Annual Report
2014–2015

Bhoochetana Plus

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

International Crops Research Institute for the Semi-Arid Tropics

Contents

Executive Summary

The Government of Karnataka has, since 2009, undertaken a science-led development approach to unlock the potential of agriculture in the state through a mission mode program called "Bhoochetana". In order to address the issues holistically, the state has adopted a systematic approach. To undertake science-led development through integrated systems, the International Crops Research Institute of the Semi Arid Tropics (ICRISAT) was requested to bring together the international expertise of the seven other CG centers as well as the Asia Vegetable Research & Development Centre (AVRDC) working in the country through a consortium and establish four pilot benchmark sites in different revenue divisions. The sites are Bijapur, Raichur, Tumkur and Chikkamagaluru, and this initiative, which was initiated in 2013-14, is called "Bhoochetana Plus".

Bhoochetana Plus is an innovative learning pilot study to test holistic solutions in an integrated manner at the landscape scale. Eight international research institutions are working together with five state agricultural and horticulture universities and all the line departments to improve the livelihoods of small farmers in the target area of 80,000 ha at each of the four pilot sites.

The specific objectives of Bhoochetana Plus are:

- To form an action-oriented consortium of CGIAR institutions to operationalize an action research upscaling model in partnership with line departments in the state of Karnataka to increase crop yields by 20% and farmers' income by 25% in four years;
- To establish four sites of learning pilot systems, to scale up approach integrated participatory research for development to benefit small and marginal farmers in irrigated and rainfed agriculture areas representing the revenue divisions in the state; and
- 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.

This initiative has adopted the strategy of building partnerships by forming a consortium of international institutions with state institutions and harnessing the synergies collectively through convergence, building the capacity of stakeholders for improving livelihoods. It builds on the processes rather than the targets through bringing in behavioral changes in the actors and internalizing the "must win" mindset. Four pilot sites in Bijapur, Chikkamagaluru, Raichur and Tumkur have been established, the baseline survey which adopted stratified sampling of households is completed and the results of constraints, farmers' perceptions, socioeconomic status as well as natural resource base status have been reported. Using satellite images, current land use and cropping patterns have been assessed. In Raichur district, the double rice crop area is 124,290 ha, in Bijapur gross cropped area indicated is 1065,000 ha, gross irrigated area is 294,000 ha (satellite image estimated area shows 163,889 ha) and rainfed area is 635,000 ha (satellite estimated area shows 706,891 ha), clearly suggesting that by using available satellite imagery, realistic estimates of different land use systems can be assessed rather than using traditionally recorded data sets. Similar results are also recorded for Chikkamagaluru and Tumkur districts.

Automatic weather stations as well as digital hydrology monitoring stations have been established at all four benchmark sites and data recorded. Climate trend analysis recorded increasing temperature trends at all the sites along with decreasing moisture availability indices resulting in increased aridity. Awareness about the impacts of climate change through capacity building courses was undertaken for the departmental staff and the possible adaptation strategies were also suggested. Soil analysis was undertaken from soil samples from farmers' fields, which revealed widespread multiple nutrient deficiencies in Bijapur (32 to 92%) for different nutrients except potash, which was found sufficient in all the fields. In Raichur sulphur deficiencies (<35%) were recorded only in Raichur taluk and no potash deficiency was observed. In Tumkur and Raichur, widespread deficiencies of multiple nutrient deficiencies were observed without much potash deficiency. Hydrological data showed that even during a deficit rainfall situation runoff was reduced in treated watershed as compared to untreated watershed in Bijapur. In all the sites, *Glyricidia* nurseries were raised and planting on bunds was done to generate N-rich organic soil on-site. Vermicomposting was also undertaken in all the sites to convert farm residues into vermicompost.

Improved cultivars obtained from the All-India Coordinated Projects, state agricultural universities (SAUs), international institutions as well as private seed companies were evaluated through farmers' participatory evaluation. This helped identify farmers' preferences among improved cultivars while establishing their yield potentials also. In Raichur, groundnut cultivar ICGV 91114 produced 2540 kg/ha with improved management compared to 1450 kg with the farmers' cultivar and management practice. The cultivar under improved management produced 75% higher yield compared to TMV 2. Two pigeonpea hybrids viz, ICPH 2671 and 2740 produced 1545 kg/ha against the average yield of 970 kg/ha. Castor cultivars DCH 177 and Jyoti produced 25 to 37% higher yields than the local cultivar used by farmers. In the Tumkur site, finger millet cultivar MR 1 produced with supplemental irrigation produced 2560 kg/ha which was 63% higher than farmers' cultivar. ICGV 91114 groundnut cultivar produced 35 to 40% higher yield whereas pigeonpea cv. ICPL 87119 produced 40 to 45% higher yield under deficit rainfall compared to farmers' cultivars. In other districts, sorghum, maize, as well as groundnut, pigeonpea and rice cultivars were evaluated and good performers were identified.

The AVRDC evaluated vegetable soybean as well as green gram (sterility mosaic tolerant) cultivars and also trained farmers in the subject of improved vegetable cultivation methods. Green gram seeds of cultivar SML 668 were evaluated by the farmers and it yielded 1.48 t/ha, highest among the 10 cultivars tested. For seed multiplication for vegetable soybean, ten lines were provided to University of Agricultural Sciences, Dharwad (UASD), for multiplication. In Chikkamagaluru, 375 farmers are identified for vegetable trials. Market linkages for chillies with Paprika Oleos Pvt. Ltd were established and farmers were trained for Good Agricultural Practices (GAPs) which enable farmers to get 20% price premium. ICARDA has demonstrated cultivation of lentil improved cultivars (PL 6, JL 3, IPL 316 and RBL 2) along with management practices in all four sites. About 31 germplasm lines were evaluated at the Regional Research Station at Dharwad by UASD. Training programs were conducted for lentil cultivation. Suitable lentil cultivars (KLS 218, HUL 57, Narendra Masoor 1 and 2, Rangali, and Noori) were identified for growing in rice fallow areas. Thornless cactus cultivars (15) were multiplied and grown on farmers' fields for evaluation. Nurseries were established at ICRISAT and University of Horticultural Sciences (UHS), Bagalkot. The International Livestock Research Institute (ILRI) undertook the assessment of feeds using the FEAST tool, and evaluated and demonstrated dual purpose cultivars of maize and sorghum. One cut of sorghum yielded 18 t/ha fodder and multi purpose maize variety produced 4500 kg/ha grains and 11200 kg fodder in Bijapur. Similarly FEAST tool was used for assessment in Chikkamagaluru also. International Water Management Institute (IWMI) conducted needs assessment for fertigation (application of fertilizer through the drip irrigation system) and undertook trainings and handholding support to farmers. The International Maize and Wheat Improvement Center (CIMMYT) assessed maize cultivars through farmers' participatory evaluation and found six suitable cultivars. The hybrid Zuvari C 1921 produced 13.19 t/ha compared to other cultivars that produced 11 to 12 t/ha. With improved management, maize cultivars produced 28 to 31% higher yields compared to farmers' practice. CIMMYT, International Rice Research Institute (IRRI) and ICRISAT evaluated the performance of direct seeded rice (DSR). CIMMYT demonstrated DSR covering 10000 ha in Raichur. IRRI undertook weed management demonstrations in rice along with improved cultivars for farmers' participatory evaluation.

In addition, a number of training courses were held for department officials, farm facilitators (FFs) and farmers. Field Days were also conducted for dissemination of improved technologies. Training material in local language was prepared and distributed. A number of women farmers from the districts were brought to ICRISAT to participate in the National Women Farmers' Day which provided them the opportunity to interact with women farmers from different states as well as be exposed to new technologies. A new ICT-based extension system using farmer to farmer videos using Pico projectors as well as tablet-based Krishi Gyan Sagar (KGS) has empowered officials as well as farm facilitators. The use of tablets in this pilot promises good scope to scale up through public private partnership (PPP) as it enhances the efficiency and effectiveness of FFs when it comes to knowledge sharing with farmers.

In brief, considering the limitations of deficit rainfall, good progress has been achieved at the four benchmark sites. Following Review Meetings in the districts, interest and internalization of Bhoochetana Plus activities has improved. The team is gearing up with renewed vigor to help farmers in the coming season.

Background

Across the world, rainfed areas are hotspots of poverty, malnutrition and degradation of natural resources. In India, of 142 million ha of arable lands, 60% is rainfed. Karnataka has the second largest area under rainfed agriculture only after Rajasthan in the country. Farmers' crop yields in dryland areas are quite low (1-1.5 t/ha), which is two to five times below potential yield. Recently, findings from the 'Comprehensive Assessment of Water for Food and Water for Life' revealed that the millennium development goal of reducing the number of poor people by half can be met only through efficient use of scarce water resources for agriculture. Food production can be increased substantially in rainfed areas through enhanced water use efficiency measures, improving soil health status and other new technologies in an integrated approach. It is evident that the vast potential of rainfed agriculture could be unlocked by using available scientific technologies including improved cultivars.

Recognizing the problem, the Department of Agriculture (DoA), Government of Karnataka, has adopted science-led initiatives for achieving impact oriented development in the state. It has sought to bring in international expertise to unlock the potential of rainfed agriculture in the state. Bhoochetana, the farmer-centric initiative taken up by GoK has benefitted more than 4.3 million farm households in the state. In addition, the government has taken up a number of innovative measures to improve agricultural production and livelihood of farmers in the state during the last four years.

Realizing high impacts in terms of increased agricultural productivity, increased gross value of agriculture production and improved livelihoods, the state government has requested ICRISAT to lead a consortium of CGIAR institutions working in India, and to operationalize impact oriented research for development with the aim of improving rural livelihoods. The ICRISAT-led consortium of CG institutions took up this challenge and established a "proof of concept" for translating strategic research knowledge into improving livelihoods through scaling-up of the participatory research for development (PR4D) model. Constraints and problem of all four pilot locations were identified by conducting a number of meetings and stakeholder consultations, and project started in 2013-14. This document reports the progress of Bhoochetana Plus in the second year.

Objectives

The specific objectives of this GoK-CGIAR initiative are:

- To form action oriented consortium of CGIAR institutions to operationalize an action research scaling-up model in partnership with line departments in the state of Karnataka to increase crop yields by 20% and farmers' income by 25% in four years;
- To establish four sites of learning pilot systems, to scale up approach integrated participatory research for development to benefit small and marginal farmers in irrigated and rainfed agriculture areas representing the revenue divisions in the state; and
- 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.

Strategy

The main strategy for this initiative is to achieve Convergence of the CGIAR research institutions with the GoK's line departments and the state agricultural universities (SAUs) and other academic institutions in the state to undertake the Participatory Research for Development (PR4D) to improve the livelihoods of small and marginal farmers in Karnataka.

The salient strategies for the program are as follows:

- The main strategy will be *to build partnerships* and *harness the synergy* to benefit farmers through science-led development strategy built on the experiences gathered during the implementation of Bhoochetana in the state. Strengthening the consortium of CGIAR centers and development agencies with the SAUs is a challenging task as it calls for *changing the mindset calling for a systemic change.* The principle of convergence tried and found good during implementation of Bhoochetana will be institutionalized for successful implementation.

- To link knowledge-generating institutions such as the CGIAR institutions and SAUs with development-oriented line departments and extension systems to benefit farmers.
- This will be a long process as successful convergence in the true sense calls for changing the mindset of different actors.
- Internalize the "*must win"* mindset among the consortium partners.
- A *missionary approach* to harness the benefits of scientific developments and convert them into increased investments and impacts through scaling-up for improving livelihoods.
- The *science-led systems approach* will ensure that we build the capacity of farmers as well as other stakeholders to minimize the impacts of frequently occurring droughts as well as impacts of climate change to which small farmers particularly rainfed farmers are more vulnerable.
- The pilot sites will become the "*Sites of Learning*" and the consortium will adopt the principle of "*Seeing is Believing".* Through *networking* farmers as well as farmer facilitators will be empowered to achieve the desired results.
- ICRISAT will lead the consortium and strive hard to *develop the capacity* of all the partners to achieve the systemic change. The strategy will be targeting *"scaling up"* the innovations with the help of the concerned line departments in the state.
- The emphasis will be on strengthening c*apacity building* of human resources through training via networking of the institutions and building partnerships through enabling environments.
- By adopting the principle of *4Cs* (Convergence, Consortium, capacity building and collective action) we will address the consortium goal through *4 Es ie, Efficiency, Economic gain, Equity and Environmental protection,* which are the important pillars of the sustainable intensification and inclusive development. The emphasis will be on enhancing the efficiency of land and water resources along with applied fertilizer nitrogen for sustainable intensification while maintaining the environment.
- The approach of the mission will be to strengthen backward and forward linkages to meet the 4 Es through 4 Cs by establishing seed villages, custom hire centers, small scale business development to undertake best-bet options for increasing agricultural productivity through sustainable intensification. The institutionalization of CBOs and service providers is envisaged for enhancing impact.
- Along with improving nutrient management, other best-bet practices such as rainwater management, pest management options and organic matter building practices will support long term sustainability and enhance the systems' productivity. The convergence of activities of the Department of Agriculture (DoA), Watershed Development Department (WDD) and Department of Horticulture (DoH) will ensure increased water availability and increased efficiency which are the important drivers for sustainable intensification.
- The most important constraint in dryland areas is the establishment of a good crop stand and availability of good quality seeds of high yielding, improved cultivars. The consortium will help in identifying farmer-preferred improved cultivars and hybrids of major crops such as sorghum, maize, rice, pigeonpea, chickpea and other crops. Training farmers and providing opportunities add value to their practices will be an objective.

- The Additional Chief Secretary and Development Commissioner (ACS&DC) will be the chair of the State Coordination Committee (SCC) which will include decision makers from various consortium partners including line departments. The SCC will meet regularly to ensure smooth convergence through the institutionalization process and to strengthen the consortium.
- The SCC will play a more active role in supporting and institutionalizing the concept of convergence and consortium for capacity development.
- The mission will have a *simple principle of accountability* and *delegation of authority* at different levels without diluting individual accountability to meet the mission goal collectively.

Operational Details

Four sites of learning will be established in the four selected pilot districts (Tumkur, Chikkamagaluru, Raichur and Bijapur) representing four revenue divisions (Bengaluru, Mysore, Raichur and Belgaum) as depicted in Figure 1.

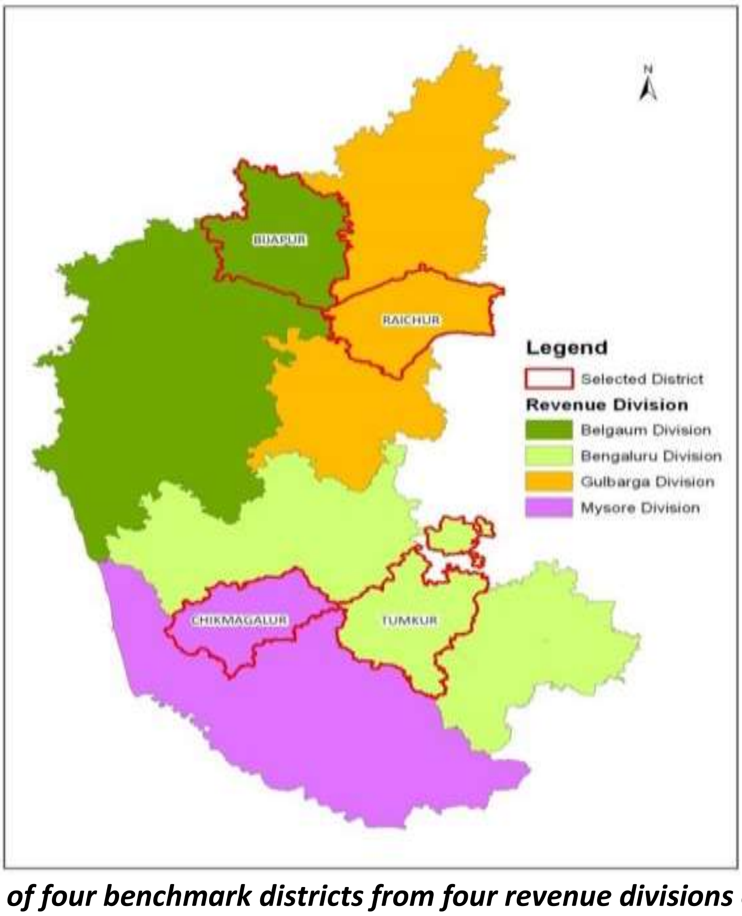

Figure 1. Map of four benchmark districts from four revenue divisions of Karnataka.

In the selected districts, representative sites were identified using the multiple criteria worked out by the multi-disciplinary team of scientists and on-site visits undertaken by CGIAR and line department representatives. The criteria included accessibility, good potential for impact to bridge the gaps, willingness of the partners to adopt new technologies, presence of suitable institutions and pre-disposition of actors for change.

Consortium Partners

The consortium includes international research organizations, national agricultural research system and line departments. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is leading the consortium. The consortium partners are:

International Research Organizations
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- International Water Management Institute (IWMI)
- International Livestock Research Institute (ILRI)
- International Rice Research Institute (IRRI)
- International Maize and Wheat Improvement Center (CIMMYT)
- International Food Policy Research Institute (IFPRI)
- International Center for Agricultural Research in the Dry Areas (ICARDA)
- The World Vegetable Center (AVRDC)

State Agricultural Universities
- University of Agricultural Sciences, Bengaluru, Dharwad, Raichur and Shimoga
- University of Horticultural Sciences, Bagalkot
- Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar

Line Departments
- Department of Agriculture (DoA)
- Watershed Development Department (WDD)
- Department of Animal Husbandry and Veterinary Services (DoAH)
- Department of Horticulture (DoH)
- Department of Water Resources
- Department of Rural Development and Panchayat Raj
- Karnataka State Seeds Corporation (KSSC)

Baseline Survey

Preliminary analysis, based on the baseline data for the four study sites of the Bhoochetana program, suggests that cultivation was the primary occupation for most households, across the four districts. However, there is evidence of some dissimilarity in the socio-economic profile of farmers in these districts. Chikkamagaluru and Tumkur reported comparatively high proportion of BPL card holders, and low proportion of APL card holders. On the other hand, the proportion of BPL card holders was low in Bijapur and Raichur, while that of the APL card holders was high. Additionally, most farmers in Bijapur, Chikkamagaluru 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.

Farmers in Bijapur and Raichur were able to bring more land under cultivation in rainy season 2012-13 and post rainy season 2012, as compared to those in Chikkamagaluru and Raichur. However, cultivation in the post rainy 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. Chikkamagaluru and Tumkur recorded even lower cropping intensities of 116 and 107%, respectively. Additionally, the recorded yields of crops, such as rainy season groundnut, rainy season pearl millet, post rainy season wheat, grown in the year 2012-13, were found to be lower than the national average in Bijapur. In Chikkamagaluru the recorded yield of post rainy season maize was lower than the national average, and in Raichur the recorded yield of post rainy season groundnut was lower than the national average.

About 50% of the farmers in Bijapur owned at least one water source. In other districts, the corresponding figure ranged between 11 and 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. Fertilizer usage per hectare, was reported to be considerably high in Chikkamagaluru and Raichur, and least in Bijapur. Further, the proportion of farmers using micro-nutrients such as boron, sulphur and gypsum was also found to be highest in Bijapur and the least in Tumkur.

This preliminary analysis suggests that the performance of the Bhoochetana program has been better in Bijapur and Raichur districts, as compared to Chikkamagaluru and Tumkur. Bijapur and Raichur have recorded higher registration rates in the program, better functioning of farm facilitators and greater application of micro-nutrients. The performance of the program has been particularly poor in Tumkur, where only about 20% of the farmers in the sample have been registered under it. Incidentally, the baseline data also indicates that Tumkur and Chikkamagaluru 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/Land Cover Mapping of Benchmark districts, Karnataka

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 (NARP). 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 in the district are very 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. 72.2% of the total irrigated area is from 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 which is spread around 47% of the area and red soils over 34% of the area.

