Department of Agriculture. In these areas, soil health information was shared by ICRISAT and that has been utilized for knowing the soil fertility status, and based on that needed fertilizers was recommended and applied.

Technology intervention

Timely transfer of important technological interventions to the farmers who took up mung bean cultivation was followed by close supervision based on the physiological stages of the crop. The details of these technological interventions are given below.

Sowing Time:

First fortnight of May to first fortnight of June

Seed Rate and Spacing:

12 kg/ha (4.8 kg/acre)

Spacing maintained at 30cm x 7.5 - 10cm

Seed Treatment

1. Seeds soaked for 1 hour in 2% Calcium chloride and then dried in the shade for 7-8 hours before sowing.
2. Seeds treatment with Carbendazim (1g a.i./kg seed) + Thiram (2g/kg seed) after seed priming followed by Rhizobium inoculation (40-45 gm/kg seed).
3. Treated seed are not exposed to direct sunlight.

Fertilizer Dose:

1. Straight fertilizer applied for mung bean cultivation in the following dose
   N:P:K @ 25-50-20 kg/ha and Gypsum @ 100 kg/ha
   (FYM @2- 5 t/ha to maintain soil health)
2. Fertilizer applied in furrows just before sowing during last ploughing followed by planking.

Foliar Spray

2 per cent urea sprayed at pre-flowering stage i.e. 25-30 days after sowing for normal sowing.

Weed Management

Two time inter cultivation at 40 days interval before and after sowing

For mung bean production, improved varieties and improved package of practices provided, on an average a yield of 350 kg/ha. The state average productivity of mung bean during 2010-11 was 270 kg/ha. Pusa Vishal variety yield potential is 1,200-1,400 kg/ha as per research studies, however, due to prolonged dry spell during the cropping period the average yield was 345 kg/ha in pilot villages. Mung bean yield in demonstration plots ranged between 200 kg/ha and 440 kg/ha with an average 350 kg/ha in the district (Figure 30).

Figure 30: Mung bean (green gram) crop after spraying 2% urea (L) Comparison of local vs early maturing Pusa Vishal variety (R).

Promotion of mung bean

Mung bean was sown in Kasbe camp and other Bhoosamrudhi villages as a farmer participatory demonstration for increasing the income of farmers by proper land use. Mung bean was sown by some using irrigation and by others with the summer rains that occurred in mid-May. Mung bean variety BGS 9 was sown by most of the Bhoosamrudhi demonstration farmers (Figure 32). Looking at the demonstrations, other farmers also raised mung bean but the variety they used was Sipai. A few farmers have raised variety Pusa 3. BGS 9 mung bean was found to be more vigorous than Sipai. Some farmers hand-weeded the mung bean fields and left the weeds in the field or placed the weeds on the bunds. The need for collecting the weeds from the fields and proper disposal of the weeds was explained to the farmers as the predominant weeds such as *Trianthema portulacastrum* have the capacity to regenerate, if left in the field. In some mung bean fields, volunteer rice seedlings were observed to be abundant. The application of post-emergence herbicide quizalofop (Turga super) at 300 mL/acre at 20–25 days after seeding was advised to farmers for properly and effectively managing weeds with less cost. Mung bean yield varied among the farmers and the varieties grown. On average, Sipai, BGS 9, and Pusa 3 yielded 8, 10, and 10 quintals per ha (Table 11). The farmers gained a net income of Rs. 21,750-29,400 because of growing mung bean prior to rice in the *kharif* season. The crop was harvested in mid-June and the rice was sown by some using zero tillage and by others after minimum tillage as advocated by Bhoosamrudhi.

Figure 31: The possibility of growing a mung bean (variety BGS 9) crop was demonstrated in a farmer participatory manner by sowing mung bean with the onset of monsoon as a part of crop intensification in Raichur District.

Table 11. The yield and economics of mung bean grown before direct-seeded/transplanted rice in Raichur District.

Variety	Yield (q/ha)	Gross income* (`/ha)	Cost of cultivation (`/ha)	Net income (`/ha)
Sipai†	8	36,450	14,700	21,750
Pusa 3 ‡	10	44,100	17,150	29,400
BGS-9¥	10	39,600	13,230	26,125

Note: Values are average of † and ‡ = 3 farmers; ¥ = 8 farmers; * at `4,500 per quintal mung bean

Bhoosamrudhi project 2016-17 gave special importance to promote mung bean in parts of Raichur district, as a part of productivity enhancement trial (PET), we have introduced mung bean varieties like BGS 9 and IPM 2-14 which are good in yield and suitable for machine harvest. Farmers got yields around an average of 4-5 quintals/acre. Farmers were able to gain additional income with very less irrigation and inputs (Figure 32). We introduced mechanical harvesting to save labor cost and time and it was a success (Figure 33).

Figure 32: Mung bean (BGS 9) grown as a pre-**kharif** ***crop to generate additional income to farmers.***

Figure 33: Mung bean variety BGS 9 grown at Kasbe camp (L); Mechanical harvesting (R).

Sustainable intensification of cotton systems through relay planting of maize in standing cotton (after 2/3rd picking)

Cotton is an important commercial crop of Raichur district in Northern Karnataka. Cotton is raised under irrigated as well as rainfed conditions especially in the tail-end command areas where irrigation is limited. In conventional practice, farmers generally raise a single crop and the yields dependent mainly on assured irrigation and availability of timely adequate rainfall. But cotton yield is subjected to uncertainties as both of the above situations are not in control. To stabilize the income opportunities of the cotton farmers, we explored the possibility of sustainable intensification of cotton through introduction of a relay crop which can be raised under residual moisture without any competition with the main crop using a novel technology (relay planter). For the success of relay crop in cotton, the timing of its introduction is very crucial. The relay crop can be sown either at the early stages, preferably sowing along with cotton, or at the latter stages such as after the second picking. We explored the possibility of inclusion of a second crop through relay seeding of maize and other crops in standing cotton to capture the residual moisture for crop establishment and advancing planting to escape the heat stress at pollination. Ten participatory validation trials have been established on relay planting of maize in standing cotton using the best-performing as well as some new maize hybrids identified during *kharif* 2013. The maize was planted in standing cotton after the third picking. This is an important strategy for sustainable intensification in these resource-constrained areas to increase the productivity, profitability and livelihoods of farmers.

Crops such as mung bean, chickpea, maize and sorghum were used as relay crops. Intensifying cotton was rewarding, especially when relayed with short-duration crops utilizing residual soil moisture. During the year 2015-16, kapas yield of cotton remained low when planted alone and became less profitable as yields were lower (1.0 to1.3 t/ha) than normal (4-5 t/ha).

Figure 34: Chickpea as a relay crop in cotton; Sorghum as a relay crop in cotton

The prevailing dry conditions and delayed canal releases led to lower yields and farm income. The cotton yield was not much affected by relayed chickpea and sorghum. When crop was relayed with chickpea in the latter stages, the cotton-chickpea system became more stabilized as the farm income increased from `42,750 to `68,375, as the cotton equivalent yield increased from 1.13 to 1.76 t/ha. An improvement of system productivity (Cotton equivalent yield: CEY) by 56 % was observed in cotton-chickpea and 43% in the cotton-sorghum system compared to cotton alone. Efforts of intensifying cotton especially with chickpea were more successful with potential multiplication in other areas where cotton is cultivated in more than 100,000 acres. Introduction of mechanization in cotton along with relay technology has gained momentum in the area.

Table 12. Profitability of cotton in relay cropping.

System	Cotton yield (t/ha)	Chickpea/ sorghum yield (t/ha)	Cotton equivalent yield(t/ha)	Cost of cultivation (`/ha)	Gross return cotton (`/ha)	Gross return of relay crop (`/ha	Total returns (`/ha)	Net returns (`/ha)
Cotton	1.1	-	1.125	24,125	42,750	-	42,750	18,625
Cotton+ chickpea	1.0	0.7	1.762	31,625	38,000	30,375	68,375	36,750
Cotton+ Sorghum	1.0	0.6	1.624	32,250	38,000	23,750	61,750	29,500

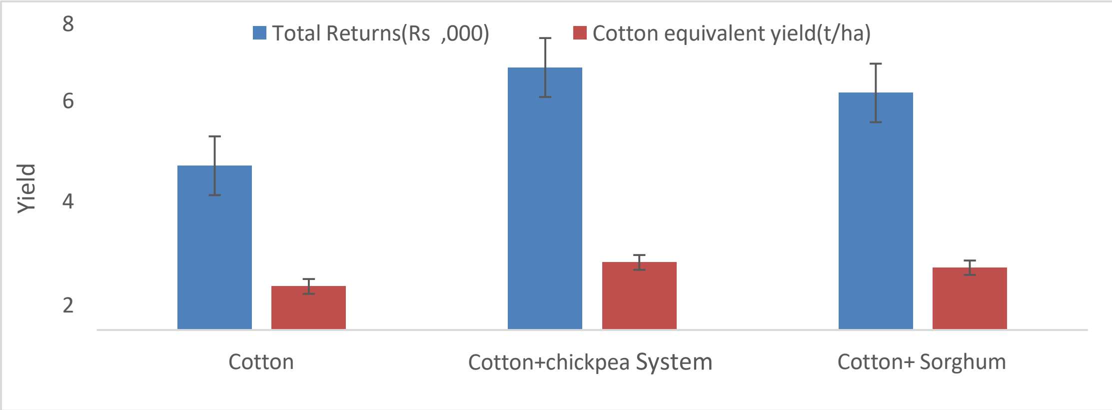


Figure 35: Comparison of cotton based cropping system in Raichur.

Evaluation trials on surface and subsurface drip irrigation

The state of Karnataka faced an unprecedented drought in succession. In canal commands, due to non-availability of water, farmers were forced to grow a single crop of rice in the rice-rice cropping systems. Farmers in the tail-end found it difficult to raise even a single crop of rice. In this region, DSR which became popular, faced shortage of water even for the *kharif* crop. To address the growing challenges of water shortage, participatory innovative research-cum-validation trials integrating DSR with micro irrigation were initiated during *kharif* 2015.

During the year 2016, four participatory strategic research trials were laid out – 16 involving surface and subsurface irrigation in DSR. This is an innovation in the state of Karnataka (Table 13).

Table 13. Details of demonstrations on surface and subsurface drip.

S.No	Name of the Farmer	Name of the village	Crop/Area
1	Hari Babu	Vijayanagar camp	Rice 2 acres
2	Satyanarayan	Vijayanagar camp	Rice 1 acre
3	Suresh	Govindoddi	Rice 1.5 acre
4	Anandgowda	Govindoddi	Rice 1.5 acre

Figure 36: Surface drip irrigation with laterals placed 60 cm and 80 cm apart.

The details of irrigation regimes followed at different sites are:

Site 1 : Transplanted rice (8 cm standing, allowed to recede to saturation before flooding again), DSR (as practiced by farmers, 5 cm standing, allowed to recede to saturation before flooding again), surface irrigation (60 and 80 cm lateral spacing), subsurface irrigation (60 and 80 cm lateral spacing placed at 10 cm depth).

Site 2: Transplanted rice (5 cm standing, allowed to recede to saturation before flooding again), surface irrigation (60 and 80 cm lateral spacing).

Site 3: Transplanted rice (8 cm standing, allowed to recede to saturation before flooding again), DSR (as practiced by farmers, 5 cm standing, allowed to recede to saturation before flooding again), surface drip irrigation (60 and 80 cm lateral spacing), subsurface irrigation (60 and 80 cm lateral spacing placed at 10 and 15 cm depth).

Site 4: Transplanted rice (8 cm standing, allowed to recede to saturation before flooding again), DSR (as practiced by farmers, 5 cm standing, allowed to recede to saturation before flooding again), surface drip irrigation (60 and 80 cm lateral spacing), subsurface irrigation (60 and 80 cm lateral spacing placed at 10 cm depth).

Results of the trial at site 1 revealed that the growth parameters viz. plant height, number of tillers and leaf area were inferior in transplanted rice (Table 14) compared to DSR. On the other hand, subsurface drip irrigation in DSR followed by surface drip irrigation with laterals spaced 60 cm apart recorded better growth parameters. Data on yield and related yield parameter are provided in Table 15. In general, higher grain yield was recorded in DSR with micro irrigation. The lowest (7.40 t/ha) grain yield was observed where rice was transplanted followed by direct seeding (7.60 t/ha) with farmers' practice of water management. The highest grain yield (10.10 t/ha) was observed in DSR receiving irrigation through surface drip irrigation with laterals placed 80 cm apart followed by same system with 60 cm laterals (9.00 t/ha). The yield performance under subsurface drip irrigation was also identical to that of surface irrigation.

Figure 37: Layout and establishment of surface and subsurface drip and Hon. Agril Minister (GoK) interacting farmers on Drip DSR.

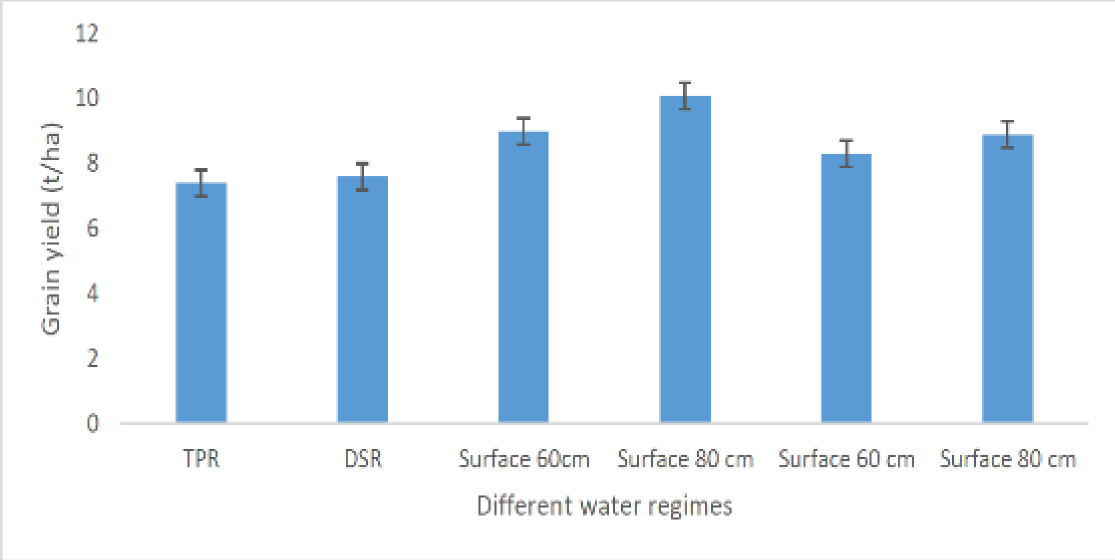


Figure 38: Effect of different water regimes on rice yield (Site 1).

Table 14. Effect of water regimes on growth parameters in rice (site 1)

Sl	Treatment	Plant height (cm)	No of tillers/hills	No of tillers/m2	SPAD	leaf area (cm2)
1	TPR	88.00±2.78	11.66±0.81	504±14.53	40.22±0.922	32.60±2.95
2	DSR (as per farmers' practice)	98.40±3.30	12.66±0.92	580±15.29	42.12±1.37	31.80±3.90
3	DSR- surface irrigation (60 cm)	92.80±2.36	13.00±0.92	679±18.54	39.04±1.66	34.73±2.57
4	DSR-surface irrigation (80cm)	82.20±3.12	12.66±0.80	600±13.83	37.66±1.37	29.95±1.95
5	DSR-subsurface irrigation (60 cm)	103.60±2.38	13.33±0.97	590±8.03	41.44±1.25	40.88±3.78
6	DSR-subsurface irrigation (80 cm)	106.28±1.56	12.33±0.92	655±15.91	41.60±1.71	36.08±2.90

Table 15. Effect of water regimes on yield parameters in rice (Site 1)

Sl	Treatment	Plant height (cm)	Seed/ panicle (no)	Chaffy seeds (%)	Test weight (gm)	Straw yield (t/ha)	Grain yield (t/ha)
1	TPR	23.22±1.11	188.60±10.09	12.83±2.52	19.03±0.12	6.00±0.02	7.40±0.05
2	DSR (as per farmers' practice)	22.24±0.44	188.00±7.09	4.89±1.71	20.00±0.26	7.60±0.05	7.60±0.03
3	DSR- surface irrigation (60 cm)	22.32±0.20	224.60±15.95	3.76±2.29	20.57±0.57	8.90±0.09	9.00±0.05
4	DSR-surface irrigation (80cm)	22.42±1.35	181.20±10.58	1.76±0.86	19.87±0.40	9.20±0.09	10.10±0.11
5	DSR-subsurface irrigation (60 cm)	22.36±1.05	22.36±1.05	2.81±1.30	20.73±0.60	8.03±0.06	8.30±0.03

All values are of 5 replicates except grain and straw which represents 3 replicates

Transplanted rice received the largest volumes of water (2,025 mm) followed by DSR (1,425 mm) where water management was still at the level practiced by farmers. Despite of water management as per farmers' practice, there was a net saving of over 30% of water in DSR compared to transplanted rice (Table 16). Looking to the low water requirement of DSR in both surface and subsurface micro irrigation systems, this practice showed the distinct possibility and could become a very potential water saving technology in the rainfed ecosystems of Karnataka. Water productivity is a best indicator of water used by the crop with response to crop yield in any production system. Lowest water productivity was observed in transplanted rice (0.36 kg m^{-3} water) which remarkably improved under direct seeding (0.53 kg m^{-3} water). However, with surface and subsurface drip irrigation, the water productivity (WP) recorded was almost three times more than the conventional flood irrigation in TPR. Layering micro irrigation with DSR led to significant increase in WP recorded at 1.52 and 1.40 kg m^{-3} water under surface and subsurface micro irrigation, respectively. However, these results are of first season and preliminary which will get confirmed for succeeding seasons/years under diverse condition. Many farmers are already convinced and started realizing the importance of this innovation.

Table 16. Water budgeting as influenced by various cultures of rice (Site 1)

Treatments	Irrigation water (mm)	Rainfall during season (mm)	Total water applied (mm)	Water productivity (kg grain m^3)	Grain yield (kg/ha)	Water saving (%)
TPR	1600	425	2025	0.36	7.4	
DSR	1000	425	1425	0.53	7.6	30
DSR Surface drip 60 cm lateral	183	425	608	1.48	9.0	70
DSR Surface drip 80 cm lateral	217	425	642	1.57	10.1	69
DSR, Subsurface drip 60 cm lateral	178	425	603	1.37	8.3	71
DSR, Subsurface drip 80 cm lateral	194	425	620	1.43	8.9	70

Micro irrigation results of site 2

At site 2, three scenarios (transplanted rice, DSR with surface micro irrigation with laterals spaced at 60 and 80 cm) were compared. The data of this site are presented in Table 17. Transplanted rice recorded lower plant height (97 cm), number of tillers (13), SPAD (43.4), and leaf area (31.3 cm^2) compared to all other two scenarios. The highest plant height (105.4 cm), number of tillers (21.6), SPAD (40.2), and leaf area (49.5 cm2) were observed with DSR which received irrigation through surface micro irrigation where laterals spaced at 80 cm.

Rice grain yield and yield parameters as influenced by surface micro irrigation compared to transplanted rice are presented in Table18 and Figure 39. All the yield attributes were recorded higher with surface drip irrigation at 60 cm laterals followed by surface drip irrigation at 80 cm and the lowest with TPR. The panicle length (25.2 cm) and seeds/panicle (315) were found to be numerically superior in DSR which received irrigation through surface micro irrigation with laterals laid at 60 cm apart. Number of seeds/panicle (262), chaffiness (5.25%), test weight (19.8 gm), and straw yield (6.6 t/ha) were numerically lower with TPR compared to micro irrigation system in DSR.

Table 17. Effect of water regimes on growth parameters in rice (Site 2).					
Treatments	Plant height (cm)	No of tillers/hill	No of tillers/m^2	SPAD	Leaf area (Cm^2)
TPR	97±1.64	13.66±2.7	490±98.0	43.44±1.13	31.32±2.80
DSR, Surface drip 60 cm lateral	103±3.16	18.00±3.6	652±130.4	43.54±1.66	46.58±2.40
DSR, Surface drip 80 cm lateral	105±1.33	21.60±4.3	738±147.6	40.28±0.85	49.54±0.92

All values are replicates of 5 data points

Highest grain yield was recorded with DSR having drip irrigation at 80 cm laterals (9.40 t/ha) followed by DSR with drip irrigation with 60 cm laterals (8.0 t/ha). DSR with surface micro irrigation system at 80 cm laterals recorded 18% and 200% more grain yield and straw yield respectively, compared to TPR. Despite high panicle length, seed/panicle with DSR surface irrigation with lateral space 80 cm recorded high grain and straw yield due to marginally high test weight.

Table 18. Effect of water regimes on yield parameters in rice (Site 2)						
Sl	Treatments	Plant height (cm)	No of tillers/hill	No of tillers/m^2	SPAD	Leaf area (Cm^2)
1	TPR	88.00±2.78	11.66±0.81	504±14.53	40.22±0.92	32.60±2.95
2	DSR (as per farmers' practice)	98.40±3.30	12.66±0.92	580±15.29	42.12±1.37	31.80±3.90
3	DSR -Surface irrigation (60 cm)	92.80±2.36	13.00±0.92	679±18.54	39.04±1.66	34.73±2.57
4	DSR- surface irrigation (80 cm)	82.20±3.12	12.66±0.80	600±13.83	37.66±1.37	29.95±1.95
5	DSR- surface irrigation (60 cm)	103.60±2.38	13.33±0.97	590±8.03	41.44±1.25	40.88±3.78
6	DSR- subsurface irrigation (80 cm)	106.28±1.56	12.33±0.92	655±15.91	41.60±1.71	36.08±2.90

All values are of 5 replicates except grain and straw which represent 3 replicates

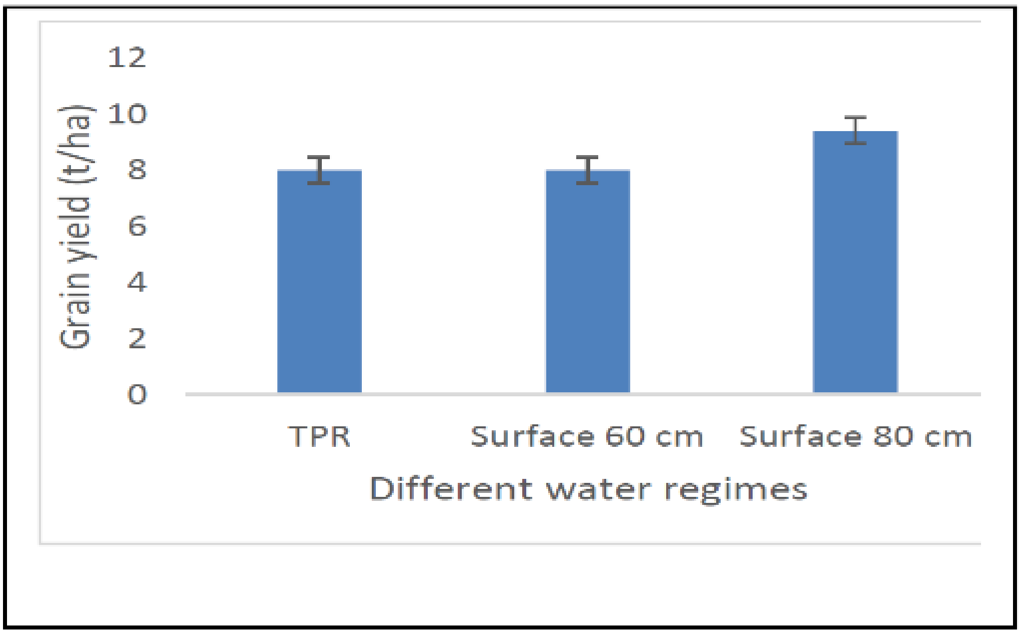


Figure 39: Effect of surface micro irrigation on rice grain yield.

Table 19. Effect of water regimes on yield parameters in rice (Site No: 2)						
Treatments	Irrigation water (mm)	Rainfall during season (mm)	Total water applied (mm)	Water productivity (kg grain (m^3)	Grain yield (kg/ha)	Water saving (%)
TPR	1100	452.2	1525.2	0.52	8000	
DSR Surface drip 60 cm lateral	177.2	452.2	602.2	1.32	8000	61
DSR Surface drip 80 cm lateral	215.4	452.2	640.2	1.46	9400	59

Surface irrigation systems resulted in saving of water to the tune of around 60% with no significant difference between the lateral spacing of 60 and 80 cm. More years of study is required on various micro irrigation regimes (both surface and sub subsurface) in DSR to understand the pattern of growth parameters and grain yield.

Dry Seeded Rice (DSR)

Seasonal scarcity of agricultural labor is one of the biggest challenges to the viability and profitability of agriculture. This is especially true for rice farmers whose primary method of crop establishment is transplanting rice seedlings into fields that have been repeatedly tilled. Labor constraints mean sowing and transplanting are often delayed, resulting in yield losses. Generally manual transplanting of rice after 2–3 puddling operations with 21–35 days-old rice seedling is common in the district. This age-old method of planting is used to reduce water percolation and also help in weed control. However, this system is labor intensive, requires huge tractor usage which often delays transplanting of paddy up to the second week of August, it ultimately leads to poor tillering, poor grain formation and low yields of rice.

Machine-sown dry DSR on the other hand is a modern agricultural technology that allows rice seeds to be sown directly into non-puddled fields, foregoing the need to raise rice nurseries and transplant seedlings. DSR generally requires one or two passes of the machine and can also be practiced under zero-tillage, offering considerable time, costs and energy savings for farmers.

- Reduces cost of cultivation (`9,000-10,000/acre) by avoiding ploughing, puddling, transplanting operations
- Facilitates timely establishment of rice that would provide opportunity to cultivate second crop in *rabi*
- Saves water by 50-70% (Irrigation frequency in DSR = once a week; Irrigation frequency in transplanted paddy = Alternate day)
- Saves energy, labor, fuel, and seed requirement
- More yield (28-30 qtls/ac) compared to transplanted paddy(22-24qtls/ac)

Introduction of new rice varieties

Under Bhoosamrudhi*,* new rice varieties viz., DRR Dhan 42 (IR 64 Drt I) and DRR Dhan 43 (released 2014-15) were evaluated for suitability and yield benefits and scaling up to larger areas in Tumkur district. The major characteristics of these varieties are given below.

DRR Dhan 42(IR 64 Drt I):

- Long slender grain type. (Released: 2014-15)

- Days to flower: 88 days; days to maturity: 120 days
- Moderately resistant to bacterial leaf blight

DRR Dhan 43 (Released: 2014-15)

- Days to flower: 88 days; days to maturity: 120 days
- Resistant to blast; moderately resistant to bacterial blight, bacterial leaf blight, neck blast, brown spot, sheath rot, etc
- About 50 acres has been covered benefiting 53 farmers in the district with new rice varieties of DRR Dhan 42 (IR 64) and DRR Dhan 43 (Figure 40).

In Bhoosamruddi program, we have demonstrated DSR technique in Hiregundagal village, Kora RSK, Tumkur taluk and Tumkur districts with the help of CIMMYT and DoA. Field experiments with Mr Dayanand Sagar, s/o Murgyappa and other neighboring farmers was undertaken in nearly 5 acres land. IR 64 which is a 120-days crop was chosen for cultivation. This experiment was undertaken between 29 July 2015 and 9 December 2016.

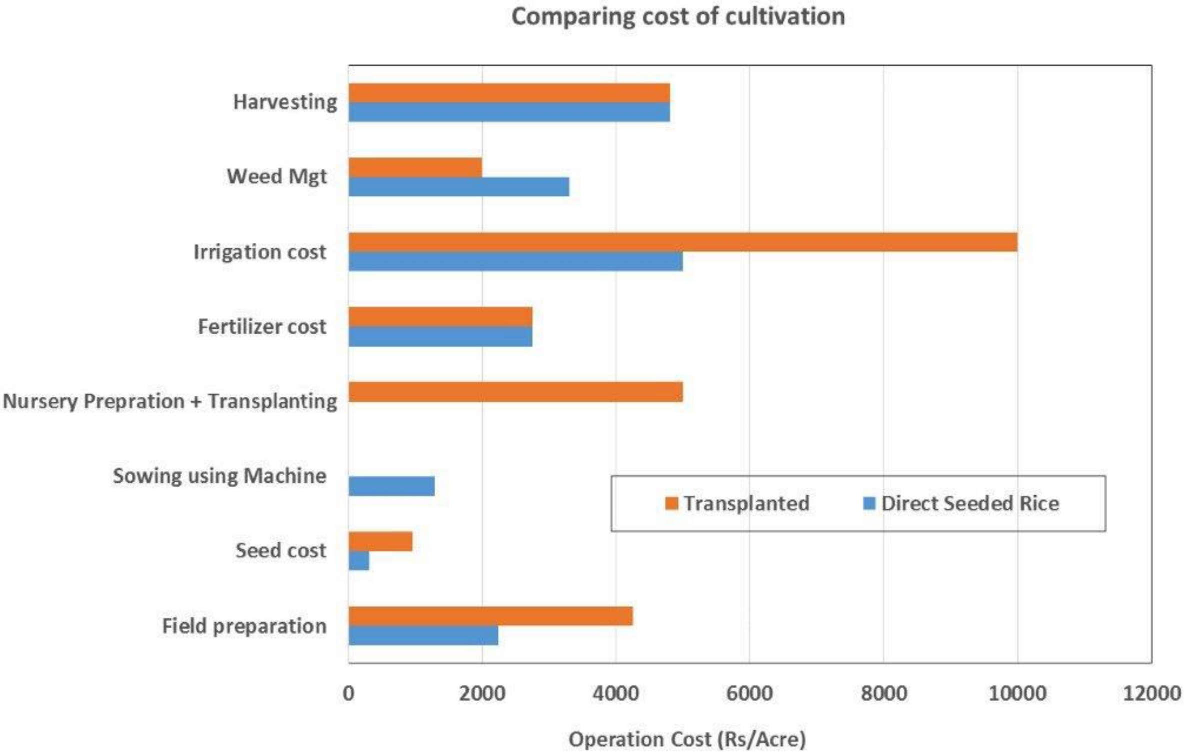
Paddy seeds were sown using zero-till multi crop planter. Zero-till multi crop planter facilitated sowing seed without any seed bed preparation or puddling which reduced a significant amount of fuel and cultivation cost. Zero-till machine makes a 4-5 cm sharp cut on the surface soil, places the seed and fertilizer appropriately and covers it with soil. As the surface soil layer is not disturbed, available moisture in the top soil is protected from non-productive evaporation losses. Recommended dose of pre-emergent weedicide (Pandi Methylene) was applied to control the weeds. Fields were irrigated once in a week or at 10-day intervals as per the need. Recommended dose of fertilizers was applied as per the defined protocol. Moreover, a nearby field was cultivated in the traditional manner (transplanted paddy method with flooded field condition).

***Figure 40: Direct Seeded Rice demonstration in Hiregundegal villages, Tumkur* taluk.**

Field days were organized to spread awareness among farmers in the neighboring villages and farmers about DSR (Figure 41).

Figure 41: DSR paddy field day organized by the Department of Agriculture.

Crop yield obtained from DSR was found to be 7.5 t ha^{-1} compared to 6 t ha^{-1} with transplantation method. Figure 43 compared the cost of different operations in both of the methods. DSR costed nearly `19,700/acre compared to `29,700/acre in case of transplantation (Figure 42a). Savings of nearly 10,000/acer was obtained mainly by avoiding puddling and minimizing irrigation. As a result, net income from DSR is found to be `22,000/acre compared to a mere `3,800/acre in transplanted condition (Figure 42b).



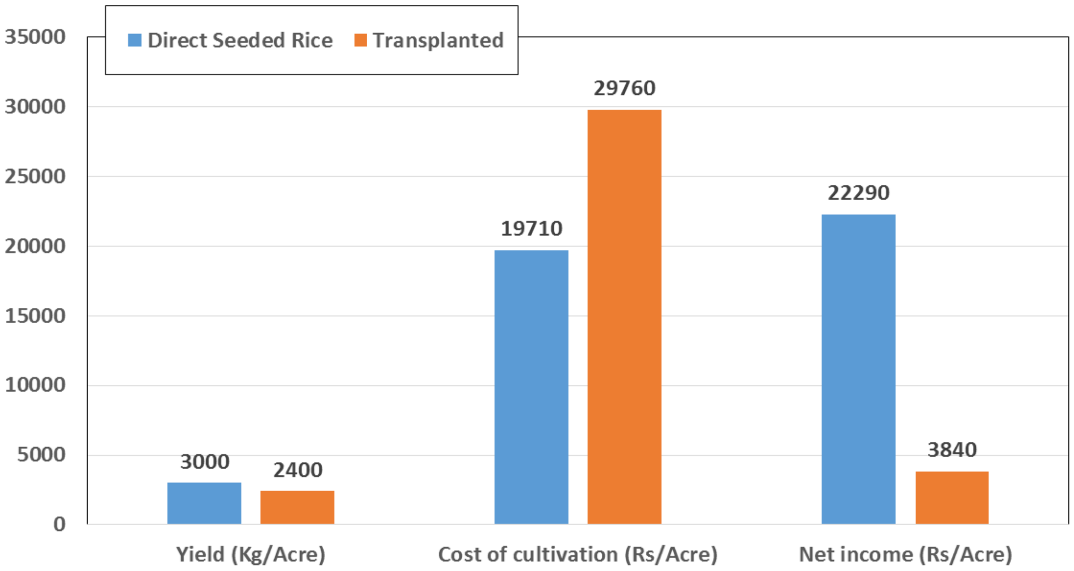


Figure 42 (a): Comparing cost of field operations among DSR method and transplanted paddy; b) comparing economic benefit of the DSR method with transplanted paddy (Data collected from Herigundegal village of Tumkur taluk, Tumkur district in year 2015-16, Farmer: Mr Dayanand Sagar).

9.2.6 Vegetable production technologies

9.2.6.1 Introduction, evaluation and scaling-up of site-specific diversification for high-value vegetables

Site-specific vegetable varieties and new crops introduced

Several new varieties/hybrids were introduced in Chikkamagalur during the project period including a) Bitter gourd (NBH-Swetha); b) Ridge gourd (NBH Raveena, Naga); c) Okra (NBH Sapna 102); d) Bottle gourd (NBH Bharat); e) Cucumber (NBH Padma); f) Cabbage (NBH Karuna Plus); g) Brinjal (Usha Kiran); h) Bird's eye chili; i) Vegetable soybean (Swarna Vasundhara, in Tumkur); j) Onion (Nasik Red in Raichur; k) French bean (Bharath) (Figure 43).

Figure 43: Nasik Red variety of onion promoted in Raichur district and French bean (Bharathi) in Chikkamagalur district.

In Raichur, farmers had been growing a local variety of onion, which was a low yielder (6.25 tons/ha). WorldVeg introduced the Nasik Red variety in the village Puchuldinne, Raichur *taluk*, which showed good promise with an average yield increase of about 30% (8.12 tons/ha). Farmers in this district have adopted this new variety and are now growing it on 35-40 ha.

Vegetable soybean

Vegetable soybean is a new crop for Karnataka, and promotion work was done through the Department of Agriculture, backed up by university research and full value-chain development by the private sector. In 2013, we supplied 2kg of seed of the vegetable soybean variety, Swarna Vasundhra to Krishi Vignana Kendra (KVK), Hirehally, Tumkur, for demonstration to farmers. In 2016, the Department of Horticulture, Raichur, developed an interest in promoting this crop in the target *taluks* and a seed procurement budget was earmarked to cover 50 ha. Though efforts were made to procure 1.5 tons of seed from vegetable soybean growers in Ranchi, Jharkhand State, the department was unable to get sufficient quantity of seed at the right time of the season.

The suitability of vegetable soybean to fit into local production systems was evaluated by Dr RV Koti, Professor, Department of Crop Physiology, University of Agricultural Sciences (UAS), Dharwad (Figure 44). Ten elite lines of vegetable soybean were evaluated at UAS, Dharwad during June-September 2013. Yields and physiological traits were collected at R_6 stage (Table 20). The photosynthetic rate and Water Use Efficiency (WUE) was measured and these measures varied significantly. The WUE of all vegetable soybean lines except AGS 459 was higher than that for the grain soybean line, JS 335 (check variety). The pod fresh weight and seed fresh weight were highest in AGS 447. The organoleptic test on a 0 to 5 scale indicated that the line AGS 406 ranked first followed by AGS 447 and AGS 457. These lines had ivory to brown colored seeds (Poornima *et al.* 2014)

In the last years of the project, the private sector showed interest in developing the whole value chain for vegetable soybean by linking farmers with higher value markets. Companies like ITC Ltd and Ruchi Hi-Rich Seeds Pvt. Ltd., came forward to promote this important protein-rich legume through contract farming.

Figure 44: Introduction of vegetable soybean in Tumkur.

Table 20. Performance of vegetable soybean in Tumkur district, Karnataka.

Lines	Leaf area/plant (cm^2)	WUE	No. of pods/plant	Fresh pod wt./plant (g)	Fresh seed wt./plant (g)	Dry pod wt./plant(g)
AGS 339	285.8	6.9	25.7	49.2	35.5	10.3
AGS380	237	6.35	20	55.2	28.6	11
AGS 406	419	6.71	36.7	57.8	34.1	13.9
AGS 447	343	5.57	34.3	62	47.1	13.2
AGS 457	220.4	5.49	27	45.2	34.6	9.6
AGS 459	518	4.46	37.7	57.6	36.1	12.7
AGS 460	443	5.82	28.7	49.1	16.3	10.9
AGS 461	447	6.22	32	31	18.8	6.5
AGS 610	224.4	5.85	21.7	48.6	28.3	10.2
Swarna Vasundhra	377	6.06	33.3	39.1	39.4	7.9
JS 335	440	5.51	43.7	32	21.4	7.7
Mean	369.1	5.89	31	48.2	30.9	12
CV	1.6	4.29	8.8	3.1	12.1	18.7
CD (5%)	98.5	0.43	4.6	2.6	6.4	3.8
SE	33.4	0.15	1.6	0.9	2.2	1.3

Bird's Eye Chili

During the project review meeting it was suggested that there was local interest in the use of bird's eye chili in Chikkamagalur district, due to its high pungency. A popular local variety from Kerala State was introduced through the Kerala Agricultural University and about 1,800 seedlings were raised in a local nursery and distributed to 16 farmers in Koppa taluk in Chikkamagalur district (Figure 45).

Figure 45: Distribution of bird's eye chili seedlings to interested farmers.

Short-duration legumes in paddy fallows and as an intercrop

A key component of the project was to increase the overall income of smallholder farmers in the project areas. Introducing high-yielding varieties of short-duration legumes into crop fallows and intercropped with long-term crops proved to be successful and practical options for increasing incomes.

Mung bean and vegetable cowpea in paddy fallows

A large number of farmers in Raichur and in a few other locations cultivate paddy during the rainy season and leave the land fallow during the rest of the year. WorldVeg introduced short-duration mung bean to be grown on residual moisture following paddy harvest, especially in Raichur. Starting in the 2013 season, 15 farmers were selected to test three varieties of mung bean; namely SML 668, PDM 139 and BGS 9 (a variety released by the University of Agricultural Sciences (UAS), Raichur). Yield data from eleven farmers was collected using crop-cuts from 5m x 5m sub plots. Four of the 15 farmers were found to have neglected their fields completely, so no yields could be obtained. Among the three mung bean cultivars, SML 668 recorded significantly (P=0.05) higher grain yield (355.7 kg/ha) compared to PDM 139 (313 kg/ha) and BGS 9 (307 kg/ha). The yield levels obtained by farmers in these trials could be increased further by adopting improved cultural practices such as timely weeding.

In the following year in 2014, WorldVeg in collaboration with IRRI promoted the cultivation of mung bean and vegetable cowpea in paddy fallows in both Raichur and Chikkamagalur (Figure 46). Five Raichur farmers cultivated mung bean in 4 ha of paddy fallow (December sown) producing an average yield of 1,250 kg/ha. The cultivation of vegetable cowpea in the paddy fallow was then adopted by 10 farmers in Raichur in December 2014. In Chikkamagalur, 10 farmers also cultivated vegetable cowpea in paddy fallows covering 4 ha (Figure 47).

Interest in this innovation has grown because not only do the legumes supplement farmers' incomes they also improve soil fertility. An additional 15 farmers in Tumkur and 12 farmers in Vijayapura district have subsequently also adopted this practice, growing both mung bean and vegetable cowpea in the paddy fallow and there is good potential for wider scaling up work to be done.

Figure 46: Cultivation of mung bean and vegetable cowpea in paddy fallows in Raichur.

Figure 47: Field days to promote cultivation of vegetable cowpea in paddy fallows were held in Chikkamagaluru (L) and Raichur districts.

The scaling-up was promoted through field days and the involvement of the private seed sector. Vegetable cowpea field days were conducted in April 2015 in Koppa Taluk of Chikkamagalur district and Manavi taluk of Raichur District (Figure 47). During 2014-15, WorldVeg facilitated the supply of 730 kg of mung bean variety SML 668 and 790 kg of vegetable cowpea variety Pragathi through Anand Biotech, a private seed company based in Indore, Madhya Pradesh, to reach out to farmers in different target districts.

Mung bean and vegetable cowpea as an intercrop in long-term crops

Mung bean and vegetable cowpea can also be successfully sown as an intercrop in coconut or sugarcane plantations. Mung bean was raised as an intercrop in coconut and areca nut gardens in Chikkamagalur and Tumkur districts. The use of vegetable cowpea in coconut plantations was promoted in Kadur Taluk of Chikkamagalur (Figure 48) and as an intercrop with sugarcane in Vijayapura district.

A total of 73 farmers in Chikkamagalur and Tumkur adopted mung bean cultivation on 27 ha and 43 farmers adopted vegetable cowpea cultivation on 19 ha. The mung bean yield was between 330 and 480 kg/ha and the yield of vegetable cowpea ranged between 2.2 and 3 t/ha.

Figure 48: Vegetable cowpea as an intercrop in a coconut plantation in Chikkamagaluru district.

Vegetable cowpea as a crop rotation with sugarcane

In Vijayapura, after the sugarcane harvest during December to January, vegetable cowpea was introduced during 2015-16 as a rotation crop to provide additional income to farmers. Data on the yields of vegetable cowpea and sugarcane in two seasons (before and after the vegetable cowpea crop), and the additional income due to vegetable cowpea were recorded from sites on six farms. The results shown in Table 21 suggest that farmers on an average obtained a yield of around 570 kg and an extra income of `130,000 by intercropping vegetable cowpea on their sugarcane farms. It is interesting to note that the second season (2016-17, post vegetable cowpea introduction year), sugarcane yield was 720 kg (accounts to 1.8% increase) higher than the previous year, which also fetched an added income of `25,276 (15.7% increase).

Table 21. Comparative assessment of growing vegetable cowpea as a rotation crop with a main crop of sugarcane in farmers' fields in Raichur district during 2015-16.

Farmer No.	Sugarcane area (m^2)	Vegetable cowpea (kg/ha)	Vegetable cowpea Total yld (kg)	Avg Price /kg	Total income (`)	Sugarcane yield (ton/ha) (2015)	Sugarcane yield (ton/ha) (2016)	*Total income (`)- Sugarcane (2015)	**Total income (`)- Sugarcane (2016)
1	8000	600	4800	12	14400	42	42.70	184163	213250
2	12000	580	6960	13	22620	38	38.80	250984	290625
3	8000	550	4400	11	12100	41	41.50	179198	207500
4	4000	620	2480	15	9300	42	43.00	92691	107250
5	4000	570	2280	12	6840	40	41.00	88303	102250
6	8000	490	3920	14	13720	38	38.30	165380	191500
Avg	7333	568	4168	13	13163	40	40.88	160120	185396
Increase in sugarcane yield (kg) & income							720		25276
% increase in sugarcane yield & income							1.78		15.79

*Sugarcane price in 2015: `2,159/ton, whereas in **2016, it was `2,500

The successful adoption of mung bean and vegetable cowpea cultivation in the paddy fallows and as an intercrop of all four districts has prompted the DoA to scale up this technology as a departmental initiative in 2017-18.

Selection and identification of vegetables and growers

In Chikkamagalur district, 375 farmers were identified in eight villages within Chikkamagalur *taluk* for project activities. Together they own 455 ha of land, out of which vegetables were cultivated on 285 ha. In Kadur *taluk*, 98 farmers were identified in three villages. Out of 148 ha of cultivated land in Chikkamagalur, vegetables were grown on 81 ha. In Chikkamagalur, the main vegetable crops grown include tomato, beans, cabbage, beetroot, onion, okra, ridge gourd, chili, brinjal, carrot, potato and leafy vegetables. In Raichur, a total of 90 vegetable growers covering an area of 100 ha were identified for interventions. Capsicum, eggplant, tomato, chili and onion were grown as the main vegetables grown in this region, mostly during the rainy season. It was observed that most farmers in Raichur with access to irrigation facilities predominantly grew paddy and were not keen on other crops. WorldVeg worked with the farmers identified by DoA officials and other project partners in scaling up of improved vegetable cultivars and production practices.

Improved agronomic practices – staking and mulching

The demonstration of open field mulching for tomato was undertaken in Chikkamagalur *taluk* and for pumpkin crops in Kadur *taluk* of Chikkamagalur district. Use of improved practices like staking (Figure 49) and mulching (Figure 50) techniques demonstrated significant benefits to farmers — an increased yield of 14%, reduction of labor costs by 30-40% and more efficient water use in the pilot areas where mulching was implemented.

Figure 49: Staking of tomato in open field and in polyroof net house.

Figure 50: Open field mulching of tomato plants in Vijayapura district.

Improved cultivation methods under protected cultivation

During 2015-16, 14 polyroof and shade net houses were constructed (160m^2) to demonstrate effectiveness of protected cultivation practices. These included 10 polyroof or shade net houses in Chikkamagalur and four shade net houses in Raichur districts. These practices provided an opportunity to demonstrate the benefits of this technology on pilot basis to farmers. All have become fully operational and farmers are successfully using them for diverse vegetable species. The commercial success of these small net house units are an important step towards promoting protected cultivation for small and marginal farmers and have encouraged the uptake of this technology and greater use of the GoK subsidies for protected cultivation in each of the target districts.

We introduced a succession of crops and improved practices over time to gradually introduce farmers to progressively more complex and remunerative technologies. In 2015, grafted capsicum seedlings were transplanted in all polyroof and shade net units, followed by indeterminate type tomatoes. Improved practices like mulching, inline drip fertigation, staking and Integrated Pest Management (IPM) practices were later adopted in all these net houses to demonstrate the integration of these technologies as critical components of the protected cultivation package. For instance, mulching and in-line drip fertigation is essential to reduce humidity and to help control diseases in protected cultivation systems.

A number of variety trials were conducted to select the best performing crops. In Vijayapura district, WorldVeg initiated trials of four indeterminate tomato varieties under protected cultivation with the assistance of the Indian Institute of Horticultural Research (IIHR). The trials were conducted under shade nets in four farmer fields to provide an extended fruiting period and to expand the yield potential. Improved practices like mulching, fertigation, in-line drip irrigation, and IPM practices were demonstrated in these net houses (Figure 51 to 54).

We also calculated the cost-benefit ratio of protected cultivation by measuring yield increases and impacts on net income (Table 22a). This will be shared with the GoK Department of Horticulture which is planning to provide different sized units of poly-net houses at subsidized rates to other farmers in the near future.

- With an initial investment of `140,000 for polyroof house and `110,000 for net house (area: 160 m^2), protected cultivation seems to be profitable, provided either government or funding body/donor support this start-up with grants to beneficiary farmers (Table 22a and b). If the initial support is not there, then farmers will take more time to recover the costs and gain profit.
- Growing capsicum under protected cultivation in Chikkamagalur district resulted in around 300% increase in the harvestable yield and ~ 1400% increase in net income. Growing capsicum under protected cultivation in Raichur district increased yields by ~102% and incomes by ~ 750%.
- There was an apparent reduced use of pesticide under protected cultivation compared to open field (2-3 fewer sprays). This benefits the health of farmers, consumers and the environment over time.
- It is important to follow crop rotation in the protection cultivation system with at least three crops per year so that farmers are able to make sufficient profits so as to offset the initial infrastructure costs. The choice of crops and off-season growing based on market demand would help to serve the above purpose.

- We have also derived the effect of protected cultivation input on the yield increase and impact on net income, considering a unit-dimension of 2000 m^2 (half an acre). The Government of Karnataka (Agri/Horti departments) is currently debating on the size of the polyroof and net house to be offered to farmers in the near future (with subsidized rates).

- Farmers claimed to be able to harvest higher quality fruits of both capsicum and tomatoes from poly-net houses as compared to the open field

- Awareness and continued training and workshops helped farmers to realize the importance of the protected way of vegetable cultivation.

Figure 51: A poly-net house structure.

Figure 52: Capsicum cultivation under shade nets provided by WorldVeg in Chikkamagalur district.

Figure 53: Demonstration of capsicum cultivation under shade nets in Vijayapura district utilizing trellising, mulching and insect traps.

Figure 54: Visit of Mr Krishna Byre Gowda, Minister of Agriculture, GoK, and the CGIAR team visiting WorldVeg's capsicum demonstration plots in Chikkamagalur.

Table 22a. On-field demonstration of effective use of protected cultivation in improving vegetable yield and income levels of farmers (Chikkamagalur district, 2015-16).

COST INCOME DETAILS 2015										COST INCOME DETAILS 2016						
Sl	Farmer / Crop	Structure	Yield (kg)	CoC	Net Income	Derived Yield (2000 m^2)	Derived NI (2000 m^2)	% increase Yield	% increase NI	Farmer	Crop	Yield (kg)	CoC	Net Income	Derived Yield (2000 m^2)	NI (2000m^2)
	Capsicum															
1	Farmer 1	P	3960	15700	27860	49500	348250			1	Tomato	1540	8650	6750	19250	84375
2	Farmer 2	P	1750	10050	10950	21875	136875			2	Tomato	1190	9130	2770	14875	34625
3	Farmer 3	P	2360	10850	15069	29490	188363									
4	Farmer 4	P	2385	11300	14935	29810	186688									
5	Farmer 5	P	2660	11400	20562	33250	257025			5	Tomato	930	8070	300	11625	3750
6	Farmer 6	P	2550	10900	17172	31900	214650									
	Average		2610	11700	17758	32640	221975	341	1650			1220	8617	3273	15250	40917
7	Farmer 7	N	2710	11700	18110	33875	226375			7	Beans	560	4440	3960	7000	49500
8	Farmer 8	N	2255	11650	13160	28190	164500			8	Capsicum	1050	9250	5408	13090	67600
	Average		2480	11675	15635	31030	195438	319	1440							
	Farmer 5	OF	560	4862	500	7000	6250									
	Farmer 1	OF	625	6264	1530	7800	19125									
	Average		590	5563	1015	7400	12688									
	Cucumber															
9	Farmer 9	N	900	8800	11000	11250	137500			9	Cucumber	630	6250	6350	7875	79375
10	Farmer 10	N	1140	9450	14490	14250	181125									
	Average		1020	9125	12745	12750	159313									
	Tomato															
11	Farmer 11	OF	850	3665	2288	10625	28600									
12	Farmer 12	OF	640	3576	1531	7975	19138									
	Average		745	3621	1910	9300	23869									
COST INCOME DETAILS 2016-17																
	Beans															
	Farmer 7	OF	130	2232	400	1600	5000									

Table 22b. On-field demonstration of effective use of protected cultivation (net house) in improving vegetable yield and income levels of farmers (Raichur District, Karnataka, 2015-16).

Farmer	Structure	Yield (kg)	CoC	Net Income	Yield (2000 m2)	NI (2000 m2)	%increase Yld	% increase NI		Farmer	Yield (kg)	CoC	Net Income	Yield (2000 m2)	NI (2000 m2)	%increase Yld	% increase NI
1	N	1750	2500	19200	21875	240000				1	1400	2500	14500	17500	181250		
2	N	1200	2300	15700	15000	196250				2	1000	2500	12500	12500	156250		
3	N	1785	3950	19150	22310	239375				3	1450	4000	15000	18125	187500		
4	N	1700	2500	17900	21250	223750				4	1520	3000	13400	19000	167500		
		1609	2813	17988	20110	224844	120	859			1340	3000	13850	16780	173125	84	639
1	OF	850	1500	1650	10625	18750											
2	OF	610	1650	2100	7625	20625											
		730	1575	1875	9125	19688											

Index: Net area (160 m^2), P-Polyroof house, N-Net house, OF- Open field, NI- Net Income, CoC- Cost of Cultivation, Derived yield (2000 m^2 or 0.5 Acre)

Grafted tomatoes and chili

Another major initiative during the project period was the introduction of grafted tomatoes and chili to farmers in Chikkamagalur and Tumkur districts during November-December 2014. Soil-borne disease such as bacterial wilt is a serious problem in growing Solanaceous vegetables like tomato, chili and brinjal in Karnataka. Grafting of commercial F_1 hybrids/ varieties suitable for cultivation in the state as scions onto resistant root stocks was considered as a viable option to tackle this problem (Figure 55). The consortium facilitated the supply of grafted seedlings from the Kerala Agricultural University's (KAU) Agricultural Research Station, Mannuthy (with the help of Prof Narayana Kutty) to meet the project needs.

Around 500 grafted tomato seedlings were introduced to farmers in Chikkamagalur district in November 2014 followed by another 500 grafted tomato and 500 grafted chili seedlings to a total of 11 farmers in Chikkamagalur and Tumkur districts in December 2014.

Figure 55: Field with grafted and non-grafted tomato seedlings.

Preliminary results from the use of grafted tomato seedlings were encouraging. It showed a 10% increased crop yield as well as 35% increased net income from growing grafted tomato compared to non-grafted crops. An added advantage was that while there was no crop loss in the grafted tomato field, there was a 15% loss of seedlings in the non-grafted field due to bacterial wilt disease.

Demand from farmers for grafted seedlings grew since this activity was initiated in November 2014. A further 1,000 seedlings were generated to supply farmers in Vijayapura district in April 2015. Based on a request from the state government, efforts were also made to transfer skills through training in the grafting of seedlings so that they could be produced from local nurseries.

Work on promoting grafted seedlings as a strategy to deal with soil-borne disease like bacterial wilt continued with the expansion of crops covered under this initiative. During the project period WorldVeg demonstrated the benefits of grafted seedling in capsicum, in addition to two other solanaceous crops taken up previously – chili and tomato.

Grafted capsicum seedlings procured from Kerala Agricultural University (KAU) were supplied to farmers in all four target districts for use in both net houses and in open field cultivation. In April 2015, 1,000 grafted capsicum seedlings were procured to be grown in 10 polyroof net houses in Chikkamagalur. Further, at the same time, farmers in Tumkur district were provided with grafted chili seedlings and exposed to their benefits through a field-based training program. Grafted tomato seedlings were also introduced to farmers in Kurkunda village of Manvi taluk in Raichur and in Hiregundagal village in Tumkur which was followed by a field training program in August 2015.

In May 2015, a training workshop was conducted in Chikkamagalur district for nursery owners and young entrepreneurs in grafting technology and its progression into a small business. Following this training, support has been extended by WorldVeg to interested nursery owners to support the development of a grafted seedling nursery.

In 2016, due to huge demands from the farmers of Raichur district, WorldVeg field staff procured the grafted tomato seedlings from KAU and distributed them to the farmers. Raichur taluk received most (17,000), followed by Lingasugur (14,000), Manvi (13,000) and Devadurga (12,000).

The grafted seedling initiative has made good progress with high acceptability in all four target districts. Farmers were exposed to the benefits of grafted seedlings and demand for these seedlings has increased since its inception. After realizing their importance WorldVeg conducted a few training workshops for young farmers to create local entrepreneurs. They may still need government support so that they would be able to supply grafted seedlings to farmers at a competitive price. Meanwhile WorldVeg has facilitated the installation of two low-cost polyroof net houses at Lingadalli Government seed farm, Tarikere, Chikkamagaluru (Figure 56) to promote grafting technique in vegetables through training.

Figure 56: Establishment of two low-cost polyroof net houses at Lingadalli Government seed farm, Chikkamagalur.