Land Use/ Land Cover

A remote sensing based land use study was conducted in Raichur district to understand the cropping patterns and the importance of direct seeded rice in terms of water use efficiency and water productivity. Normalized difference vegetation index (NDVI), a signature based spectral matching technique was used to identify land use/cover along with extensive ground truth. Since this district is bound by two major rivers in the north and south, these feed the irrigation system as arteries. Large scale irrigated rice, grown as double crop, is mostly found in Sindhanur and Manvi talukas which are irrigated by 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 2). Oilseeds like groundnut, sunflower also play an important role in intercropping with pigeonpea and maize, and also in many places with jowar. Cotton is a very important cash crop in many parts of Raichur.

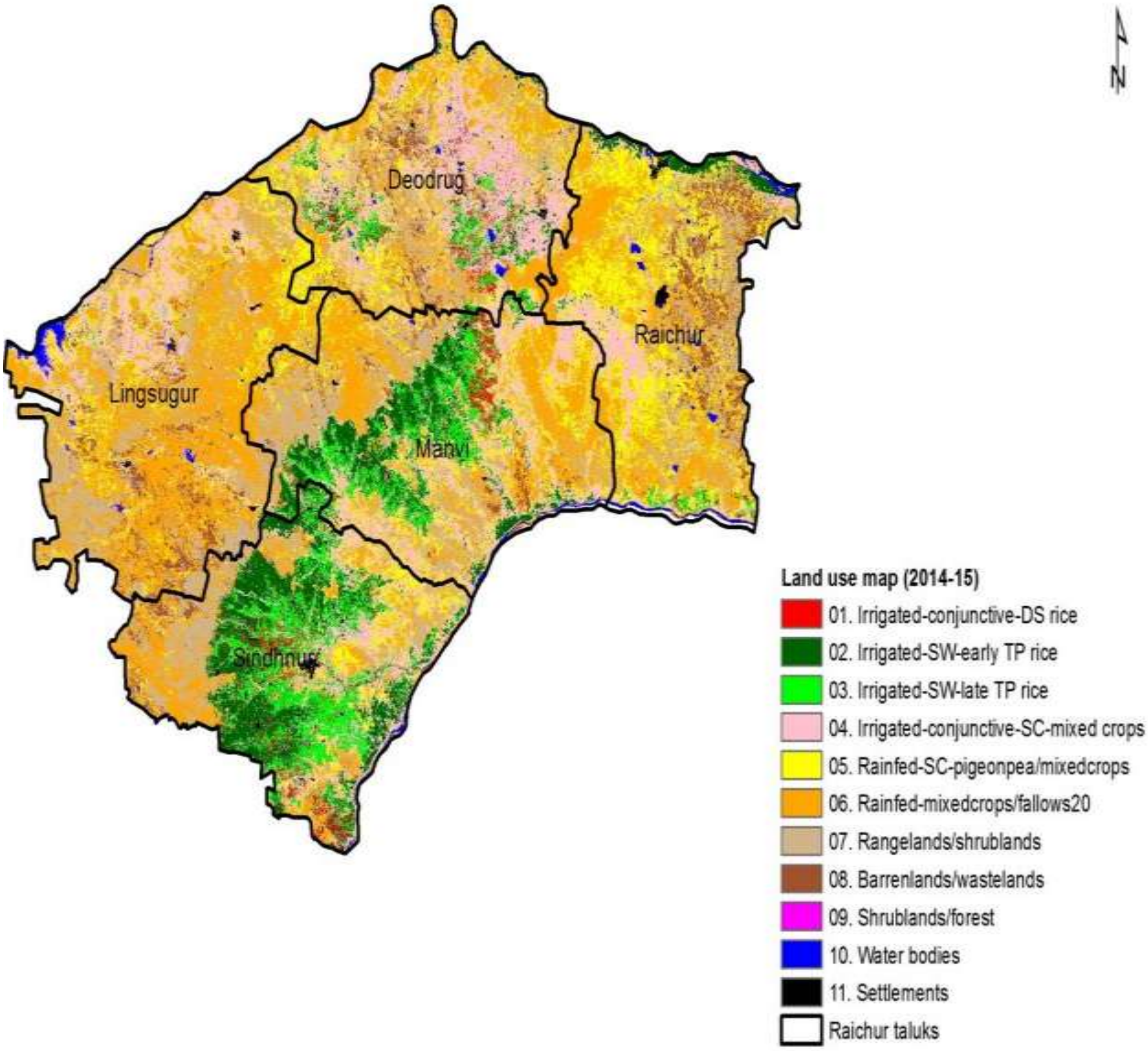

Figure 2. Land use/land cover in Raichur district, 2014-15.

Table 1. Land use/land cover in Raichur (2013-14).

Raster Attribute Editor - raichur_ricemap_final2a_2014-15.img(:Layer_1)

Row	Class_Names	Area (ha)	Histogram	Color
0	Unclassified	822788	25394704	
1	01. Irrigated-conjunctive-DS ric	12942	399443	
2	02. Irrigated-SW-early TP rice	67417.5	2080787	
3	03. Irrigated-SW-late TP rice	49983.4	1542699	
4	04. Irrigated-conjunctive-SC-mix	157650	4865738	
5	05. Rainfed-SC-pigeonpea/mixedcr	122778	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

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-sub-region (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 mill ha, it has a normal annual rainfall of 632 mm. Bijapur has more rainfall during the winter than in the summer. January is the driest month while the wettest month is September. The warmest month during a year is May (30.8°C) and the coolest month is December with an average temperature of 22°C. 99% of the soils are black (medium 40%, shallow 26%, deep 23%), and the rest is red soils (sandy, loamy and mixed with black). The major field crops grown in Bijapur are jowar, groundnut, sunflower, bajra, maize, wheat, chickpea and pigeonpea. Rivers Krishna and Bhima flow along the southern and northern borders and River Don passes in the middle of the district cutting it into half horizontally.

Land Use/Land Cover

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. 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 3. The remote sensing based analysis very clearly shows that the major agriculture area of the district (Table 2) 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. 84,475 ha of rangelands and shrub lands form potential areas for agricultural development and livelihood improvement.

Table 2. Land use/land cover for Bijapur (2013-14).	
Land use/land cover	**Area (ha)**
01. Irrigated-conjunctive-Double crop-mixed crops	163889
02. Rainfed-mixed crops	527717
03. Rainfed-mixed crops/fallow (20%)	223968
04. Rangelands/shrub lands	84475
05. Barren lands/wastelands/trees	15373
06. Shrub lands/forest	1532
07. Water bodies	23118
09. Built-up lands	8832
Total geographical area	1048903
Net sown area	870780
Area sown more than once	163889
Gross cropped area	1034669

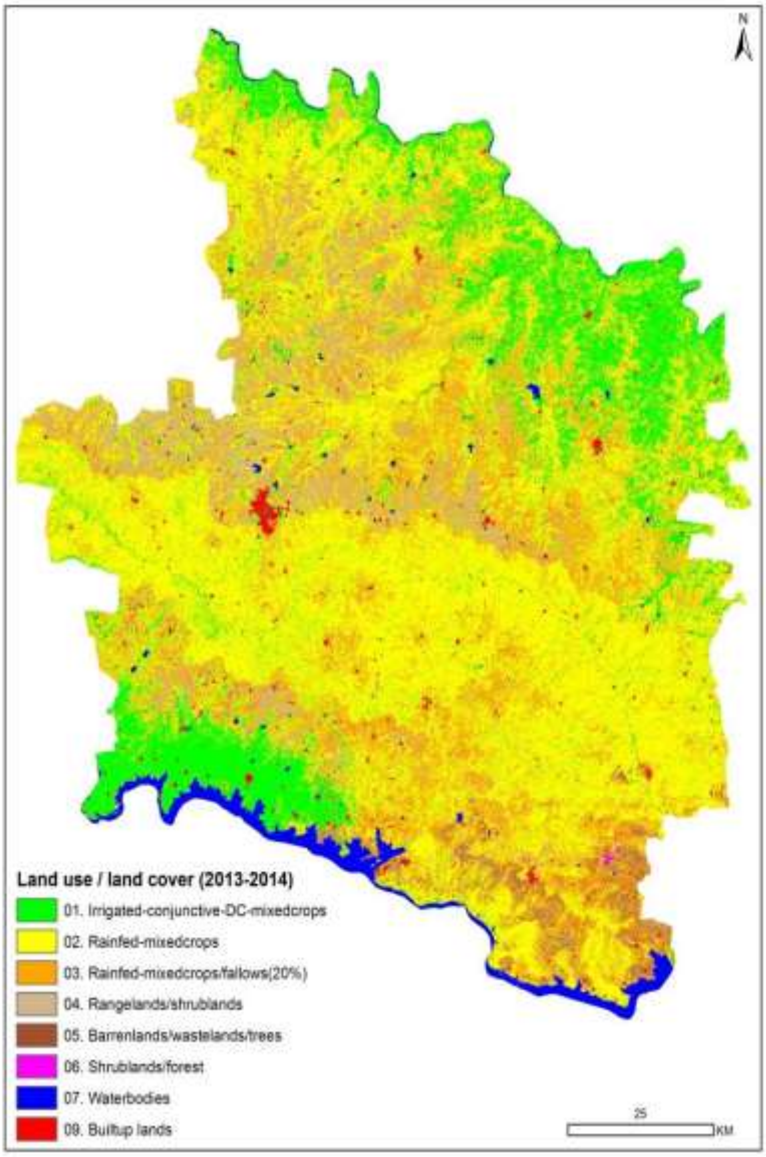

Figure 3. Land use/land cover in Bijapur district, 2013-14.

Tumkur District

Tumkur, a southeastern district of Karnataka borders with southern Andhra Pradesh. With 10 taluks in the district, it has one taluk, Pavagada, which is totally delinked from the district, and surrounded by a strip of Anantapur district of Andhra Pradesh. 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. It also has three important rivers Shimsa, Jayamangali, Suvarnamukhi passing through it and many streams join these at different points in the district.

Land use in Tumkur

As seen in Figure 3, 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 mill ha with ragi dominating along with groundnut + pigeonpea taking 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 4 & Table 3).

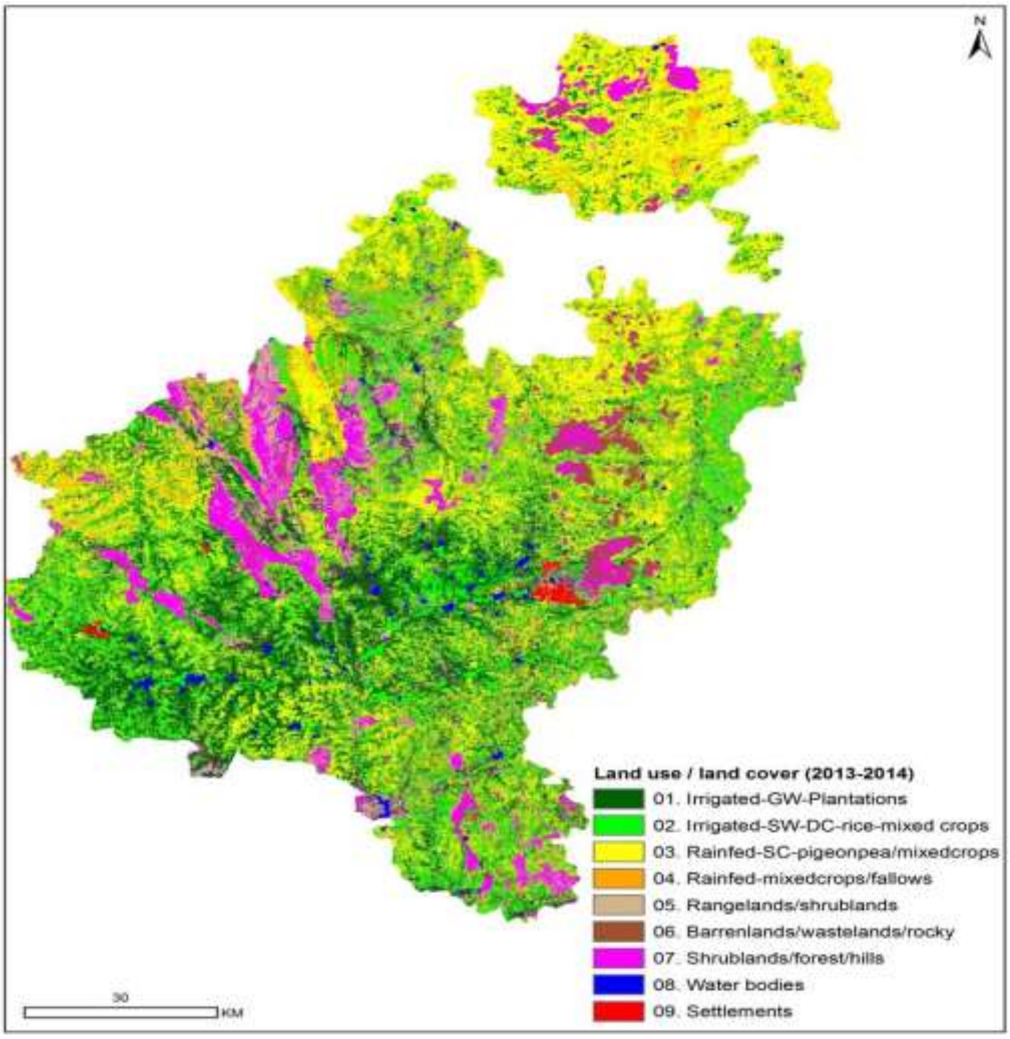

Figure 4. Land use/land cover in Tumkur district, 2013-14.

Table 3. Land use/land cover in Tumkur (2013-14).	
Land use/land cover	**Area (ha)**
01. Irrigated-groundwater-plantations/orchards	200,451
02. Irrigated-Surface water-Double crop-rice-mixed crops	240,110
03. Rainfed-Single 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	1,051,890
Net sown area	554,010
Area sown more than once	240,110
Gross cropped area	794,120
Satellite images used: Landsat 8	

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 district 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 2500 mm annually. It is also famous for its coffee plantations and the Central Coffee Research Institute (CCRI) is situated here at Balehonnur.

Land use/Land cover

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 5). Coffee plantations are the highlight in this district, known to be brought originally from Yemen. Ragi, paddy, maize and sorghum are major growing cereals in the district. Horse gram and Bengal gram are two important pulses. Sesamum, 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 (Table 4) in the district.

Table 4. Land use/land cover in Chikkamagaluru (2013-14).	
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-Single 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	

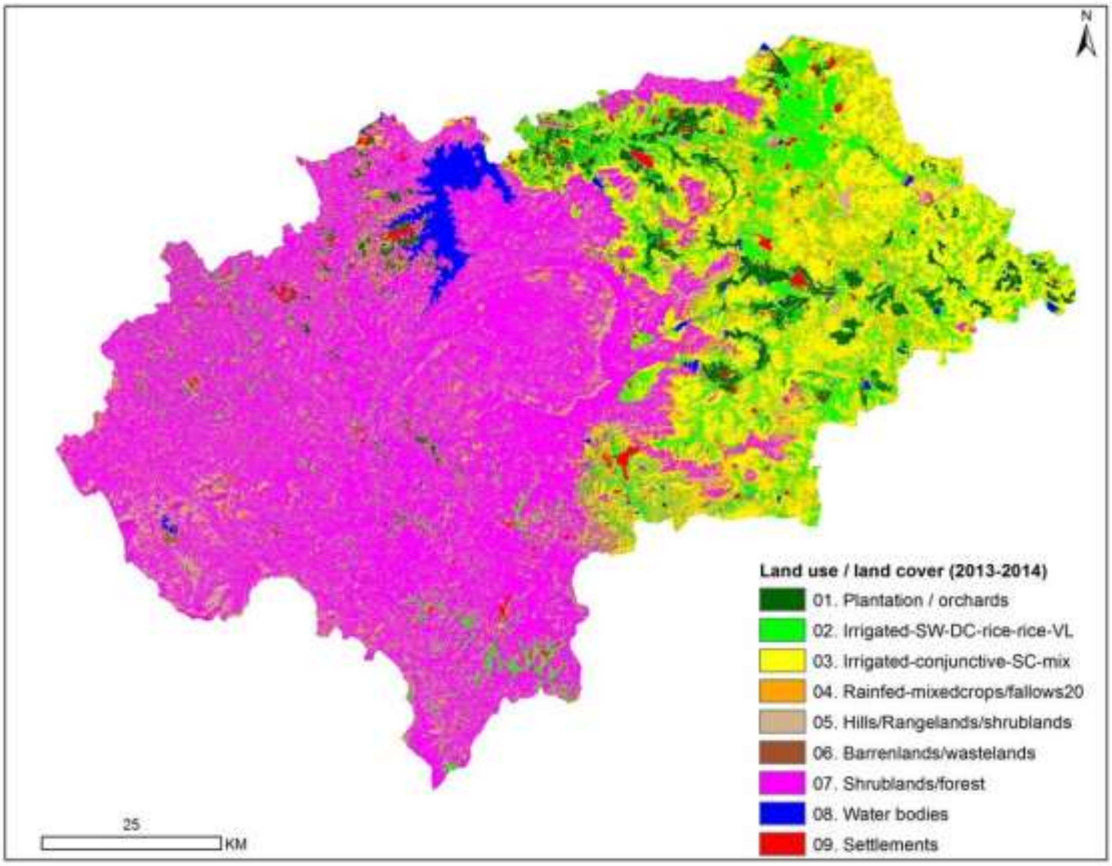

Figure 5. Land use/land cover in Chikkamagaluru District in 2013-14.

Tablet-based Extension System

A new innovative extension system is being piloted with Samsung Galaxy Tab 2. However, any tablet with a similar specification – including a seven-inch touch screen, 3G and Wi-Fi connectivity, voice calling facility, good resolution primary and secondary camera, GPS, Bluetooth, expandable memory and 1 GB RAM – is suitable for the tablet based extension system. Since this tablet will be used in farmers' fields, ruggedness of the gadget is also a most preferable feature. The proposed tablet runs on Android operating system. The price range for an android tablet is from USD 65 to 450. However, low cost tablet devices may not be suitable for outdoor conditions. Details of the devices distributed in the four districts are mentioned in Table 5.

Krishi Gyan Sagar

A tablet-based extension system 'Krishi Gyan Sagar' (KGS) has been developed by ICRISAT in collaboration with NUNC Systems, a Hyderabad-based software design company. KGS is a generic framework for a digital extension system that can be deployed in any part of the world (Figure 6). The KGS app in Bhoochetana is available in English as well as Kannada. Krishi Gyan Sagar is designed to assist knowledge sharing from laboratory to farmers as well as an information gathering tool from farmers to laboratory. KGS has two platforms for two different user groups. The first part is an Android app, which is designed as an information dissemination as well as data collection tool. Farmer facilitators are the primary users of this application. Each FF has a jurisdiction of about 500 ha area, which covers one or two villages. Once logged in, FFs can access information available in the app and pass on the advice to farmers. In addition, they can capture details of on-going farming activities using various options available in the app. Availability of information is restricted based on the jurisdiction of logged-in user. The second platform of KGS is the web application. The web app is directed at the policy maker and development agents for monitoring and report generation. Web app users can generate query-based reports from data captured by FFs at the field level. Both the mobile app and the web app are backed with a common database server. The server receives data from remote users as well as the database administrator.

Table 5. Distribution of tablets and PICO projectors in the four districts.

Designation	Chikkamagaluru	Tumkur	Raichur	Bijapur
Director, (DoA) and BC Plus cell	3			
CEOs	0	2	1	1
JDAs	1	1	1	1
ADAs	3	3	4	4
AOs	4	1		6
AAOs	5	5	5	
FFs	25	30	19	16
ICRISAT				
SO/VSs (all districts of Karnataka)	11			
RTs (all districts of Karnataka)	36			
Total tablets	188			
Pico projectors	13	13	15	20
Video camera	1	1	1	1

Tablet: Samsung Galaxy Tab 2; Pico Projectors: Portronics POR-312; Video Camera: Sony Handy Cam

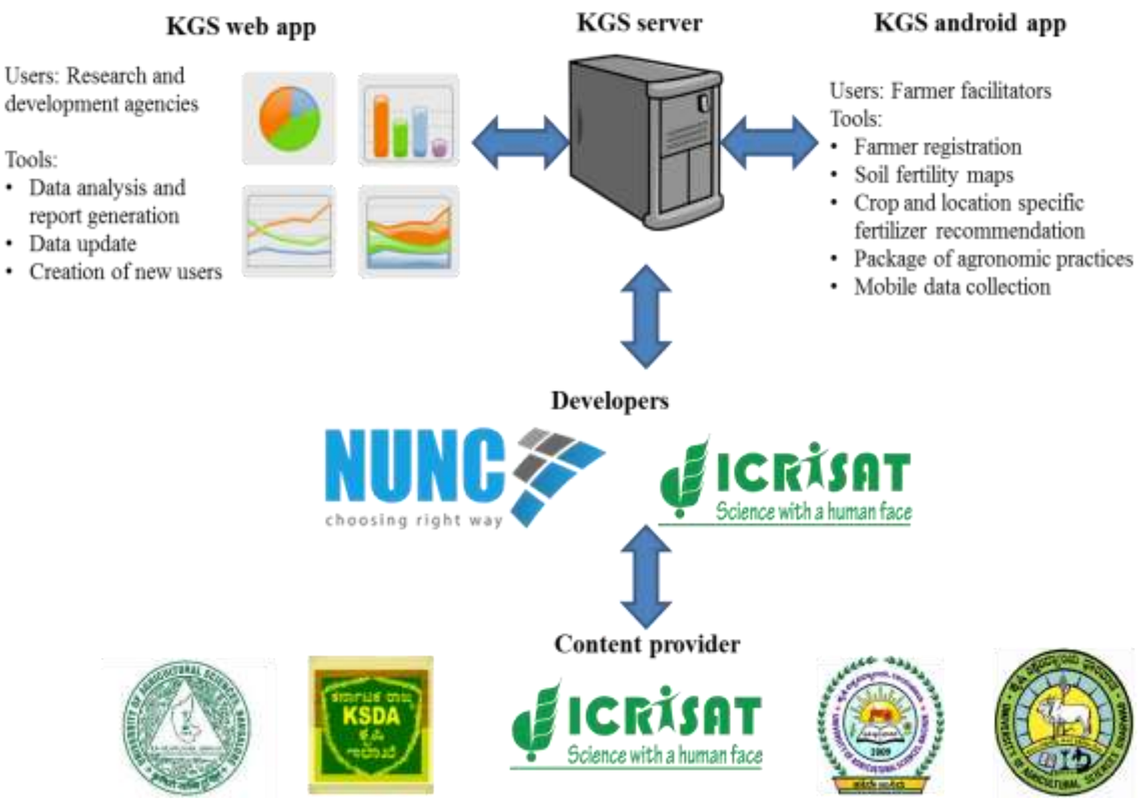

Figure 6. Structure of the Krishi Gyan Sagar system and roles of consortium partners.

Modules Available in the KGS App

Farmers' registration

Farmer database is the base of any agricultural extension system. Farmers' details include their basic information and farm information. The basic information is a one-time entry, though it can be edited at any time. All this information is captured by FFs while interacting with farmers. Earlier, this information was collected through paper form when farmers came to local extension centers for taking inputs. The location information of each farmer is linked with geo-referenced soil fertility data, which is used for providing site specific fertilizer recommendations. The farmer registration progress is very poor in all districts. A total of 5117 (12.9%) farmers have registered while the target number is 39399 farmers.

Figure 7. Farmer registration module in the KGS app.

Table 6. Farmer registration count in four pilot districts.			
District	**Registered**	**Target**	**Percent**
Bijapur	702	8000	8.7
Chikkamagaluru	1165	7900	14.7
Raichur	1160	9499	12.2
Tumkur	2090	14000	14.9
Total	5117	39399	12.9

Soil test-based fertilizer recommendation

One of the important outputs expected from the Bhoochetana project is the soil fertility atlas of Karnataka state. This data is adopted in the KGS app in two forms: 1) district wise soil fertility maps including status of organic carbon, phosphorous, potassium, sulphur, boron, and zinc; 2) site specific fertilizer recommendation. Based on the user's district, the appropriate soil maps will be displayed in the app. KGS is backed by geo-referenced soil fertility data and individual farmer's location information recorded at the time of registration. The queried data is processed on the basis of location, farm area and crop specific nutrient requirements to provide customized fertilizer recommendation. This dynamic customization is not possible with soil health cards or information written on walls.

Figure 8. District wise soil fertility maps embedded in KGS app.

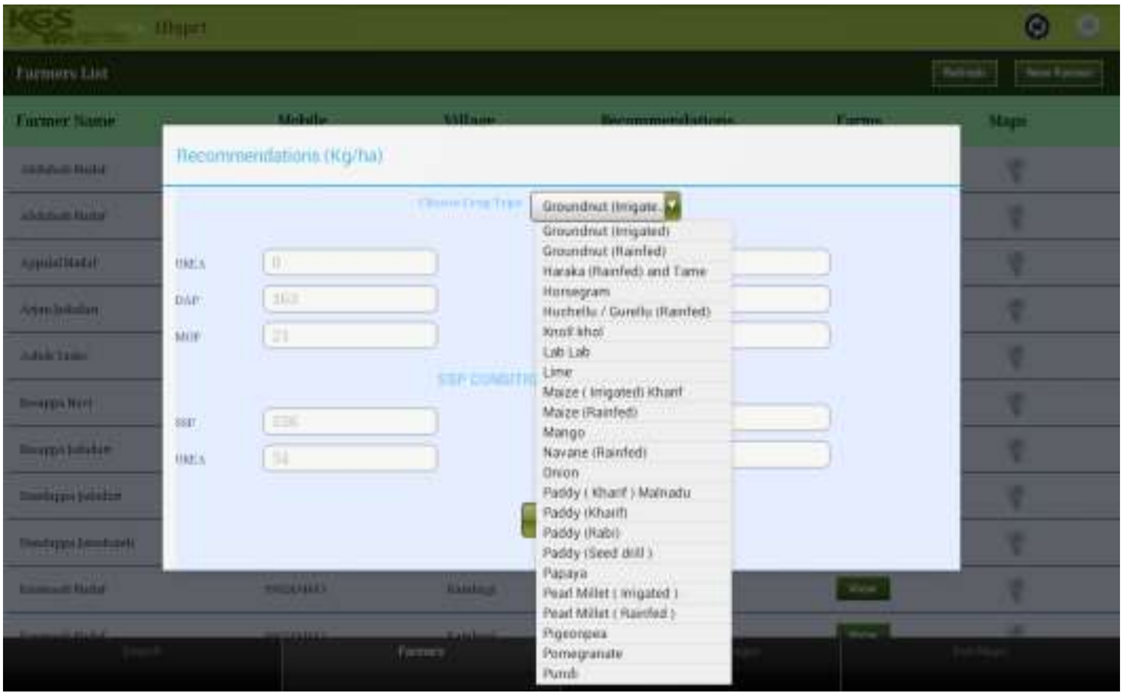

Figure 9. Crop and location wise fertilizer recommendation for each farmer.

Package of Agronomic Practices

This portion of the app provides updated information about good agricultural practices with respect to crop. It contains information about soil and climate requirement, land preparation, available cultivars, seed treatment, sowing/planting, fertilizer and water management, plant protection practices, harvesting and postharvest practices etc. based on the recommendations of the SAUs. The updated information is provided by National Agricultural Research and Extension Systems and ICRISAT. This information is translated into local language and supported with pictures so that the FFs can easily understand it.

Figure 10. A package of agronomic practices in Kannada.

Field operation of KGS app

Mobile data collection techniques have provided an option of paperless and real time monitoring of on-farm activities. The app features various data collection forms for recording the geo-referenced data from field.

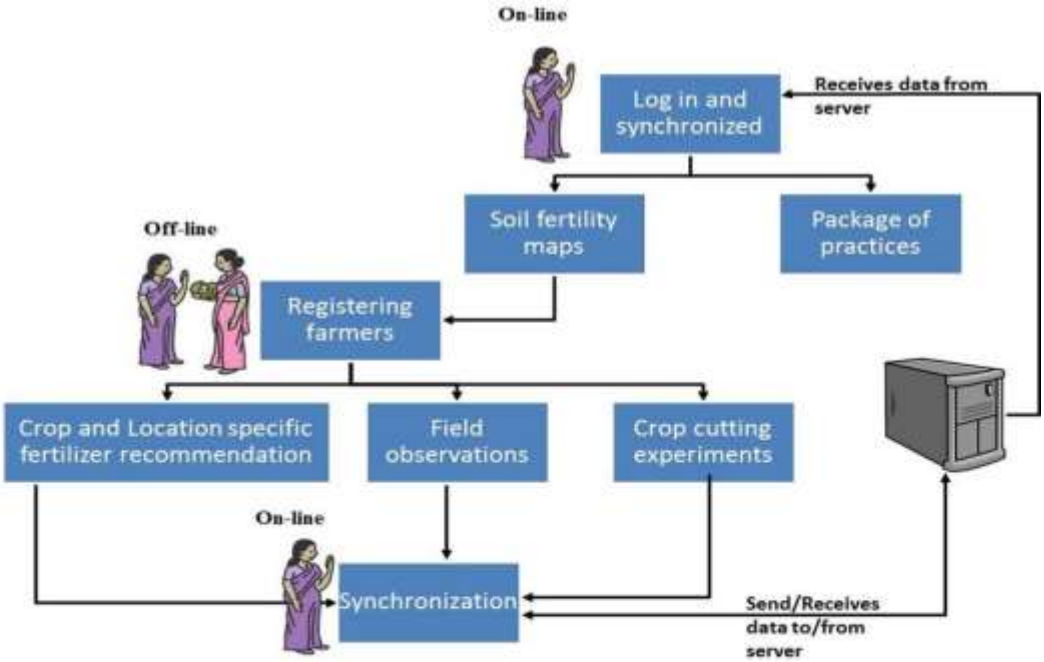

Figure 11. Flow diagram of field operation of the Krishi Gyan Sagar System.

1. Trained farmer facilitators (FF) visit farmers during mass registration drives for the Bhoochetana project.
2. Farmer facilitators sign into the KGS app and initiate synchronization of data between the KGS server and the KGS app. The sign-in and synchronization processes require internet connectivity.
3. District wise soil fertility maps are available with respect to the district of the farmer facilitator.
4. Basic farmer information including name, location, unique identity number, contact number and photograph are recorded on the KGS app.
5. The location of farms, crops cultivated are registered under each farmer's profile. As per the farm's location and crop sown, the KGS app provides fertilizer recommendations, which are narrated to the farmer by the FF.
6. Production packages of various crops and insect and pest management practices provided in Kannada help FF to easily read and pass on efficiently to farmers.
7. During the harvest period, the FF collects crop cutting experiment data from selected farmers' fields.
8. All the data recording processes are offline, which stores the data in the device. A partial synchronization process uploads all stored data in the KGS app to the remote server.

Figure 12. Farmer facilitator using the KGS app on Samsung Galaxy Tab 2.

Table 7. Capacity development courses for farmer facilitator and ICRISAT staff.				
Training	**Chikkamagaluru**	**Tumkur**	**Raichur**	**Bijapur**
Tablet distribution and handling	1	1	1	1
KGS application	2	2	2	2
Krishi Vani	-	-	1	1
Farmer-to-farmer video	3	5	3	4

Web App

The Android KGS app is a field tool for information dissemination and data collection, whereas the web app is the website for visualizing the data gathered by farmer facilitator using mobile app. Both the android app and web app share a common database server. The web address for this application is www.krishigyansagar.com; however this application is not accessible to all users. Only a few people such as web administrators, govt. officials and technical staff from ICRISAT have to access to this application. The web app contains all the information available on tablet app. The important features of this app are user registration and report generation tools.

Figure 13. Participants of a training program at Bijapur.

Figure 14. Participants of a training program at Chikkamagaluru.

Figure 15. Participants of a training program at Tumkur.

Figure 16. Participants of a training program at Raichur.

Krishi Vani

The Krishi Vani platform was initiated in collaboration with IFFCO Kisan Sanchar Limited (IKSL) and Bharti Airtel. This initiative has been piloted in 171 villages in Telangana and Karnataka benefitting 40,000 farmers (ICRISAT 2013). Krishi Vani is a mobile phone/phablet based application. Through this, generic advisories are delivered to groups of farmers in a location through the mobile phone enabled by Green SIM. IKSL has pioneered the voice message based agro-advisory. To subscribe to Krishi Vani, a user needs to buy a Green SIM from Airtel. These SIM cards are specially configured for receiving voice messages and other agro-advisory services. Every day, four free voice messages are delivered to the subscribers. The contents of voice messages is advised by a subject matter specialist and cover diverse areas such as soil management, crop management, dairy and animal husbandry management, horticulture and vegetable management, plant protection, market rates, weather forecasts information, human & cattle health, employment opportunities, government schemes, etc.

Dissemination from farmer to farmer through videos

In addition, for the effective dissemination of good management practices a farmer-to-farmer (F2F) dissemination route has been explored through a 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 the fact 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.

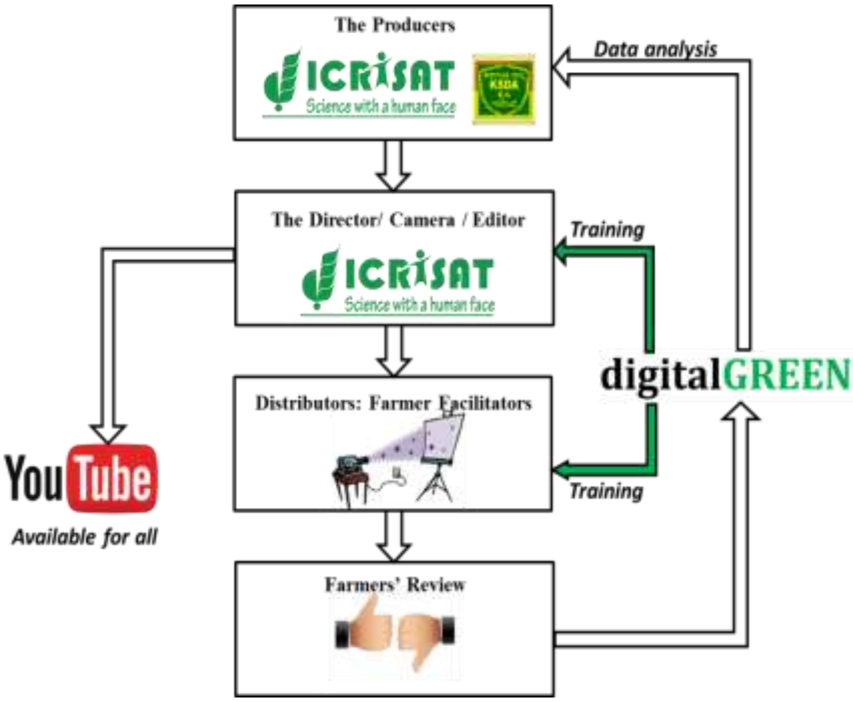

Figure 17. Flow diagram of various processes in farmer-to-farmer video documentation and screening.

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 on the crop. Since these videos are real life stories, producer's field staff identifies a progressive farmer who has adopted the improved agricultural practices in focus. 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 the ICRISAT's staff in the video production process.

Table 8. 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

Table 9. List of videos produced for farmer-to-farmer dissemination.	
Districts	**Video identified**
Chikkamagaluru	Raitha Samparka Kendra (RSK) benefits to farmers in Chikmagalur
	Seed germination test of green gram using paper
	Application of Trichoderma in tomato field
	Bhoochetana scheme–farmers' experience in Chikmagalur
	How to take a soil test sample
	Ragi seed treatment using Azospirillum
	Potato seed treatment using Trichoderma
	Importance of micro-nutrients for field crops
	Seeds availability in RSK
	Demonstration of Tropicultor
Raichur	Neem oil application in paddy field
	Pheromone trapping in toor crop
	RSK benefits to farmers in Raichur
	Installation of yellow trap in cotton field
	Jowar seed hardening method
	Groundnut seed treatment
	Jowar seed treatment
	Precautions before handling pesticides
	Bhoochetana scheme in Raichur
	Bhoochetana scheme – Farmers' & Farm Facilitators' experience
	Benefits of vermicompost
	Germination test for paddy and red gram – Raichur
Bijapur	Fertilizer quality testing
	Importance of micronutrients
	Plastic mulching in brinjal crop
	Soil test
	Summer ploughing
	Integrated farming system
	Seed germination test of green gram using paper
	RSK benefits to farmers
	Seetani (Sihitene) preparation
	Sulakai cultivation
	Guava cultivation
	Toor seed treatment
	Groundnut seed treatment
	Maize seed treatment
Tumkur	Banana bunch feeding for high yields in Tumkur
	Jowar seed treatment
	Red gram seed treatment
	Bhoochetana impact on field crops
	RSK benefits in Tiptur
	Importance of fertigation in coconut plantation
	Coconut planting method
	Integrated disease management
	Banana special spray
	Application of Trichoderma
	Importance of soil sampling
	Intercropping in coconut plantation

The process videos are given to the FFs for screening in the villages. Battery operated portable projectors (PICO projector) along with necessary accessories were provided to them. The FF screens the video to a small gathering (20 – 30 farmers) in villages. At the end of the video, he or she collects feedback from farmers regarding previous videos. The feedback system also captures the adoption rate of screened technologies. Digital Green has developed an online/offline data management framework (COCO) that captures data related to the key processes of the Digital Green approach – video production, dissemination and adoption of practices. A total of 48 videos were produced by ICRISAT staff and were screened in target villages by FFs. Based on the feedback from the farmers, one in seven farmers has adopted the screened technology.

Critical constraints

- The registration process requires that the FF should meet each and every farmer and spend at least 5 minutes for filling the form. Thus, FF needs to dedicate a couple of weeks for registration.
- Internet connectivity: FFs do not have 3G SIM card or they are not able to pay for 3G data packages. We have so far worked with SIM cards belonging to Research Technicians (RTs) and Scientific Officers (SOs) to sync the data, but a permanent solution is needed for this.
- Krishi Vani needs the users to buy a new SIM card/new number.

Climate Related Activities

Climate related activities carried out under Bhoochetana plus were:

1. Weather monitoring at the micro watershed scale
2. Climate variability analyses
3. Capacity development on climate change

Weather Monitoring at Watersheds

Automatic weather stations (AWS) were installed at all the four locations in the target districts in 2014. The AWS at Bijapur was installed on 30 May, Tumkur on 7 July, Raichur on 25 July and Chikkamagaluru on 5 August. The weather elements being monitored are air temperature, rainfall, relative humidity, wind speed, wind direction and solar radiation. These data are collected at hourly intervals and uploaded to the FTP Server at ICRISAT through GPRS modem.

Table 10. Monthly rainfall (mm) recorded at watersheds in 2014.

District	Location	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bijapur	Shivanagi	NA	329	219	47	33	27	655
Chikkamagaluru	Kunnalu	NA	93**	58	77	12	1	241
Raichur	Hoovinbhavi	NA	84	109	78	7	6	284
Tumkur	Haralakatte	68*	288	292	291	22	8	969

*from 07 Jul; ** from 5 August

Figure 18. Automatic Weather Stations installed in Bijapur and Chikkamagaluru

Climate Variability Analyses

Long-period daily climate data of the four locations was procured from India Meteorological Department for analyzing climate variability in the target regions, Bijapur, Chikkamagaluru, Raichur and Tumkur in Karnataka (Table 11). Climate data on daily maximum temperature, minimum temperature and rainfall was collected.

Table 11. Details of climate data collected.

Location	**Latitude**	**Longitude**	**Data period**
Bijapur	16.8	75.4	1983-2012
Chikkamagaluru	13.3	75.8	1974-2012
Raichur	16.2	77.4	1969-2012
Tumkur	13.3	77.1	1972-1998

The procured raw data has several missing values, which were filled using suitable methods, quality checked and finally, climate databases were developed. Software was developed to convert daily data into weekly, monthly and seasonal formats and to compute reference crop evapotranspiration following the Penman-Monteith method as well as Hargreaves–Samani, and to compute weekly climatic water balances following the Thornthwaite–Mather code.

Climate trend analysis of the target locations indicated that in general, maximum temperature has shown an increasing trend, while minimum temperature has shown either no trend or a slight decreasing trend. No trends in rainfall are seen except at Raichur, where a statistically non-significant decreasing trend is observed. Annual maximum temperature at Raichur has increased from about 33 to 35°C (an increase of 2°C) in the last 44 years (Figure 19); which is equivalent to about 4.6°C per 100 years.