Evaluating the suitability of indeterminate tomato under protected cultivation system
WorldVeg initiated trials of four indeterminate tomato varieties (Arka Rakshak, Arka Samrat, IIHRPH 1025 and IIHRPH 2136) under protected cultivation in Vijayapura district with the assistance of the Indian Institute of Horticulture Research (IIHR) during the project period (Figure 57). The trials in four farmer shade nets in Angadageri, Aheri and Devar Nimbaragi villages were successful (Figure 58). These alternative tomato varieties had an extended fruiting period, and the crop grew like vines to heights of 6-10 feet, thus expanding the yield potential. Improved practices like mulching, fertigation, inline drip, and IPM practices were demonstrated in these net houses.

Figure 57: Indeterminate tomato with improved practices adopted in farmer shade net in Vijayapura District.

Figure 58: Indeterminate tomato field day conducted on 26 February 2016.

In Chikkamagalur district, seedlings of the indeterminate tomato Arka Samrat were transplanted in July 2016 in three poly-net houses, and capsicum seedlings in two poly-net houses. Common bean and white cucumber were sown in each shade net house during this period. Improved practices as described earlier, were adopted in these poly-net and shade net houses to demonstrate an effective integration of these technologies as critical components of a protected cultivation package.

Use of IPM methods to address tomato leaf miner incidence
The incidence of South American tomato leafminer, *Tuta absoluta* in India (Karnataka) was reported by Sridhar *et al.* (2014). The need for suitable management practices to manage the continuing spread of this invasive pest were emphasized. Trials were conducted during 2015 in

Chikkamagalur and Tumkur districts with different types of traps (supplied by the Pest Control of India, Bengaluru) to control the infestation of tomato leaf miner in 10 farmers' fields (Figure 59). In each district, four farmers' fields had both yellow sticky traps and water traps; two had only yellow sticky traps; two had only water traps; and two were check plots without any traps. In both the districts, the combination of a yellow sticky trap and a water trap gave the highest (P = 0.001) yield (Table 23).

During 2016, yellow sticky traps and water traps with pheromone lures were installed on a total of 6 ha in 15 farmer fields in Chikkamagaluru and on 3 farmers' fields in Tumkur districts to assess their performance. Results were positive and encouraging. After noting this good and effective result, the Department of Horticulture officials recommended the Karnataka government to scale up this intervention. In 2017, an area of 240 ha has been identified for this intervention to cover 600 tomato growers in Chikkamagaluru district.

Figure 59: Pheromone traps installed in Chikkamagalur and Tumkur districts to address the growing Leaf Miner challenge.

Table 23. Effect of traps on tomato yield in two districts in Karnataka.

District	Trap Type	Tomato Yield (kg/m^2)
Chikkamagalur	Control	3.40
Chikkamagalur	W	4.00
Chikkamagalur	Y	3.80
Chikkamagalur	YW	6.00
Tumkur	Control	5.40
Tumkur	W	6.00
Tumkur	Y	6.10
Tumkur	YW	7.10

Y- yellow sticky trap, W - water trap and YW- yellow sticky trap and water trap

9.2.7 Link farmers to markets through the vegetable value chain

9.2.7.1 Linking chili farmers to Paprika Oleos (India) Limited, India

During the project period, efforts were made to link chili farmers with a major chili buyer, Paprika Oleos (India) Ltd. In Chikkamagalur, the Deputy Commissioner, District Registrar and Deputy Director of Horticulture conducted meetings with vegetable growers to establish a District Horticultural Producers' Cooperative Society. Two promoters from each *taluk* were identified to initiate membership. Senior officers of Paprika Oleos (India) Ltd. were invited by WorldVeg to the region where red chili is the main crop. In January 2014, the WorldVeg team along with the company conducted two trainings on IPM for chili. Farmers started adopting the IPM practices in 24 ha. Random samples of locally produced chili were analyzed for their pesticide residues by Spices Board Lab and negative results were obtained. As a result, Paprika Oleos (India) Ltd. decided to purchase chili at a price of `110-120 per kg (standard price of the day in the major chili market), which was higher than the local market price of `70-80 per kg. Farmers felt comfortable in dealing with Paprika Oleos (India) Ltd. The company appointed one extension officer for Chikkamagalur to guide the farmers to grow clean chili for the company with a buy back arrangement. The company requested the WorldVeg team to select and accompany representative/progressive farmers to their processing plant and farms for training on chili cultivation, postharvest and buy back arrangements (Figure 60). Two farmers from Chikkamagalur district along with WorldVeg Research Technician, visited Paprika Oleos (India) Ltd. Virudhanagar, Coimbatore, Tamil Nadu, and attended the training from 30 April to 2 May 2014.

Figure 60: Chili drying operations by Chikkamagalur farmers and chili farmers in Chikkamagalur district interacting with the staff of Paprika Oleos (India) Ltd.

Advantages to farmers from this new arrangement:

1) Paprika Oleos (India) Ltd purchased the chili based on the daily price in Guntur/Agricultural Produce Market Committee (APMC) Price.
2) Local vendors normally deduct 1 kg as 'wastage' per gunny bag of 30 kg and this accounted for 4 kg loss of chili per 100 kg. No 'wastage' deduction was done by the buyer resulting in savings of 4%.

3) Weighing of produce using electronic scales with digital display gave greater confidence to farmers and was more accurate than traditional mechanical scales.
4) No spending for transportation and handling saved 2-6% of the total production cost.
5) Immediate cash payment by the company.

Further collaborative linkages were explored with the Global Green Company (which processes gherkins, tomatoes and jalapenos) and Griffith Laboratories (producer of seasonings and sources several vegetable products, particularly chili and tomato). WorldVeg also met with the Art of Living (organic vegetable farming) to explore linkages with its farmers in Chikkamagalur and a Bengaluru-based NGO, TIDE, which processes dried products for sale to major wholesale and retail outlets in Southern India. Options with the Tumkur Mega Food Park were discussed to explore collaboration prospects in facilitating the development of market linkages between project farmers in Tumakuru district and buyers/processors/exporters at the Food Park.

Postharvest – drying of vegetables using solar dryers

To overcome the constraints of open sun-drying, WorldVeg in collaboration with national partners developed and customized several types and sizes of solar dryers in South and Southeast Asia which worked well with chili and other vegetables (e.g. tomato, eggplant, cabbage and cauliflower). Solar dryers accelerate drying, protect the produce from rain, avoid food safety hazards, and produce better quality and safer products. In addition, it just takes only 1-3 days for drying vegetables. In the case of chili those processed in a solar drier have better color and are more hygienic than sun-dried crops.

For drying test quantities of chili peppers, a small solar dryer with 50 kg volume capacity is suitable. These types of solar dryers were installed for farmer groups in Chikkamagaluru and Raichur districts to demonstrate hygienic drying methods and familiarize farmers with the drying process (Figure 61). Fresh chili peppers can be dried to less than 10% moisture content in three days and the dry weight is higher than sun-dried fruits. Using this intervention, farmers sold the dried chilies at a higher price than open sun-dried ones. Based on the outcome of the preliminary trials, the state government has planned to establish similar sized dryers in other regions of the state for both chili and other horticulture produces.

Figure 61: Customized solar dryers.

In addition, initial work was undertaken to help establish a larger 1-1.5 ton commercial solar dryer for chili farmers in Chikkamagalur *taluk* who were already engaged in the chili value chain enhancement program and were used to selling their chili for production of high-value oleoresins through Paprika Oleos. These Chikkamagalur farmers have suffered crop loss during the first harvest over the past two seasons due to unexpected rains. In the absence of a hygienic drying and storage facilities the crop is not harvested or remains damp resulting in fungal growth and rotting.

An assessment of drying needs was undertaken during the visit of the WorldVeg postharvest specialists to Raichur during July-August 2016. Following consultations with farmers and departmental officials, two WorldVeg small-scale solar drying units with a drying capacity of 40-50 kg each were fabricated and installed for use by farmers through a community-owned arrangement. Test drying of samples was demonstrated. The units were also used for chili and onion drying as well as to produce sun-dried tomatoes in the district. Based on the results of these trials, the state government (GoK) has approved 12 more solar dryer units with a similar 50 kg volume capacity (year plan 2017-18) – 6 units for Chikkamagalur, 4 units for Raichur, 2 units for Tumkur.

In response to the farmers' request, WorldVeg commissioned a community-based greenhouse solar dryer (GSD) with a drying capacity of 500 kg (0.5 ton). This was installed in Basavana Baghevadi, Taluk, Vijayapura district, especially for onion growers (Figure 62). The GoK is also planning to have similar such units in other districts/regions for chili and other horticulture crops.

Figure 62: Greenhouse solar dryer in farmers' fields in Vijayapura district.

9.2.8 Feed & fodder development

Based on the PRA results of FEAST and TECHFIT tools, the International Livestock Research Institute (ILRI) demonstrated different fodder varieties in Tumkur, Bijapur and Raichur districts. Dual purpose, multi-cut hybrid maize demonstration was undertaken in Bijapur district and the performance is yet to be assessed. In Tumkur, new fodder varieties such as Sorghum CSV 41 and NK6240 maize variety were demonstrated. The performance is quite good as one-cut harvest of sorghum produced 18 t/ha fodder and multi-purpose maize variety produced grain yield of 4.5 t/ha and fodder 11.2 t/ha respectively.

In Raichur, ILRI undertook demonstration of dual-purpose maize and sorghum varieties in 20 acres of farmers' fields and the performance was quite good (Table 24).

Table 24. Participatory evaluation of dual-purpose maize cultivars			
Sl. no.	Name of the cultivar	Grain yield (q)	Stover yield (t)
1	NAC 6004	55	10
2	NK6204	70	9.5
3	NMH 731	60	9.0
4	Bioseed 9681	55	8.0
5	PMH-1	56	8.0
6	Arium (Local)	50	7.0

For Chikkamagaluru district, ILRI suggested a few important interventions based on the FEAST and TECHFIT tools results which can enhance the performance of livestock sector and increase resilience. The PRA results are most revealing.

The average land holding capacity in Lakkamanahalli village, Chikkamagaluru, was 7.5 acres per household and household size was 4-5.60; 70% of households in the village have irrigation facility and groundwater (bore wells) was the main source of irrigation. The demand for labor was more during planting and harvesting seasons. Men and women laborers were paid ₹300 and ₹200 respectively. Farmers felt that land, credit and agricultural inputs were adequately available whereas water and labor were the main constraints in carrying out farming operations.

Local breeds of livestock were reared by grazing and during summer months they were stall fed. Improved cattle were maintained only by stall feeding. Thatched and *pucca* (concrete) sheds were used to house the livestock. Roughage was chopped manually using sickles before feeding the livestock. Farmers were satisfied with the veterinary services available and farmers had good knowledge of dairy farming. They preferred indigenous cattle over crossbreds because local ones can be used for draught in addition to milk and manure. Crossbreds were not maintained because of the low price of milk and non-availability of an organized milk market. They also felt private milk traders were exploiting them by paying less money for their milk.

Fodder development

Fodder scarcity is one of major constraint faced by farmers in some parts of Karnataka. To enhance the fodder availability, measures like dual-purpose maize and multi-cut sorghum have been introduced by International Livestock Research Institute (ILRI). Field demonstrations were conducted on dual-purpose maize (NK 6240) and multi-cut forage sorghum (CSH 20 MF and CSH 24 MF). ILRI has imparted training to technicians on feed quality assessment tool and feed management.

Livestock development
Sirohi bucks (male goats) have been introduced to improve meat production of the local breed of goats in all the project areas. At least two Sirohi bucks were provided for natural insemination with local breeds of goats (Figure 63). Sirohi goats adapt to various agro-climatic conditions ranging from hot to cool climate. The breed is preferred mainly for increased meat production as it is fast-growing. It has lower mortality in kids. For natural insemination for a herd of 25 goats, one Sirohi buck was kept.

Figure 63: Beneficiary farmers with Sirohi bucks in Beeraldinni village, Vijayapura.

9.2.9 Online monitoring and evaluations of projects through monitoring software
ICRISAT developed an android-based software which is used to track activities of Bhoosamrudhi staff across all the eight BS districts on a daily basis. This captures the staffs' activities within their locations. In addition, weekly activities against workplan targets were monitored online in defined formats. In the second phase of Bhoosamrudhi, we will target to facilitate a similar tool for monitoring of all stakeholders activities/ interventions as per the defined work plan across all BS districts.

The soil sampling and crop cutting were georeferenced, which helps in mapping and identifying key issues to be addressed. DSR is one of the important activities that was scaled up especially in Raichur district. The area coverage of DSR was mapped using remote sensing technologies in 2014 and 2016, indicating the clear evidence of spread of DSR across the pilot areas in Raichur district.

9.2.10 Dissemination through farmer-to-farmer videos

In addition, for effective dissemination of good management practices a farmer-to-farmer (F2F) dissemination route has been explored through farmer-centric video documentation. Digital Green (http://www.digitalgreen.org/) is the technology partner for this innovative dissemination route. Digital Green has initiated the concept of the participatory video and mediated instruction for agricultural extension. The advantage of the F2F system is that farmers trust fellow farmers when it comes to adopting improved management practices. Farmers can easily understand these farming practices when it is explained in their language. This system has two processes: video production and video screening (Figure 64).

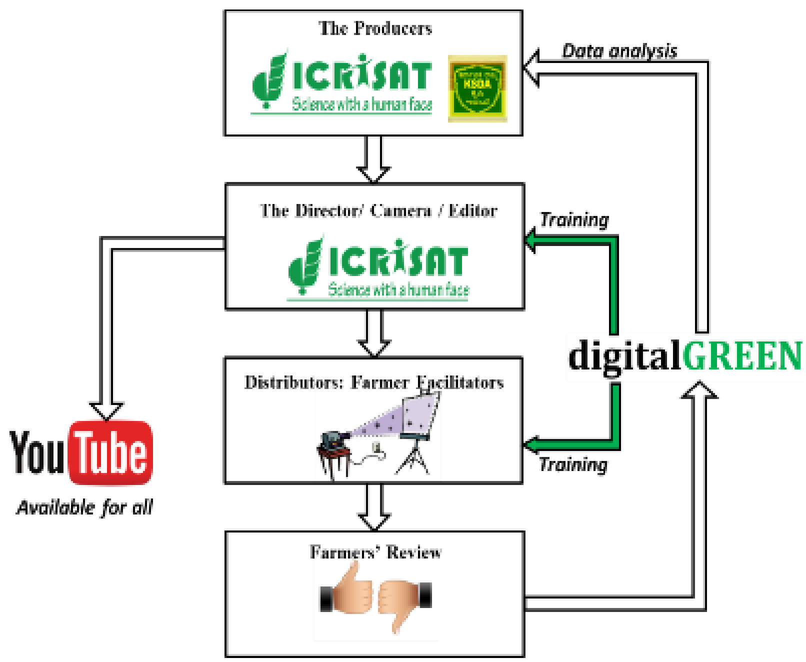


Figure 64: Flow diagram of various processes in farmer-to-farmer video documentation and screening.

The entire process of video production to screening and the various personnel involved in this process are analogous to the movie industry. In this process, the 'Producer' is research and development agencies or scientists from ICRISAT. The producer decides the subjects of the videos based on location, crops and stage of the crop. Since these videos are real-life stories, producer's field staff identifies a progressive farmer who has adopted the improved agricultural practices. The video usually contains two characters conversing about the improved technology and demonstration. Typically, the farmer shares his/her experience about the technology on camera, while a farmer facilitator plays a supporting role as interviewer. The interviews were scripted in a pithy and succinct mode. However, the message from the video is very clear so that other farmers can easily adopt the demonstrated technology. The director, camera person and editors of these productions are ICRISAT's ground staff. Digital Green has trained ICRISAT's staff in the video production process. The video production and adoption is given in Table 25.

Table 25. Progress of farmer-to-farmer video dissemination.

District	Viewers	Villages	Videos produced	Disseminations	Viewer adoptions
Tumkur	359	17	14	71	290
Chikkamagaluru	526	16	10	36	285
Raichur	257	8	12	22	162
Bijapur	858	12	14	82	240
Total	2000	53	54	211	977

9.2.11 Wastewater management

The main objective of wastewater management is to improve overall water productivity by reuse of domestic wastewater through establishing low-cost decentralized wastewater treatment (DWT) plant at the village level. The rationale behind developing DWT is water scarcity; direct use of wastewater in agriculture which is not good for farmers and consumers; disposal of untreated wastewater pollutes the environment; and all localities do not have sewage treatment plants. Safe reuse of wastewater as a part of Integrated Water Resources Management is not only helpful in enhancing crop production and income of smallholder farmers but also in improving water quality of groundwater wells and downstream water bodies.

9.2.11.1 Treatment technology: constructed wetlands

Constructed wetlands are human-made wetlands built to remove various types of pollutants (sulfate, phosphate, nitrogen load, pathogens, etc.) present in wastewater that flows through these systems (Figure 65).

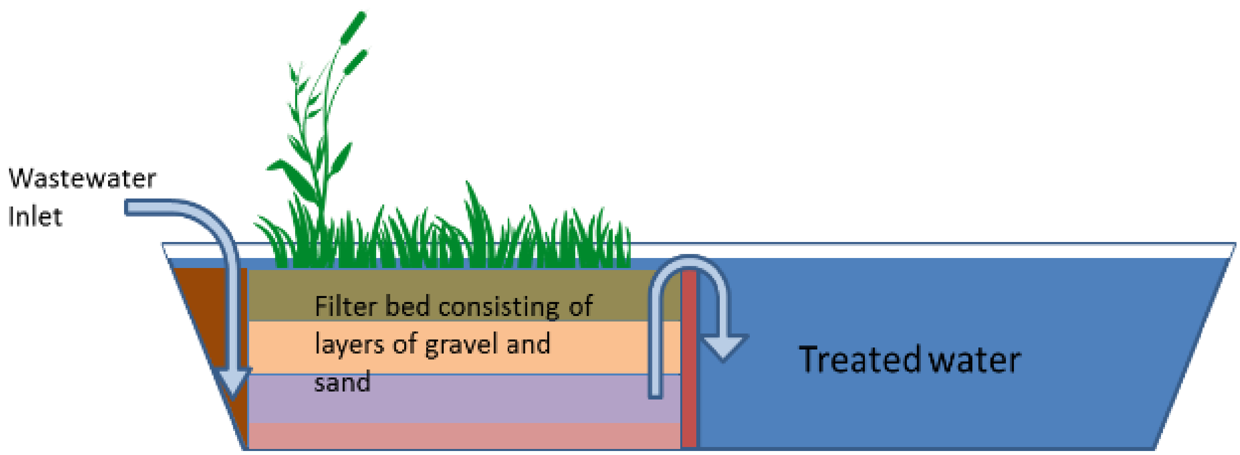


Figure 65: Schematics of constructed wetland.

Filter media

- Layers of gravel and sand

Vegetation

- Local wetland vegetation such as Cattails, *Cana indica*, water hyacinth, water lettuce, etc.

Reuse of treated water

- Non-edible crops such as lemongrass
- Fodder crop

In three out of four Bhoosamrudhi districts, wastewater treatment units were proposed and operationalized. The details are discussed below.

Vijayapur

A suitable site for the activity was selected based on a field survey in Mulasavalagi village in December 2015. The village drains were found to be silted and the wastewater sump near a local school was a threat to the health and hygiene of the local villagers (Figure 66).

Figure 66: Absence of wastewater management at Mulasavalagi village, Bijapur; a wastewater sump near the local primary school (A, B and C); and a silted drain (D).

Figure 67: Site-inspection by the ICRISAT team and local panchayat members (during December 2015).

Site description: The location (Lat: 16°53’19.6” N; Long: 76°01’26.5”) gets wastewater from approximately 900 households, however because of poor drains and hot climate (and hence the evaporation loss) an inlet flow of 90 m^3/day can be expected. The dimensions for the constructed wetlndCW was computed and was crosschecked with the land-availability. Overall, the site was feasible for the activity. A layout of the location selected is given in Figure 68. Wastewater samples were collected from the sump multiple times and the average wastewater characteristic

(Table 26) highlighted the fertigation potential with high nitrogen value specially in the absence of heavy-metals.

Table 26. Wastewater characteristics for the samples collected from Mulasavalagi village, Bijapur.		
Sl No.	Bijapur-1 water sample analysis data	Concentrations (mg/L)
1	Alkalinity (Total)	390.30 as $CaCO_3$
2	Arsenic	Below Detection Limit
3	Boron	0.28
4	Cadmium	Below Detection Limit
5	Calcium	78.00
6	Chlorides	397.40
7	Chromium	Below Detection Limit
8	Cobalt	Below Detection Limit
9	Chemical Oxygen Demand	680.00
10	Copper	Below Detection Limit
11	Electrical Conductivity	2.44
12	Fluorides	1.88
13	Hardness (Total)	636.60 as $CaCO_3$
14	Lead	Below Detection Limit
15	Magnesium	74.50
16	Manganese	Below Detection Limit
17	Nickel	Below Detection Limit
18	Nitrogen-Ammoniacal	81.82
19	Nitrogen-Nitrate	9.57
20	pH at 25 oC	7.24
21	Phosphates	2.29
22	Potassium	18.85
23	Sodium	89.70
24	Sulfate	163.63
25	Sulfur	50.00
26	Total Dissolved Solids	1464.50
27	Total iron	0.11
28	Total Suspended Solids	1214.50
29	Zinc	0.07
Sodium Adsorption Ratio (SAR)		2.45

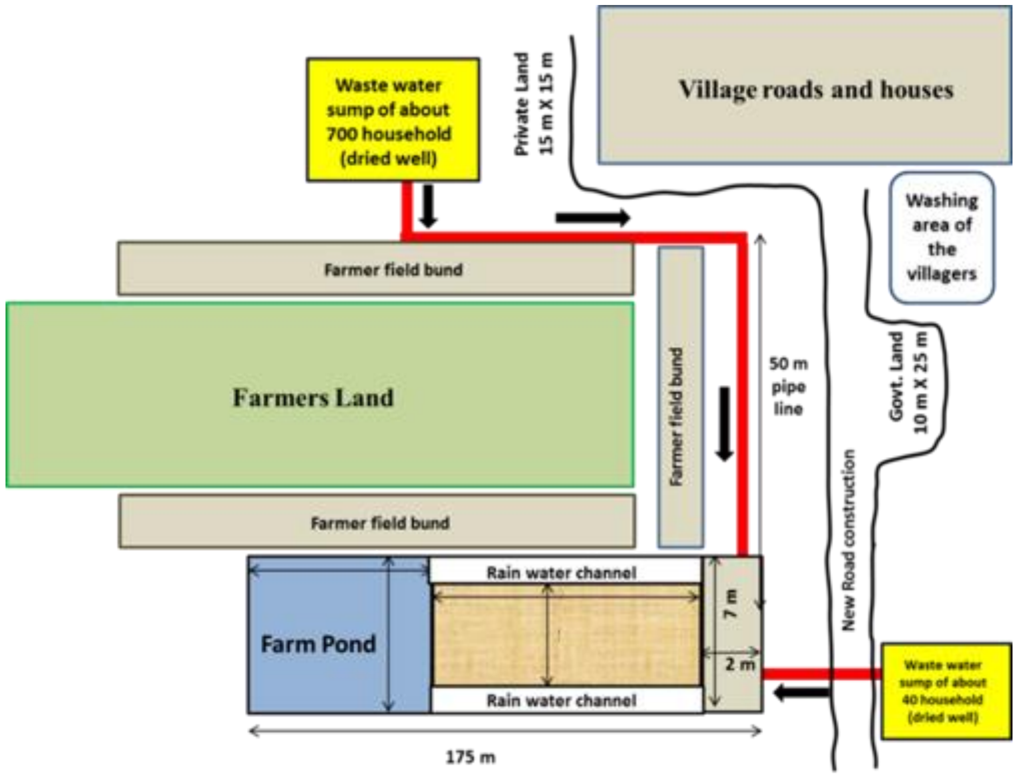


Figure 68: A layout of the proposed site for the activity (Mulasavalagi village, Bijapur).

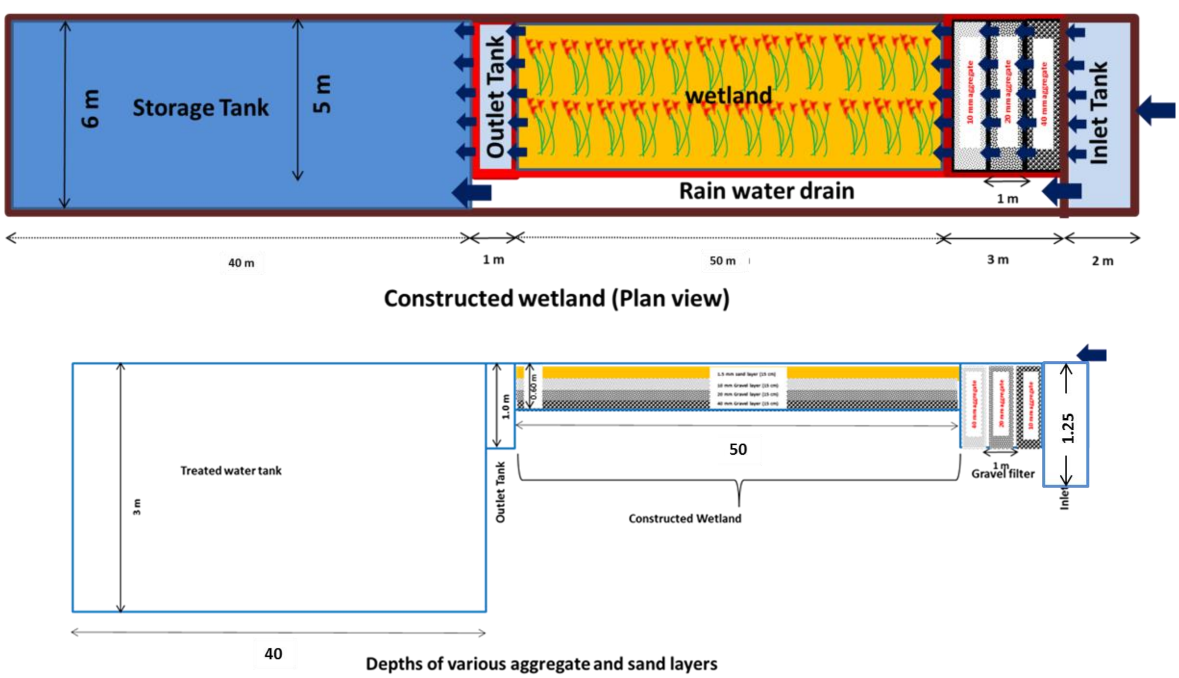


Figure 69: Design of decentralized wastewater treatment at Mulasavalagi village, Bijapur.

The site details and design was subsequently discussed with the chief-executive engineer on 20 January 2016. Taking inputs from the engineers in the department, suitable modification was incorporated in the design. The design details were subsequently described to the contactor engineer (on 24 February 2016), who was assigned the task of implementation by the department.

Figure 70: Meeting and discussions about the design and cost estimate with officials from the engineering department (A and B), contactor engineer (C) and local ICRISAT team (D).

The construction work began but was never completed. There were some phone calls that the local contactor engineer is looking for an additional fund of `200,000 to complete the constructed wetland work in Mulasavalagi village in Bijapur, on 6 October 2016. It was explained to him that ICRISAT team is not fixing the budget and he should contact through Panchayati Raj Engineering Department (PRED) and JDA, CEO for additional budget with proper justification. Till date, the construction work is not complete as the gravel and sand beds were never properly prepared.

Chikkamagaluru

Site selection work started during December 2015. One site at the Sadarahalli village (Lat: 13.358661ºN, Long: 75.892760ºE) was found suitable for the activity. The adjacent farmer was found to be co-operating and during the visit he explained that his shallow well water is smelly. We found the village wastewater was contaminating the shallow well. The site-specific design was prepared and shared with the local engineering department. Multiple site inspections were subsequently carried out for more prospective locations in the district. Subsequently extensive field survey was conducted along with the department (PRED) engineers during the period between December 2015 and March 2016.

Figure 71: Site selection activity for wastewater management activity at Chikkamagalur.

Figure 72: Explaining the activity, site and design to PRED engineers in the specific villages.