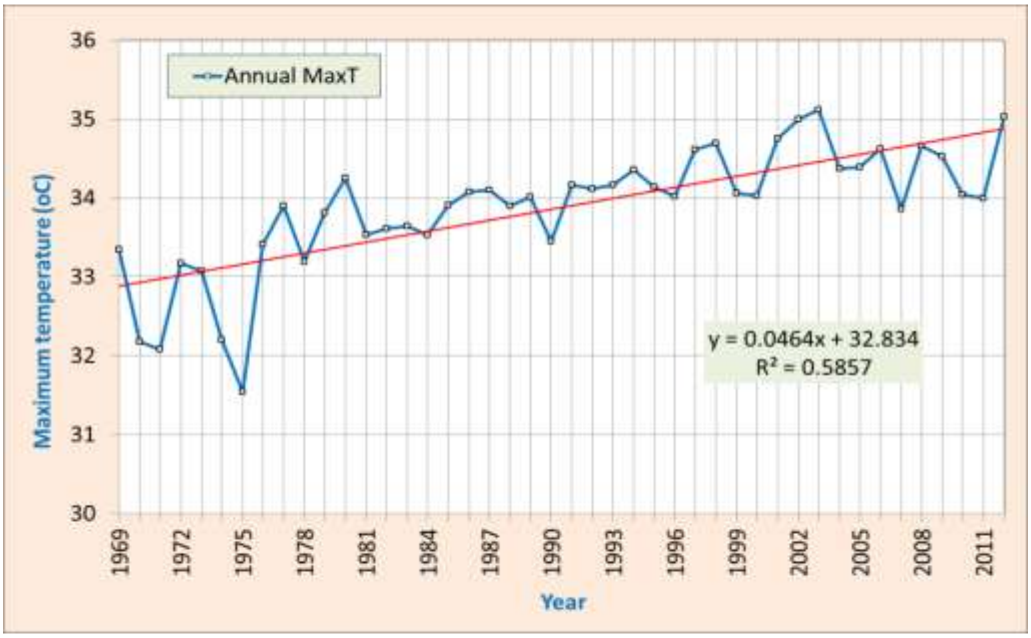

Figure 19. Trend in annual maximum temperature at Raichur.

Water balance analysis outputted various water balance parameters and indices like humidity index, aridity index and moisture index. Using the moisture index, climates were classified and climate variability is assessed. Raichur falls under the semi-arid climate and is slowly tending towards the dryer side. If the trend continues Raichur may soon come under arid type of climate (Figure 20).

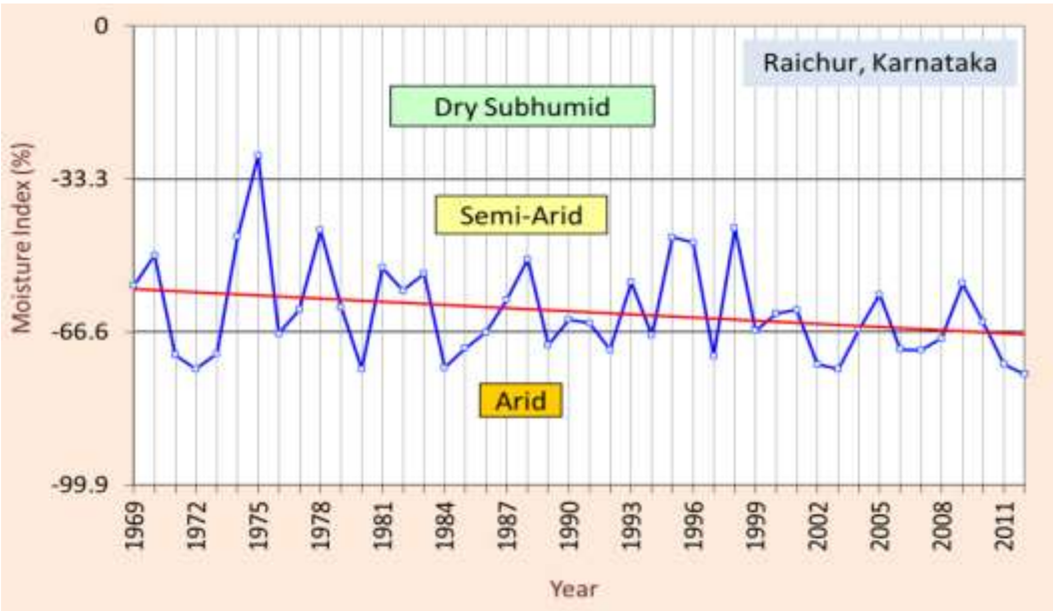

Figure 20. Climate variability at Raichur.

A shift towards the drier side will also impact the length of rainfed-growing period (LGP) and the LGP is likely to shorten by about 10-15 days. Shift in the length of growing period, if not understood by the farmers, generally results in greater incidence of crop failure due to late season drought. Adaptation through identification of climate smart cultivars and better water management will lead to resilience.

Analysis of data for 38 years (1974-2011) at Chikkamagaluru indicated (Figure 21) that the annual maximum temperature increased by about 1°C from 27.7 to 28.7°C; the annual minimum temperature also increased, but at a lower rate and the increase was about 0.5°C from 17.5 to 18.0°C.

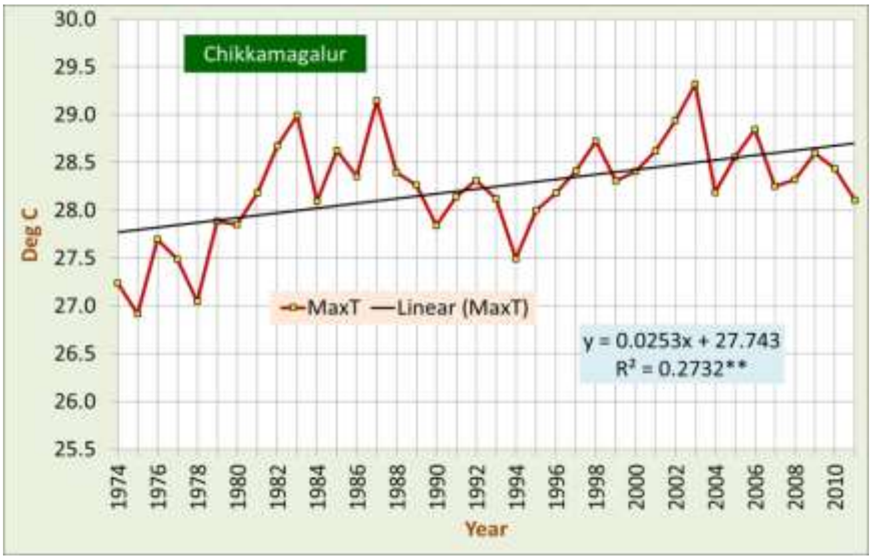

Figure 21. Trend in annual maximum temperature at Chikkamagaluru.

Chikkamagaluru district receives a normal annual rainfall of about 1490 mm; however, there is great variability in rainfall, and about 2640 mm was received year 2007.

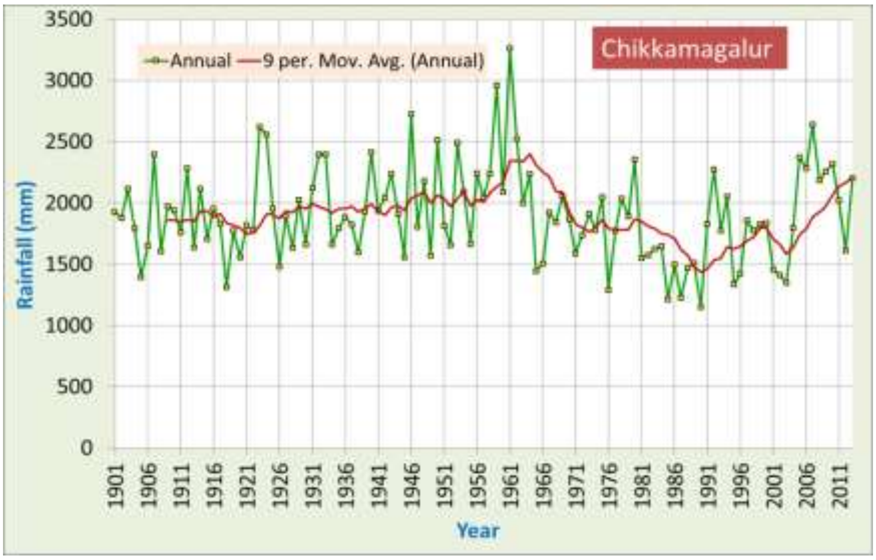

Figure 22. Annual rainfall variability at Chikkamagaluru.

Analysis of 113 years of rainfall data of Chikkamagaluru district indicated that a decreasing trend (Figure 22) is seen during the 30-year period 1961-90; later, the annual rainfall appears to be increasing. Due to drastic changes in topography, spatial variability of rainfall over the various talukas is phenomenal (Figure 23). Kadur in the eastern part of the district receives just 340 mm while Sringeri taluka in the Western Ghats region receives almost 3400 mm annually.

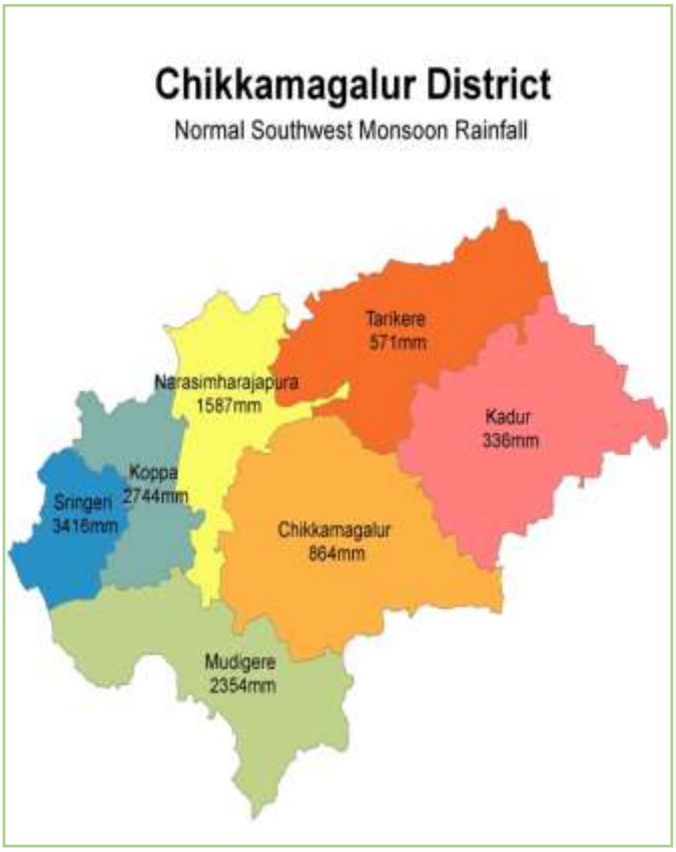

Figure 23. Average rainfall during southwest monsoon in Chikkamagaluru.

Climate change projections for the four target locations were downloaded from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) site. UKMO HadGEM2-ES projections under RCP 4.5 and 8.5 scenarios for 2030s were considered.

Projections for Chikkamagaluru indicate that both maximum and minimum temperatures are projected to increase by 2 to 3°C compared to the present conditions. In general, minimum temperature is projected to increase more compared to maximum temperature, particularly during the three months September to November. Rainfall projections indicate a reduction of 30-50 mm per month for June and July. August to November period is projected to receive more rainfall compared to the present. September is projected to receive almost 65 mm more than present. However, many studies indicate that though the rainfall might increase, the number of rainy days is likely to decrease, making flooding a more frequent event during the sensitive crop-growing period. Duration between two rain events in the crop-growing period is likely to be longer. This leads to a peculiar situation of extreme events such as droughts and floods occurring one after another in the prime crop-growing period. All of this makes integrated watershed management one of the most appropriate solutions for managing climate aberration in the near future.

Software was developed to create weekly files with projected climates. Weekly water balances were worked out for the present and projected climate scenarios, with seasonal and annual values computed.

A few water balance elements have shown considerable changes in projections compared to the present. Actual Evapotranspiration (AET) is the actual amount of water lost in to the atmosphere through soil evaporation and plant transpiration, which depends on soil moisture storage and atmospheric requirement. Thus AET indicates the crop water usage to some extent. During the southwest monsoon period at Bijapur, AET under projected conditions was almost 60 mm lower than the present scenario at 70% probability level (Figure 24). This indicates possible increase in crop water stress during the southwest monsoon period in the future at Bijapur.

Assessment of water surplus at Chikkamagaluru indicated that under projected climate conditions, no surplus can be expected in 50% of the years, though about 130 mm is available under present conditions (Figure 25).

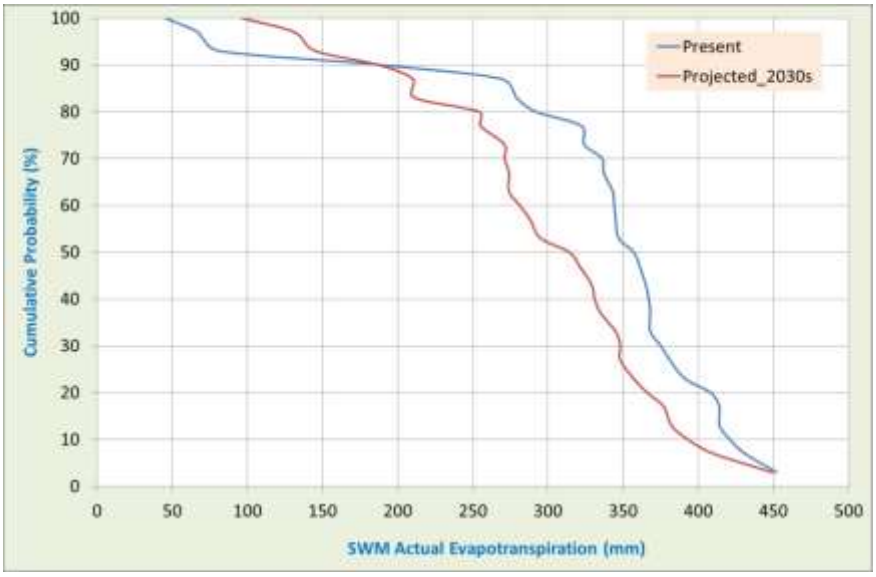

Figure 24. Impact of projected climate change on SW Monsoon AET at Bijapur.

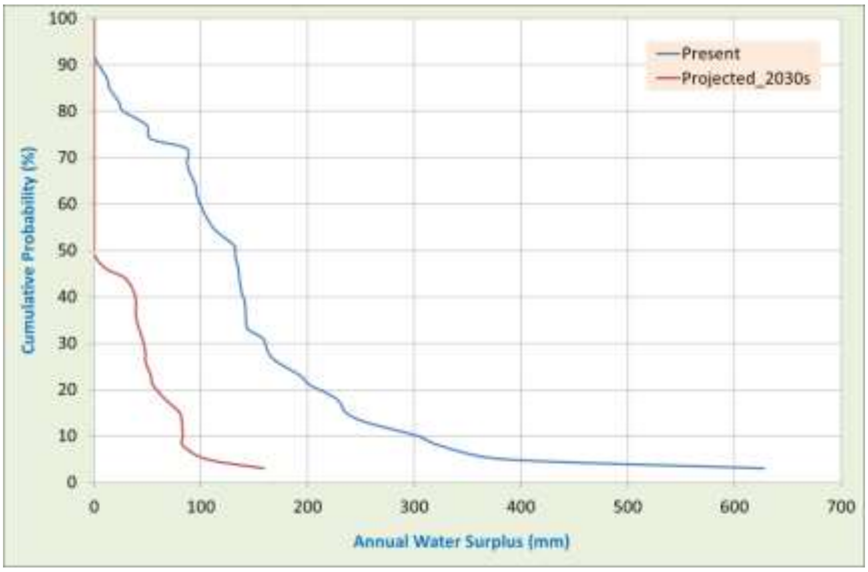

Figure 25. Impact of projected climate change on annual water surplus at Chikkamagaluru.

Capacity Development on Climate Change

Awareness building about climate issues was addressed through a workshop organized at the District Agriculture Training Centre (DATC), Lingadahalli, Chikkamagaluru district, on 21 October 2014. A two-hour lecture with a PowerPoint presentation was delivered on "Climate change and resilient agriculture in Karnataka with reference to Chikkamagaluru district". This workshop was attended by several agricultural officers from the district including the Joint Director of Agriculture (JDA), Deputy Director of Agriculture (DDA) and others. The talk has created a great interest among the participants and it was suggested that a detailed agroclimatic analyses for the Chikkamagaluru district was needed. Similar lectures are planned for the other three locations.

Activities and outputs related to the various climate related activities carried out at ICRISAT during the year 2014 are shown in Table 12.

Table 12. Climate related activities and outputs.

Activity	**Utility/Output**
AWS installation, weather monitoring near to runoff recorder	• Helps in documenting the weather variability • Helps in modeling runoff, soil loss, better design of water harvesting structures
Climate database development and agroclimatic analyses	• Better understanding of agroclimate • Documenting variability in crop water availability, changes in rainfed LGP, drought analyses • Climate data sharing with stakeholders
Climate change analyses based on downscaled climate projections	• Examine suitability of major crops and varieties in the present climate and assess crop productivity under projected climate changes • Suggest suitable adaptation strategies for bringing in resilience to climate change
Capacity development on climate related issues	• Enhanced awareness for the community to harness favorable weather and cope better with aberrant weather situations

Some of the future activities planned are as follows:

- Updating climate databases
- Further analyses on climate variability and change
- Assess impacts of projected climate change (CC) on water balance, LGP and crop productivity (selected crops)
- CC workshops for the remaining three districts viz., Bijapur, Raichur and Tumkur
- Sharing of agroclimatic information with farmers – wall writings on a regular basis

Soil Sample Collection and Analysis

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 available.

Table 13. District-wise area covered for soil sampling and number of soil samples analyzed.			
District	Area covered	No. of villages	Samples analyzed
Bijapur	20,000 Ha	9	484
Chikkamagaluru	20,000 Ha	40	600
Raichur	20,000 Ha	23	680
Tumkur	20,000 Ha	101	1010

Figure 26. Demonstrating soil sample collection in farmers' fields.

Results

Soil analysis results in Bijapur district clearly indicate that organic carbon, available phosphorus, sulphur and zinc are severely deficient in all the villages whereas boron is severely deficient only in Nivalkhed village in Sindagi taluk (Table 14). In Raichur district organic carbon is severely deficient in all the villages except in Govindoddi village in Manvi taluk whereas available phosphorus is deficient in Lingsugur and Devadurga taluks, available sulphur is severely deficient in most of the villages, available zinc is severely deficient in all the villages whereas boron is severely deficient in Pucchaldinni, Kurukunda, Patakamdoddi and Buddinni villages in Raichur district (Table 15). In Chikkamagaluru district, organic carbon, available sulphur and zinc are severely deficient in most of the villages whereas in Tumkur district soil organic carbon, available sulphur, zinc and boron are severely deficient in all the villages (Figure 27). The details of the four districts are given in Annexure 1.

Table 14. Soil analysis results from Bijapur revealed widespread deficiency of organic nutrients.							
Taluk	Village	OC	Av P	Av K	Av S	Av Zn	Av B
		% deficiency					
2013							
Sindagi	Mulasavalagi	72	64	0	56	96	36
Sindagi	Nivalkhed	92	88	0	68	92	80
Vijayapura	Kumathe	92	75	0	75	92	42
Vijayapura	Nidoni	79	58	0	58	67	29
2014							
B. Bagewadi	Angaddageri	58	78	4	82	84	14

Table 14. Soil analysis results from Bijapur revealed widespread deficiency of organic nutrients.							
B. Bagewadi	Beeraladinni	67	73	0	43	83	10
B. Bagewadi	Hunsyal PC	42	54	0	50	88	10
Indi	Chadachan	54	74	0	56	88	27
Indi	Havinal	52	85	1	65	91	5

Table 15. Soil health status of pilot sites in Raichur.

Taluk	Village	OC	Av P	Av K	Av S	Av Zn	Av B
2013							
Raichur	Pucchaldinni	100	15	35	65	80	85
Raichur	Idapnur	98	32	1	66	96	49
Raichur	Midgaldinni	75	0	10	35	75	50
Manvi	Govindoddi	30	10	0	0	50	0
Manvi	Haravi	82	12	2	8	75	37
Manvi	Kurukunda	82	27	0	90	97	73
Manvi	Patakamdoddi	93	48	0	75	98	55
Manvi	Sangapur	65	5	0	0	50	5
Manvi	Wadavatti	93	43	0	75	74	30
2014							
Lingsugur	Ankushdoddi	52	48	0	83	74	30
Lingsugur	Buddinni	40	60	10	185	90	60
Lingsugur	Katagal	70	55	0	55	80	20
Lingsugur	Mittekalluru	54	46	4	71	79	42
Lingsugur	Mudabhal	95	80	0	65	90	20
Devadurga	Banddegudda	85	25	0	45	85	30
Devadurga	Malkamdinni	93	85	0	85	93	11
Devadurga	Malledevaragudda	73	45	0	64	68	18
Devadurga	Rekalmaraddi	84	68	0	80	88	28

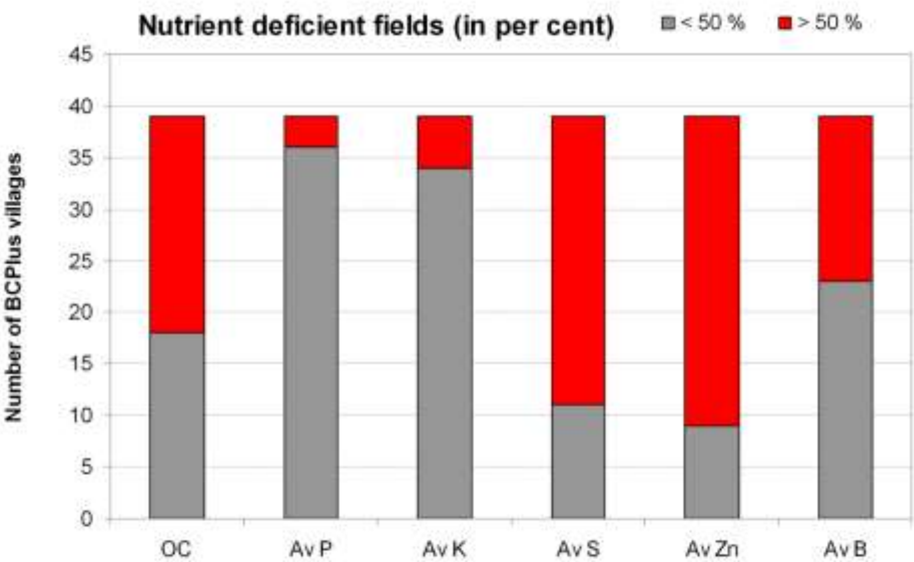

Figure 27. Soil nutrient status in Chikkamagaluru.

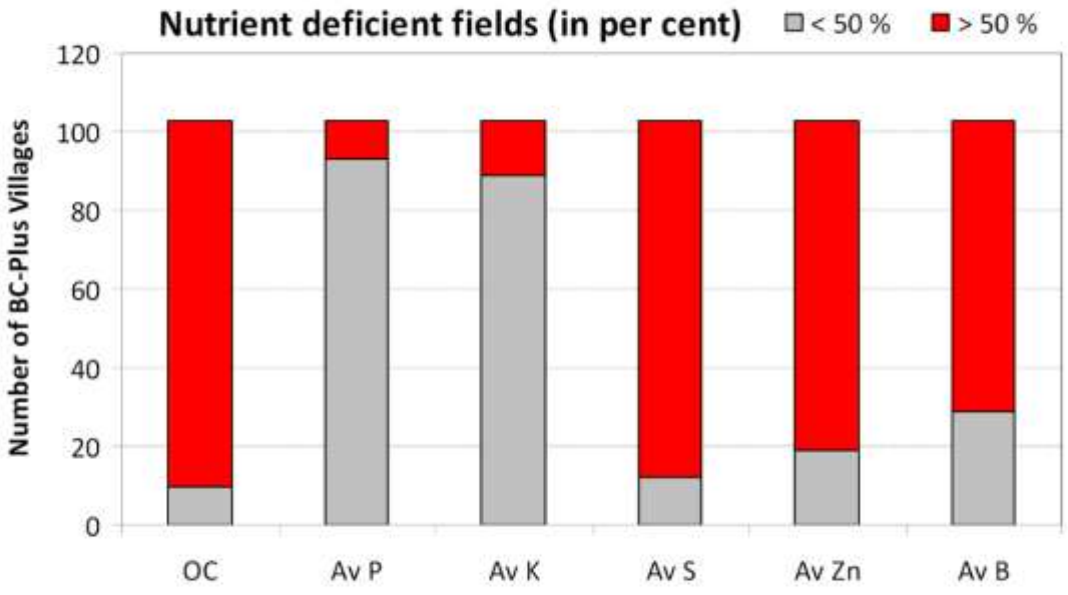

Figure 28. Soil nutrient status in Tumkur.

Distribution of *Gliricidia* Seeds for Nursery Raising

Adequate quantity of *Gliricidia* seeds has been supplied to districts to establish nurseries with the help of the forestry department and the department of horticulture. In Bijapur, from the nursery raised by the forest department, saplings and 12,000 cuttings were planted on field bunds.

Figure 29. Gliricidia plantation at Beeraladinni village, Bijapur district.

Hydrological Monitoring in Selected Bhoochetana Plus Villages

Hydrological monitoring device: DIVER along with BARO (barometric measurement device)

DIVER is a pressure transducer which precisely measures the pressure head at defined intervals (programmed at 15-min interval in this case). Installing DIVER at the outlet of the watershed provides inflow details. It has an inbuilt battery which is supposed to work for 10 years and does not require to be charged.

Rationale of hydrological monitoring: Hydrological data of a watershed at the meso-scale is rare. Most inflow calculations for designing water harvesting structures (check dam and farm pond at field) are either based on thumb rules or by empirical equations derived for different rainfall, soils and agro-ecological regions. In the absence of real field or watershed scale monitoring, we either over design structures or under utilize available water resources. This monitoring will help us in generating hydrological data about meso scale watersheds (500-2000 ha). We will be able to understand rainfall–runoff relationship for a given landscape and the same information will be applicable for scaling up (similar rainfall, soil and land use condition) within the district and elsewhere in the state.

The Integrated Watershed Management Program (IWMP) is a national scale program that has spent more than 6 billion USD for the welfare of society since its inception. It has made a significant contribution in terms of enhancing water resources and further, on cropping intensity, crop and livestock productivity and livelihoods. Despite a huge investment made on IWMP, we do not have much understanding of its impact on hydrology and various ecosystem services. To keep these points in mind, we have selected almost two identical watersheds of similar land use and topography. Hydrology is being compared for treated and control watershed by these monitoring systems.

Objectives of hydrological monitoring:

i) Establishing rainfall–runoff relationships
ii) Understanding the impact of various AWM interventions and change in land use on water balance components
iii) Designing suitable water harvesting protocols at field and watershed scale

Table 16. Location of hydrological monitoring set up in a Bhoochetana Plus village.

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	1000 ha

Tumkur

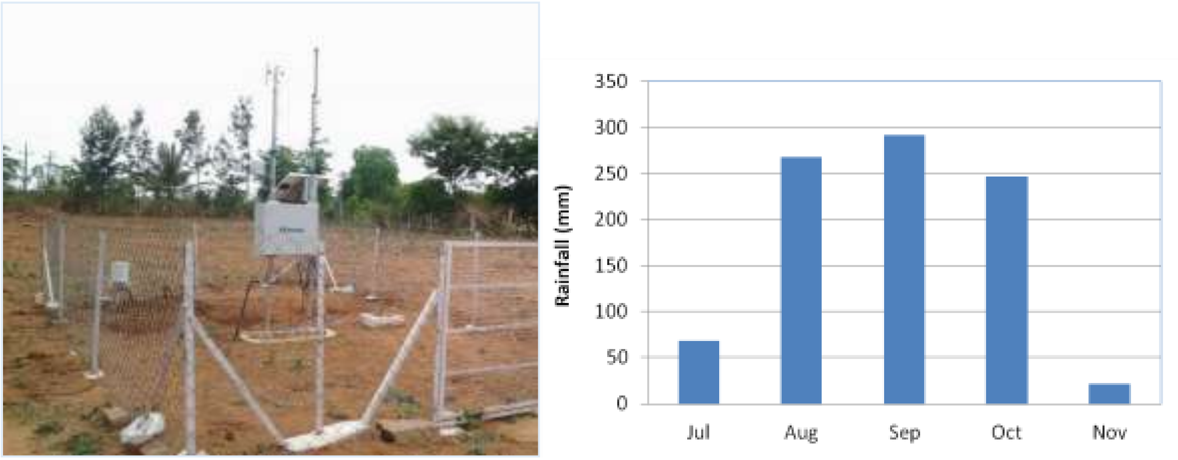

Figure 30. a) A weather station established in Harelkatte village, Tumkur; b) Variation of rainfall from month to month in 2014; Total 897 mm rainfall recorded in villages during the monsoon period.

Figure 31. Runoff set up at Harelkatte village in Tumkur.

Figure 32. Hydrograph obtained against the rainfall received in 2014 at Tumkur district.

Table 17. Rainfall–runoff coefficient obtained from treated and non-treated watershed in Tumkur during 2014.		
Station at Tumkur	Rainfall (mm)	Runoff (mm)
Non-treated w/s	897	89 (10%)
Treated w/s	897	65 (7%)

Bijapur

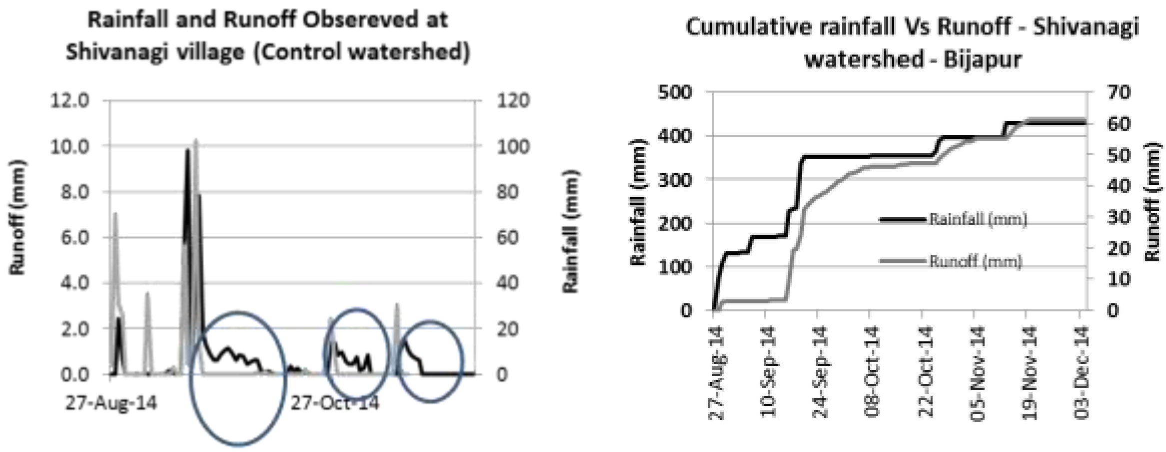

Figure 33. Hydrograph obtained during monsoon of 2014 in Bijapur.

Table 18. Rainfall–runoff coefficient obtained from non-treated watershed in Bijapur during 2014.				
Station	Rainfall (mm)	Runoff (mm)	GW recharge (mm)	ET (mm)
Shivanagi (control)	625	61	33	531
Niwalkhed (Treated)	Logger lost			

Chikkamagaluru

Figure 34. Hydrological monitoring station installed at Chikkamagaluru.

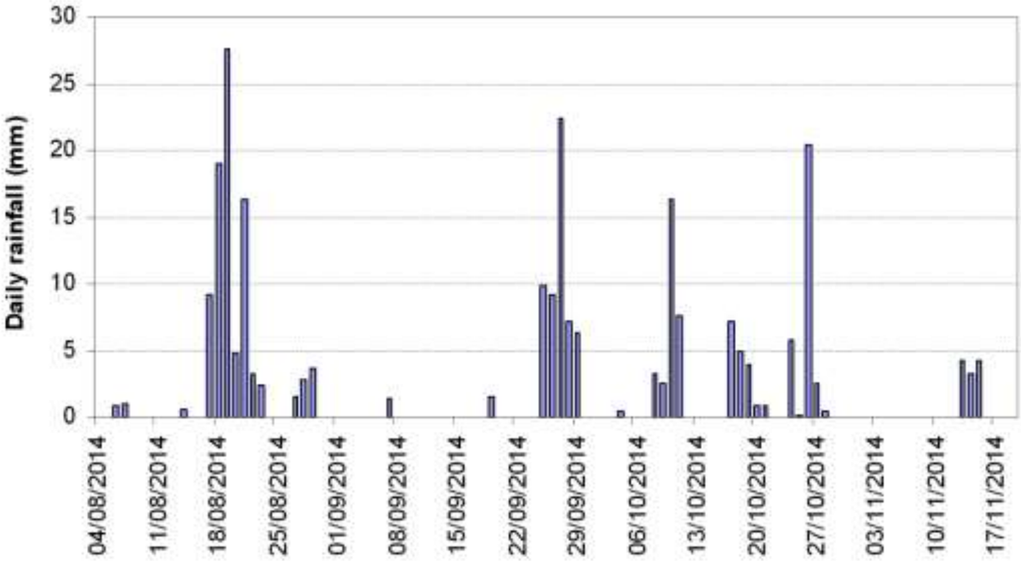

Figure 35. Daily rainfall in Lakkamanahalli, Lakya RSK, Chikkamagaluru.

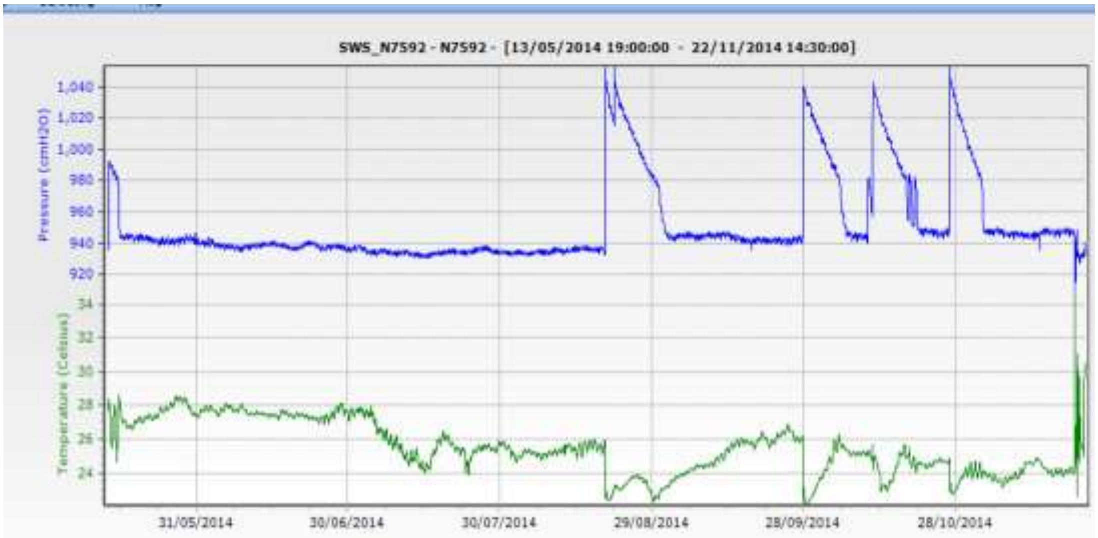

Figure 36. Hydrograph obtained against the rainfall received in 2014 at Chikkamagaluru district.

Farmers' Participatory Varietal Evaluation during Kharif 2014-15

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 2540 kg/ha in improved practice compared to the farmers' practice yield of 1450 kg/ha (Fig. 40). 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, Oilpalm 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 has recorded a maximum yield in Raichur (1545 kg/ha) whereas average yield across the district was 971 kg/ha which is 66% higher than farmers’ practice (525 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 has tolerance for *Fusarium* wilt and whitefly insect. Overall, average increase in yield across all the districts over the traditional variety was 28%. Castor cultivar Jyothi was evaluated in trials for which seed was supplied from ICRSIAT. Maximum yield in Raichur district was observed to be 2170 kg/ha, which is 25 to 37% increase in seed yield compared to farmers’ practice using traditional variety.

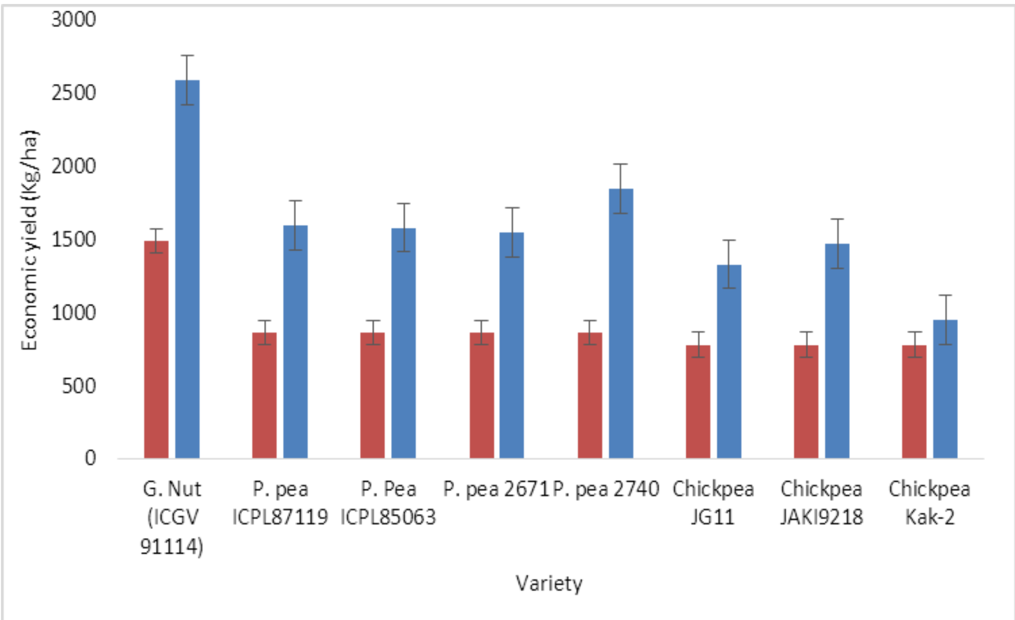

Figure 37. Farmer participatory varietal evaluation of pulses in Raichur district.

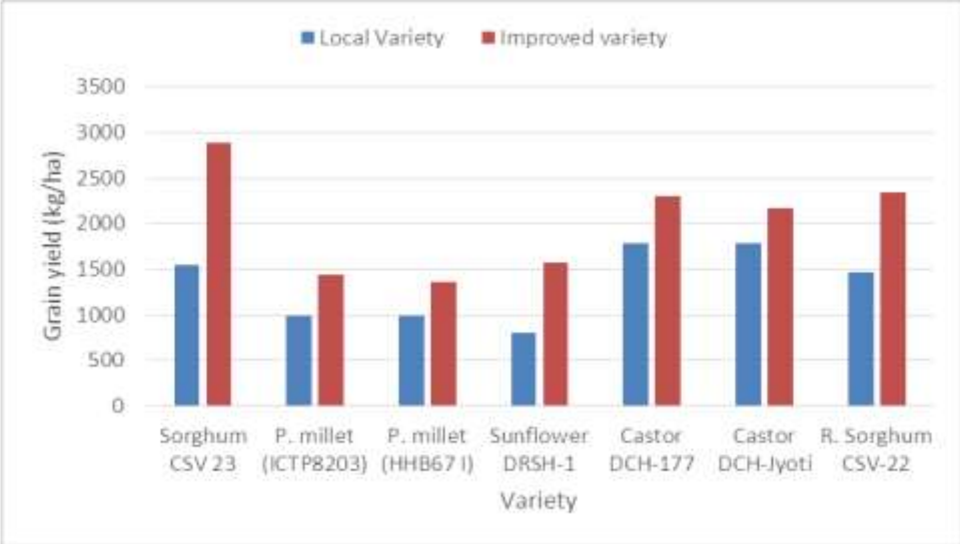

Figure 38. Farmer participatory varietal evaluation of cereals and oilseeds in Raichur district.