Table 27. Wastewater analysis report for Sadarahalli, Chikkamagaluru (Sampling: 4 December 2015)		
Sl. No.	Parameters	Concentration
1	Arsenic (mg/L)	BDL
2	Boron (mg/L)	0.09
3	Biochemical Oxygen Demand or BOD(mg/L)	75.20
4	Cadmium (mg/L)	BDL
5	Calcium (mg/L)	113.00
6	Chlorides (mg/L)	317.50
7	Chromium (mg/L)	BDL
8	Cobalt (mg/L)	BDL
9	Chemical Oxygen Demand or COD (mg/L)	96.00
10	Copper (mg/L)	BDL
11	Electrical Conductivity or EC (ms/cm or ds/m)	1.60
12	Fluorides (mg/L)	1.18
13	Lead (mg/L)	BDL
14	Magnesium (mg/L)	61.00
15	Manganese (mg/L)	BDL
16	Ammoniacal-Nitrogen (mg/L)	33.90
17	Nickel (mg/L)	BDL
18	Nitrate-nitrogen (mg/L)	0.73
19	pH	7.26
20	Phosphates (mg/L)	1.86
21	Potassium (mg/L)	5.00
22	Sodium (mg/L)	95.00
23	Sulfate (mg/L)	79.10
24	Sulfur (mg/L)	17.94
25	Total Alkalinity (mg/L as CaCO3)	192.00
26	Total Dissolved Solids or TDS (mg/L)	1492
27	Total Hardness (mg/L as CaCO3)	720
28	Iron (Fe3+ and Fe2+) (mg/L)	BDL
29	Total Suspended Solids (mg/L)	44
30	Zinc (mg/L)	BDL

Subsequently, four sites were selected for the activity. It was understood that in some of the sites water flow may not be very high during the dry season; nevertheless as the sub-surface flow design helps the constructed wetland vegetation to survive long dry-spells, low-wastewater flow sites were picked up for the activity as well to increase the overall water use efficiency.

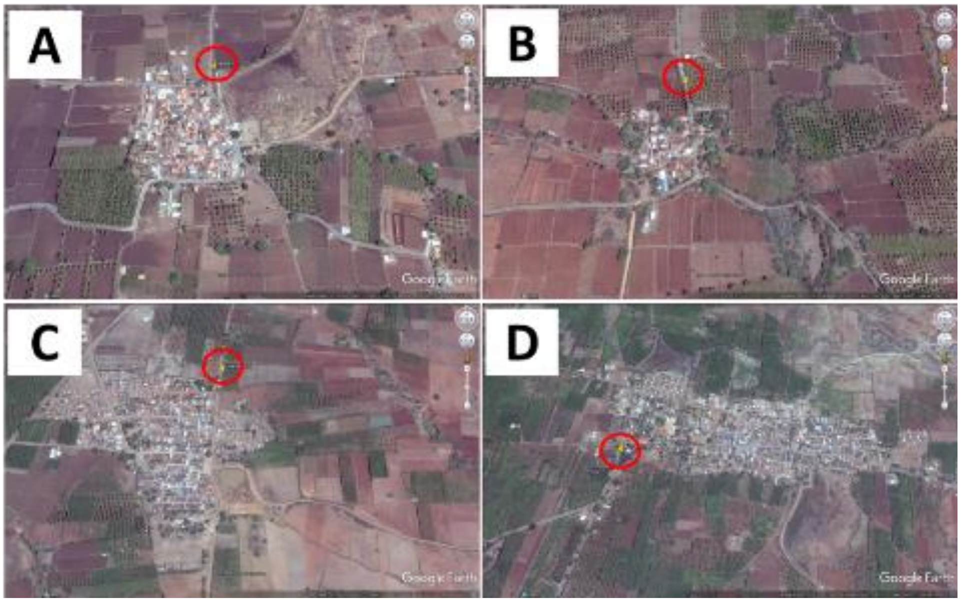


Figure 73: Sites identified for the activity in Sadarahalli (A), Lakumanahalli (B), Udeva (C) and Lingdahalli (D) villages of Chikkamagaluru (encircled in red).

Table 28. Details of the sites of constructed wetlands.

Sl. No.	Village Name	Latitude	Longitude
1	Sadarahalli	13.21'26.37''N	75.53'34.1''E
2	Kunnalu	13 ° 22'44.38'' N	75 ° 54'46.1''E
3	Udeva	13 ° 33'14.89'' N	75 ° 50'3.24''E
4	Lingdahalli	13 ° 35'42.42'' N	75 ° 50'20.22''E

The construction work started in Sadarahalli in April 2016. The brick-masonry work was completed by 26 April 2016. Anticipating quick execution of the construction work, the local ICRISAT team raised a nursery of *Cana indica* (plant species selected for phytoremediation) in a local farmer's field (Figure 74). However, some part of the side-wall collapsed and required subsequent repair (Figure 75). The gravel and sand layer were never laid in this CW and the wastewater collected inside the structure raised stench and created a mosquito menace in the nearby areas.

Figure 74: Raising of **Cana indica** *nursery in a local farmer's field.*

Figure 75: The status of construction at Sadarahalli, Chikkamagaluru, A) 7 April 2016; B) 26 April 2016; C) 25 May 2016; D) 2 June 2016; and E) 6 Nov 2016.

Construction work started in other selected locations as well though they remained semi-complete in all these places. In Udeva, the construction was done as per the design and only the gravel filling was pending in June 2016. However, despite repeated reminders, the work was not completed (Figure 76). The ICRISAT team requested the local officers to finish the remaining work.

Figure 76: The Udeva constructed wetland: a) Situation in June 2016; b) Situation in October 2016.

At the Lingadahalli site, construction was carried out with very poor quality material and the structure collapsed during construction (Figure 77). The site was selected based on the drainage line, public land availability as well as it being not in the immediate proximity of households (the site was near a graveyard). However, it seems that the construction of a marriage hall for the minority community has been sanctioned adjacent to the site (in the plantation area). The alternative site at a distance of 60 meter proposed by the local leaders (next to the graveyard) is not fit for the activity. It must be noted that the issue has cropped up after 45 days of construction activity. The contractor engineer has claimed that he has already completed 80 % of the assigned work (though the inferior quality of the work executed is evident). It is difficult to commission constructed wetlands at such proximity to a marriage hall as even temporary nuances of any wastewater treatment unit such as bad smell or temporary waterlogging (immediately after a heavy shower) may become reasons of severe public grievances. As a result, the site has become unfit for the activity after considering all the options during discussions with officials and village leaders. It is impossible for ICRISAT officials to know the land holding details of a proposed site and plans or projects in the pipeline.

Figure 77: The Lingdahalli constructed wetland site: a) Situation in June 2016; b) Situation in October 2016.

Tumakuru

In Tumakuru the scoping study for the wastewater management activity began even before the formal inclusion of the activity in the Bhoosamrudhi action plan during February 2015.

Figure 78: Improper wastewater management in Gondihalli village, Madhugiri* taluk*, Tumakuru.

ICRISAT team met the CEO, Tumakuru on 12 February 2015, to discuss the scope of this activity in the district. During the meeting, officials from the horticulture department raised strong health concerns about the reuse of treated wastewater and JDA too highlighted the acute water scarcity in the district. Due to the objection, the activity was not included in the workplan.

Subsequently, in September 2015, the new CEO of Tumakuru expressed interest in this activity and asked us to identify suitable sites during a meeting held on 14 September 2015. The CEO enquired about the fund availability for this activity for Tumakuru district and after consultation with JDA it emerged that the fund has not been approved for this activity for Tumakuru as it was not part of the action plan. The status of the activity which was proposed through supplementary work plan was "proposed" and not "approved". As per the instruction of the CEO, the ICRISAT team submitted a field survey targeting eight possible locations and submitted the proposal including site selection criteria to the JDA office on 21 September 2015.

The CEO also asked ICRISAT to study the scope of the activity in Brammasandra village of Sira *taluk* for which some CSR fund from ISRO was available. Subsequently, the ICRISAT team carried out a detailed site inspection of the district and submitted the report to JDA and CEO office during December 2015. During our meeting with the CEO of Tumakuru on 3 December, the issue of the activity not listed in the list of approved activity was highlighted. The CEO explained that the present GO (Governmental order) reflects only activities of the initial plan; however, the wastewater activity was later added as a supplementary plan. She further told that the activity has been approved although the department has not released the GO yet.

During our subsequent meeting with the CEO on 21 September, CEO asked us to revisit the feasible sites as new *taluks* have been added under Bhoosamrudhi, in an attempt to make a more uniform distribution of the activity. CEO also advised to involve the PRED officials along with Rural Water Supply officials in selecting the sites. In this regard, CEO asked for a list of site selection criteria so that the department officials can identify possible sites for the activity in their respective zones of operation. CEO also asked to finalize the locations once such a list of probable sites has been prepared by the officials. ICRISAT team revisited all the *taluks* and submitted the details of the most feasible four sites to the JDA office on 2 October 2016. As per the discussion during the meeting with the CEO held on 6 January 2017 at the ZP office, Tumakuru, details for an additional four feasible sites were sought. The same was submitted to the RWS department (eerwstmk@gmail.com) via email on 11 January 2017. As per the instruction of the JDA during the meeting held on 11 January at her office, an additional three sites were included as back-up for surplus fund if any.

Apart from Madhugiri, construction in other locations was completed by 31 March 2017. In Chinuga the construction did not include rain water bypass drain as per the design and it created a local issue of ponding of wastewater. In both the locations of Koratagere, construction was going on as per design but at a slow pace. The excuse cited most often by the local engineers is lack of funds due to utilization certificate and fund release and utilization mismatch for this activity started at the end of the financial year 2016-2017 (Table 30).

Table 29. List of sites identified for the wastewater management activity in Tumakuru.				
Sl. No.	Taluk	Village found most suitable	Specific site identified	Purpose
1	Tumakuru	Chinuga	Lat: 13.427868°; Long: 77.169626°	Reuse and pollution prevention
2	Madhugiri	Gondihalli	Lat: 13.687138°; Long: 77.286510°	Reuse and pollution prevention
3	Sira	Baragur	Lat: 13.933751°; Long: 76.982358°	Pollution prevention
4	Sira	Doddabanagera-1	Lat: 14.002960°; Long: 76.968208°	Pollution prevention
5	Kunnigal	Yediyur	Lat: 12°58’32.2229’’ N Long:76°51’48.7000’’ E	Pollution prevention and reuse
6	Gubbi	Hagalavadi-1	Lat: 13°30’16.8653’’ N Long: 76°45’31.8107’ E	Pollution prevention
7	Koratagere	Holavana Halli-1	Lat: 13°31’48.7596’’ N Long: 77°17’55.7092’’ E	Pollution prevention
8	Koratagere	Holavana Halli-2	*Lat:* 13°31’55.4617’’ N *Long:* 77°18’7.5859’’ E	Pollution prevention and reuse
9	Turuvekere	Mayasandra Kodihalla-Mavinakere	*Lat:* 13.0792344142086° *Long:* 76.751203046372°	Pollution prevention
10	Gubbi	Hagalavadi-2	*Lat:* 13°30’19.0008’’ N *Long:* 76°45’48.0096’’ E	Reuse and pollution prevention
11	Sira	Tadakalur	*Lat:* 14°1’39.6370’’ N *Long:* 76°54’46.1099’’ E	Reuse and pollution prevention
Back-up site				
1	Sira	Doddabanagera-2	*Lat:* 14.002960° N; *Long:* 76.968208° E	Pollution prevention

Table 30. Wastewater characteristics of Gondihalli village, Madhugiri Taluk, Tumakuru, Karnataka.

Parameters	Unit	Concentrations
Alkalinity (Total)	mg/L	360
Boron	mg/L	2.3
Calcium	mg/L	13.4
Chemical Oxygen Demand	mg/L	480
Chloride	mg/L	86.3
Electrical Conductivity	ms/cm	1.925
Fluorides	mg/L	2.192
Hardness (Total)	mg/L	680
Magnesium	mg/L	3.72
Nitrogen-Ammoniacal	mg/L	52.932
Nitrogen-Nitrate	mg/L	7.404
pH	-	7.51
Phosphates	mg/L	2.31
Potassium	mg/L	8.25
Sodium	mg/L	67.5
Sulfates	mg/L	78.1
Total Suspended Solids	mg/L	34
Total Dissolved Solids	mg/L	1155
Heavy metals		
Arsenic	mg/L	Below detection limit
Cadmium	mg/L	Below detection limit
Cobalt	mg/L	Below detection limit
Copper	mg/L	Below detection limit
Chromium	mg/L	Below detection limit
Iron (Total)	mg/L	0.01
Lead	mg/L	Below detection limit
Nickel	mg/L	Below detection limit
Zinc	mg/L	Below detection limit

9.2.12 Capacity building of stakeholders

Discussions with departmental staff, Agricultural Technology Management Agency (ATMA) staff and scientists at the University of Agricultural Sciences and University of Horticultural Sciences, Bagalkot, were initiated towards local capacity building initiatives. A number of capacity building programs were organized for different stakeholders in different districts in consultation with the local stakeholders and line departments (Table 31).

The ICRISAT led consortium provided practical insights to the farmers to help them adopt improved practices in various interventions. Periodic hands-on trainings were provided during the cropping season, coinciding with the critical stage of the crop, so that farmers could immediately apply what they had learned. It helped in lateral spread of technologies among the other farmers in the project villages.

Table 31. Capacity building activities carried out in different Bhoosamrudhi districts.

Training	No. of trainings	CGIAR/SAUs
Team building workshops for review, workplan preparation and mid-course correction at State level	5	All CGIAR centers
Team building workshops for review, workplan preparation and mid-course correction at District level	85	All CGIAR centers, CEOs and Line departments
BBF land management	25	ICRISAT
Laser levelling	35	CIMMYT
Climate change	8	ICRISAT-DoA, RARS, KVK, AC-Vijayapura campus
Video dissemination and data management training	75	Digital Green -ICRISAT
Aerobic compost preparation	68	ICRISAT
Integrated nutrient management	25	ICRISAT/CIMMYT, IRRI
Leaf color chart	45	IRRI
Integrated pest management	28	All CGIAR institutes, SAUs
Zero-till multi crop planter	65	CIMMYT
Relay planter	20	CIMMYT
Water impact calculator for computing crop water requirement and irrigation scheduling	6	ICRISAT
Thornless cactus as cattle feed	23	ICRISAT-DoA, ICARDA
Efficient management of drip system and efficient water application	120	IWMI/ICRISAT
Field days	32	All CGIAR centers, and Line departments

Need based trainings on vegetable cultivation, crop management, INM and IPM aspects helped in reducing the input costs in spraying, weeding and harvesting, thereby increasing the net returns of farmers. When the farmer trainees of IPM were interviewed before the course, they indicated that they were using chemicals that were mostly suggested by private pesticide dealers, at least twice in a week to manage serious pests like thrips and other sucking pests. These trainings helped them understand the importance of cultural practices to manage major insect pests. They have now started adopting a good package of IPM right from pre-sowing till harvest, with a reduced dependency on chemicals and could distinguish pest and disease problems and make a right choice of pesticides at appropriate time.

As an external input into our capacity development activities, a number of students pursuing their postgraduate and Ph. D degrees in different disciplines visited the project sites. Students from Carey Business School of John Hopkins Institute in USA, who are doing their Masters in Business Administration, visited Raichur in early January 2014, to conduct a study on the vegetable markets. The student team met agriculture students from UAS, Raichur, and also met stakeholders along the vegetable value chain in Raichur. Improving market information system and collectivization of smallholder farmers to improve their collective scale of operations were two main suggestions in their report.

10. List of publications, documents prepared

1. Bhoosamrudhi - Improving Rural Livelihoods through Innovative Scaling-up of Science-led Participatory Research for Development (Progress Report (2016-17)). ICRISAT (2017)

2. Bhoosamrudhi - Improving Rural Livelihoods through Innovative Scaling-up of Science-led Participatory Research for Development (Annual Report 2015-16). ICRISAT (2016)

3. Bhoosamrudhi - Improving rural livelihoods through innovative scaling-up of science-led participatory research for development (Annual Report 2014-15). ICRISAT (2015)

4. Bhoosamrudhi - Improving rural livelihoods through innovative scaling-up of science-led participatory research for development (Annual Report 2013-14). ICRISAT (2014)

5. Bhoosamrudhi - Improving rural livelihoods through innovative scaling-up of science-led participatory research for development (Annual Report 2012-13). ICRISAT (2013)

6. Proceedings of GoK-CGIAR initiative for improving rural livelihoods in Karnataka [3–4 January 2013]. ICRISAT (2013)

7. Bhoosamrudhi - A Compendium of Success Stories (Research Report IDC-2). SP Wani, KH Anantha, BK Dharmarajan and K Krishnappa (Ed.) (2015)

11. Summary of the project

The program covered 80,000 ha and tested various innovative technologies at each pilot site in the state during 2012-13 to 2016-17. The baseline survey revealed that cultivation is the primary occupation for most of the households in all the four revenue divisions. Chikkamagaluru and Tumakuru reported comparatively high proportion of below poverty line card holders compared to Vijayapura and Raichur districts. Most farmers in Vijayapura, Chikkamagaluru and Raichur have land holdings greater than one ha whereas in Tumakuru, the land holding was less than one ha per family which indicated that the "one size fits all" approach will not work. We needed to have specific strategies and interventions for each agro-eco-region.

A number of innovative proven technologies were scaled out with a focus on increasing the yield and income. The program targeted to harness low-hanging fruits during its initial phase and subsequently tested and scaled up many innovative technologies which aimed to achieve resource use efficiency, tackle labor scarcity and climate change, build resilience and improve rural livelihood.

The technologies evaluated/demonstrated to the farmers included mechanization using smart machines like relay planter, power weeder, easy planter, nipping machine, solar-based drip machine and tractor-drawn machinery like BBF maker, poly mulch laying, drip irrigated BBF maker, chipper and shredder machine, zero-till multi crop planter, laser leveler etc., along with simple technologies like magnetic water conditioner for enhancing resource use efficiency and to address issues of labor scarcity. Farm mechanization was identified as one of the best growth engines for scaling-up.

The ICRISAT-led consortium focused on agriculture and allied sectors to improve the livelihood system. In the agriculture sector, a number innovative technologies have been demonstrated and scaled-up during the project period. The DSR technology has been scaled-out in Raichur and Tumakuru districts and showed an average net income of ₹ 20,000/acre as against ₹ 8,000/acre with transplanted method. The DSR technology has shown on par or increased paddy yields with significantly reduced water usage as well as saving in time which has enabled timely sowing of the second crop. The yield under DSR was 2,800 kg/acre compared to 2,200 kg/acre with transplanted rice. The surface and sub-surface drip irrigation method was demonstrated in DSR in Raichur and Tumakuru districts. The results indicated that lowest water productivity was observed in transplanted rice (0.36 kg grain m^{-3} water) which remarkably improved under DSR (0.53 kg grain m^{-3} water). In addition, the surface irrigation system resulted in saving of water to the tune of around 60% with no significant difference between the lateral spacings of 60 and 80 cm.

In-situ soil and water conservation technologies such as Broad Bed and Furrow (BBF) were piloted in nearly 500 ha in Raichur and Vijayapura districts. Water saving technologies such as surface and sub-surface drip irrigation in paddy was evaluated at Raichur and Tumakuru districts on a small scale to test the suitability and efficiency of the system. The initial results revealed that a highest grain yield of 10 t ha^{-1} was observed in DSR receiving irrigation through surface drip irrigation with laterals placed 80 cm compared with the same system with 60 cm laterals (9 t ha^{-1}). Magnetic water conditioner was piloted in Vijayapura to evaluate the beneficial effects on salt content of irrigation water. In treated water lines farmer harvested around 9 kg of brinjal whereas in untreated lines the harvest was 7.5 to 8 kg per plant.

Sustainable intensification of cotton systems through relay planting of chickpea and sorghum was demonstrated in Raichur. The prevailing dry conditions and delayed canal water release led to lower yields and farm income. However, the cotton yield was not much affected by relayed chickpea and sorghum. When crop was relayed with chickpea in the latter stages, the cotton-chickpea system became more stabilized as the farm income increased from ₹ 42,750 to ₹ 68,375 ha^{-1}, as cotton equivalent yield (CEY) increased from 1.13 to1.76 t ha^{-1}. An improvement of system productivity by 56% was observed in cotton-chickpea and 43% in cotton-sorghum systems over cotton alone.

Using the power weeders, farmers saved ₹4000 to ₹5000 per ha in cash crops like sugarcane and cotton. Easy planters which are manually operated saved ₹3000 to ₹4000 per ha for transplanting as well as for dibbling the seeds using a seed dibbler. Nipping machine in pigeonpea helped and cut down the labor cost for nipping operations but also increased pigeonpea crop yield by 7 to 8%.

The consortium made efforts to enhance productivity and adaptation to climate change scenarios through introduction of improved crop varieties like groundnut, sorghum, castor, finger millet, pearl millet, pigeonpea, green gram and black gram. Although the state has experienced below normal rainfall during these years, the crop cutting experiments showed increased yields with improved varieties by more than 10 %. The crop-wise analysis revealed that the grain yield increased ranging from 7 and 39% in Chikkamagaluru; 5 and 114% in Raichur; 14 and 24% in Tumakuru and 7 and 36% in Vijayapura across different crops and seasons. Further, fallow management with short-duration legume crops showed significant results as the improved varieties of cowpea such as Pragathi and KM 5 performed better compared to the local variety i.e., C 152. The yield data showed that nearly 35% higher yield was achieved in the case of Pragathi and 18.4% in the case of KM 5 compared to C 152 variety. Similarly, green gram and black gram were introduced during pre-monsoon and farmers obtained net income of ₹ 21,750 to ₹ 29,400 ha^{-1}.

Fodder varieties of sorghum (CSH24MF) and maize (NK 6240) were evaluated in all pilot sites with a view to ensure fodder security to livestock population. As cattle fodder, multipurpose thornless cactus were also evaluated and farmers were educated in feeding techniques. In the breed improvement program, Sirohi bucks were supplied to all pilot districts and the results were encouraging. On an average more than 50 progenies were expected from two sirohi bucks in each district.

In addition to the improved cultivars and water management practices like BBF and supplemental irrigation through drip, Aquasap sea weed extract was used for increasing the agricultural productivity. Use of Aquasap increased crop yields by 14-36% in the case of pearl millet and in the case of pigeonpea increased yields ranged from 12 to 25%. Similarly for maize, yields increased by 9 to 14% and in the case of chickpea, crop yields increased by 16% over the controlled plots. In the case of vegetables, the benefits due to Aquasap spray were more remunerative as crop yields increased by 11 to 13% in tomato, chilies and beans.

In order to enhance the water management in four pilot sites, meso-scale watersheds were monitored hydrologically using automatic hydrological gauging device and water samples were collected for all locations. The results from the hydrological studies clearly indicated that during heavy rains, more water goes out of watersheds. In order to enhance the water use efficiency and build resilience against climate change impacts, rainwater variability was measured during the season for planning the rainwater harvesting structures in the watersheds instead of relying on conventional historical weather data sets.

With a focus on enhancing water use efficiency and land use efficiency, mechanization was promoted in all the pilot districts. Mechanization of agricultural operations benefitted farmers in terms of enhancing water use efficiency by 15 to 20% through use of laser leveler and tractor drawn seed-cum-BBF machine which enabled soils to store more moisture and provide protection during longer dry spells.

A number of crop and site-specific technologies were piloted and showed benefits across the pilots. The technologies included weed management through inter-cultivation and power weeder, relay planting in cotton, insect-monitoring through pheromone traps, aerobic composting using bioculture, easy planter for vegetable planting, etc.

Number of innovative technologies to enhance vegetable production were piloted and scaled-up during the project period. Improved vegetable soybean cultivars and bird's eye chili were introduced. Vegetable cowpea as a rotation crop with sugarcane was introduced in Raichur. Farmers on an average obtained a yield of around 570 kg and additional income of ₹130,000. The successful adoption of green gram and vegetable cowpea cultivation in the paddy fallows and as an intercrop in all four districts has prompted the department to scale up this technology as a departmental initiative. Grafted capsicum seedlings were transplanted in low-cost polyroof and shade net units, followed by indeterminate type tomatoes. It showed a 10% increased crop yield as well as 35% increased net income from growing grafted tomato compared to non-grafted crops. Improved practices like mulching, inline drip fertigation, staking and IPM practices were adopted to demonstrate the integration of these technologies as critical components of the protected cultivation package.

An effort was also made by the Deputy Commissioner, CEO and Deputy Director of Horticulture in Chikkamagaluru, to link farmers to the market with the help of a major chili buyer, Paprika Oleos (India) Ltd. By adopting IPM methods, the chili quality improved and Paprika Oleos (India) Ltd., decided to purchase chili at a price of ₹110-120 per kg (standard price of the day in the major chili market) which was higher than the local market price of ₹70-80 per kg. This arrangement reduced spending on transportation and handling charges that saved 2-6% of the total production cost and immediate cash payment to the farmers was ensured. The wastage was not deducted by the buyer and resulted in a savings of 4% when compared to the local vendor practice.

Wastewater recycling was one of the important activities promoted across three districts to improve overall water productivity by reuse of domestic wastewater through establishing low-cost decentralized wastewater treatment (DWT) plants at village level. More than 10 units were established with the help of the Panchayati Raj and Engineering Department.

The ICRIAT-led consortium also designed an android-based online monitoring and evaluation software which was used to track the activities of Bhoosamrudhi staff across all Bhoosamrudhi districts on a daily basis. In addition, weekly activities against work plan targets were monitored online in defined formats. For capacity building and innovative extension, farmer-to-farmer videos were promoted in partnership with the Digital Green. In this initiative, farm facilitators were trained to shoot videos which are edited by the ICRISAT staff and screened in the villages by farm facilitators to a small group of farmers using battery-operated pico-projectors. The advantage of this particular initiative is that farmers share their experiences in their own language and the feedback mechanism also is available to track the followers and their availability on YouTube for download as and when needed. Farmer-to-farmer videos are recommended for strengthening the Farmer Field Schools.

Need-based training programs were organized periodically with the help of line department staff, Agricultural Technology Management Agency (ATMA) staff and scientists at the University of Agricultural Sciences and University of Horticultural Sciences. More than 1,000 trainings focusing on diverse topics were organized with participation from more than 5,000 stakeholders during the project period in consultation with the local stakeholders and line departments.

Farmers in the four pilot sites in four different revenue divisions have benefitted through the holistic and integrated approach adopted by the Bhoosamrudhi project. Based on the results, Bhoosamrudhi can be recommended for scaling-up in all the districts in a phased manner.

Name and Signature
Nodal institute- Project coordinator

Date:

Recommendations

The following recommendations are based on the research and development activities undertaken in four pilot districts:

1. In all four districts, during the summer season, lands are left fallow due to scarcity of water and the cropping intensity in all four revenue divisions varied from 107 to 135%, notably in Chikkamagaluru and in Tumakuru low cropping intensity of 116 and 107% was observed. Therefore, there is large scope for rainwater management exists to increase sustainable crop intensification.

2. Stratified soil sampling methods standardized in the Bhoochetana initiative were found to be an excellent knowledge-based entry point activity in all the four pilot sites. The recorded multiple-nutrient deficiencies which could be addressed and provide tangible benefits to the farmers acted as a trigger for enabling community participation.

3. The soil analysis results indicated that organic carbon, available phosphorus, sulphur and zinc were severely deficient in all the villages in Vijayapura district where as boron was severely deficient in Nivalkhed village in Sindagi taluk. In Raichur, organic carbon was severely deficient as well as available phosphorus and sulphur deficiencies varied across villages clearly indicating that "one size fits all" does not work as nutrient deficiencies varied from village to village even in a cluster selected as a pilot for Bhoosamrudhi. This clearly calls for village level recommendations for fertilizer applications based on soil analysis to benefit farmers in terms of increasing productivity and reducing the cost of cultivation as well as environmental protection.

4. It was observed that in all the four pilot districts for the major crops grown, large crop yield gaps were observed between what the farmers were harvesting and the potential achievable yields clearly indicating a huge scope for increasing productivity by adopting suitable technologies including improved cultivars. It was also observed that the Bhoochetana program interventions like soil test-based use of micronutrients was adopted by a large number of farmers in Vijayapura, whereas in Tumakuru the adoption was poor. This indicated that adoption rates in different districts varied for the interventions recommended in Bhoochetana which need to be considered while scaling-up in these districts.