Evaluation of Improved Cultivars in Tumkur

Ragi/finger millet (*Elusine coracana)* is the most important cereal food crop in Tumkur and farmers continued to be interested in evaluating 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 2550 kg/ha which is 63% higher than the farmers' practice with traditional variety.

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

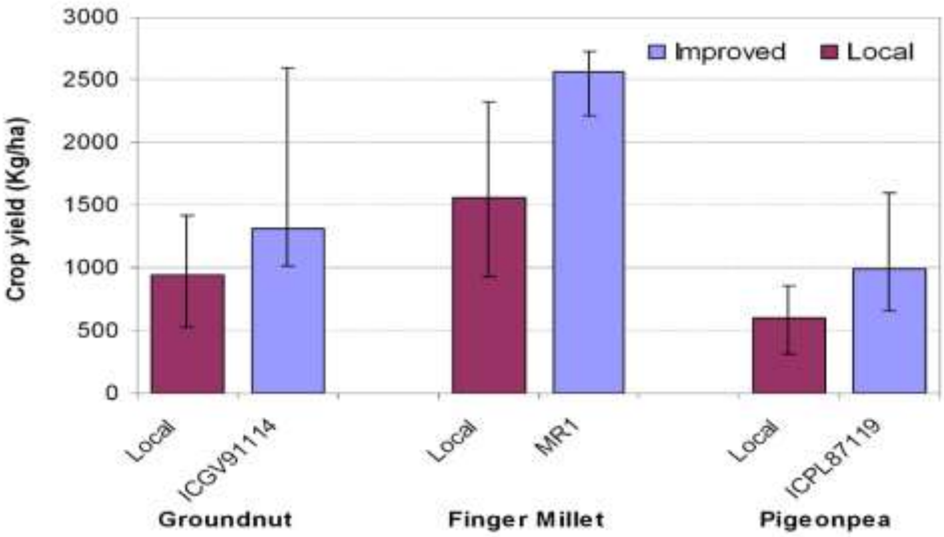

Figure 39. Farmer participatory varietal evaluation in Tumkur district.

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 be better in performance compared to local variety whereas other ICRISAT varieties also found to be the better option in the targeted sites in the district. All these varieties and hybrids recorded 15 to 20% increase in the yield over local check.

The variety CSV 15 was tested in seven districts. Maximum grain yield was observed in Koppal (2640 kg/ha) district whereas low yield was recorded in Haveri district (1800 kg/ha) (Figure 40). Overall average yield for CSV 15 cultivar (2240 kg/ha) is 23% higher than farmers' practice of using traditional variety (1820 kg/ha).

Twenty trials on sorghum variety CSV 23 were conducted in eight districts on 9.6 ha area. Overall, average grain yield from four districts was 2580 kg/ha (28% higher) against 2020 kg/ha with their local variety (Figure 41). Heavy rainfall during the crop season damaged trials in four districts. Observed data indicated that CSV 23 has recorded 13 to 33% more grain yield across all the districts compared to traditional variety.

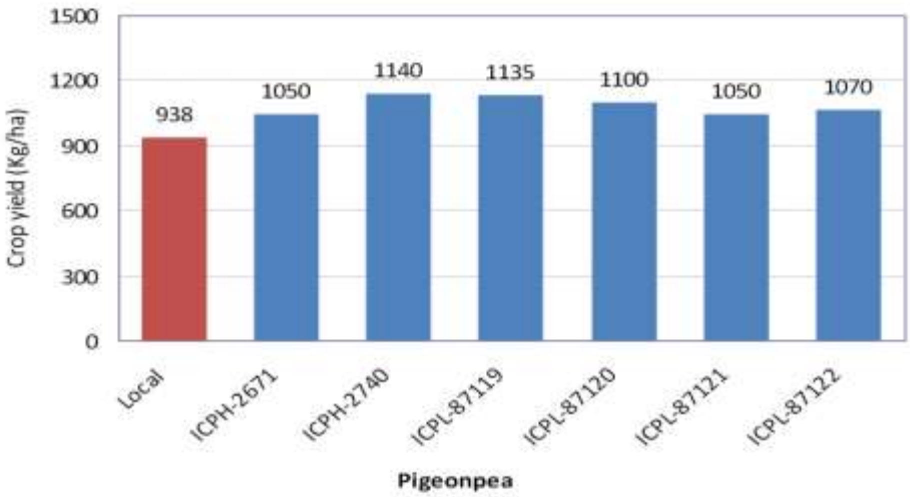

Figure 40. Farmer participatory varietal evaluation of pigeonpea cultivars.

For ragi, the variety evaluated MR 1 was found to have 15 to 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 2790 kg/ha for ICGV 91114 while the local variety yielded 1120 kg/ha. The increase in pod yield with improved management for these three varieties ranged from 120 to 150% compared to local variety TMV 2.

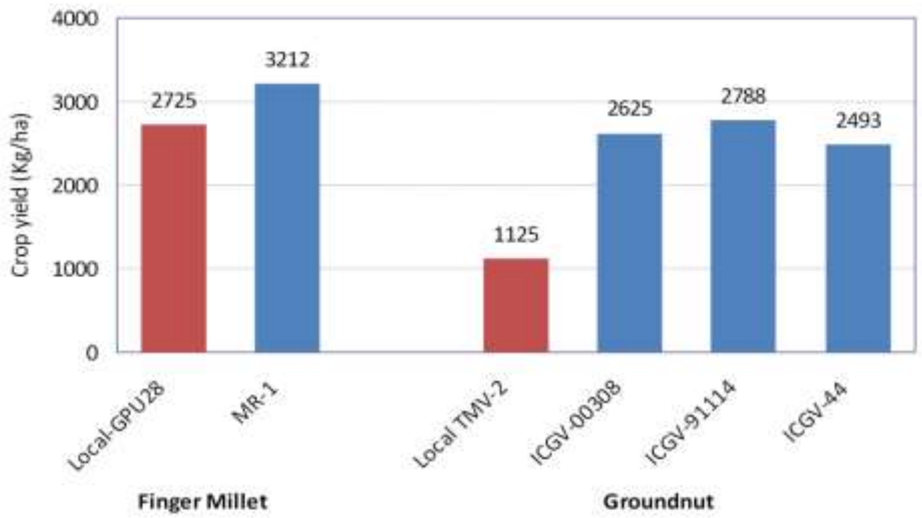

Figure 41. Farmer participatory varietal evaluation in Chikkamagaluru district.

Evaluation of Improved Crop Cultivars in Vijayapura

Evaluation of pearl millet with two hybrid cultivars ICTP 8203 and HHB67 (improved) were conducted in Vijayapura. Hybrid ICTP 8203 is of medium duration variety (75 to 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.

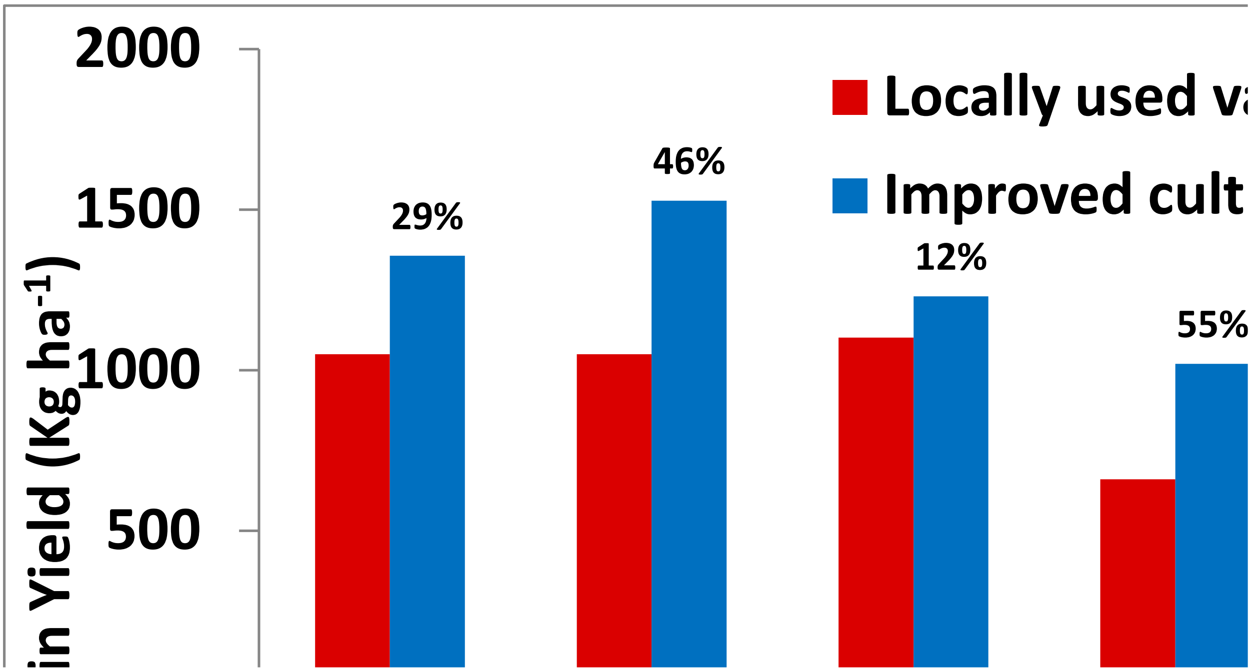

Figure 42. Farmer participatory varietal evaluation in Vijayapura district.

World Vegetable Centre (AVRDC)

Site Specific Diversification of High Value Vegetables

Field visits and discussions were conducted with the farmers and DoA officials in the project sites. In order to diversify the cropping system, legume crops such as mungbean and vegetable soybean were introduced into the project sites. Seeds (4 kg) of SML 668 mung bean variety and nine other mung bean lines were sent to the Joint Director of Agriculture, Chikkamagaluru for testing in farmer fields. In Kadur taluk, the farmers recorded average yield of 1.48 t/ha by growing SML 668. In addition, seed multiplication of SML 668 and preliminary testing of other mung bean lines were conducted by UAS Raichur. SML 668 recorded the highest yield compared to other lines/cultivars. Ten lines of vegetable soybean were supplied to UAS, Dharwad, for preliminary trials. The performance of these lines has been promising and seed multiplication will be carried out to scale up the cultivation. Seeds (1 kg) of vegetable soybean variety Swarna Vasundhra were supplied to Krishi Vigyan Kendra, Raichur (Indian Council of Agricultural Research) for demonstration purpose.

Improved Vegetable Cultivars

In Chikkamagaluru district, 375 farmers were identified in eight villages within Chikkamagaluru taluk for project activities. Together they own 455 ha of land, out of which vegetables are cultivated on 285 ha. In Kadur taluk, 98 farmers have been identified in three villages. Of 148 ha of cultivated land, vegetables are being grown on 81 ha. The identification of vegetable growing farmers is in progress in Raichur district and is expected to be completed by the end of October. In Chikkamagaluru, the main vegetable crops grown include tomato, beans, cabbage, beet root, onion, okra, ridge gourd, chili, brinjal, carrot, potato and leafy vegetables. In Raichur, the main vegetable crops are tomato, brinjal, okra, chilli and onion. AVRDC, the World Vegetable Center will be working with the farmers identified in scaling-up of improved vegetable cultivars and production practices. Discussions were held with the IWMI team regarding the possibilities of interventions in the form of micro-irrigation in the fields of the selected farmers.

Farmer-to-Market Linkages

As part of a competition, AVRDC was selected by the Johns Hopkins Carey Business School in their 'Innovation for Humanity' Project, for which 3-5 global MBA students worked for one trimester with AVRDC to come up with recommendations by April 2014 for improving market access for vegetable growers in Karnataka. The Carey student team working on this project considered the following issues:

I. Analysis of current market challenges for small-scale farmers in Karnataka
II. Report on best practices for improving market access and addressing market gaps, investigating how local laws and supply and value chains affect market dynamics
III. Proposed tactics to develop new markets for small scale farmers, including the private sector's role in market development, information exchange, e.g., ITC Chaupal, IFFCO, Reuters Market Lite, MCMX, etc.

Based on discussions with key stakeholders, it was established that excessive use of pesticides, aflatoxin contamination and poor market linkages were major problems in the chili farming belts of Raichur. A large chili processing company in Tamil Nadu, Paprika Oleos Private Limited, has been identified as a potential market for Raichur farmers. They are willing to pay 20% premium if farmers would follow good agricultural practices (GAP). We are in the process of organizing a workshop for chili farmers and the company representatives in order to understand the quality and quantity requirements as well as the contractual matters.

Figure 43. Inline dripper with staking in tomato at Uddeboranahally, Chikkamagaluru.

ICARDA

In selected four Bhoochetana Plus districts of Karnataka, International Center for Agricultural Research in the Dry Area (ICARDA) planned for lentil demonstrations in rabi (2014-15) for varieties of PL 6, JL 3, IPL 316 and RBL 2. The seed production program was carried out in two districts, Bijapur and Raichur, in four talukas and ten villages covering 60 farmers with cropped area of 100 acres. Field preparation and logistics coordination was done and 16 quintals of seeds were sown in rabi 2014-15. In addition, 31 different germplasms/breeding lines are evaluated in collaboration with IARI Regional Research Center in Dharwad during 2014-15. Among them, 8-10 best performing lines will be taken into project activities in 2015/16 in two districts to constitute Participatory Varietal Selection (PVS).

Four pre-sowing training programs were conducted in selected benchmark districts between April and Sept 2014 to raise awareness among farmers about the benefits of improved lentil production technologies, which succeeded in inspiring them. Two leaflets were published in Kannada and distributed to farmers to educate and sensitize. These project interventions have successfully motivated farmers to expand lentil cultivation in the area.

Selection of Villages and Farmers

Selection of farmers, villages, lentil varieties were discussed in advance at one awareness camp, four farm field days/events and seven seed production trainings covering more than 600 farmers which included more than 100 women. During this rabi cultivation, depending on the performance and vigor of different varieties in different fields, seed selection will be made for sowing in subsequent years.

Table 19. Summary of achievements in the project during 2014-15

SL. No.	Activities	Numbers
1	Number of villages covered	10
2	Number of farmers involved	60
3	Area covered (acres)	100
4	Number of varieties introduced	4
5	New genetic material evaluated	31
7	Pre-sowing training on lentil cultivation	4
8	Number of farmers participated in pre-sowing training	120

Lentils are major rabi pulse crops grown in India since ancient times and contribute significantly to food feed and sustainable farming systems. They contain high amounts of digestible protein (up to 35%), macro and micro nutrients, particularly iron and zinc and vitamins, thus providing nutritional security to its consumers. Lentil is grown in an area of 1.43 million ha with a total production of 0.92 million tons. The average yield of lentil in India (648 kg/ha) is much lower than the world average (963 kg/ha) (FAO 2010). Low yields are due to various biotic, abiotic and edaphic factors at different growth stages. Some of the varieties suitable for rice fallows are KLS 218, HUL 57, Narendra Masoor 1, Narendra Masoor 2, PL 6, Moitree, Pant L 639, Pant L 406, Noori, Rangali, Moitree and Pant L 5.

The present study is taken up to promote high yielding, early maturing and disease resistant lentil varieties along with matching production technologies. Emphasis has been laid on production of quality seed through farmers' participatory approach and developing village-based seed enterprises (VBSEs) in the state with a view to improving farm income, employment, rural livelihoods and nutritional security through increased production of lentils in Karnataka.

Capacity Development of Researchers, Technicians, Farmers

- Farmers acquired knowledge on lentil production techniques and on varietal characteristics, IPM, IDM, INM, soil health, etc
- Individual farmers/farmer groups/FF, particularly women, are trained in seed production, storage at household/village/block/district level and value addition
- Training materials, booklets, flyers, leaflets, pamphlets, posters, etc on production technologies in local language were prepared and distributed

Figure 44. Capacity building training program on lentil production.

Pre-sowing trainings

Four different pre-sowing training sessions elaborately discussed the final farmers' list, lentil production practices and seed selection methods. Two leaflets were published in Kannada and distributed to educate and sensitize the community. These project interventions have successfully motivated farmers to expand lentil cultivation in the area.

Introduction of thornless Cactus (*Opuntia* spp.) and its value addition

ICARDA in collaboration with UHS, Bagalkot, and ICRISAT is introducing thornless cactus (*Opuntia* spp.) varieties to address feed deficit by cultivating them in unused lands. In this endeavor, 1200 cladodes/pads of three cactus varieties (1270, 1271 and 1280) collected from Central Soil Salinity Research Institute (CSSRI) were planted during June 2014. Additionally, 1000 cladodes/pads were planted in Tumkur and Belgaum districts in August 2014 and more will be planted in all four districts in collaboration with the state department of agriculture. The plants are in vegetative growth stage. Additionally 15 different varieties of multi-purpose cactus introduced from Italy have been planted at UHS Bagalkot in September 2014. A total of 100 farmers were trained on improved production technology for cactus growing.

Table 20. Summary of project achievements during 2014-15.

Sl. no.	Activities	Numbers
1	Number of villages	12
2	Number of farmers participated in training	100
3	Area covered (acres)	7
4	Number of varieties introduced	18
5	Number of cladodes planted	2,241
6	Field day/field school	1
7	Farmer's training program	1

Cactus *(Opuntia ficus-indica)*, commonly known as prickly pear, belongs to the family Cactaceae. Family Cactaceae is known to contain about 130 genera and nearly 1,500 species, which are originally native to the new world. Cacti have a special carbon dioxide fixation pathway, known as Crassulacean acid metabolism (CAM) and are ideally suited to water-scarce dry zone of the world as an alternate source of food and fodder (Wessels 1988; Mizrahi et al. 1997; Singh and Felker 1998; Han and Felker 1997). Being so water-use efficient, they are highly useful in arid and semi-arid environments, particularly during prolonged dry spells or monsoon failure. However, cactus is not merely a hardy ornamental plant, as is commonly believed; it is a storehouse of virtues that have been commercially unexploited so far in India. In addition, certain genera, such as Optuntia and Nopalea have economically useful plant parts. Different parts of the cactus can be used as fruit and vegetable for human consumption, fodder for cattle and raw material for various industries to prepare plywood, soap, dyes, adhesives and glue, pharmaceutical products for treating blood sugar and various other disorders, and cosmetics such as shampoo, cream, and body lotion, etc. (Barbera et al. 1995; Pimienta 1994). Use of cactus pear as a waterproof paint for homes is also reported (The Hindu 27 June 2002). Many species of cactus are found growing either as wild plants in arid and semi-arid regions of India or as ornamental plants in urban homes and gardens. Generally, these species are used as live fences to protect agricultural fields from human and animal encroachments.

The future of the arid regions depends on the development of sustainable agricultural systems and on the cultivation of appropriate crops which now has been more hit by climate change and its impact. Crops grown in these regions must successfully withstand water shortages, high temperatures and poor soil fertility. Cacti can satisfy these requirements and are becoming increasingly important for both subsistence and market-oriented activities.

Keeping these in mind, the present study has been proposed to introduce the thornless cactus through improved germplasm exchange, frontline demonstration and value addition of the spp. in degraded and wastelands in Karnataka.

Appropriate cactus varieties/species introduced, identified, multiplied and disseminated

A total of 18 varieties of multi-purpose spineless cactus were introduced in Karnataka. Three varieties collected from CSSRI have been planted in Bhoochetana Plus districts in Karnataka in June 2014. Additionally, 15 varieties of multi-purpose spineless cactus materials were originally collected from Brazil cactus nursery. These were planted in September 2014 at the cactus nursery at UHS, Bagalkot. In addition to feed value, these accessions possess fruit value as well. Planting material should be collected from robust, productive and healthy plants. The pads can be collected at the end of the growing season and subjected to slight dehydration to induce suberization of the joints. The prescribed method is to collect pads of medium to large size, devoid of suspicious dark spots or discolorations; after collection, they are stored in a shaded dry place for two weeks. To reduce rotting, the pads are treated with systemic fungicide Bavistin 50 DF 1kg dilute to 50 liters of water, prepared on the same day for seed treatment. Planting was done keeping 1 m between row to row and 1 m between plants to plant in flat bed and broad bed furrow system planting. Immediately after planting, protective irrigation was applied.