5. At pilot sites, CG and consortium partners demonstrated a number of technologies for increasing the productivity of agricultural crops, horticultural crops, livestock as well as increasing the efficiency of the natural resources use were demonstrated and benefited the farmers substantially in increasing crop yields and reducing the cost of cultivation for increasing incomes from agriculture. Good scope exists which needs to be harnessed for bridging the yield gaps.

6. The technologies evaluated/demonstrated included mechanization using smart machines like relay planter, power weeder, easy planter, nipping machine, solar-based drip machine and tractor-drawn machinery like BBF maker, poly mulch laying, drip irrigated BBF maker, chipper and shredder machine, zero-till multi crop planter, laser leveler, etc., along with simple technologies like magnetic water conditioner were demonstrated to the farmers for enhancing resource use efficiency and to address the issues of labor scarcity. Farm mechanization was identified as one of the best growth engine for scaling-up.

7. Mechanization of agricultural operations benefitted farmers in terms of enhancing water use efficiency by 15 to 20%, through use of laser leveler and use of tractor drawn seed-cum-BBF machine which enabled soils to store more moisture and provide protection from longer dry spells.

8. Using the power weeders, farmers can save ₹4000 to ₹5000 per ha in cash crops like sugarcane and cotton. Easy planters which are manually operated save ₹3000 to ₹4000 per ha for transplanting as well as for dibbling the seeds using seed dibbler. Nipping machine in pigeonpea helped cut down the labor cost for nipping operations and increased pigeonpea crop yield by 7 to 8%.

9. For crop intensification, rice and maize fallows were used by growing green gram as well as vegetable cowpea benefitting the farmers through additional income of ₹ 8000 to ₹ 10000 per ha. This particular initiative was demonstrated in 1,100 ha to farmers and was widely adopted by farmers. Sustainable intensification of rice fallows using crops like green gram, maize and vegetable cowpea is recommended for scaling-up to meet the pulses demand.

10. Farmer participatory evaluation of improved cultivars of various crops was demonstrated by farmers in the pilot sites by the consortium partners. Varieties and cultivars of various crops like pearl millet (HHB 67) which is a cultivar breed by using molecular associated breeding demonstrated good benefits not only in terms of reducing downy mildew but also increasing crop yields substantially. Farmers benefitted from improved cultivars of finger millet which gave an increased yield of 63% over the local cultivars. Similarly in case of groundnut cultivars, ICGV 91114, ICGV 0351, ICGV 308, ICGV 44 and K 9 proved their high yields over the traditional cultivars like TMV 2. ICGV cultivars mature early, are tolerant to mid-season and end of season drought, have a higher shelling percentage and 48% oil content. These varieties liked by the farmers had increased yields ranging from 120-150% compared to local variety TMV 2.

11. Pigeonpea hybrid ICPH 2611 and ICPH 2740 were prefered by the farmers across the districts. It was found that hybrid cultivars of pigeonpea yield 25 to 66% more in different districts over farmers' cultivars. The hybrid pigeonpea is the first hybrid among legumes in the world developed by ICRISAT. The hybrid cultivars have good *dal* quality, flavor, taste and cooking time as indicated by the farmers. Pigeonpea hybrids are recommended for scaling-up in Karnataka.

12. In order to address the issues of water scarcity in pilot areas, DSR was promoted and demonstrated. For DSR, the water use efficiency was substantially increased to 0.53 kg per m^3 of water as compared to 0.36 per m^3 of water in the transplanted paddy. With drip, for DSR with laterals at 80 cm water use efficiency increased to 1.5-2 kg. per m^3 of water resulting in 60% savings of water and yielding ₹38,000 net income per acre as compared to an income of ₹22,000 per ha.

13. In addition to the improved cultivars and water management practices like BBF and supplemental irrigation through drip, Aquasap sea weed extract was used for increasing the agricultural productivity. Spraying of Aquasap increased crop yields by 14-36% in the case of pearl millet and in the case of pigeonpea increased yields ranged from 12-25%. Similarly for maize crop, yields increased by 9-14% and in the case of chickpea, crop yields were increased by 16% over the control plots. In the case of vegetables, the benefits due to Aquasap spray were more remunerative as crop yields increased by 11-13% in tomato, chilies and beans.

14. In order to enhance water management in four pilot sites, meso-scale watersheds were monitored hydrologically by installing automatic hydrological gauging devices and water samples were collected for all locations. The results from the hydrological studies clearly indicated that during the heavy rains due to climate change impacts, more water goes out of watersheds. In order to enhance the water use efficiency and build the resilience against climate change impacts, we need to undertake rainwater variability during the season for planning the rainwater harvesting structures in the watersheds and not rely on conventional historical weather data sets.

15. In general, it was observed that in Vijayapura, out of 625 mm rainfall, 10% of rainfall was lost as runoff and 5% resulted in groundwater recharge. A large volume of rainfall (531 mm) was lost as evapotranspiration.

16. During 2014-15 and 2015-16, Tumakuru received heavy rainfall resulting into higher runoff loss (above 30%) as compared to the former year co-efficient (11 to 16%). In Chikkamagaluru during 2015-16, a severe drought was recorded with only 400 mm rainfall and there was no runoff going out of the watershed. These hydrological studies have highlighted the need to take into account the changes in rainfall pattern (increased intensity of rainfall and reduced number of rainy days) into consideration by planning rainwater harvesting structures.

17. Simple devices like mechanical water conditioner where borewell water is used for irrigation showed good benefits to the farmers as this water reduced the salinity and pH which resulted in increased nutrient uptake by the crops increasing the crop yields.

18. More than 350 farmers were trained in use of drip systems for enhancing efficiency through proper maintenance of drip systems indicating an urgent need to build capacity of the drip-using farmers for enhancing water use efficiency.

19. The improved cultivars of other crops such as castor (Jwala, Jyoti, RC 8), vegetable cowpea (Pragathi, KM 5 and C 152), green gram (Pusa vishal, KKM 2, BGS 9 and Pusa3) and rice (IET 21478, ICG 21479, KHB 10, KHB 2, Tunga), Ragi ,(MR 1), Maize (NK 6420), vegetables, grafted capsicum, grafted tomato, sorghum(CSV 23), Pearl Millet (HH67, ICTP 8203), chickpea (JG 11, Jacki 2198, KAK 2).

20. In order to enhance crop diversification and incomes of farmers, vegetable cultivation was promoted and demonstrated. New crops like vegetable soybean and different varieties were provided to the farmers for evaluation and farmers have selected the varieties as well as private companies like ITC Limited and HI-Rich Seeds Private Limited which have come forward to promote these important legumes as a vegetable crop. For increasing the yields and providing protection against soil-borne diseases, grafted seedlings of tomato and capsicum were evaluated by the farmers and recorded 25% to 30% higher yield under fallow conditions. Grafted seedlings are becoming popular amongst the farmers.

21. New varieties of chilies, bird's eye chilies from Kerala was introduced and 16 farmers in Chikkamagaluru district have evaluated new varieties. For increasing the productivity, enhancing water use efficiency and incomes of farmers through vegetable cultivation, the farmers were given demonstrations on protected vegetable cultivation in poly houses. This method increased yields to the extent of three fold in crops like capsicum and tomato and net profits substantially increased by 8 to 16 fold. In order to minimize postharvest losses, farmers were trained to use small solar dryers for crops like chilies, onion etc., and the government has promoted and provided 500 kg drying capacity solar dryers to the farmers.

22. In order to link farmers to the private companies, chili farmers were linked with Paprika Oleos Limited in Chikkamagaluru district. Through this linkage, farmers were trained in the adoption of integrated pest management practices by reducing the use of pesticides. The company purchased chilies from the farmers at ₹ 110-120 per kg while the market price was ₹ 70-80 per kg. In addition to the higher rates, farmers also saved money on transport as well as the wastage reduction which is generally done at the rate of 4% by the local traders.

23. In order to address the issues of food and fodder, based on the RRA results, ILRI demonstrated different fodder varieties using FEAST and Techfit tools, sorghum fodder varieties like CS 349 and NK 6240 of maize were demonstrated. Sorghum produced 18 tons per ha in one cut and dual purpose maize varieties produce 4.5 ton grains per ha and 11 ton per ha fodder. In Raichur, farmers have grown these varieties in 20 acres as they were happy with the performance of these varieties. Other multi-cut varieties of sorghum (CSGH-2 MF and CH524 MF) were also promoted in the districts.

24. For improving livelihoods, women self-help groups were provided with a fast-growing goat breed (Sirohi) in the district. These goats have lower mortality rates in the kids and they gain weight rapidly compared to the other goats.

25. To address issues of fodder during the summer months, thornless edible cacti were promoted and demonstrated to the farmers by growing these plants on the bunds. Cultivars (Cactus clone 1270; Cactus clone 1271 and Cactus clone 1280) were grown and nurseries of the same for scaling-up were established in the Horticultural University, Bagalkot, and ICRISAT campus. Feed trials clearly demonstrated the performance of the animals during the summer months for this fodder.

26. For capacity building of innovative extension, farmer-to-farmers videos were promoted in partnership with Digital Green. In this initiative, farm facilitators are trained to shoot the videos which are edited by the ICRISAT staff and screened in the villages by farm facilitators to a small group of farmers using battery-operated pico-projects. The advantage of this particular initiative is that farmers share their experiences in their own language and a feedback mechanism also is available to track the followers and their availability on YouTube for download as and when needed. Farmer-to-farmer videos are recommended for strengthening Farmer field schools.

27. In order to address water scarcity, waste water treatment using a simple decentralized wastewater treatment using constructed wetlands (CWTs) was demonstrated and are being operated in Gondihalli (Madhugiri, Tumakuru) and Chigatagere (Gauribidanur, Chikbalapur) villages. More number of such sites were constructed by the district administration with technical support from ICRISAT. The CWTs technology is recommended for scaling-up in all rural areas to use water efficiently.

28. Number of capacity building initiatives have been conducted on various topics of improved management practices for the farmers, officers and farm facilitators. In addition, need-based training for the farmers in the area of INM, IPM, vegetable cultivation etc., were organized.

29. Research scholars from the University of Agricultural Sciences, Raichur, Dharwad and Shimoga were trained at ICRISAT for undertaking research on farmer fields for their M.Sc. and Ph.D. thesis. The students were trained as well as provided with scholarships for completing their post-graduate studies.

30. For project monitoring and evaluation, the format for weekly reporting is being used. ICRISAT's geo-reference based reports are uploaded everyday which are archived and used for monitoring and evaluating the performance in different districts.

31. Farmers in the four pilot sites in four different revenue divisions have benefitted through the holistic and integrated approach adopted by the Bhoosamrudhi project. Based on the results, Bhoosamrudhi can be recommended for scaling-up in all the districts in a phased manner.

Annexures

Annexure-A
Bhoosamrudhi Phase-1 (2013 to 2016-17)

1. Name of the District: **Chikkamagaluru**
2. Name of the taluk/ hobli: Chikkamagaluru, Kadur, Tarikere, Koppa
   (Data of the hobli-wise to be compiled to district report)
3. Area (ha) and Number of families: 80,000 ha and 12,308 families
4. Location of the project:

Taluk	Gram Panchayats	Villages
Chikkamagaluru	Hiregouja Lakkammanahalli Bilekallahally Belavadi Kalasapura Eshwarahalli Belavadi Sindigere Machenahalli K.B.Hal	Kaarehally, Karisiddanahally, Kengenahally, Kunnalu, Kurichikkanahally, Lakumanahally, Siribadagi, Uddeboranahally GungaraHally, HanchiHally, Hiregouja, SarpanaHally, ThadaBenahally, Baktharahalli, Lakya, Hale Lakya, Kyathanabeedu, Kanivehalli, Ganadalu, Devarahalli, Kanive, Dasarahalli, Chikka Gowja, Sadarahalli, Bilekallahalli, Srinivasapura, Kenkere, Padhamane, Chikkere Kaval, Beeranahalli, Balenahalli, Kalasapura, Chikkakalasapura, Payagondanahalli, Sooragondnahalli, Devagondanahalli, Kowthalu, Mallammanahalli, Eshwarahalli, Galihalli, Hannindadike, Kalenahalli, Belavadi, Kallahalli, Narasipura, Govindapura, Vaddarahalli, Yarehalli, Hosahalli, Sindigere, Kabbigarahalli, Buchenahalli, Arekallahalli, Surashetty Halli, Kurubarahalli, Subramanyadahalli, Shankaranhalli, K.B.Hal, Kottigenahalli
Kadur	Chikkangala Emmedoddi Haralagatta Pattanagere Saraswathipura Kaduruhally JodiThimmapura Balliganuru Hullehalli Balliganuru Bisalehalli	Chikkangala, Emmedoddi, Gandhinagara, Gollarahally, Haralagatta, Howthanahally, Kannenahally, Karithimmanahally, Shakunipura, Angajanahalli, Chikkapattanagere, Dombarahalli, Gopishettihalli, Haruvanhalli, Karehalli, Devarahalli, Galihalli, Yarehalli, Balliganuru, Huvinahalli, B.kodihalli, Aladahalli, Hogarehalli, Birur grama, Hiriyangala, Hosalli, Ramanahalli, Nagadevarahalli, Hullehalli, Dogehalli, Byagadehalli, Ulinagaru, Kodihalli, Linglapura, Birurkavalu, Jodithimmapura, Dodagatta, Horithimmanahalli, Englaranahalli, Hanumapura, Doddabukkasagara
Tarikere	Begur Sollapura Gowarapura Mugali Lingadahalli	Begur, Chinnapura, Gowarapura, Kaatiganere, Mugali, Sollapura, Sowthanahally, Tamatada Hally, Lingadahalli, Udeva
Koppa	Haranduru	Haranduru, Agalagandi, Kuluru

5. Project Details:

I. Activities undertaken : Agriculture:

A. New varieties popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Area Covered (ha)	Best varieties for scaling up
Groundnut	ICRISAT	ICGV 91114/2340kg ha^{-1} ICGV 0350/2000kg ha^{-1} ICGV 0351/1650 kg ha^{-1} ICGV 44/2493kg ha^{-1} K9/1530 kg ha^{-1}	100	ICGV 91114 K9
Pigeonpea	ICRISAT	ICPH 2740/1140kg ha^{-1} ICPL87119/1135kg ha^{-1} ICPL87120/1100kg ha^{-1}	15	ICPH 2740 ICPL87119
Finger millet	ICRISAT	MR 1/2212kg ha^{-1}	50	MR 1
Castor	ICRISAT	Jwala/300kg ha^{-1} Jyothi/250kg ha^{-1}	5 (intercrop with groundnut)	Jwala
Rice	IRRI/ICRISAT	IET 21478/7290kg ha^{-1} IET 21479/5230 kg ha^{-1} Intan/5360kg ha^{-1} KHP 10/4080 kg ha^{-1} KHP 2/4800kg ha^{-1} KHP 5/4970kg ha^{-1} Sharavathi/5240 kg ha^{-1} Tunga/5460 kg ha^{-1}	100	IET21478
Green gram	ICRISAT/ICARDA/AVRDC	SML 668/950kg ha^{-1} Pusa vishal/980 kg ha^{-1} KKM2/900kg ha^{-1}	100	SML668 Pusa vishal
Chickpea	ICRISAT	JAKI 9218/1200kg ha^{-1}	45	JAKI 9218
Vegetable Cowpea	AVRDC	Pragathi/930kg Ha^{-1} KM 5/690kg ha^{-1}	4	Pragathi
Maize	CIMMYT	GK 3059/6900kg ha^{-1} NK6240/7400kg ha^{-1} CP 818/8150kg ha^{-1} CP808/7500kg ha^{-1}	65	CP818
Dual purpose maize	ILRI/ICRISAT	NK6240/	25	NK6240
Multi-cut sorghum	ILRI/ICRISAT	CSV 23/	25	CSV 23
Cactus	ICARDA	Cactus-1270 Cactus-1271 Cactus-1280	1800 cladodes	All varieties

B. Innovative Agri equipment demonstrated and in Use

Name of the Crop	Innovative Agri Equipment Demonstrated	Impact of the technology
Rice	Leaf color chart	Reduced usage and cost of N fertilizer
Vegetables	Easy planter	Reduced cost of manual planting by `3000-4000 ha^{-1}
Vegetables	Polyroof and shade net houses	Increased crop yield and income

C. Fertigation Schedule:

Sl. No	Number of Soil samples taken	Soil testing results	Nutrient recommendations
1. Chikkamagaluru	657	Ref. Appendix 1	Ref. Appendix 2
2. Kadur	444	Ref. Appendix 1	Ref. Appendix 2
3. Tarikere	119	Ref. Appendix 1	Ref. Appendix 2
4. Koppa	56	Ref. Appendix 1	Ref. Appendix 2

D. Fodder demonstrated and area enhancement

Name of the Crop	Varieties demonstrated and results	CG Institution involved	Adoption level
Maize	NK 6240/Quality maize fodder available from dual purpose cultivars (fodder yield: 7 t ha^{-1}; grain yield: 5 t ha^{-1})	ILRI/ICRISAT	5% adoption Farmers found alternative high yielding fodder varieties which are suitable to the district and efforts are made by the line departments to scale up with convergence from animal husbandry department
Sorghum	CSH24MF/ Multi-cut sorghum recorded yield of 65 t ha^{-1}	ILRI/ICRISAT	
Cactus	Cactus-1270 Cactus-1271 Cactus-1280	ICARDA	Needs awareness among farmers/extension officers

E. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Hydrological monitoring	Lakumanahalli	During 2015-16 experienced severe drought situation as received rainfall was less than 400 mm compared to 700 mm during normal years. This has resulted into drying of streams (except one-two months) during the 2015-16 and 2016-17. Treated watershed harvested most of surface runoff and negligible amount received at watershed outlet compared to non-treated watershed	Scope for scaling up in the entire district by WDD with minimum investment and regular monitoring
Farmer-to-farmer (F2F) videos	Chikkamagaluru Kadur Tarikere	9 short videos produced and screened by farm facilitator and nearly 2200 farmers have adopted the technology	Large scope exists as farmers are willing to adopt new method/technologies to enhance their crop yield and income

Name of the Activity	Location	Results	Scope for scaling up
Evaluation of manual, machine transplanted and direct seeded rice using advanced technologies like SSNM & IWM	Koppa		Large scope as farmers demanding for low cost technologies to overcome labour scarcity
Vegetable Value Chain Enhancement	Chikkamagaluru	▪ Higher price of `110-120 per kg as against to `70-80 per kg ▪ No 'Wastage' deduction was done by the buyer resulting in savings of 4%. ▪ Weighing of produce using electronic scales with digital display gave greater confidence to farmers and was more accurate than traditional mechanical scales.	Efforts are needed to scale up market linkages through producers' organizations and handholding by the line departments
Enhancing organic matter through aerobic composting	Chikkamagaluru	Better utilization organic wastes into compost Increased organic matter availability in soil	Large scope exists as there is plenty of crop residue available which can be decomposed within 45-50 days
Plant growth promoter (Aquasap - sea-weed extract)	Chikkamagaluru Kadur Tarikere	Improved crop yield of maize, vegetables by 7 to 30%	From the environmental point of view, scaling up of sea weed based growth promoted gaining importance and has great potential in enhancing the crop yield as well as soil health

II. Activities undertaken: Horticulture

A. New varieties demonstrated popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Best variety for scaling up
Chili	AVRDC	Sitara/4200 kg ha^{-1} Priyanka/4800 kg ha^{-1}	Priyanka
Tomato	AVRDC	Alankar/11600kg ha^{-1} Ayush/9800kg ha^{-1} EO1059/8900kg ha^{-1} EO1060/9000kg ha^{-1} Grafted tomato/10% increased crop yield as well as 35% increased net income	Alankar Ayush Grafted tomato
Capsicum	AVRDC	Grafted capsicum/2610 kg per 160m^2; Net income of `17758	Grafted capsicum with protected cultivation

Vegetable cowpea	AVRDC	Pragathi/875kg Ha^{-1} KM 5/700kg ha^{-1}	Pragathi KM 5

B. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Production Enhancement Activities ▪ Yellow sticky traps ▪ Water traps	Installed on a total of 6 ha in 15 farmer fields in Chikkamagalur	Water traps have helped tomato to yield to increase by 4 kg/m^2; yellow sticky traps increased tomato yield by 3.80 kg/m^2; yellow sticky and water trap increased tomato yield by 6 kg/m^2 compared to control plot of about 3.40 kg/m^2	In 2017, an area of 240 ha has been identified for this intervention to cover 600 tomato growers in Chikkamagalur district
Machineries related components (Easy planters)	Chikkamagaluru	Minimizes labour requirement Reduced cost of manual planting by `3000-4000 ha^{-1}	Department of horticulture has procured 160 easy planters and supplied to farmers with subsidy
Postharvest technologies (solar dryers)	Chikkamagalur	Fresh chili peppers can be dried to less than 10% moisture content in 3 days and the dry weight is higher than sun-dried fruits	Initial work was undertaken to help establish a larger 1 – 1.5 ton commercial solar dryer for chili farmers in Chikkamagalur
Protected cultivation	Chikkamagaluru Kadur	3-4 fold higher yield; Less labour (mulching); Moisture conservation; healthy produce	10 units have been established and standardized for the local conditions and DoH is scaling up this technology by converging different schemes

III. Activities undertaken: Animal husbandry, Social forestry, Sericulture, Fisheries

Name of the Activity	Location/Village Name	CG Institution involved	Results	Scope for scaling up
Production Enhancement activities	Chikkamagaluru/Kunnalu Tarikere	ILRI/ICRISAT	Maize hybrid: NK 6240/Quality maize fodder available from dual purpose cultivars (fodder yield: 7 t ha^{-1}; grain yield: 5 t ha^{-1}) Sorghum: CSH 24 MF/ Multi-cut sorghum recorded yield of 65 t ha^{-1}	Dual purpose and multi-cut fodder crops are

6. Institution wise Activities undertaken and impact:

Name of the Hobli/Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
Chikkamagaluru (Lakya, Halelakya, Ganadalu, Hiregouja, Kunnalu) Birur (Emmedoddi,	ICRISAT	New crop cultivars of groundnut, Pigeonpea, castor, Chickpea	2013-14, 2014-15, 2015-16, 2016-17	The ICGV 91114 recorded yield of 2340 kg/ha as against to 1430 kg/ha
Chikkamagaluru (Hiregouja, Lakya) Birur (Emmedoddi)	CIMMYT	Participatory evaluation Maize hybrids and site-specific nutrient management	2014-15, 2015-16, 2016-17	GK 3059/6900kg ha^{-1} NK6240/7400kg ha^{-1} CP 818/8150kg ha^{-1} CP808/7500kg ha^{-1}
Chikkamagaluru (Sadarahalli)	ICRISAT	Sirohi bucks for breed improvement	2014-15	Expected no. of progenies
Chikkamagaluru (Lakumanahalli)	ICRISAT	Automatic weather station for rainfall and weather monitoring	2014-15	
Chikkamagaluru (Lakumanahalli)	ICRISAT	Hydrological monitoring unit	2014-15	3 units have been established and monitored regularly
Chikkamagaluru (Lakumanahalli, Ganadalu, Sadarahalli, hiregouja, Kunnalu) Birur (Emmedoddi)	ICRISAT	Farmer to farmer videos for dissemination of best practices	2014-15	9 short videos have been produced and linked with YouTube for wider dissemination and more than 2000 farmers adopted new practices
Tarikere Kadur Chikkamagaluru	ICRISAT	Madhyam culture for organic compost preparation	2014-15, 2015-16, 2016-17	More than 200 tons of compost was produced by farmers
Sadarahalli, Lingadahalli, Kunnalu, Udeva	ICRISAT	Decentralized wastewater treatment unit	2015-16, 2016-17	4 units have been constructed but the quality of construction is not satisfactory
Haranduru, Kuluru	IRRI	Farmer participatory rice varietal evaluation of IET 21478, IET 21479, Intan, KHP 10, KHP 2, KHP 5, Sharavathi and Tunga	2013-14, 2014-15, 2015-16, 2016-17	As compared to Local IET variety cultivation with Transplanting method, KHP10 variety results 14% more yield. In case of IET21478 it is 3%. KHP10 and IET-21478 varieties resulted 47% and 23% increment in profit of the farmers respectively. In terms of unit cost, DSR and IET21478 result 16% fall in unit cost and this reduction in cost is highest for KHP10 (20%).
Kunnalu, Uddeboranahalli	AVRDC	Grafted tomato	2015-16, 2016-17	Grafted tomato was found to be remunerative to farmers with less diseases and high yield
Koppa	AVRDC	Vegetable cowpea	2015-16, 2016-17	Pragathi/930kg ha^{-1}

Name of the Hobli/Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
				KM 5/690kg ha^{-1}
Ganadalu, Uddeboranahalli, Emmedoddi, Haralaghatta,	AVRDC	Protected cultivation, shade net	2014-15, 2015-16, 2016-17	Ensures moisture conservation and 3-4 fold higher yield was achieved with less labour (mulching)

7. Capacity building/Manpower trained under the project

Capacity building program	Taluk	Year	No. of persons
Water impact calculator for irrigation scheduling	Chikkamagaluru	2014-15	32
Tablet based extension system	Chikkamagaluru Kadur, Tarikere Koppa	2014-15 2015-16	10
Farmer-to-farmer videos	Chikkamagaluru Kadur, Tarikere Koppa	2014-15 2015-16	18
INM and leaf colour chart for efficient N management	Koppa	2014-17	500
Target based yield achievement through site-specific nutrient management	Chikkamagaluru Kadur, Tarikere	2014-17	60
Best management practices mung bean	Kadur Tarikere	2013-14 2014-15 2015-16 2016-17	65
Irrigation and fertigation scheduling	Chikkamagaluru Kadur Tarikere	2013-14 2014-15 2015-16 2016-17	60
Field days	All pilot taluks	2013-14 2014-15 2015-16 2016-17	145
Creating awareness about drip irrigation in horticulture crops	Kadur Tarikere Chikkamagaluru	2013-14 2014-15 2015-16 2016-17	30
Awareness building about climate change issues	Tarikere	2015-16	30
Site-specific nutrient management in Maize	Chikkamagaluru	2013-17	60
Best management practices of DSR, INM using LCC	Koppa	2013-17	60

8. Impact of the Project

a. New varieties adopted: In Chikkamagaluru district, new crop cultivars of Groundnut (ICGV 91114), pigeonpea (ICPH 2784), Chickpea (JAKI 9218), Castor (Jwala) and rice varieties IET

21478 and KHP10 have been widely adopted by farmers. However, seed requirement of new variety groundnut (ICGV 91114) seed is the limitation. Farmers obtained 400kg ha^{-1} yield of green gram by adopting Pusa Vishal variety as compared to 2700kg ha^{-1} yield from Local variety.

b. Change in cropping pattern: Efforts were made to introduce vegetable cowpea in rice fallow areas of Koppa and farmers got good results. However, due to variation in temperature during winter season as well as animal menace, farmers are not taking risks to cultivate these crops although these are profitable. It calls for required awareness creation among farmers through line departments and progressive farmers need to be trained and educated for wider adoption.
c. Change in crop yield levels: Farmers' participatory promotion of different crops have shown that improved crop cultivars have increased crop yield by 10-30%. The improved management practices also have larger impacts on increased carbon sequestration and water saving. By adopting ICGV 91114 groundnut variety farmers minimizes 77% of their income loss which could observed by adopting Local variety of Groundnut due to poor rainfall and adverse weather condition. The ICGV 91114 variety resulted 11% less cost per quintal of groundnut production.
d. Improvement in family income: The technologies have led to increased crop yield from 10-30%, reduced cost of cultivation by 5000-10,000, resulted into increased family income minimum by 10,000/family. The initial impact analysis indicated that average milk production per household is higher for beneficiary farmers i.e. 6.8 lit/day/household as compared 5.4 lit/day/household despite having equal size of livestock holdings.

Name and Signature
Nodal institute- Project coordinator

Annexure-A

Bhoosamrudhi Phase-1 (2013 to 2016-17)

1. Name of the District: **Vijayapura**
2. Name of the taluk/ hobli:Vijayapura, Indi, Muddebihal, Basavanabagewadi, Sindagi (Data of the hobli-wise to be compiled to district report)
3. Area (ha) and Number of families: 198 Villages/18500 Families (Hobli as a Unit from 3rd year)*
4. Location of the project:

Taluk	Gram Panchayaths	Hobli	Villages
Vijayapura	Kumathe Sarwad	Babaleshwar	Kumathe, Nidoni Sarwad
Indi	Inchageri D. Nimbaragi Jigajeevani Chadachan Hattalli Baradol	Chadachan	Inchageri Devara Nimbaragi, Jeerankalagi Jigajeevani Chadachan Havinal Baradol
Muddebihal	Dhavalagi	Dhavalagi	Agasabal
Basavanabagewadi	Beeraladinni	Kolhar	Beeraladinni, Angadageri, Hunashyal PC
Sindagi	Mulsavalagi	D. Hipparagi	Mulasavalagi, Nivalkhed

5. Project Details:

IV. Activities undertaken : Agriculture:

F. New varieties popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Area Covered (ha)	Best varieties for scaling up
Castor	ICRISAT	DCH 177/1600 kg ha^{-1}	30 ha	DCH 177
Sorghum	ICRISAT	BJV 44/2000 kg ha^{-1} M 35-1/770 kg ha^{-1}	14 ha	BJV44
Safflower	ICRISAT	PBNS 12/1140 kg ha^{-1}	20 ha	PBNS12
Pigeonpea	ICRISAT	ICPL 88039/300 kg ha^{-1} ICPL 161/520 kg ha^{-1} ICPL 85063/1500 kg ha^{-1}	24 ha 40 ha 4 ha	ICPL85063
Pearl millet	ICRISAT	Dhanashakti/1950 kg ha^{-1} JK 249 Hybrid/1820 kg ha^{-1} ICTP 8203/2000 kg ha^{-1}	35 ha 6 ha 6 ha	ICTP8203
Chickpea	ICRISAT	KAK 2/1500 kg ha^{-1} JG 130/1800 kg ha^{-1} JAKI 9218/1900 kg ha^{-1} JG 11/1900 Kg Ha^{-1} JAKI 9218/740 kg ha^{-1}	4 ha 8 ha 8 ha 10 ha	JAKI9218, JG 11

G. Innovative Agri equipment demonstrated and in Use.

Name of the Crop	Innovative Agri Equipment Demonstrated	Impact of the technology
Pigeonpea, sorghum, chickpea, safflower	Broadbed and furrow system	Crop yield increased by 19 and 24% over farmers practice in sorghum and safflower respectively
Field crops	Laser leveler	Land smoothening, avoiding the uneven distribution of moisture on surface due to small depressions resulting uneven growth of crop
Pigeonpea, Capsicum	Solar light pest trap	No. of pesticide spray reduced by one-fourth; improved quality of produce
Brinjal	Magnetic water conditioner (MWC)	Increased efficiency of drip system and crop yield (brinjal 9 kg/plant in MWC treated vs 7 kg/ plant in control)
Pigeonpea	Nipping machine	Increased yield by 7 to 8% in pigeonpea
Vegetables	Easy planter	Reduced cost of manual planting by `3000-4000 ha^{-1}

H. Fertigation Schedule:

Sl. No	Number of Soil samples taken	Soil testing results	Nutrient recommendations
Vijayapura	292	Ref. Appendix 1	Ref. Appendix 2
Indi	988	Ref. Appendix 1	Ref. Appendix 2
Muddebihal	27	Ref. Appendix 1	Ref. Appendix 2
Basavanabagewadi	125	Ref. Appendix 1	Ref. Appendix 2
Sindagi	50	Ref. Appendix 1	Ref. Appendix 2

I. Fodder demonstrated and area enhancement

Name of the Crop	Varieties demonstrated and results	CG Institution involved	Adoption level
Sorghum	CSH 20 MF/ CSH 24 MF/	ILRI/ICRISAT	5% 5%
Maize	NK 6240/	ILRI/ICRISAT	50%
Cactus	Cactus-1270 Cactus-1271 Cactus-1280	ICARDA	5%

J. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Hydrological monitoring	Shivanagi Mulsavalagi	Non Treated Treated	Scope for scaling up in the entire district by WDD
Farmer-to-farmer (F2F) videos	Kumathe, Nidoni Sarwad Inchageri Devara Nimbaragi, Jeerankalagi Jigajeevani Chadachan Havinal Baradol Beeraladinni, Angadageri, Hunashyal PC Mulasavalagi, Nivalkhed Agasabal	18 Video production 200 Screening 1156 Beneficiaries 240 Adoption	Large scope exists as farmers are willing to adopt new method/technologies to enhance their crop yield and income
Enhancing organic matter through aerobic composting	Agasabal Inchageri Jigajeevani Mulasavalagi, Nivalkhed Total-100 farmers	Better utilization organic wastes into compost Increased organic matter availability in soil	Large scope exists as there is plenty of crop residue available which can be decomposed within 45-50 days
Plant growth promoter (Aquasap - sea-weed extract)	Agasabal Inchageri Jigajeevani Mulasavalagi, Nivalkhed Beeraladinni, Angadageri Sarwad	The yield gain in improved cultivar of pearl millet (Dhanashakati) and pigeonpea (ICPL 88039) was 6-11%, while Aquasap sprayed on pigeonpea and pearl millet was 14-36%.	From the environmental point of view, scaling up of see weed based growth promoted gaining importance and has great potential in enhancing the crop yield as well as soil health
Sirohi bucks for natural breeding	Beeraldinni, Havinal	For natural insemination for herds of 25 goats, one Sirohi buck was kept and 50 progenies are expected	Cross breed with local breeds 23 male and 40 female With 12 farmers families

V. Activities undertaken: Horticulture

C. New varieties demonstrated popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Best variety for scaling up
Capsicum	AVRDC	Indra/	Indra
Tomato	AVRDC	IIHR PH 6321/ IIHR PH 1025/ IIHR PH 1021/ ArkaRakshak/	IIHR PH 1025 ArkaRakshak

D. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Production Enhancement Activities ▪	Beeraladinni, Angadageri, Inchageri, Agasabal, Havinal, Sarwad, Jigajeevani, Jeerankalagi	349 ha 285 beneficiaries Yield increase over farmer practice is 27 % to 40 %	BBF Technology adoption
Machineries related components	Sarawad, Angadageri, Inchageri	6 ha 10 Beneficiaries Water holding capacity increased	Laser land Leveler
Postharvest technologies (solar dryers)	Beeraladinni		500 kg Capacity

VI. Activities undertaken: Animal husbandry, Social forestry, Sericulture, Fisheries

Name of the Activity	Location/Village Name	CG Institution involved	Results	Scope for scaling up
Production Enhancement activities	Vijayapura/	ILRI/ICRISAT		
Machineries related components				

6. Institution wise Activities undertaken and impact:

Name of the Hobli/Village	Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
Kolhar	Beeraladinni, Angadageri,	ICRISAT	BBF/ Variety	2014-15	Increased yield over farmer practice
Chadachan	Inchageri, Havinal, Jigajeevani, Jeerankalagi	ICRISAT	BBF/ Variety	2015-16	Increased yield over farmer practice
Dhavalagi	Agasabal,	ICRISAT	BBF/ Variety	2015-16	Increased yield over farmer practice
Babaleshwar	Sarwad,	ICRISAT	BBF/ Variety	2015-16	Increased yield over farmer practice
D Hipparagi	Mulsavalagi, Nivalkhed	ICRISAT	Variety	2014-15	Increased yield over farmer practice
Chadachan	Hattalli, Havinal	ILRI	Feed Trails	2016-17	

Chadachan	Inchageri, Havinal, Jigajeevani, Jeerankalagi, Hattalli, Havinal, Chadachan	ILRI	Fodder variety in Maize, Sorghum	2014-15, 2015-16	
D Hipparagi	Mulsavalagi, Nivalkhed	ILRI	Fodder variety in Maize, Sorghum	2014-15	
Kolhar	Angadageri	AVRDC	Vegitables	2016-17	
Chadachan	Inchageri, Jigajeevani	AVRDC	Vegitables	2016-17	
Babaleshwar	Kumathe, Nidoni	AVRDC	Vegitables	2015-16	
Chadachan Babaleshwar Kolhar	Inchageri, Sarwad Angadageri	CIMMYT	Technology and Variety comparison	2015-16	
Chadachan Kolhar Vijayapura	Inchageri, Jigajeevani, Jeerankalagi Angadageri, Beeeraladinni KVK	ICARDA	Cactus introduced	2015-16	

7. Capacity building / Manpower trained under the project

Taluk	Gram Panchayaths	Hobli	Villages	No of Trainings/ Beneficiary	Year	CG Centers
Vijayapura	Kumathe Sarwad	Babaleshwar	Kumathe, Nidoni Sarwad	5/130 5/120 2/200	2014-17 2014-17 2015-17	ICRISAT, ILRI, AVRDC, IWMI
Indi	Inchageri D. Nimbaragi Jigajeevani Chadachan Hattalli Baradol	Chadachan	Inchageri Devara Nimbaragi, Jeerankalagi Jigajeevani Chadachan Havinal Baradol	3/180 2/60 2/40 3/80 6/230 5/160 2/60	2015-17 2015-17 2015-17 2015-17 2014-17 2014-17 2015-17	ICRISAT, ILRI, AVRDC, IWMI
Muddebihal	Dhavalagi	Dhavalagi	Agasabal	3/75	2015-17	ICRISAT, ILRI, AVRDC, IWMI
Basavanabagewadi	Beeraladinni	Kolhar	Beeraladinni, Angadageri, Hunashyal PC	5/150 5/210 3/60	2015-17 2015-17 2015-17	ICRISAT, ILRI, AVRDC, IWMI
Sindagi	Mulsavalagi	D.Hipparagi	Mulasavalagi, Nivalkhed	4/120 4/80	2014-17 2014-17	ICRISAT, ILRI, AVRDC, IWMI

8. Impact of the Project

e. New varieties adopted: ICPL 88039, ICPL 161, NK 6240, JG 11, JAKI 9218
f. Change in cropping pattern: Wide row spacing, intercropping with BBF landform
g. Change in crop yield levels: 27% to 45%
h. Improvement in family income: `10,000-15,000 per annum
i. Innovative machineries introduced and adopted: Solar Light Trap, Nipping Machine, Magnetic Water Conditioner, Easy Planter, BBF planter, Laser Land Leveler , Solar Dryer, shredder
j. Any other information related to project: Tablet Based Extensions System, KGS, Krishi Vani

Name and Signature
Nodal institute- Project coordinator

Annexure-A
Bhoosamrudhi Phase-1 (2013 to 2016-17)

1. Name of the District: **Tumakuru**
2. Name of the taluk/ hobli:Tumakuru, Tiptur, Sira, Pavagada, Madhugiri, Kunigal, Turuvekere (Data of the hobli-wise to be compiled to district report)
3. Area (ha) and Number of families: 80,000 ha area and 10,000 families
4. Location of the project:

Taluk	Gram Panchayaths	Villages
Tumakuru	Bellavi, Thimmarajanalli. Chikkachotlukere, Devalapura, Obalapura, Beladhara	Bellavi,Chikkabellavi, Devarajanahalli, Dodderi, T.Gollahalli, Chennenahalli, Haralakatte, Ajjagondanahalli, Harivanapura, Laxmisagara, Mashanapura, Nagarjunahalli, Lingenahalli, Hanumanthagiri, Kenchaiahnapalya, MM Kaval, Bittanakurike, Nayakanapalya, Amrthgiri, Beladhara, Ahobala agrahara, M.Gollahalli, Narasipura, Chindagiripalya, Chennamuddanahalli, Jakkenahalli, Hiregundagallu, Chinuga, Obalapura, Chikkakodathakallu, Appaiahnapalya, Bommanahalli, Thirumalapalya, ADA Palya, Chikkagunfdagallu
Tiptur	Gurugodahalli, Mattihalli, Balavanerlu, Gyaragatta, Kuppalu, Aralaguppe.	Mattihalli, Karikere,Chikkabidare, Kallushettihalli, Kadashettihalli,Kottigehalli, Ayarahalli,Rudrapura, Suragondanahalli, Muddenahalli, Rangapura, Bommenahalli, Hosalli, Vaderahalli, Balavanerlu, Hulihalli, THammadihalli, Patrehalli, Vittalapura, Anivala, Ratenahalli, Dasanakunte, Mallidevihalli,
Sira	Hulikunte, Dwaranakunte, Tadakaluru,	Varadapura, Gandihalli, Hoskote, Chiratarahalli, Needagatte, Tadakaluru, Bejjihalli, Doddahulikunte, Musukalotti, Shysamoru, Karehalli, Vajarahalli, Neejayanthi, Dwaranakunte, Bettappanahalli, Lakvanahalli.
Pavagada	Maridasanahalli, Y.N.Hoskote, J.Achhmnahalli, Kamanadurga, Ponnasamudra, Bhudibetta, Neelammanahalli, Pothaganahalli.	Hanumanthanahalli, J.Achhmmanahalli, Y.N.Hoskote, Thippaganalli, Thippaiahnadurga, Katthikyathanalli, Maridasanahalli, B.Hosalli, Yarrammanahalli, Etthinahalli, Ponnasamudra, Sulanayakanahalli, Buddareddy halli, Kamanadurga, Rachamaranahalli, Saravatapura, Hosdurga, Pothaganahalli, Dalavahihalli, Chennaiahnaroppa, Beemanakunte.
Madhugiri	Kondavadi, Gondhihalli, Puravara, Chikkamaluru, Doddamaluru, Kallidevipura, Singonahalli.	Arasapura, Byrenahalli, Handaralu, Kondavadi, Battigere, Naviladaku,Hunasavadi, Kulumenahalli, Doddamaluru, Reddyhalli, Kalenahalli, Suranagenahalli, Hosahalli, Chikkamaluru, PuravaraMallenahalli, Shambonahalli, Raguvanahalli, Gondhihalli, Narasapura, Halethimmanahalli, Thimmasandra, Siddanahalli, Yarrappanahalli, Shivapura, Doddahosalli, Obalapura, Shankarapura, Gamkaranahalli, Ramenahalli, Haralapura, Kodlapura, Immagondanahalli, Veeranagenahalli, Govindanahalli, Kempapura, Haralimaradahalli, Venkatapura, Kamsanahalli, Joogihalli, Kodigenahalli,Adavinagenhalli, Bachihalli, Bommenahalli, Gundagallu, Gutte, Jalihalli, Kadagatthur, Kallidevipura, Muthyalammanahalli, Mydanahalli, Shrandahnahalli,

Taluk	Gram Panchayaths	Villages
		Singanahlli, Thereyuru, Thingaluru, Yaklaralahalli, Yarragunte.
Kunigal	Kasaba, Yadiyur and Amruthur Hoblis villages	Kasaba, Yadiyur and Amruthur Hoblis villages
Turuvekere	Mayasandra Hobli all villages	Mayasandra Hobli all villages
Gubbi	Chelur Hobli all villages	Chelur Hobli all villages
Chikkanayakanalli	Shettikere Hobli all villages	Shettikere Hobli all villages
Koratagere	Kolala Hobli all villages	Kolala Hobli all villages

5. Project Details:

VII. Activities undertaken : Agriculture:

K. New varieties popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Area Covered (ha)	Best varieties for scaling up
Castor	ICRISAT	DCH 177/800kg ha^{-1} DCH 519/650kg ha^{-1} 48-1 (Jwala)/600 kg ha^{-1}	36	DCH 177
Pearl millet	ICRISAT	ICTP8203 (Dhanshakti)/1200kg ha^{-1}	20	ICTP8203 (Dhanshakti)/
Sorghum	ICRISAT/ILRI	CSV17/1200 kg ha^{-1} CSV27/1150 kg ha^{-1} CSV-23/1250 kg ha^{-1} PVK801/1200 kg ha^{-1}	22l	CSV23
Groundnut	ICRISAT	ICGV91114/1500 kg ha^{-1} ICGV0350/900kg ha^{-1} ICGV0351/1050kg ha^{-1} ICGV2266/850 kg ha^{-1} K-9/1200 kg ha^{-1}	110	ICGV91114 K9
Green gram	ICARDA/ICRISAT	Pusa Vishal/1125 kg ha^{-1} LGG 460/920 kg ha^{-1} KKM 2/890 kg ha^{-1}	32	Pusa Vishal, LGG 460
Cactus	ICARDA	Cactus-1270 Cactus-1271 Cactus-1280	1500 cladodes	
Maize	CIMMYT	GK3059/7200 kg ha^{-1} NK6240/6950 kg ha^{-1} HTMH5402/7050 kg ha^{-1}	40	GK3059 HTMH5402
Rice	CIMMYT/IRRI	DRR Dhan 42/5500 kg ha^{-1} DRR Dhan 43/5200kg ha^{-1}	25	DRR Dhan 42

L. Innovative Agri equipment demonstrated and in Use.

Name of the Crop	Innovative Agri Equipment Demonstrated	Impact of the technology
Rice	Zero till Multi crop planter	Reduced cost of cultivation ranging between 5000 and 12500/ha
Maize	Zero till Multi crop planter	
Finger millet	Zero till Multi crop planter	
Vegetables	Easy planter	Reduced cost of manual planting by `3000-4000 ha^{-1}

M. Fertigation Schedule:

Sl. No	Number of Soil samples taken	Soil testing results	Nutrient recommendations
Tumakuru	299	Ref. Appendix 1	Ref. Appendix 2
Tiptur	428	Ref. Appendix 1	Ref. Appendix 2
Sira	160	Ref. Appendix 1	Ref. Appendix 2
Pavagada	193	Ref. Appendix 1	Ref. Appendix 2
Madhugiri	580	Ref. Appendix 1	Ref. Appendix 2

N. Fodder demonstrated and area enhancement

Name of the Crop	Varieties demonstrated and results	CG Institution involved	Adoption level
Maize	NK 6240/Quality maize fodder available from dual purpose cultivars (fodder yield: 7-8 t ha^{-1}; grain yield: 5-6 t ha^{-1})	ILRI/ICRISAT	Farmers found alternative high yielding fodder varieties which are suitable to the district and efforts are made by the line departments to scale up with convergence from animal husbandry department
Sorghum	CSH24 MF/ CSV 23/ Multi-cut sorghum recorded yield of 65-70 t ha^{-1}	ILRI/ICRISAT	
Cactus	Cactus-1270 Cactus-1271 Cactus-1280	ICARDA	Needs awareness among farmers/extension officers

O. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Hydrological monitoring	Hiregundgal	Obtained on an average 10% of rainfall as surface runoff	Scope for scaling up in the entire district by WDD

Name of the Activity	Location	Results	Scope for scaling up
Farmer-to-farmer (F2F) videos	Tumakuru Madhugiri	Produced 15 short videos of different crop production technologies	Large scope exists as farmers are willing to adopt new method/technologies to enhance their crop yield and income
Enhancing organic matter through aerobic composting	Tumakuru, Madhugiri, Sira, Pavagada, Tiptur	Better utilization organic wastes into compost Increased organic matter availability in soil	Large scope exists as there is plenty of crop residue available which can be decomposed within 45-50 days
Plant growth promoter (Aquasap - sea-weed extract)	Madhugiri	Maize hybrid yield increased by 10-12% over farmers' practice	From the environmental point of view, scaling up of see weed based growth promoted gaining importance and has great potential in enhancing the crop yield as well as soil health

VIII. Activities undertaken: Horticulture

E. New varieties demonstrated popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Best variety for scaling up
Tomato	AVRDC	**Grafted tomato** Tolerance against bacterial wilt / blight and nematodes. Grafted tomato Success rate / survival rate is 98 % in field after transplanting No incident of bacterial wilt Expecting 30-50% increased yield (70 ton/ha in Grafted tomato compared to 35 ton/ha in non-grafted tomato	

F. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Production Enhancement Activities ▪ Yellow sticky traps ▪ Water traps	Installed on a total of 6 ha in 3 farmer fields	Water traps have helped tomato to yield to increase by 6 kg/m^2; yellow sticky traps increased tomato yield by 6.10 kg/m^2; yellow sticky and water trap together increased tomato yield by 7.10 kg/m^2 compared to control plot of about 5.40 kg/m^2	DoH is planning to scale it up by converging different programmes

Name of the Activity	Location	Results	Scope for scaling up
Machineries related components (Easy planters)	Madhugiri	Minimizes labour requirement Reduced cost of manual planting by `3000-4000 ha^{-1}	Department of horticulture has procured 200 easy planters and supplied to farmers with subsidy
Postharvest technologies (solar dryers)	Tumakuru		Based on the results achieved in Chikkamagaluru, the state government (GoK) has approved 2 units to Tumakuru

IX. Activities undertaken: Animal husbandry, Social forestry, Sericulture, Fisheries

Name of the Activity	Location/Village Name	CG Institution involved	Results	Scope for scaling up
Production Enhancement activities	Tumakuru /Madhugiri /sira	ILRI/ICRISAT	Maize hybrid: NK 6240/Quality maize fodder available from dual purpose cultivars (fodder yield: 8 t ha^{-1}; grain yield: 6 t ha^{-1}) Sorghum: CHS 24MF/ Multi-cut sorghum recorded yield of 65-70 t ha^{-1}	Large scope as dairy animal are in large numbers and quality fodder is the need for the farmers to increase milk yield.
Machineries related components (Zero-till multi crop planter)	Tumakuru	CIMMYT/ ICRISAT	In advanced method of DSR technology, paddy is sown using Zero-tiller multi crop planter which reduced cost of cultivation significantly (reduced cost was 10,000-15,000/ha compared to transplanting methods) Zero-till is one of the promising technology as farmers don't have to till their fields and this machine facilitate to do sowing under no-till condition, which not only saves time and reduce the cost of cultivation but also save significant in-situ soil moisture from top soil layers.	This technology hold large scope for scaling up especially in paddy grown areas and also in rice-fallow regions in which land is left fallow after cultivating paddy. Legumes crops such as chickpea, lentils, cowpea, green gram etc can be cultivated in those areas.

6. Institution wise Activities undertaken and impact:

Name of the Hobli/Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
Kodigenahalli, , Doddahosahalli,Hulikunte, YN Hoskote, Nagalamadike Chiniga, Gondihalli,	ICRISAT	• Introduction of improved crop cultivars of groundnut, castor, pearl millet, sorghum, green gram and paddy • Introduction of Moisture	2012-16	Increased crop yield by 20-50% depending on rainfall variability and land management practices

Name of the Hobli/Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
Baragur, Doddabanagera, Tadakalur, Chelur, Holavanahalli		conservation technology such as Broad-bed and furrow for enhancing green water availability • Aerobic composting for enriching organic carbon • Farmers to farmers video for better dissemination • Decentralized wastewater treatment system		
Hiregundagal	CIMMYT	• DSR technology • Use of zero-till multi-crop planter	2012-16	• Reduced cost of cultivation by 10,000-15,000/ha for paddy cultivation; • Water saving more than 50%
Hiregundagal	IRRI	• Introduction of improved paddy cultivars suitable for DSR • Weed management technology	2012-16	Increased crop yield by 15-20% and reduced labor cost
Chikkagundagal, Doddahosahall, Chikkagundagal	ILRI	• Balanced rationing of animal feed and fodder by following mass balance/need based approach • Introduction of dual purpose Maize/ multi-cut sorghum	2012-16	• Improved fodder availability • Increased average milk minimum by 1-1.5 Liter/day/animal;
Hiregundagal, YN Hoskote	AVRDC	Introduction of vegetable production technology such as grafted tomato and pest management	2012-16	• Increased vegetable yield • Improved farmers capacity on vegetable production techniques
Hiregundagal	ICARDA	Introduction of thorn-less cactus/ mung bean	2012-16	Additional income from pre-kharif as mung bean
Kodigenahalli, , Doddahosahalli,Hulikunte, YN Hoskote, Nagalamadike	IWMI	Capacity building of farmers on proper use of drip irrigation system and	2012-16	Increased water use efficiency by 30-40%

Name of the Hobli/Village	CG Institution involved	Technology Proposed	Year of implementation	Impact
		irrigation/fertigation scheduling		

7. Capacity building / Manpower trained under the project

Capacity building program	No. of trainings	No. of persons
Tablet based extension system	3	10
Farmer-to-farmer videos	5	15
Target based yield achievement through site-specific nutrient management	5	130
Best management practices for mung bean	3	55
Irrigation and fertigation scheduling	5	225
Field days	4	300
Creating awareness about drip irrigation in horticulture crops	10	130
Awareness building about climate change issues	1	30
Site-specific nutrient management in maize	5	60
Best management practices of DSR	3	60

8. Impact of the Project

k. New varieties adopted: There is increasing demand of improved groundnut (ICGV91114, K9), pearl millet (ICTP8203 (Dhanshakti) and Castor (DCH177). Availability of groundnut seeds is the limitation yet.
l. Change in cropping pattern: Tumakuru is one of the dryland area; where groundnut, pigeonpea, finger millet is largely grown in rainfed system. As such there is no significant change in cropping system but the yields levels improved with adoption of improved practices.
m. Change in crop yield levels: There is clear evidences from farmers participatory trials that improved technology either reduced cost of cultivation or increased crop yield along with other environmental benefits such as increased carbon sequestration and water saving.
n. Improvement in family income: These technologies are led to increase crop yield from 20-50%, reduced cost of cultivation by 5000-15000, resulted into increased family income minimum by 10,000-15000/family.
o. Innovative machineries introduced and adopted: Zero-till multi crop planter has shown promising results as it is used by paddy and other cereals growing farmers. There is demand but require capacity building on how to operate machine along with weed management.
p. Any other information related to project.