Figure 45. Tumkur CEO, Mr. Govindaraj visiting the cactus field.

Major Activities

1. Benchmark survey through selection of 10-15 farmers/farmers' group in GOK-CGIAR selected villages in the districts.
2. Supply of inputs and demonstration of edible cactus varieties (Cactus-1270, Cactus-1271 and Cactus-1280) and improved technology (seed rate, time of planting, priming and weeding schedules, fertilizers, insecticides, fungicides, rhizobium cultures etc.).

3. Quality crop production of selected improved varieties by farmers and creation of village seed hub to use the pads for cultivation.
4. Planning for preparation of publication viz., leaflets in local language.

Technology intervention

Technological interventions were provided to farmers on multi-purpose fodder cactus cultivation. According to the physiological stages of the crop, the details of these interventions are as follows.

Site selection

Planting sites are more convenient if located near the household or in a backyard, which allows for continuous care and protection. If plantations are located in open fields, then the plot with easiest access must be chosen. Fresh [*Opuntiaficus-indica* (L.) Mill.] pads are heavy feed stuff, therefore it is necessary to ensure quick access to roads in good condition at any season of the year.

In consultation with farmers and state agricultural department, site selection for dissemination of cactus has been done. Lands have been prepared and pads will be collected from ICRISAT, CSSRI and UHS-Bagalkot nurseries, and planted in farmers' fields.

Figure 46. Site selection and land preparation with bullocks.

Plantation layout

The flat bed and broad bed farrow system provides high planting density and productivity per unit area. Several options are possible, according to the machinery available. However, the best dimensions of the ridge and farrow are 120 cm wide with a 90 cm top, and the length is adjusted as needed. Broad-beds are built using animal-drawn devices. Farmers should eliminate any buds or roots that have sprouted during storage, as they can interfere with the planting operation. The pads should be buried halfway into the ground.

Fertilization

To ensure high yields, it is convenient to apply manure prior to planting. Manure is to be broadcast and ploughed in prior to planting. The best results are obtained when manure is supplemented with synthetic fertilizers.

Figure 47. Cactus planting at Lakya; Cactus planting along the bund.

Figure 48. UAS-Dharwad scientists planting cactus; women planting cactus in fields.

Table 21. List of *Opuntia* spp. planted at in the four districts and UHS, Bagalkot.		
Sl. no.	**Cultivars**	**No. of cladodes**
1	Cactus 1270	700
2	Cactus 1271	700
3	Cactus 1280	800
4	Gialla Roccapalumba	4
5	Trunzara Bianca - San Cono	2
6	Rossa Roccapalumba	3
7	Bianca Roccapalumba	1
8	Seedless Rocccapalumba	2
9	Spineless	3
10	Seedless Santa Margherita Belice	2
11	Trunzara Rossa Bronte	3
12	Trunzara Gialla Bronte	3
13	Trunzara Bianca Bronte	3
14	Trunzara Gialla san cono	3
15	Trunzara Bianca San Cono	3
16	Rossa San Cono	3
17	Gialla San Cono	3
18	Bianca San Cono	3
Total		2241

Table 22. Details of cactus varieties planted at Bhoochetana Plus action sites in Karnataka.							
Sl. no	**Districts**	**Village**	**Name of the farmers**	**Varieties given**	**No. of cladodes/ pads planted**	**Date of sowing**	**Growth stages**
1	Bijapur	Hitanalli	KVK main farm	Cactus-1270	100	19.06.2014	Vegetative
				Cactus-1271	100		
				Cactus-1280	100		
Total					**300**		
2	Raichur	Mittikellur	Amaragwdappa	Cactus-1270	25	12.06.2014	Vegetative
			Channabasappa	Cactus-1271	30		
			Hulagappa	Cactus-1270	25		
			Siddanagwda	Cactus-1280	25		
			Basappa	Cactus-1271	30		
			Sangappa	Cactus-1280	25		
		Mettur	Shankranna	Cactus-1270	25		
			Basavaraj	Cactus-1270	25		
		Basapur	Amaresh	Cactus-1271	40		
		Gudinal	Nagaraj	Cactus-1280	25		
		Kannal	Sangmesh	Cactus-1280	25		
Total					**300**		
3	Tumkur	Chikanalli	DATC	Cactus-1270	100	05.06.2014	Vegetative
				Cactus-1271	100		
				Cactus-1280	100		
		Hirehalli	KVK	Cactus-1270	150	07.08.2014	Vegetative
				Cactus-1271	175		
				Cactus-1280	175		
Total					**800**		
4	Chikmag alur	Lakya	Murthy KN	Cactus-1270	50	06.06.2014	Vegetative
				Cactus-1271	50		
				Cactus-1280	50		
		Geginahalli	Rudrappa B M	Cactus-1270	40		
				Cactus-1271	50	07.06.2014	Vegetative

Table 22. Details of cactus varieties planted at Bhoochetana Plus action sites in Karnataka.							
Sl. no	**Districts**	**Village**	**Name of the farmers**	**Varieties given**	**No. of cladodes/ pads planted**	**Date of sowing**	**Growth stages**
		Ajampur	Basappa	Cactus-1280	60	08.06.2014	Vegetative
Total					**300**		
5	Belgaum	Chachadi	Nagraj I Desai	Cactus-1270	150	06.08.2014	Vegetative
				Cactus-1271	175		
				Cactus-1280	175		
				Total	**700**		
6	UHS-Bagalkot	Udyanagiri	UHS-Campus	Gialla Roccapalumba	4	08.09.2014	Sprouting
				Trunzara Bianca - San Cono	2		
				Rossa Roccapalumba	3		
				Bianca Roccapalumba	1		
				Seedless Rocccapalumba	2		
				Spineless	3		
				Seedless Santa Margherita Belice	2		
				Trunzara Rossa Bronte	3		
				Trunzara Gialla Bronte	3		
				Trunzara Bianca Bronte	3		
				Trunzara Gialla san cono	3		
				Trunzara Bianca San Cono	3		
				Rossa San Cono	3		
				Gialla San Cono	3		
				Bianca San Cono	3		
Total					41		
Grand Total					**2241**		

Capacity Development of Researchers, Technicians, Farmers in Cactus Production

A series of awareness programs such as field visits, farmers' training, trainers' training and scientist–farmer interaction were organized by ICARDA and DoA and different collaborative partners. The idea was to disseminate production technologies viz., selection of variety, disease identification & management, postharvest management, seed multiplication and processing etc. These programs were well accepted by farmers and successful in reaching the grass root level. More than 100 farmers were trained under this program since August 2014.

Figure 49. Field visit by UAS-Dharwad scientists and farmers; Farmers observing cactus growth progress.

Figure 50. Discussion on cactus; farmers are attentive to knowledge dissemination.

ILRI

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 23).

Table 23. Participatory evaluation of dual-purpose maize cultivars.

Sl. no.	Name of the cultivar	Grain yield (q)	Stover yield (t)
1	NAC 6004	54	10.2
2	NK6204	68	9.4
3	NMH 731	62	8.6
4	Bioseed 9681	55	8.2
5	PMH-1	55.8	7.8
6	Arjum (Local)	48	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 pukka sheds were used to house the livestock. Roughages were chopped manually before feeding to the livestock by using sickles. Farmers were satisfied with the veterinary services available and farmers have good knowledge of dairy farming. They prefer 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.

FEAST tool output

The data collected were analyzed through excel based FEAST software.

a. Landholding patterns

According to the farmers' opinion, those with landholding of less than 1.2, 1.3-4 and more than 4 ha were classified as small, medium and large farmers in the selected village of Chikmagalur district (Figure 51). Majority of the farmers belong to the medium category (88%). Large and small farmers were and 7 and 3% respectively.

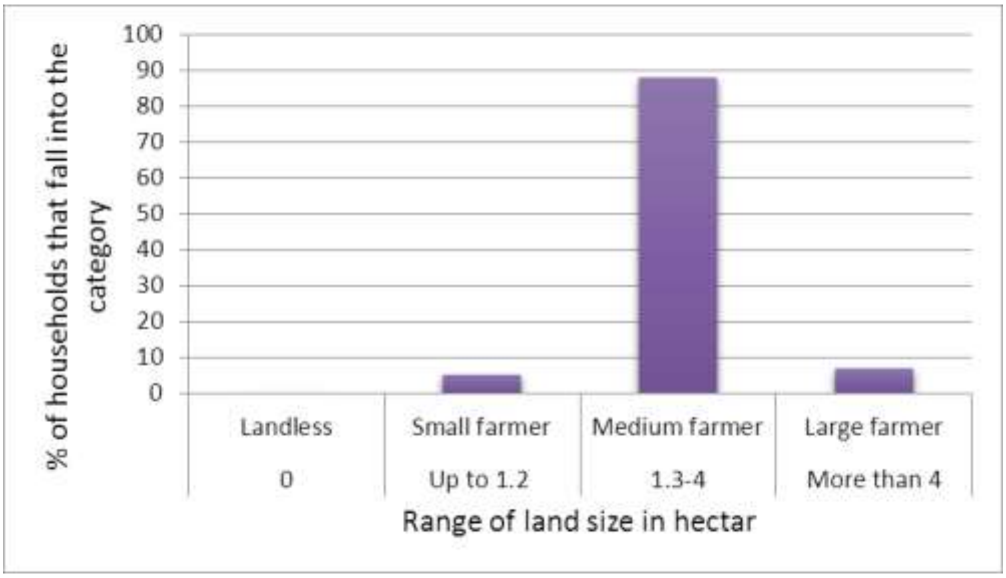

Figure 51. Farmers categorization based on landholding capacity.

b. Average livestock species holdings per household in Tropical Livestock Units (TLU)

Mainly large ruminants were reared by the farmers mainly for milk, manure and draught purpose. Among the livestock reared, local dairy cattle followed by improved dairy cattle, local buffaloes and draught cattle (Figure 52) followed by local dairy cattle, goats, local buffaloes, poultry and sheep. Average tropical livestock units holding per household was 8.7.

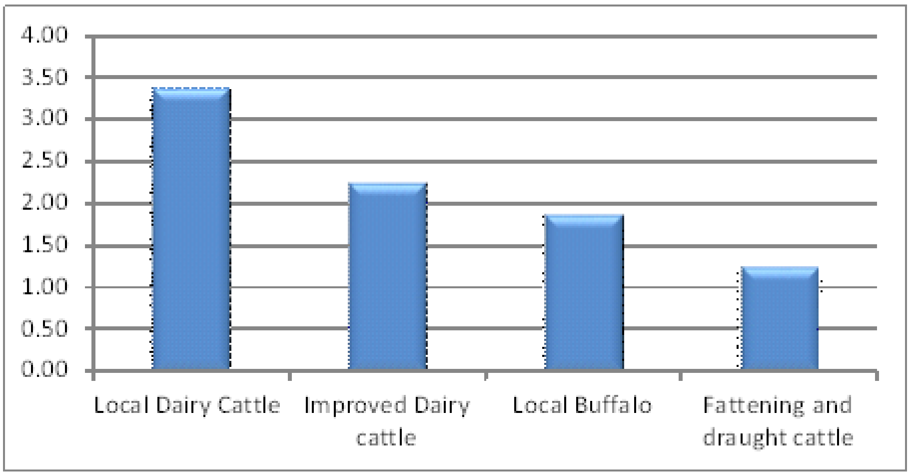

Figure 52. Average livestock species holdings per household in Tropical Livestock Units (TLU).

c. Cropping pattern

Crop diversity is high in Chikmagalur district. Both food and commercial crops were cultivated by the farmers in Lakkamanahalli village, Chikkamagaluru. Main food crops cultivated by the farmers were maize and finger millet and commercial crops were cotton, sugarcane, coconut and tomato (Figure 56). In addition, various fruit and vegetable crops such as banana, beans, cabbage, green pepper and coriander were grown.

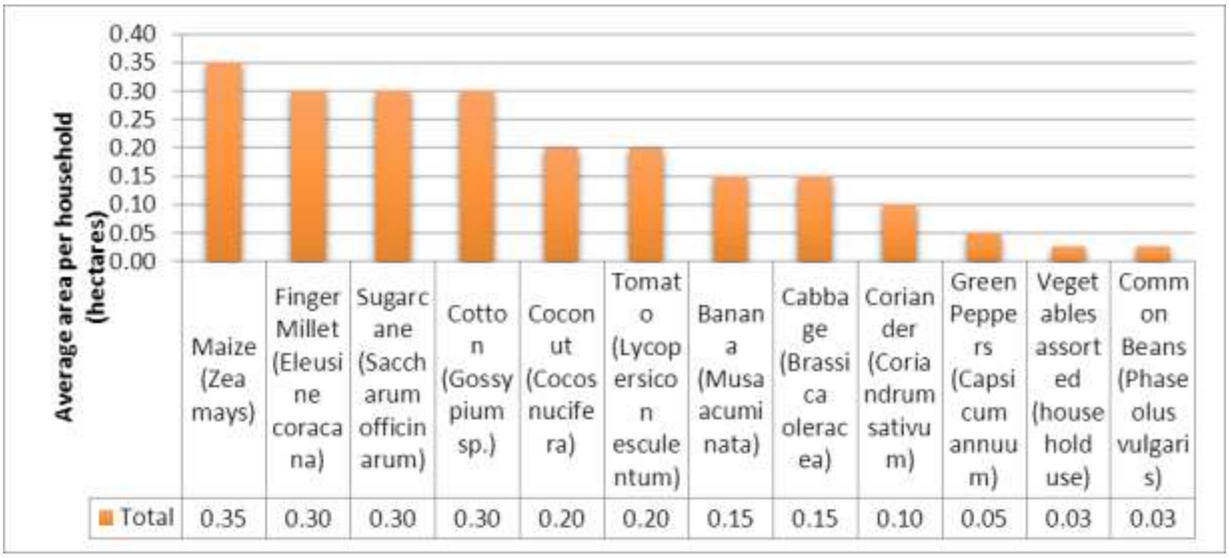

Figure 56. Cropping pattern in visited villages.

d. Fodder crops grown

Maize and hybrid napier were the fodder crops commonly cultivated by the farmers for feeding of their livestock (Figure 53). Each farmer on average cultivated 0.13 ha with maize and 0.1 ha with hybrid napier.

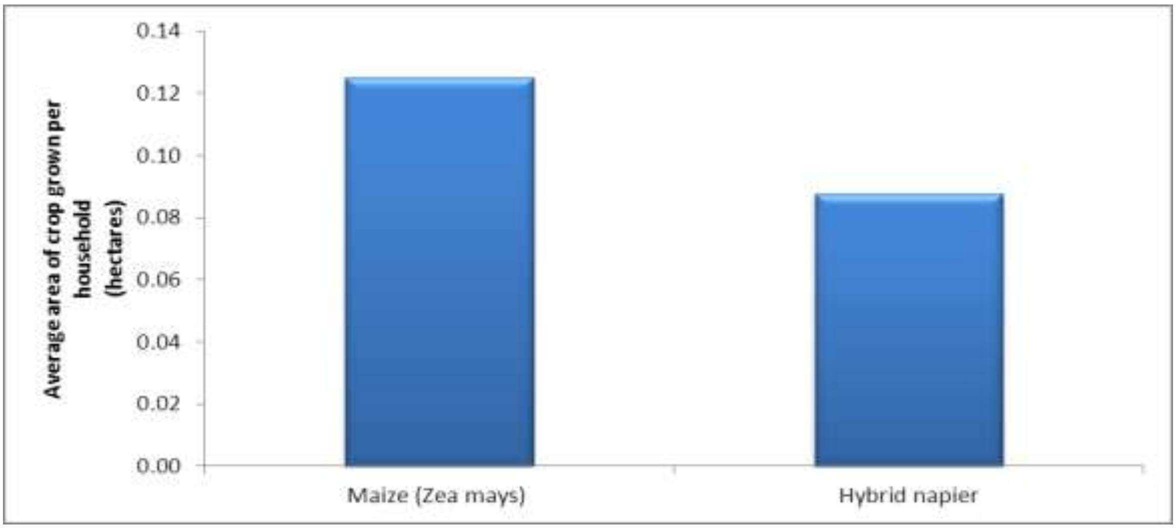

Figure 53. Fodder crops grown in the area.

e. Purchased feed

Around 4.2 tons of both crop residues and concentrates were purchased by each farmer in a year for feeding their livestock (Table 24). Crop residues purchased were rice straw, finger millet straw and sorghum stover which constitutes 75% of the purchased feed. Concentrates constitutes only 25% of purchased feed, which was mainly commercially mixed ration and oil meals (Figure 54).

Table 24. Dry matter quantity purchased over a month	
Feed purchased	Quantity (kg)
Cotton (Gossypium sp.) - seed meal	105
Commercially mixed ration	500
Rice (*Oryza sativa*) - bran (with germs)	34
Groundnut (*Arachis hypogaea*) - seed meal	358
Rice (*Oryza sativa*) – straw	1378
Finger millet (*Eleusine coracana*) - crop residue	1346
Sorghum (*Sorghum bicolor*) - crop residue	426
Grand total (kg)	**4147**

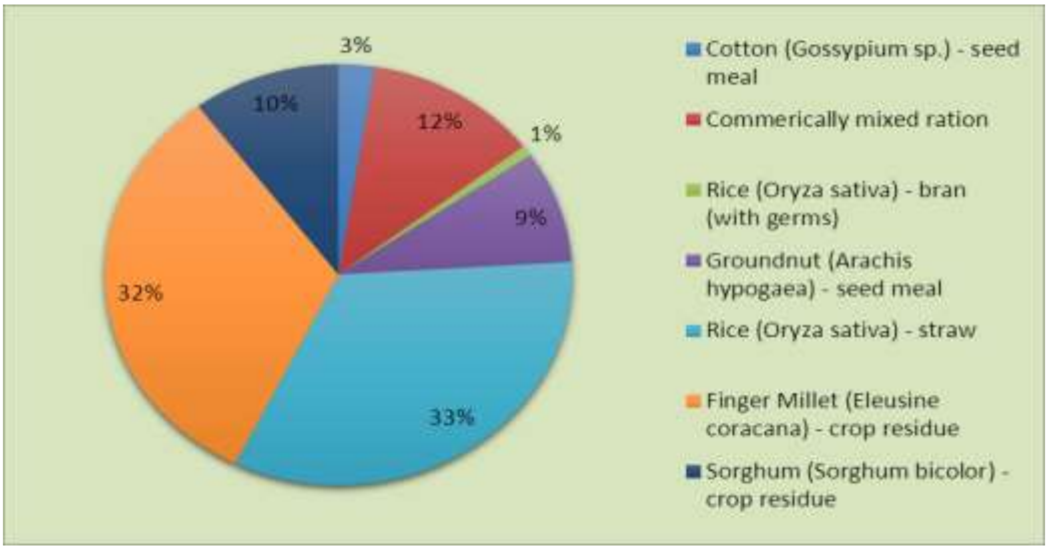

Figure 55. Percent distribution of feed and fodder purchased over a period of 12 months.

f. Household income sources

Household income sources were agriculture, livestock and business in Lakkamanahalli village. Among the income sources agriculture was the main source of income (81%) to the households (Figure 56). Livestock contributes only 11% to the household income.