Name and Signature
Nodal institute- Project coordinator

Annexure-A

Bhoosamrudhi Phase-1 (2013 to 2016-17)
PERFORMA FOR SUBMISSION OF DISTRICT WISE PROJECT COMPLETION REPORT

1. Name of the District: **Raichur**
2. Name of the taluk/ hobli: Manvi, Raichur, Deodurga, Lingasugur, Sindanoor
   (Data of the hobli-wise to be compiled to district report)
3. Area (ha) and Number of families: 80,000 ha and 16,450 families
4. Location of the project: Raichur, Karnataka

Sl No.	Taluk	Hobli /Panchyati	Villages
1	Raichur	Gillesgur Yeragera Kalmala Chandrabanda Kasba RCR CMC Raichur	Idapanur Puchaladinni Midagaldinni Vijayanagar camp Jagirvenkatapur Kasbe camp Palkamdoddi Siddanbavi camp Sriramanagar camp
2	Manvi	Neermanvi Chimlapura Mallat .Kurukunda Patkamdoddi	Haravi Govindoddi Karadigudda Kurakunda Vadavatti Patkamdoddi
3	Devdurga	Jagirjadaldinni Kyadagera Deodurga Jalahalli Arakera Devdurga Jalahalli Gabbur	Rekalmaradi Malladevargudda malkamdinni Nagoli Agrhar Bandegudda Karigudda Ganadal Somanamaradi Galag Jalahalli Kyadagiri Jadaldinni+Markamdinni Yeldoddi Masarukallu Irubigera HN Tanda+Kotigudda Vandali Palkamdinni Gabbur(all)
4	Lingasugur	Ankushdoddi Kota Kotagal Mettur Gurgunta	Ankushdoddi Hoovinabhavi Mudabal Buddinni Hutti Kotagal Santekalluru

Sl No.	Taluk	Hobli /Panchyati	Villages
			Mittekallur Gowduru Tavaga Hatti
5	Manvi	Hirehanagi Kavital Hirekotnekal	Hirehanagi Hussainapur Saydapur Kavital Hirekotnekal
	Sindhanur	Gorebala Camp Sindhanur	Gorebala Camp Sindhanur

5. Project Details:

X. Activities undertaken : Agriculture:

P. New varieties popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Area Covered (ha)	Best varieties for scaling up
Green gram	ICRISAT	Pusa Vishal/395 kg ha^{-1} LGG 460/380 kg ha^{-1} KKM 2/405 kg ha^{-1} DGGV2/250 kg ha^{-1} Sipai/810 kg ha^{-1} Pusa 3/980 kg ha^{-1} BGS 9/880 kg ha^{-1}	400	Pusa 3 BGS 9
Groundnut	ICRISAT	ICGV 91114/2590 kg ha^{-1}	250	ICGV 91114
Pigeonpea	ICRISAT	ICPL 87119/1590 kg ha^{-1} ICPL 85063/1580 kg ha^{-1} ICPH2671/1550 kg ha^{-1} ICPH2740/1840 kg ha^{-1}	1000	ICPH 2740
Kh. Sorghum	ICRISAT	CSV 23/2880 kg ha^{-1}	50	CSV 23
Pearl millet	ICRISAT	ICTP 8203/1440 kg ha^{-1} HHB 671/1370 kg ha^{-1}	70	ICTP8203
Sunflower	ICRISAT	DRSH 1/1580 kg ha^{-1}	20	DRSH1
Castor	ICRISAT	DCH 177/2300 kg ha^{-1} DCH Jyothi/2170 kg ha^{-1}	50	DCH 177
R. sorghum	ICRISAT	CSV 22/2340 kg ha^{-1}	50	CSV 22
Chickpea	ICRISAT	JG 11/1330 kg ha^{-1} JAKI 9218/1470 kg ha^{-1} KAK-2/950 kg ha^{-1}	1000	JAKI 9218
Rice	IRRI/ICRISAT	Jagityal Mashuri-JGL 11470 JGL 18047 Sannalu (WGL 32100) RNR 15048 JGL 1118 - Anjana	1500	RNR 15048 Jagityal Mashuri-JGL 11470

Q. Innovative Agri equipment demonstrated and in Use.

Name of the Crop	Innovative Agri Equipment Demonstrated	Impact of the technology
Pigeonpea, Maize	Broad bed and furrow system	Crop yield increased by 1075 kg ha^{-1} and 1625 kg ha^{-1} over farmers practice in pigeonpea
Cotton+Chickpea; Cotton+Sorghum	Relay planter	Net income increased between `29,000 to 37000/ha
Pigeonpea	Nipping machine	Increased yield by 7 to 8% in pigeonpea
Vegetables	Easy planter	Reduced cost of manual planting by `3,000-4,000 ha^{-1}
Rice	Leaf color chart	Optimizing the nitrogen use and attain optimal rice productivity
Rice	Surface and sub-surface drip irrigation	Water saving by 60-70% compared to transplanting and 25-30% by direct seeding of rice

R. Fertigation Schedule:

Sl. No	Number of Soil samples taken	Soil testing results	Nutrient recommendations
Manvi	269	Ref. Appendix 1	Ref. Appendix 2
Raichur	300	Ref. Appendix 1	Ref. Appendix 2
Deodurga	326	Ref. Appendix 1	Ref. Appendix 2
Lingasugur	113	Ref. Appendix 1	Ref. Appendix 2

S. Fodder demonstrated and area enhancement

Name of the Crop	Varieties demonstrated and results	CG Institution involved	Adoption level
Sorghum	CSV 27 PVK 801	ILRI/ICRISAT	120 demos for sorghum; 250 demos for Fodder sorghum and 100 demos for maize
Maize	NK 6240/	ILRI/ICRISAT	
Cactus	Cactus-1270 Cactus-1271 Cactus-1280	ICARDA	10 farmers

T. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Farmer-to-farmer (F2F) videos	Manavi, Raichur Lingasgur Devadurga and Sindanur	9 short videos produced and screened by farm facilitator and nearly 3500 farmers have adopted the technology Helped in understanding the good management practices in agriculture and allied	Large scope exists as farmers are willing to adopt new method/technologies to enhance their crop yield and income

Name of the Activity	Location	Results	Scope for scaling up
		sectors in local language, resulting in increased adoption rate.	
Enhancing organic matter through aerobic composting	Raichur Lingasgur Devadurga	Better utilization organic wastes into compost Increased organic matter availability in soil	Large scope exists as there is plenty of crop residue available which can be decomposed within 45-50 days
Plant growth promoter (aquasap - sea-weed extract)	Manavi, Raichur Lingasgur Devadurga and Sindanur	Optimizing the nutrients use and attain optimal crop productivity as per farmers opinion	From the environmental point of view, scaling up of see weed based growth promoted gaining importance and has great potential in enhancing the crop yield as well as soil health
Sirohi bucks for natural breeding	Lingasgur	Helped in improving the local breeds with increased productivity	Good scope exists in improving the local breed suitable for higher meet as well as improving other production factors

XI. Activities undertaken: Horticulture

G. New varieties demonstrated popularized:

Name of the Crop	CG Institution involved	Varieties demonstrated and results	Best variety for scaling up
Tomato	AVRDC	Grafted (open field), yield 32.5 t/ha	32.5
Capsicum	AVRDC	Grafted (shade net), yield 26 t/ha	26
Capsicum	AVRDC	Grafted (Open field), yield 20 t/ha	20
Mung bean (Paddy fallow)	AVRDC	Vegetable type yield 20 t/ha	0.68
Cowpea(Paddy fallow)	AVRDC	Pragathi/1225kg Ha^{-1} yield 1.225 t/ha KM 5/1150kg ha^{-1} yield 1.15 t/ha	1.23

H. Other activities

Name of the Activity	Location	Results	Scope for scaling up
Production Enhancement Activities ▪ Aquasap, Humic acid	Raichur, Manvi tq	Increased crop yield by 12-22% in pigeonpea, cotton and paddy	Department of agriculture and horticulture should promote this material for further scaling up
Machineries related components viz. easy planters	Lingasgur, Manavi	Help in reducing cost of cultivation (by (`1,500-2,500/- ha in transplanting cotton, pigeonpea and vegetable seedlings	

Name of the Activity	Location	Results	Scope for scaling up
Postharvest technologies (tarpoline sheet)	Manavi, Raichur	Used for un drying and also thereby to helps in improving quality of chili	
Solar irrigation pump set	Raichur, Lingasgur	Solar irrigation pump sets are being used for irrigation and farmers is using it in Bt Cotton, vegetables and pigeonpea crops	5 HP solar units were shared with 4 farmers in BS program
Protected cultivation	Lingasgur	3-4 fold higher yield; Less labour (mulching); Moisture conservation; healthy produce	8 units have been established and standardized for the local conditions and DoH is scaling up this technology by converging different schemes

XII. Activities undertaken: Animal husbandry, Social forestry, Sericulture, Fisheries

Name of the Activity	Location/Village Name	CG Institution involved	Results	Scope for scaling up
Production Enhancement activities	Raichur, Manavi, Lingasgur	ILRI/ICRISAT	Maize hybrid: NK 6240/Quality maize fodder available from dual purpose cultivars (fodder yield: 10.8 t ha^{-1}; grain yield: 6.5 t ha^{-1}) Sorghum: CSH 24 MF/ Multi-cut sorghum recorded yield of 78 t ha^{-1}	Dual purpose, multi-cut fodder crops and choppers are preferred by farmers so need to be scaled up by department
Machineries related components (Choppers)	Lingasugur	ILRI/ICRISAT	Help in chopping the fodder in to pieces there by improve its use efficiency	

5. Institution wise Activities undertaken and impact:

Location			CG Institution involved	Technology Proposed	Year of implementa tion	Impact
Taluk	Hobli	Villages				
1.Raichur 2.Lingasugur 3Deodurga	1.Gilesguru Gurugunta Gabburu	1Kasbecamp, 2.Anvari Honnatagi,Masyala Salkyapur and Irbegera	ICRISAT	New crop cultivars of groundnut, Pigeonpea, castor, Chickpea	2013-14, 2014-15, 2015-16, 2016-17	The ICGV 91114 recorded yield of 2560 kg/ha as against to 1130 kg/ha of local popular variety
1.Raichur 2.Manvi	1.Kalmala 2.Neermanvi	1.Kalmala 2.Govinadoddi and chimlpur	CIMMYT	Participatory evaluation Maize hybrids and site-	2014-15, 2015-16, 2016-17	NK6240/8400kg ha^{-1}

Location			CG Institution involved	Technology Proposed	Year of implementation	Impact
				specific nutrient management		
1.Lingasugur 2.Devadurga	1.Maski 2.Arakera	1.Mittekalluru 2.Bandegudda	ICRISAT	Sirohi bucks for breed improvement	2014-15	10 progenies
1.Lingasugur 2.Manvi	1.Maski 2.Neermanvi	1Mittekallur, 2.Haravi and shanthinagara camp	ICRISAT	Automatic weather station for rainfall and weather monitoring	2014-15	Weather data set on all parameters recorded through this station were shared periodically to all the farmers, JDAs, CEO-ZP and other stakeholders on periodic basis.
1.Raichur 2.Deodurga 3.Manvi	1Gilesguru 2.Gabbur 3.Neermanvi	1Idapanur, 2Ganadal,Puchaladinni,Kalluru, Haravi,govinadoddi,Karadigudda,Neermanvi, Katagal,Mittekalluru,Hoovinabhavi	ICRISAT	Farmer to farmer videos for dissemination of best practices	2014-15, 2015-16	10 short videos have been produced and linked with YouTube for wider dissemination and more than 2500 farmers adopted new practices
1.Raichur 2.Deodurga 3.Manvi	1Gilesguru 2.Gabbur 3.Neermanvi	1Idapanur, 2Ganadal,Puchaladinni,Kalluru, Haravi,govinadoddi,Karadigudda,Neermanvi, Katagal,Mittekalluru,Hoovinabhavi	ICRISAT	Madhyam culture for organic compost preparation	2014-15, 2015-16, 2016-17	More than 2000 tons of compost was produced by farmers
1.Raichur 2.Manvi 3.Lingasugur 4.Sindhanur 5.Deodurga	1.Dillesugur 1.Yaragera 1.Kalmala 2.Mallat 2. Kavital 2.neermanvi 2.Kotnekal 3.Gurugunta 4.Sindanur 4.Gorebal 5Arakera 5.Gabbur	1.Idapanur,Ganadal Puchaladinni, Midagaladinni Vijayanagaracamp, Siddanabhavi and Sreeramanagaraa camp Kasbe camp and Jagirvenkatapur 2.Kurkunda,Vadavati 3. HirehanagiKavital 4.neermanvi,Chimlapura,Haravi ,govinadoddi 5.Amareswara camp potnal 3.Anvari,Honnali and Kota and hutti 4.RH Camp1,2 1nd 3 Camp	ICRISAT	Hybrid pigeonpea (ICPH 2740) demos of Transplanting and Dibbling	2014-15, 2015-16, 2016-17	Yield up to 36.5 q/ha was recorded with an average yield of 22.5 q/ha under different field condition as against farmers yield of 14.5 q/ha with popular TS3R variety

Location			CG Institution involved	Technology Proposed	Year of implementation	Impact
		4.Gorebal ,Shantinagara and Badarli 5.Bandegudda,jalahalli Galag and Ganadal 5. Masyala				
1.Raichur 2.manvi	1.Kalmala 2. Neermanvi	1.Shreerannagara camp, Siddanabhavi camp, Shimlapura, 2. Haravi and Shantinagara	IRRI	Farmer participatory rice varietal evaluation of RNR 15048, Jagityal Mashuri-JGL 11470 JGL 18047 Sannalu (WGL 32100) RNR 15048 JGL 1118 – Anjana	2013-14, 2014-15, 2015-16, 2016-17	As compared to BPT 5204, cultivation with DSR, machine Transplanting method, resulted in 7% and 23% increment in profit of the farmers. In terms of unit cost, DSR, 10-15% fall in unit cost was recorded
1.Raichur 2.Manvi	1.Raichur 2.Manvi	Kurkunda,Chandrabanda,Yaragera,Puchaladinni,Idapunur and katagal	AVRDC	Grafted tomato	2015-16, 2016-17	Grafted tomato was found to be remunerative to farmers with less diseases and high yield
1.Raichur 2.Manvi	1.Raichur 2.Manvi	Kurkunda,Bandegudda ,Puchaladinni,Idapanur and Yaragera	AVRDC	Vegetable cowpea	2015-16, 2016-17	Pragathi/1225 kg ha^{-1} KM 5/1150kg ha^{-1}
1.Raichur 2.Manvi	1.Raichur 2.Manvi	Kurkunda,Yaragera and Idapanur	AVRDC	Protected cultivation, shade net	2014-15, 2015-16, 2016-17	Ensures moisture conservation and 3-4 fold higher yield was achieved with less labour (mulching)

Capacity building / Manpower trained under the project

Capacity building program	Taluk	Year	No. of persons
Water impact calculator for irrigation scheduling	Raichur, Manavi, Deodurga, Lingasugur	2014-15	42

Capacity building program	Taluk	Year	No. of persons
Tablet based extension system	Raichur, Manavi, Deodurga, Lingasugur	2014-15 2015-16	24
Farmer-to-farmer videos	Raichur, Manavi, Deodurga, Lingasugur	2014-15 2015-16	500
INM and leaf colour chart for efficient N management	Sindanur, Raichur, Manavi, Deodurga, Lingasugur	2014-17	2000
Target based yield achievement through site-specific nutrient management	Manavi, Deodurga	2014-17	90
Best management practices for mung bean	Raichur, Manavi, Deodurga	2013-14 2014-15 2015-16 2016-17	250
Irrigation and fertigation scheduling	Raichur, Manavi, Deodurga,	2013-14 2014-15 2015-16 2016-17	40
Field days	Sindanur, Raichur, Manavi, Deodurga, Lingasugur	2013-14 2014-15 2015-16 2016-17	55
Creating awareness about drip irrigation in Paddy and horticulture crops	Raichur, Manavi, Deodurga, Lingasugur	2013-14 2014-15 2015-16 2016-17	110
Awareness building about climate change issues	Lingasugur, Raichur, Deodurga	2014-15 2015-16	10

Capacity building program	Taluk	Year	No. of persons
		2016-17	
Site-specific nutrient management in Maize	Raichur, Manavi, Deodurga,	2013-17	110
Best management practices of DSR, INM using LCC	Sindanur, Raichur, Manavi, Deodurga	2013-17	4000

6. Impact of the Project

a. New varieties adopted: In Raichur district, new crop cultivars of pigeonpea (ICPH 2740), Chickpea (JAKI 9218), Groundnut (ICGV 91114), and rice varieties RNR 15048, Jagityal Mashuri-JGL 11470, JGL 18047, JGL 1118 – Anjana have been widely adopted by farmers. However, seed requirement of new variety groundnut (ICGV 91114) seed is the limitation. Hybrid pigeonpea in protected irrigated condition and RNR 15048 under direct seeded condition became highly popular and are being scaled in different pockets of Raichur district by farmers themselves with active support from Agricultural department and farmer themselves.

b. Change in cropping pattern: Proper crop rotation was ensured amongst the targeted households particularly in rotating cotton with legumes and pulses etc. In this direction, large area was covered under crop diversification along with all CGIAR institutes and departments. Efforts were also made to intensify the paddy based cropping system with legume viz. cowpea, green gram, and chickpea as well as mustard during *rabi*. The farmers obtained benefit of `8,000 to `15,000/ha with this activity.

c. Change in crop yield levels: Farmers' participatory evaluation of different interventions leads to incares in crop productivity ranging from 7-28% in different crops and with different interventions. The improved management practices have larger impacts on increased carbon sequestration and water saving. Hybrid pigeonpea recorded 30-50% increased in crop yield compared to local popular variety TS3R. Similarly, DSR with RNR 15048 recorded same yield level as of transplanted paddy but the cost of cultivation is less than `10,000-15,000/ha compared to transplanting method.

d. Improvement in family income: The technologies have led to increased crop yield from 7-50%, reduced cost of cultivation by `5,000-15,000, resulted into increased family income minimum by `8,000/family. In pilot taluks of Raichur, farmers' income was observed maximum 16% increment in income as compared to base year.

Name and Signature
Nodal institute- Project coordinator

Appendix 1. Soil testing results

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Raichur	Manvi	Govindoddi			30	10	0			0	50	0				20
Raichur	Manvi	Haravi			82	12	2			8	75	37				60
Raichur	Manvi	Kurukunda			82	27	0			90	97	73				60
Raichur	Manvi	Patakamdoddi			95	49	0			77	100	56				39
Raichur	Manvi	Sangapur			65	5	0			0	50	5				20
Raichur	Manvi	Wadavatti			93	43	0			75	95	33				40
Raichur	Raichur	Idapnur			98	32	1			66	96	49				140
Raichur	Raichur	Midgaldinni			75	0	10			35	75	50				20
Raichur	Raichur	Pucchaldinni			100	15	35			65	80	85				20
Raichur	Devadurga	Banddegudda			85	25	0			45	85	30	5	10	0	20
Raichur	Devadurga	Malkamdinni			98	89	0			89	98	11	0	0	0	44
Raichur	Devadurga	Malledevaragudda			80	50	0			70	75	20	10	5	0	20
Raichur	Devadurga	Nagooli			76	65	0			71	82	24	6	6	0	17
Raichur	Devadurga	Rekalmaraddi			84	68	0			80	88	28	0	4	0	25
Raichur	Lingasugur	Ankushdoddi			60	55	0			95	85	35	0	0	0	20
Raichur	Lingasugur	Buddinni			40	60	10			85	90	60	0	0	0	20
Raichur	Lingasugur	Hoovinabhavi			100	94	0			100	100	88	0	0	0	16
Raichur	Lingasugur	Katagal			74	58	0			58	84	21	5	11	0	19
Raichur	Lingasugur	Mittekalluru			68	58	5			89	100	53	5	0	0	19
Raichur	Lingasugur	Mudabhal			100	84	0			68	95	21	0	0	0	19
Raichur	Deodurga	Karigudda			93	10	3	23	0	37	100	67	10	20	0	30
Raichur	Deodurga	0			93	10	3	23	0	37	100	67	10	20	0	30
Raichur	Deodurga	Galag			43	30	0	30	0	63	67	47	60	20	0	30
Raichur	Deodurga	Ganadal			38	5	25	35	0	20	35	38	3	20	0	40
Raichur	Deodurga	Jalahalli			70	22	15	18	0	18	70	25	15	3	0	60
Raichur	Deodurga	Somanamaraddi			75	38	3	10	0	20	80	10	10	5	0	40
Raichur	Deodurga	0			59	23	12	22	0	27	64	28	19	11	0	170
Raichur	Deodurga Total	Deodurga Total			64	21	11	23	0	29	69	34	18	12	0	200
Raichur	Manvi	Husenapur			67	20	3	33	0	43	97	40	7	30	0	30
Raichur	Manvi	Kavita Total			67	20	3	33	0	43	97	40	7	30	0	30
Raichur	Manvi Total	Manvi Total			67	20	3	33	0	43	97	40	7	30	0	30
Raichur	Raichur	Palkamdoddi			63	8	8	23	0	33	65	48	8	30	0	40

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Raichur	Raichur	Chandrabanda Total			63	8	8	23	0	33	65	48	8	30	0	40
Raichur	Raichur	J.Venkatapura			75	85	0	0	0	65	100	5	15	0	0	20
Raichur	Raichur	Kasbe Camp			63	37	3	0	0	17	50	7	13	0	0	30
Raichur	Raichur	Vijayanagar Camp			13	0	0	0	0	0	0	0	0	0	0	30
Raichur	Raichur	Kalmal Total			48	35	1	0	0	23	44	4	9	0	0	80
Raichur	Raichur Total	Raichur Total			53	26	3	8	0	26	51	18	8	10	0	120
Raichur District Total	Raichur District Total	Raichur District Total			60	23	7	18	0	29	65	29	13	13	0	350
Chikkamagaluru	Chikkamagaluru	Kaarehally			46.7	0.0	0.0			26.7	13.3	53.3				15
Chikkamagaluru	Chikkamagaluru	Karisiddanahally			20.0	0.0	0.0			53.3	53.3	6.7				15
Chikkamagaluru	Chikkamagaluru	Kengenahally			40.0	0.0	0.0			53.3	40.0	20.0				15
Chikkamagaluru	Chikkamagaluru	Kunnalu			53.3	6.7	0.0			46.7	86.7	33.3				15
Chikkamagaluru	Chikkamagaluru	Kurichikkanahally			73.3	0.0	0.0			60.0	66.7	33.3				15
Chikkamagaluru	Chikkamagaluru	Lakumanahally			53.3	26.7	0.0			80.0	60.0	40.0				15
Chikkamagaluru	Chikkamagaluru	Siribadagi			53.3	6.7	0.0			60.0	93.3	66.7				15
Chikkamagaluru	Chikkamagaluru	Uddeboranahally			46.7	20.0	0.0			86.7	53.3	53.3				15
Chikkamagaluru	Kadur	Chikkangala			100.0	6.7	6.7			93.3	93.3	73.3				15
Chikkamagaluru	Kadur	Emmedoddi			7.1	7.1	0.0			78.6	92.9	0.0				14
Chikkamagaluru	Kadur	Gandhinagara			58.3	0.0	0.0			75.0	83.3	66.7				12
Chikkamagaluru	Kadur	Gollarahally			92.3	7.7	0.0			69.2	92.3	15.4				13
Chikkamagaluru	Kadur	Haralagatta			92.3	23.1	7.7			53.8	84.6	23.1				13
Chikkamagaluru	Kadur	Howthanahally			75.0	25.0	0.0			50.0	100.0	0.0				8
Chikkamagaluru	Kadur	Kannenahally			100.0	0.0	0.0			86.7	73.3	66.7				15
Chikkamagaluru	Kadur	Karithimmanahally			100.0	22.2	0.0			77.8	100.0	66.7				9
Chikkamagaluru	Kadur	Shakunipura			6.7	6.7	0.0			80.0	93.3	0.0				15
Chikkamagaluru	Koppa	Haranduru			0.0	12.5	43.8			37.5	25.0	100.0				16
Chikkamagaluru	Tarikere	Begur			93.3	40.0	0.0			20.0	100.0	26.7				15
Chikkamagaluru	Tarikere	Chinnapura			93.3	46.7	0.0			60.0	73.3	13.3				15
Chikkamagaluru	Tarikere	Gowarapura			100.0	6.7	0.0			60.0	100.0	6.7				15
Chikkamagaluru	Tarikere	Kaatiganere			100.0	28.6	0.0			78.6	100.0	64.3				14
Chikkamagaluru	Tarikere	Mugali			93.3	26.7	0.0			73.3	100.0	33.3				15
Chikkamagaluru	Tarikere	Sollapura			93.3	6.7	0.0			40.0	80.0	40.0				15
Chikkamagaluru	Tarikere	Sowthanahally			100.0	26.7	6.7			46.7	66.7	60.0				15
Chikkamagaluru	Tarikere	Tamatada Hally			100.0	20.0	6.7			53.3	80.0	46.7				15

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Chikkamagaluru	Chikkamagaluru	GungaraHally			15.8	15.8	0.0			73.7	84.2	21.1	0	0	0	19
Chikkamagaluru	Chikkamagaluru	HanchiHally			16.7	38.9	0.0			61.1	50.0	5.6	0	0	0	18
Chikkamagaluru	Chikkamagaluru	Hiregouja			35.0	10.0	10.0			60.0	85.0	45.0	0	0	0	20
Chikkamagaluru	Chikkamagaluru	SarpanaHally			0.0	0.0	0.0			43.8	50.0	0.0	0	0	0	16
Chikkamagaluru	Chikkamagaluru	ThadaBenahally			5.0	5.0	0.0			75.0	20.0	15.0	0	0	0	20
Chikkamagaluru	Kadur	Angajanahalli			89.5	21.1	47.4			63.2	31.6	89.5	0	5.263157895	0	19
Chikkamagaluru	Kadur	Chikkapattanagere			100.0	11.1	55.6			77.8	33.3	88.9	0	44.44444444	0	9
Chikkamagaluru	Kadur	Dombarahalli			40.0	0.0	40.0			60.0	60.0	60.0	0	0	0	5
Chikkamagaluru	Kadur	Gopishettihalli			100.0	0.0	83.3			100.0	66.7	100.0	0	0	0	6
Chikkamagaluru	Kadur	Haruvanhalli			100.0	57.1	57.1			95.2	61.9	100.0	0	9.523809524	0	21
Chikkamagaluru	Koppa	Agalagandi			0.0	55.0	60.0			95.0	55.0	85.0	0	5	0	20
Chikkamagaluru	Koppa	Kuluru			30.0	100.0	95.0			100.0	95.0	100.0	0	0	0	20
Chikamagalur	Chikamagalur	Baktharahalli			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Lakya			60	0	0	0	0	80	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Hale Lakya			0	0	0	0	0	90	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Kyathanabeedu			0	0	0	0	0	30	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Kanivehalli			0	0	0	0	0	100	30	0	0	0	0	10
Chikamagalur	Chikamagalur	Ganadalu			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Devarahalli			0	0	0	0	0	100	70	0	0	0	0	10
Chikamagalur	Chikamagalur	Kanive Dasarahalli			10	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Chikka Gowja			0	0	0	0	0	10	10	0	0	0	0	10
Chikamagalur	Chikamagalur	Sadarahalli			0	0	0	0	0	0	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Bilekallahalli			0	10	0	0	0	80	20	0	0	0	0	10
Chikamagalur	Chikamagalur	Srinivasapura			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Kenkere			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Padhamane			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Chikkere Kaval			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Beeranahalli			10	30	0	0	0	100	50	10	0	0	0	10
Chikamagalur	Chikamagalur	Balehalli			60	0	0	10	0	80	30	0	0	0	0	10
Chikamagalur	Chikamagalur	Kalasapura			70	10	0	0	0	100	60	60	0	0	0	10
Chikamagalur	Chikamagalur	Chikkakalasapura			90	0	0	0	0	100	80	50	0	0	0	10
Chikamagalur	Chikamagalur	Payagondanahalli			60	0	0	0	0	100	70	60	0	0	0	10
Chikamagalur	Chikamagalur	Sooragondnahalli			50	0	0	10	0	80	40	50	0	0	0	10
Chikamagalur	Chikamagalur	Devagondanahalli			100	0	0	0	0	70	100	100	0	0	0	10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Chikamagalur	Chikamagalur	Kowthalu			80	0	0	0	0	100	80	40	0	0	0	10
Chikamagalur	Chikamagalur	Mallammanahalli			60	0	0	0	0	100	70	30	0	0	0	10
Chikamagalur	Chikamagalur	Eshwarahalli			60	0	0	0	0	100	70	30	0	0	0	10
Chikamagalur	Chikamagalur	Galihalli			60	0	0	0	0	100	40	20	0	0	0	10
Chikamagalur	Chikamagalur	Hannindadike			80	0	0	0	0	100	70	10	0	0	0	10
Chikamagalur	Chikamagalur	Kalenahalli			100	10	0	0	0	100	100	70	0	0	0	10
Chikamagalur	Chikamagalur	Belavadi			100	0	0	50	0	100	0	100	0	0	0	10
Chikamagalur	Chikamagalur	Kallahalli			100	0	0	50	0	100	0	100	0	0	0	10
Chikamagalur	Chikamagalur	Narasipura			100	0	0	10	0	100	0	60	0	0	0	10
Chikamagalur	Chikamagalur	Govindapura			100	0	0	0	0	100	0	50	0	0	0	10
Chikamagalur	Chikamagalur	Vaddarahalli			60	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Yarehalli			100	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Hosahalli			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Sindigere			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Kabbigarahalli			0	0	0	0	0	100	0	0	0	0	0	5
Chikamagalur	Chikamagalur	Buchenahalli			0	0	0	0	0	70	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Arekallahalli			0	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Chikamagalur	Surashetty Halli			10	0	0	0	0	90	10	0	0	0	0	10
Chikamagalur	Chikamagalur	Kurubarahalli			90	0	0	10	0	100	0	90	0	0	0	10
Chikamagalur	Chikamagalur	Subramanyadahalli			100	0	0	50	0	100	0	100	0	0	0	10
Chikamagalur	Chikamagalur	Shankaranhalli			100	0	0	30	0	100	0	100	0	0	0	10
Chikamagalur	Chikamagalur	K.B.Hal			80	0	0	10	0	90	0	30	0	0	0	10
Chikamagalur	Chikamagalur	Kottigenahalli			100	0	0	0	0	100	0	56	0	0	0	9
Chikamagalur	Chikamagalur	Lakya RSK Total			45	1	0	5	0	90	23	27	0	0	0	444
Chikamagalur	Chikamagalur Total	Chikamagalur Total			45	1	0	5	0	90	23	27	0	0	0	444
Chikamagalur	Kadur	Karehalli			100	0	0	70	0	90	100	20	0	0	0	10
Chikamagalur	Kadur	Devarahalli			80	0	0	0	0	100	90	0	10	10	0	10
Chikamagalur	Kadur	Galihalli			100	0	0	100	0	100	90	10	0	0	0	10
Chikamagalur	Kadur	Yarehalli			60	30	0	50	0	70	70	40	0	0	0	10
Chikamagalur	Kadur	Balliganuru			40	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Kadur	Huvinahalli			30	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Kadur	B.kodihalli			100	50	0	0	0	90	0	90	0	0	0	10
Chikamagalur	Kadur	Aladahalli			20	0	0	0	0	100	0	0	0	0	0	10
Chikamagalur	Kadur	Hogarehalli			100	0	0	0	0	100	0	0	0	0	0	10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Chikamagalur	Kadur	Birur grama			20	0	0	0	0	0	0	0	0	0	0	10
Chikamagalur	Kadur	Hiriyangala			90	40	0	0	0	40	0	40	0	0	0	10
Chikamagalur	Kadur	Hosalli			100	100	0	0	0	90	0	100	0	0	0	10
Chikamagalur	Kadur	Ramanahalli			50	50	0	0	0	40	0	50	0	0	0	10
Chikamagalur	Kadur	Nagadevarahalli			30	0	0	0	0	30	0	0	0	0	0	10
Chikamagalur	Kadur	Hullehalli			80	10	0	70	0	70	0	60	0	0	0	10
Chikamagalur	Kadur	Dogehalli			100	20	0	60	0	60	90	60	0	0	0	10
Chikamagalur	Kadur	Byagadehalli			10	80	0	20	0	80	30	20	0	0	0	10
Chikamagalur	Kadur	Ulinagaru			100	30	0	20	0	90	0	50	0	0	0	10
Chikamagalur	Kadur	Kodihalli			0	0	0	0	0	0	50	0	0	0	0	10
Chikamagalur	Kadur	Linglapura			40	60	0	0	0	60	60	0	0	0	0	10
Chikamagalur	Kadur	Birurkavalu			50	60	0	20	0	60	60	30	0	0	0	10
Chikamagalur	Kadur	Jodithimmapura			80	0	20	80	0	70	70	70	0	0	0	10
Chikamagalur	Kadur	Dodagatta			90	0	0	100	0	70	60	50	0	0	0	10
Chikamagalur	Kadur	Horithimmapura			0	0	0	0	0	0	0	0	0	0	0	10
Chikamagalur	Kadur	Englaranahalli			70	0	0	70	0	60	10	10	0	0	0	10
Chikamagalur	Kadur	Hanumapura			100	0	0	60	0	90	90	50	0	0	0	10
Chikamagalur	Kadur	Doddabukkasagara			0	0	0	0	0	0	0	0	0	0	0	10
Chikamagalur	Kadur	Birur RSK Total			61	20	1	27	0	65	32	28	0	0	0	270
Chikamagalur	Kadur Total	Kadur Total			61	20	1	27	0	65	32	28	0	0	0	270
Chikamagalur District Total	Chikamagalur District Total	Chikamagalur District Total			51	8	0	13	0	81	26	27	0	0	0	714
Tumakuru	Madhugiri	Arasapura			80	20	10			100	90	50				10
Tumakuru	Madhugiri	Battigere			80	0	0			40	50	80				10
Tumakuru	Madhugiri	Byrenahalli			90	30	0			70	90	100				10
Tumakuru	Madhugiri	Chikkamaluru			50	0	0			30	60	30				10
Tumakuru	Madhugiri	Doddamaluru			60	40	0			50	60	50				10
Tumakuru	Madhugiri	Handralu			60	10	0			100	60	60				10
Tumakuru	Madhugiri	Hosahally			90	10	0			90	90	30				10
Tumakuru	Madhugiri	Hunasavadi			50	0	0			50	80	20				10
Tumakuru	Madhugiri	Kalenahally			90	30	10			50	80	30				10
Tumakuru	Madhugiri	Kondavadi			60	10	0			60	50	40				10
Tumakuru	Madhugiri	Kulamenahalli			90	0	0			50	30	30				10
Tumakuru	Madhugiri	Naviladaku			70	0	0			60	50	40				10
Tumakuru	Madhugiri	Puravara			70	0	0			50	40	40				10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Tumakuru	Madhugiri	Reddyhallynahally			70	20	10			100	100	40				10
Tumakuru	Madhugiri	Suranagenahally			70	0	0			70	60	30				10
Tumakuru	Tiptur	B.Kaval(P)			100	40	10			90	100	100				10
Tumakuru	Tiptur	Chikkabidare			100	0	50			90	90	90				10
Tumakuru	Tiptur	Gowdanakatte			100	10	0			100	90	100				10
Tumakuru	Tiptur	Gurugadahalli			80	10	60			90	100	90				10
Tumakuru	Tiptur	Hirebidhare			90	0	0			90	70	90				10
Tumakuru	Tiptur	Karikere(P)			90	0	20			90	70	100				10
Tumakuru	Tiptur	Mathihalli			90	0	50			80	70	100				10
Tumakuru	Tiptur	Rudrapura			90	10	10			70	90	90				10
Tumakuru	Tiptur	Siddapura			60	20	0			100	80	80				10
Tumakuru	Tiptur	Thimlapura			80	0	0			70	80	100				10
Tumakuru	Tumakuru	Ajjagondanahalli			90	40	20			90	60	100				10
Tumakuru	Tumakuru	Bellavi			100	10	40			100	80	100				10
Tumakuru	Tumakuru	Channenahalli			90	10	60			100	80	90				10
Tumakuru	Tumakuru	Chikkabellavi			100	20	30			90	60	80				10
Tumakuru	Tumakuru	Devarajanahalli			100	50	10			100	100	90				10
Tumakuru	Tumakuru	Dodderi			80	50	0			100	90	100				10
Tumakuru	Tumakuru	Hanumanthagiri			90	0	10			80	90	90				10
Tumakuru	Tumakuru	Haralakatte			100	10	40			90	80	80				10
Tumakuru	Tumakuru	Harivanapura			90	20	0			80	50	100				10
Tumakuru	Tumakuru	Kenchanapalya			100	0	40			90	80	100				10
Tumakuru	Tumakuru	Lakshmisagara			80	30	0			100	70	100				10
Tumakuru	Tumakuru	Lingenahalli			100	40	20			90	89	100				10
Tumakuru	Tumakuru	M.M.Kaval			100	60	10			100	100	100				10
Tumakuru	Tumakuru	Masanapura			70	20	10			90	60	70				10
Tumakuru	Tumakuru	Nagarjunahalli			100	0	10			90	100	90				10
Tumakuru	Tumakuru	T.Gollahalli			80	10	20			100	60	90				10
Tumakuru	Madhugiri	Aralapura			60	30	20			60	70	30				10
Tumakuru	Madhugiri	Aralimarada Hosahalli			40	40	0			40	70	0				10
Tumakuru	Madhugiri	Doddahosalli			80	70	20			100	100	70				10
Tumakuru	Madhugiri	Gamakaranahalli			50	0	0			50	40	40				10
Tumakuru	Madhugiri	Gondihalli			100	0	0			100	80	100				10
Tumakuru	Madhugiri	Govindanahalli			50	90	0			90	90	10				10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Tumakuru	Madhugiri	Halethimmanahalli			100	0	0			90	80	100				10
Tumakuru	Madhugiri	Immadagondanahalli			90	70	20			90	90	90				10
Tumakuru	Madhugiri	Jogihalli			90	20	0			100	80	60				10
Tumakuru	Madhugiri	Kamsanahalli			80	30	10			90	80	40				10
Tumakuru	Madhugiri	Kempapura			70	80	0			100	70	50				10
Tumakuru	Madhugiri	Kodigenahalli			70	20	10			90	70	20				10
Tumakuru	Madhugiri	Kodlapura			60	0	0			40	40	40				10
Tumakuru	Madhugiri	Mallenahalli			100	20	10			100	80	90				10
Tumakuru	Madhugiri	Narasapura			90	0	0			90	70	70				10
Tumakuru	Madhugiri	Oblapura			80	40	0			100	100	0				10
Tumakuru	Madhugiri	Raghuvanahalli			100	0	0			80	0	60				10
Tumakuru	Madhugiri	Ramenahalli			30	20	0			70	40	40				10
Tumakuru	Madhugiri	Reddihalli			90	10	0			100	90	30				10
Tumakuru	Madhugiri	Shambonahalli			70	30	0			90	70	70				10
Tumakuru	Madhugiri	Shankarapura			0	0	0			20	60	0				10
Tumakuru	Madhugiri	Shivapura			80	30	0			90	40	60				10
Tumakuru	Madhugiri	Siddanahalli			80	0	0			90	0	0				10
Tumakuru	Madhugiri	Thimmasandra			90	0	0			90	30	60				10
Tumakuru	Madhugiri	Veeranagenahalli			100	30	0			50	100	70				10
Tumakuru	Madhugiri	Venkatapura			10	20	0			80	100	0				10
Tumakuru	Madhugiri	Yarrapanapalya			100	0	0			100	70	60				10
Tumakuru	Tiptur	Anivala			100	60	20			80	100	100				10
Tumakuru	Tiptur	Baluvaneralu			80	0	10			70	30	90				10
Tumakuru	Tiptur	Bommenahalli			90	20	30			50	90	90				10
Tumakuru	Tiptur	Dasanakatte			70	10	0			70	90	90				10
Tumakuru	Tiptur	Hosahalli			90	0	0			90	90	100				10
Tumakuru	Tiptur	Hulihalli			100	33	0			11	100	67				9
Tumakuru	Tiptur	Mallidevihalli			100	0	56			67	78	100				9
Tumakuru	Tiptur	Muddenahalli			100	30	0			90	40	100				10
Tumakuru	Tiptur	Patrehalli			90	10	20			70	90	60				10
Tumakuru	Tiptur	Rangapura			90	20	70			90	100	90				10
Tumakuru	Tiptur	Rattenahalli			100	0	0			90	100	100				10
Tumakuru	Tiptur	Suragondanahalli			60	0	30			100	40	50				10
Tumakuru	Tiptur	Thammadihalli			90	0	30			90	100	90				10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Tumakuru	Tiptur	Vaderahalli			100	10	90			100	100	100				10
Tumakuru	Tiptur	Vitalapura			90	20	0			70	80	90				10
Tumakuru	Tumakuru	A.D.S.Palya			60	20	30			100	90	80				10
Tumakuru	Tumakuru	Appayyanapalya			90	70	30			100	80	90				10
Tumakuru	Tumakuru	Bommanahalli			100	30	70			100	90	100				10
Tumakuru	Tumakuru	Channamuddanahalli			100	70	60			100	100	100				10
Tumakuru	Tumakuru	Chikkagundagallu			70	20	10			90	60	80				10
Tumakuru	Tumakuru	Chikkakodatakallu			90	10	10			100	50	90				10
Tumakuru	Tumakuru	ChindagiriPalya			80	40	50			70	60	100				10
Tumakuru	Tumakuru	Chiniga			100	0	100			90	100	100				10
Tumakuru	Tumakuru	Hiragundakal			90	20	70			80	80	100				10
Tumakuru	Tumakuru	Hirakodatakallu			100	0	20			100	40	100				10
Tumakuru	Tumakuru	Jakkenahalli			100	20	100			100	100	100				10
Tumakuru	Tumakuru	Narasipura			70	20	30			80	80	90				10
Tumakuru	Tumakuru	Obalapura			89	22	33			78	78	100				9
Tumakuru	Tumakuru	Tirumalapalya			80	10	80			100	70	100				10
Tumakuru	Madhugiri	Mydanahalli			100	0	0	0	0	70	70	0	0	0	0	10
Tumakuru	Madhugiri	Gutte			70	10	10	30	10	70	70	30	0	20	0	10
Tumakuru	Madhugiri	Jalihalli			30	20	0	0	0	80	80	0	0	0	0	10
Tumakuru	Madhugiri	Singanahalli			90	0	0	20	0	50	70	0	0	0	0	10
Tumakuru	Madhugiri	Mutyalammanahalli			70	10	0	10	0	60	80	10	0	0	0	10
Tumakuru	Madhugiri	Tereyuru			100	30	0	50	0	100	80	60	0	10	0	10
Tumakuru	Madhugiri	Shravandanahalli			100	30	0	50	0	60	60	40	0	0	0	10
Tumakuru	Madhugiri	Bommenahalli			80	0	0	40	0	70	40	30	0	0	0	10
Tumakuru	Madhugiri	Kalidevipura			80	20	10	30	0	80	70	40	0	0	0	10
Tumakuru	Madhugiri	Gundagallu			90	20	0	10	0	90	80	30	0	0	0	10
Tumakuru	Madhugiri	Bachenahalli			80	30	0	40	0	60	60	40	0	0	0	10
Tumakuru	Madhugiri	Yakaralahalli			90	0	0	10	0	80	80	40	0	0	0	10
Tumakuru	Madhugiri	Kadagatthuru			40	0	0	10	0	70	100	10	0	0	0	10
Tumakuru	Madhugiri	Thingaluru			60	50	0	40	0	90	70	40	0	0	0	10
Tumakuru	Madhugiri	Yaragunte			50	40	0	0	0	80	80	0	0	0	0	10
Tumakuru	Madhugiri	Adavinagenahalli			90	20	0	70	0	60	70	0	0	10	0	10
Tumakuru	Madhugiri	Kodigenahalli Total			76	18	1	26	1	73	73	23	0	3	0	160
Tumakuru	Madhugiri Total	Madhugiri Total			76	18	1	26	1	73	73	23	0	3	0	160

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Tumakuru	Pavagada	Hanumanhtanahalli			90	10	0	80	0	100	100	100	0	10	0	10
Tumakuru	Pavagada	J.Acchammanahalli			70	0	0	40	0	90	90	60	0	0	0	10
Tumakuru	Pavagada	Y.N.Hoskote			20	20	0	10	0	70	50	30	0	30	0	10
Tumakuru	Pavagada	Thimmammanahalli			100	20	0	90	0	90	100	90	0	50	0	10
Tumakuru	Pavagada	Thippaiahnadurga			70	10	0	80	0	100	100	90	0	20	0	10
Tumakuru	Pavagada	Kathikyathanahalli			100	20	0	100	0	100	70	100	0	0	0	10
Tumakuru	Pavagada	Maridasanahalli			100	10	0	90	0	100	90	100	10	40	0	10
Tumakuru	Pavagada	B.Hosalli			100	20	0	90	0	100	100	100	0	10	0	10
Tumakuru	Pavagada	Yarrammanahalli			90	20	10	60	0	100	100	80	10	70	0	10
Tumakuru	Pavagada	Ettenahalli			90	0	0	70	0	100	90	60	0	40	0	10
Tumakuru	Pavagada	Ponnasamudra			60	0	0	60	0	80	100	80	0	0	0	5
Tumakuru	Pavagada	Rachamaranahalli			80	0	0	70	0	100	80	50	0	30	0	10
Tumakuru	Pavagada	Saravatapura			80	50	20	50	0	90	90	60	0	30	0	10
Tumakuru	Pavagada	Hosadurga			80	30	0	40	0	100	80	90	40	30	0	10
Tumakuru	Pavagada	Pothaganahalli			100	40	0	90	0	100	100	90	10	50	0	10
Tumakuru	Pavagada	Dalavayihalli			80	10	10	70	0	90	100	80	0	30	0	10
Tumakuru	Pavagada	Thippaganahalli			90	10	10	60	0	60	80	70	0	0	0	10
Tumakuru	Pavagada	Budibetta			80	40	10	40	0	100	90	80	0	30	0	10
Tumakuru	Pavagada	0			83	18	3	66	0	93	89	78	4	27	0	175
Tumakuru	Pavagada	Buddareddyhalli			88	75	13	50	0	100	100	88	0	13	0	8
Tumakuru	Pavagada	Neelammanahalli			100	100	0	50	0	100	100	100	0	20	0	10
Tumakuru	Pavagada	Nagalamaqdike Total			94	89	6	50	0	100	100	94	0	17	0	18
Tumakuru	Pavagada Total	Pavagada Total			84	24	4	65	0	94	90	80	4	26	0	193
Tumakuru	Sira	Varadapura			100	10	0	80	0	100	100	90	0	0	0	10
Tumakuru	Sira	Gandihalli			60	10	0	20	0	50	90	30	0	0	0	10
Tumakuru	Sira	Hosakote			90	40	10	70	0	80	90	70	0	0	0	10
Tumakuru	Sira	Chiratharahalli			30	10	0	0	0	50	60	20	0	0	0	10
Tumakuru	Sira	Nidagatte			40	10	0	0	0	20	50	0	10	0	0	10
Tumakuru	Sira	Tadakaluru			50	30	10	10	0	40	80	10	10	10	0	10
Tumakuru	Sira	Bejjihalli			90	10	20	40	0	90	90	70	0	10	0	10
Tumakuru	Sira	Dodda Hulikunte			80	20	0	30	0	80	100	50	0	0	0	10
Tumakuru	Sira	Musukalotti			80	40	10	40	0	60	100	40	0	40	0	10
Tumakuru	Sira	Shyasamaru			60	0	0	30	0	70	70	30	0	10	0	10
Tumakuru	Sira	Karehalli			80	40	10	30	0	90	90	60	10	0	0	10

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Tumakuru	Sira	Vajarahalli			80	10	0	30	0	70	70	80	0	0	0	10
Tumakuru	Sira	Neejayanthi			80	0	10	60	0	90	100	60	10	0	0	10
Tumakuru	Sira	Dwaranakunte			100	50	20	40	0	100	100	80	10	30	0	10
Tumakuru	Sira	Hulikunte Total			73	20	6	34	0	71	85	49	4	7	0	140
Tumakuru	Sira	Bettappanahalli			100	80	0	30	0	100	100	90	20	0	0	10
Tumakuru	Sira	Lakvanahalli			100	60	10	40	10	100	100	70	20	10	0	10
Tumakuru	Sira	Gowdagere Total			100	70	5	35	5	100	100	80	20	5	0	20
Tumakuru	Sira Total	Sira Total			76	26	6	34	1	74	87	53	6	7	0	160
Tumakuru	Tiptur	Mallenahalli			80	0	10	40	0	100	70	90	0	0	0	10
Tumakuru	Tiptur	Byrapura			80	20	20	60	0	100	60	80	0	0	0	10
Tumakuru	Tiptur	Kondligatta			90	10	30	90	0	90	70	90	0	20	0	10
Tumakuru	Tiptur	Kattehalli			70	40	20	90	0	100	20	90	0	0	0	10
Tumakuru	Tiptur	Shivapura			100	10	30	80	10	100	90	100	0	0	0	10
Tumakuru	Tiptur	Madlehalli			90	20	40	100	10	100	90	90	0	10	0	10
Tumakuru	Tiptur	Kadashettihalli			100	20	50	80	10	100	50	100	0	20	0	10
Tumakuru	Tiptur	Ballekatte			80	40	20	80	10	80	70	80	0	20	0	10
Tumakuru	Tiptur	Eranakallu kaval			100	50	30	100	20	100	80	90	0	60	0	10
Tumakuru	Tiptur	Kottigehalli			70	20	20	80	10	90	70	70	0	0	0	10
Tumakuru	Tiptur	Karadalu			100	0	30	80	10	100	80	100	0	0	0	10
Tumakuru	Tiptur	Ginakikere			100	0	60	100	30	100	80	100	0	0	0	10
Tumakuru	Tiptur	Ayurahalli			100	10	70	100	30	100	80	100	0	20	0	10
Tumakuru	Tiptur	Kallushettihalli			100	20	60	90	30	100	100	100	0	30	0	10
Tumakuru	Tiptur	Uppanahalli			100	20	40	80	10	100	70	90	0	40	0	10
Tumakuru	Tiptur	Kuppalu			80	0	50	80	20	100	70	100	0	20	0	10
Tumakuru	Tiptur	Shettihalli			90	0	20	80	10	80	80	100	0	0	0	10
Tumakuru	Tiptur	Mallipatna			90	0	20	80	0	100	50	90	0	0	0	10
Tumakuru	Tiptur	Biligere Total			90	16	34	83	12	97	71	92	0	13	0	180
Tumakuru	Tiptur Total	Tiptur Total			90	16	34	83	12	97	71	92	0	13	0	180
Tumkur District Total	Tumkur District Total	Tumkur District Total			82	21	12	53	3	85	80	64	2	13	0	693
Vijayapura	Sindgi	Mulasavalagi			72	64	0			56	96	36				25
Vijayapura	Sindgi	Nivalkhed			92	88	0			68	92	80				25
Vijayapura	Vijayapura	Kumathe			92	75	0			75	92	42				24
Vijayapura	Vijayapura	Nidoni			79	58	0			58	67	29				24
Vijayapura	Basavana Bagevadi	Angaddgeri			62	83	4			87	89	15	2	0	0	47

District	Taluk	Village	pH	EC dS/m	OC	Av P	Av K	Av Ca	Av Mg	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	No. Of Samples
					% deficient fields											
Vijayapura	Basavana Bagevadi	Beeraladinni			71	79	0			46	89	11	4	0	0	28
Vijayapura	Basavana Bagevadi	Hunsyal PC			42	54	0			50	88	10	0	0	0	50
Vijayapura	Indi	Chadachan			54	74	0			56	88	27	3	0	0	120
Vijayapura	Indi	Havinal			55	90	1			68	96	6	0	0	0	142
Vijayapur	Vijayapur	Sarwad			89	80	0			91	93	0	1	0	0	244
Vijayapur	Vijayapur	Babaleshwar Total			89	80	0			91	93	0	1	0	0	244
Vijayapur	Vijayapur Total	Vijayapur Total			89	80	0			91	93	0	1	0	0	244
Vijayapur	Muddebihal	Agasbal			74	74	4			56	96	7	15	0	0	27
Vijayapur	Muddebihal	Dhavalagi Total			74	74	4			56	96	7	15	0	0	27
Vijayapur	Muddebihal Total	Muddebihal Total			74	74	4			56	96	7	15	0	0	27
Vijayapur	Indi	Jigajeevani			53	63	5			47	83	16	8	0	0	226
Vijayapur	Indi	Inchageri			77	72	4			60	93	33	2	0	0	134
Vijayapur	Indi	Baradol			55	69	3			66	92	31	4	1	0	178
Vijayapur	Indi	Devara Nimbaragi			76	71	4			66	93	31	1	0	0	107
Vijayapur	Indi	Jeerankalagi			74	74	5			57	99	22	0	0	0	81
Vijayapur	Indi	Chadachan Total			63	68	4			58	90	26	4	0	0	726
Vijayapur	Indi Total	Indi Total			63	68	4			58	90	26	4	0	0	726
Vijayapur District Total	Vijayapur District Total	Vijayapur District Total			70	72	3			66	91	19	4	0	0	997

Appendix 2: Soil nutrient recommendations

Chikkamagaluru — Nutrient recommendations (kg ac^{-1})

Sl No	Crop:	N	P_2O_5	K_2O	S	Zn	B	Fe	Cu	Mn
1	Paddy (Kharif)	40	20	20	12	2	0.2	0.4	0.2	0.2
2	Maize (Irrigated) Kharif	60	30	16	12	2	0.2	0.4	0.2	0.2
3	Ragi (Rainfed)	20	16	10	12	2	0.2	0.4	0.2	0.2
4	Pearl Millet (Rainfed)	20	10	0	12	2	0.2	0.4	0.2	0.2
5	Sorghum (Rainfed)	26	16	16	12	2	0.2	0.4	0.2	0.2
6	Sunflower (Rainfed)	15	20	15	12	2	0.2	0.4	0.2	0.2
7	Castor (Rainfed)	15.2	15.2	10	12	2	0.2	0.4	0.2	0.2
8	Cotton (Hybrids)	60	30	30	12	2	0.2	0.4	0.2	0.2
9	Groundnut (Rainfed)	10	20	10	30	2	0.2	0.4	0.2	0.2
10	Pulses	10	20	10	12	2	0.2	0.4	0.2	0.2
11	Chilly (Irrigated)	60	30	30	12	2	0.2	0.4	0.2	0.2
12	Tomato (Irrigated)	60	24	24	12	2	0.2	0.4	0.2	0.2
13	Onion	50	20	30	12	2	0.2	0.4	0.2	0.2

Note: Based on University of Agricultural sciences Bangalore Nutrient recommendations

Raichur — Nutrient recommendations (kg ac^{-1})

Sl No	Crop:	N	P_2O_5	K_2O	S	Zn	B	Fe	Cu	Mn
1	Paddy (Kharif)	40	20	20	12	2	0.2	0.4	0.2	0.2
2	Maize (Irrigated) Kharif	60	30	15	12	2	0.2	0.4	0.2	0.2
3	Ragi (Rainfed)	20	16	10	12	2	0.2	0.4	0.2	0.2
4	Pearl Millet (Rainfed)	20	10	0	12	2	0.2	0.4	0.2	0.2
5	Sorghum (Rainfed)	24	16	16	12	2	0.2	0.4	0.2	0.2
6	Sunflower (Rainfed)	14	20	14	12	2	0.2	0.4	0.2	0.2
7	Castor (Rainfed)	16	16	8	12	2	0.2	0.4	0.2	0.2
8	Cotton (Hybrids)	60	30	30	12	2	0.2	0.4	0.2	0.2
9	Groundnut (Rainfed)	10	20	10	30	2	0.2	0.4	0.2	0.2
10	Pulses	10	20	5	12	2	0.2	0.4	0.2	0.2

11	Chilly (Irrigated)	60	30	30	12	2	0.2	0.4	0.2	0.2
12	Tomato (Irrigated)	60	24	24	12	2	0.2	0.4	0.2	0.2
13	Onion	50	20	50	12	2	0.2	0.4	0.2	0.2

Note: Based on University of Agricultural sciences Dharwad Nutrient recommendations

Tumakuru Nutrient recommendations (kg ac^{-1})

Sl No	Crop:	N	P_2O_5	K_2O	S	Zn	B	Fe	Cu	Mn
1	Paddy (Kharif)	40	20	20	12	2	0.2	0.4	0.2	0.2
2	Maize (Irrigated) Kharif	60	30	16	12	2	0.2	0.4	0.2	0.2
3	Ragi (Rainfed)	20	16	10	12	2	0.2	0.4	0.2	0.2
4	Pearl Millet (Rainfed)	20	10	0	12	2	0.2	0.4	0.2	0.2
5	Sorghum (Rainfed)	26	16	16	12	2	0.2	0.4	0.2	0.2
6	Sunflower (Rainfed)	15	20	15	12	2	0.2	0.4	0.2	0.2
7	Castor (Rainfed)	15.2	15.2	10	12	2	0.2	0.4	0.2	0.2
8	Cotton (Hybrids)	60	30	30	12	2	0.2	0.4	0.2	0.2
9	Groundnut (Rainfed)	10	20	10	30	2	0.2	0.4	0.2	0.2
10	Pulses	10	20	10	12	2	0.2	0.4	0.2	0.2
11	Chilly (Irrigated)	60	30	30	12	2	0.2	0.4	0.2	0.2
12	Tomato (Irrigated)	60	24	24	12	2	0.2	0.4	0.2	0.2
13	Onion	50	20	30	12	2	0.2	0.4	0.2	0.2

Note: based on University of Agricultural sciences Bangalore Nutrient recommendations

Vijayapura Nutrient recommendations (kg ac^{-1})

Sl No	Crop:	N	P_2O_5	K_2O	S	Zn	B	Fe	Cu	Mn
1	Paddy (Kharif)	40	20	20	12	2	0.2	0.4	0.2	0.2
2	Maize (Irrigated) Kharif	60	30	15	12	2	0.2	0.4	0.2	0.2
3	Ragi (Rainfed)	20	16	10	12	2	0.2	0.4	0.2	0.2
4	Pearl Millet (Rainfed)	20	10	0	12	2	0.2	0.4	0.2	0.2
5	Sorghum (Rainfed)	24	16	16	12	2	0.2	0.4	0.2	0.2
6	Sunflower (Rainfed)	14	20	14	12	2	0.2	0.4	0.2	0.2
7	Castor (Rainfed)	16	16	8	12	2	0.2	0.4	0.2	0.2
8	Cotton (Hybrids)	60	30	30	12	2	0.2	0.4	0.2	0.2

9	Groundnut (Rainfed)	10	20	10	30	2	0.2	0.4	0.2	0.2
10	Pulses	10	20	5	12	2	0.2	0.4	0.2	0.2
11	Chilly (Irrigated)	60	30	30	12	2	0.2	0.4	0.2	0.2
12	Tomato (Irrigated)	60	24	24	12	2	0.2	0.4	0.2	0.2
13	Onion	50	20	50	12	2	0.2	0.4	0.2	0.2

Note: Based on University of Agricultural sciences Dharwad Nutrient recommendations