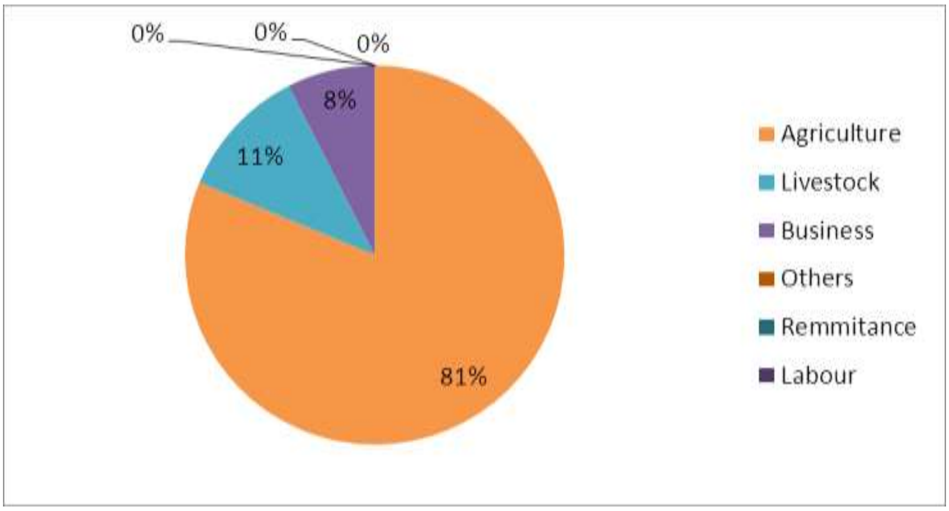

Figure 56. Contribution of livelihood activities to household income (as a percentage).

g. Dietary composition

Pasture from grazing lands was the main source of dry matter (DM), energy and protein to the livestock followed by cultivated fodder (Figures 57, 58 and 59). About 66-70% of daily DM, energy and protein intake of livestock was contributed by grazing lands and cultivated fodder and about 20-21% by crop residues and collected fodder. Dietary contribution (DM, energy and protein) of purchased feed was only 9-13%.

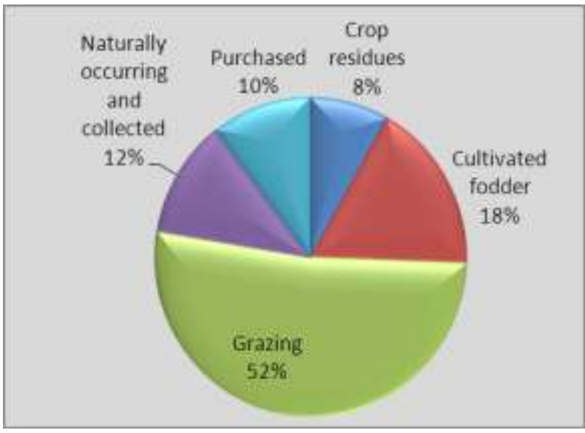

Figure 57. Contribution of different feed resources to DM content of total diet.

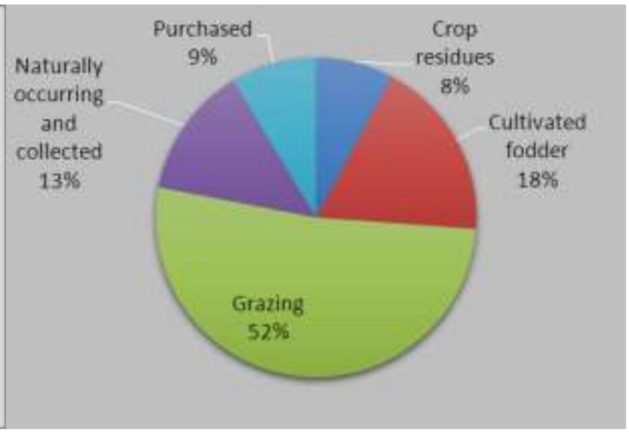

Figure 58. Contribution of different feed resources to Metabolizable Energy (ME) content of total diet.

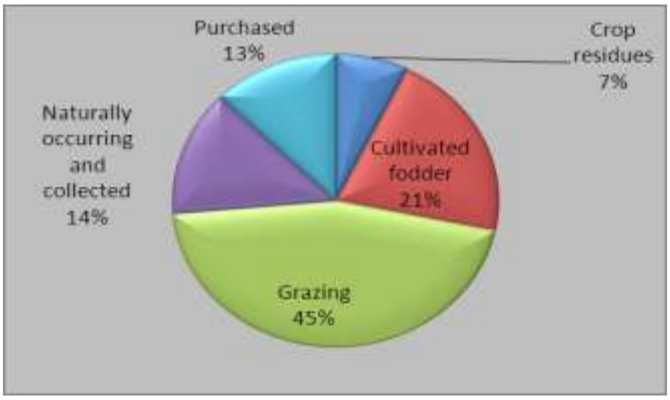

Figure 59. Contribution of different feed resources to Crude Protein (CP) content of total diet.

h. Feed availability

Adequate feed was available exclusively for two months in a year for feeding livestock (September to October) and for the remaining period farmers felt a shortage of feed (Figure 60) and the deficit was critical during the summer months (April to June). A score of 50 and above was considered as adequate feed available for feeding livestock.

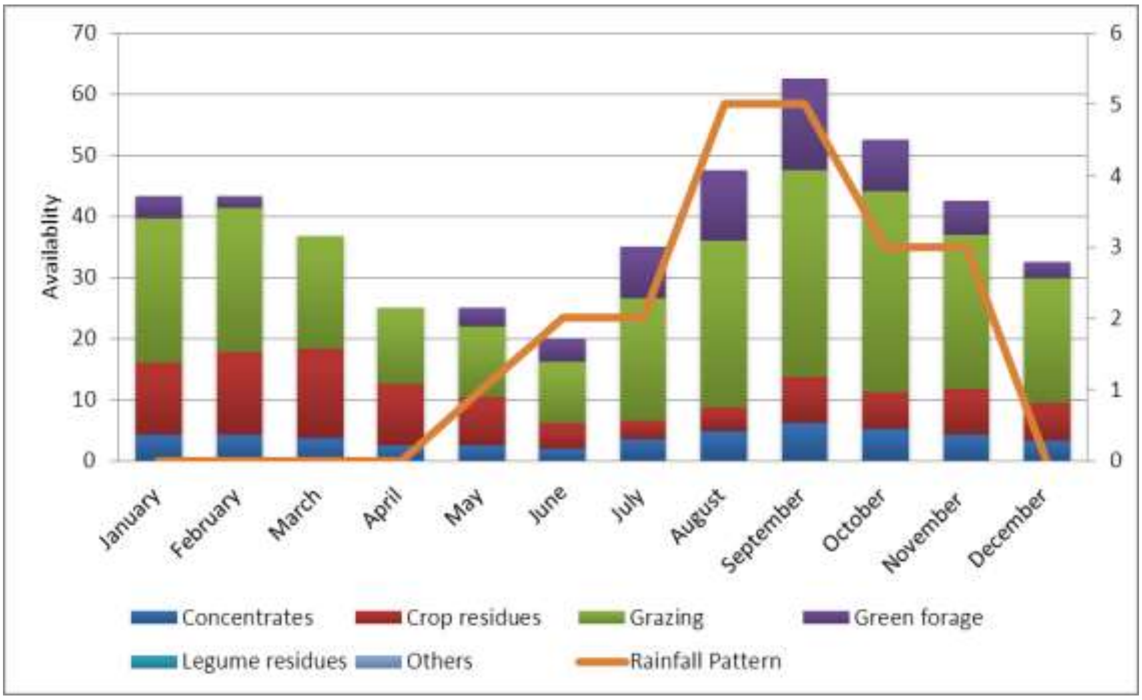

Figure 60. Seasonal availability of feed resources.

Problems and issues

The following were the main constraints felt by the farmers in the order of priority:

1. Market and price of milk
2. Cost of feed and fodder
3. Water

The following are major suggestions that emerged from the study:

1. Since grazing lands are the main sources of nutrients they need to be improved through introduction of climate resilient fodder grasses/trees.

2. Water economy fodder crops such as sorghum, pearl millet and maize with high digestibility need to be introduced (ex. CSH 24 MF variety of sorghum)

3. The practice of chopping crop residues needs to be inculcated among the farmers by introducing small scale chaffing machines since it reduces wastage and increases intake.

4. Crop residue utilization can also be enhanced by the introduction of dual purpose maize (NK 6240), sorghum (BJV 44), groundnut (ICGV 91114, ICGV 89104, TMV 2, ICGV 92093) and pigeonpea. The residues of these varieties have higher digestibility which in turn increases intake and production.

5. Introduction of moderate to high yielding climate resilient dairy cow breeds (Sahiwal, Gir, Red Sindhi, Tharparkar) and buffaloes (Murrah) for increased milk production need to be considered.

The above interventions can be meaningfully implemented provided there is (1) good market for milk (2) graded animals and (3) farmer based institutions for collective action. Fortunately there is good demand for milk in the towns close by. But the dairy animals are mainly non-descript. So development of breed assumes high importance. Moderate to high yielding indigenous dairy breeds can be used for this purpose. Similarly, formation of farmer based institutions such as cooperatives is a prerequisite for starting the feed based interventions proposed.

IWMI

The International Water Management Institute has conducted demonstrations on drip irrigation systems and organized capacity building training programs in different Bhoochetana Plus districts. A manual on drip irrigation system was prepared in Kannada for dissemination to farmers in these districts. IWMI has demonstrated drip irrigation in the following crops in Tumkur district.

- Tissue culture banana at Kora RSK of Tumkur district.
- Drip in tissue culture pomegranate at Dasanakatte, Tiptur
- Drip in china aster (cut flower) at Beladhara
- Capacity building training on-
    - Irrigation scheduling as per water requirement by 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

Figure 61. IWMI scientists assessing the performance of drip irrigation system in Tumkur district.

In Chikkamagaluru district, 10 farmers in each village 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 62. IWMI scientists monitoring drip irrigation facilities in Chikkamagaluru district.

CIMMYT

The Center for International Maize and Wheat Improvement prioritized interventions that are designed and implemented to address issues regarding water, labor and energy storage, poor mechanization, mono-cropping with subsistence with low diversity, high cost of production and low resource use efficiency. A number of interventions were made, technologies were demonstrated.

Participatory evaluation of hybrid maize was demonstrated in 25 acres belonging to farmers in Tumkur and Madhugiri talukas of Bhoochetana Plus sites in Tumkur district. The major interventions were weed management and target based yield achievement through site specific nutrient management. The demonstrations were followed by strong capacity building training programs to farmers and field level practitioners on the package of practices offered.

Figure 63. Improved maize hybrid demonstrations in Madhugiri taluka, Tumkur district.

The initial results of farmer participatory hybrid maize revealed that the Zuvari C 1921 hybrid performed better than other hybrids. However, all the new varieties performed better compared to farmers' practice.

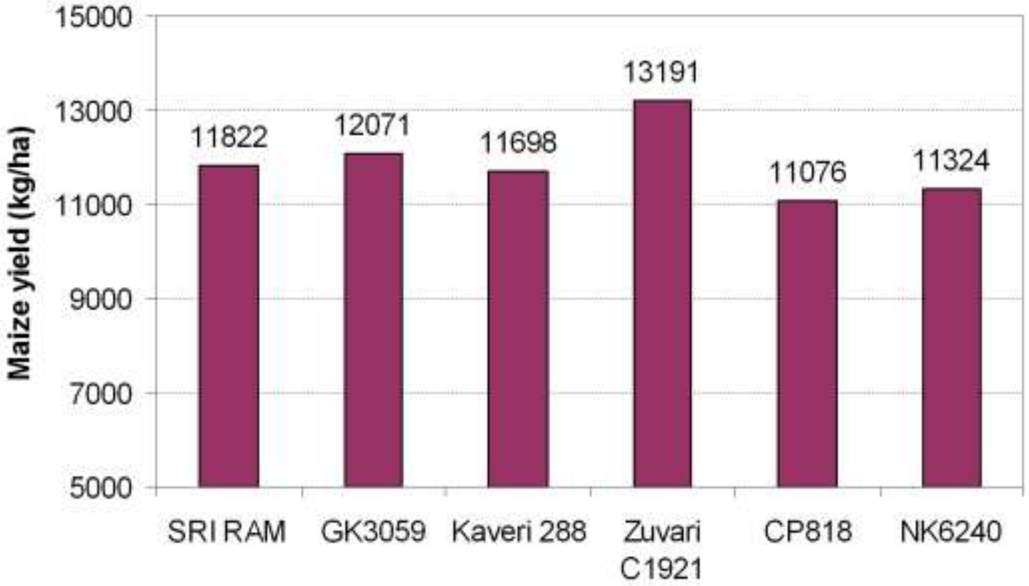

Figure 64. Maize hybrid performance in Bhoochetana Plus action sites in Tumkur district.

In Chikkamagaluru, CIMMYT took up 11 demonstrations in 25 acres belonging to farmers of Lakkammanahalli, Hiregouja, Uddeboranahalli and U Hosalli of Lakya RSK and Emmedoddi and Chikkagangla of Emmedoddi RSK. Depending on the availability of hybrid seeds at RSKs, the best selling were selected for the demos. The sowing and other cultural operations were carried out as per prescriptions. Two demonstrations ie, farmer participatory selection and target oriented nutrient management were conducted in the fields.

The initial crop yield data shows that the hybrid maize performance with improved management practice is significant. The grain yield increased between 27 and 31% over farmers' practice.

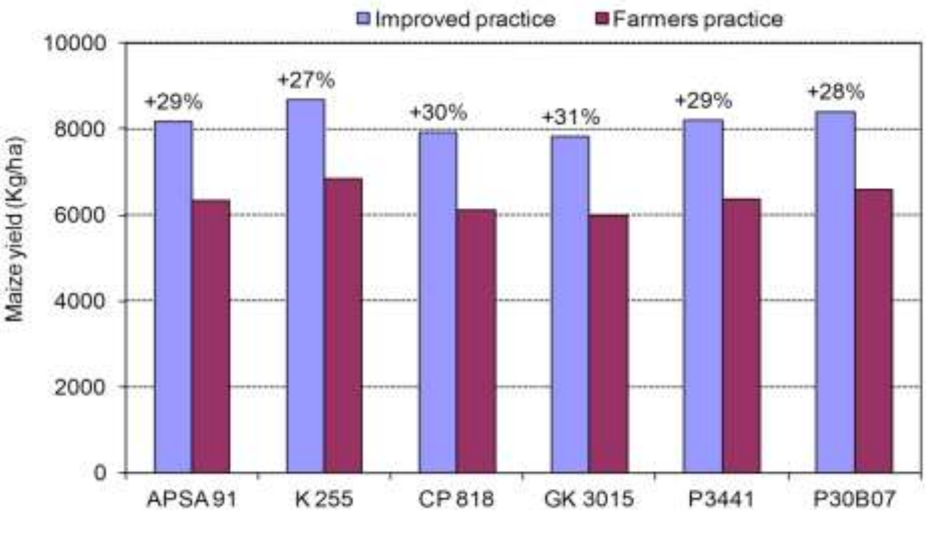

Figure 65. Performance of hybrid maize in Bhoochetana action sites in Chikkamagaluru district.

Figure 66. Maize crop growth (left); and (right) Field day conducted at Emmedoddi, Birur Hobli, Kadur taluk, Chikkamagaluru.

In Bijapur, CIMMYT undertook improved hybrid maize demonstrations in 12 ha area with participatory varietal evaluation and site specific nutrient management. The crop yield increased substantially with site specific nutrient management over farmers' practice (Figure 71).

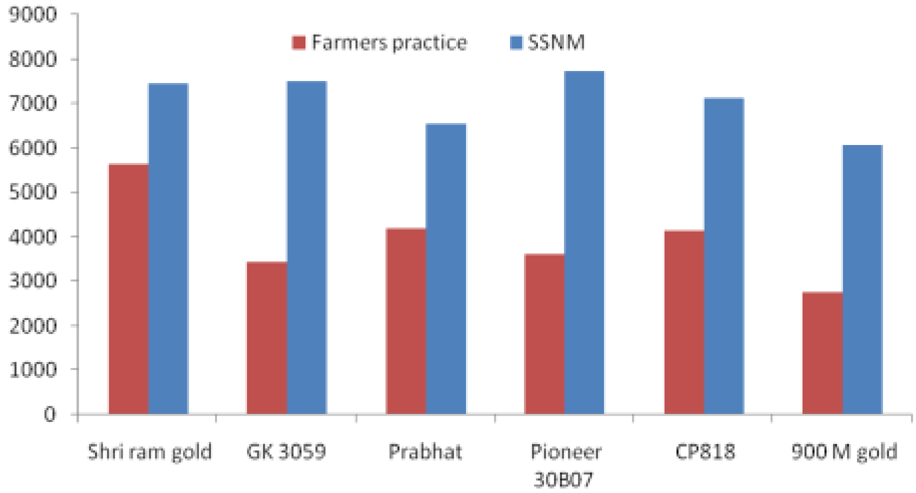

Figure 67. Maize hybrid performance with farmers' practice and SSNM at Bijapur.

In Raichur district, CIMMYT has undertaken DSR demonstration in 25000 acres. As part of crop intensification in rice fallows, DSR–maize/chickpea/mustard under zero tillage was demonstrated in 40 acres. Farmer participatory evaluation of maize cultivars was done in 65 acres and cotton intensification (cotton + maize/sorghum) was done in 65 acres respectively. The improved maize hybrid performance was assessed and the yield was quite impressive with improved management practices (Figure 68).

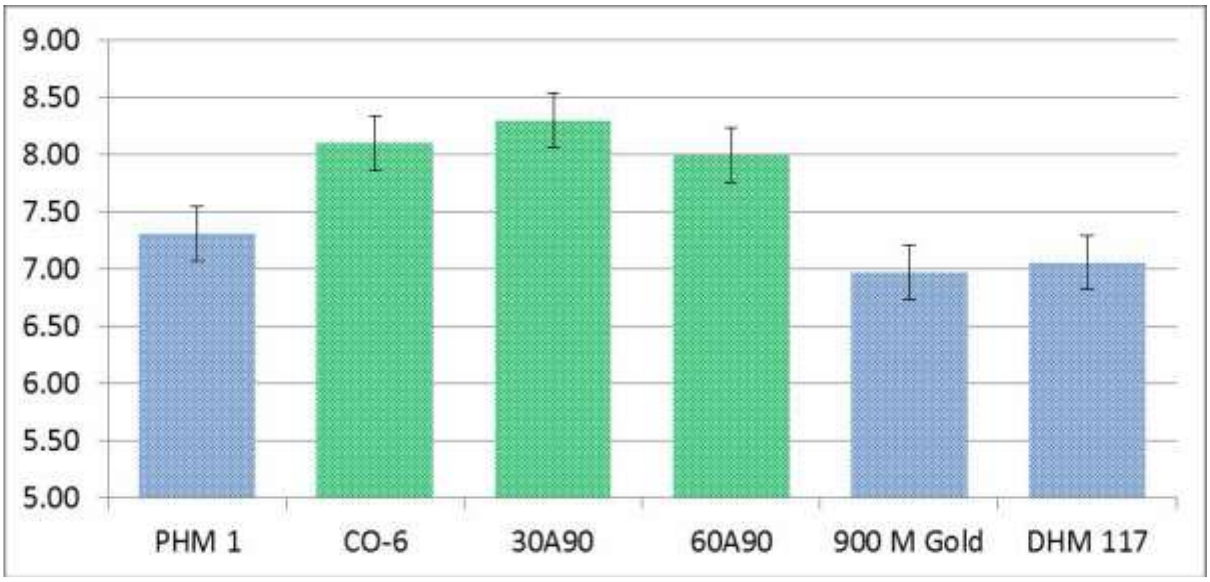

Figure 68. Farmer participatory evaluation of maize cultivars in Raichur district.

IRRI

Rice is a major crop in the Raichur and Chikkamagaluru districts. Hence, the activities of the International Rice Research Institute (IRRI) were mainly confined to these two districts.

IRRI has participated in the Chikmagalur and Tumkur district level workshops and created awareness among the department staff on the best management technological options. Efforts were made to incorporate the available technological options in the proposed demonstrations by the DoA in farmers' fields, which are still in progress. In Tumkur, after discussing with farmers an experiment was planned in five farmers' fields to explore the possibility of cultivating aerobic rice.

Rabi season demonstrations at Chikkamagaluru district: The area under rice in the rabi season was very less in selected districts, due to lack of water availability. Best management practices and water pipe usage for improved water management were demonstrated in farmers' fields of Chikkamagaluru.

Interventions demonstrated in Rabi season in Raichur district: Along with ICRISAT, IRRI has demonstrated a number of interventions in collaboration with DoA in rice based cropping systems. Weed management using herbicides was found to be effective in farmers' fields of chickpea (pendimethalin) and sorghum (atrazine) during this rabi season. Up to 20% increase in those crops was recorded due to adoption of best weed and crop management practices.

Figure 69. Water pipe demonstration in a farmers' field during rabi season, 2014, at Koppa taluk in Chikkamagaluru district.

Figure 70. Excellent chickpea crop in one of the demonstration fields where seed treatment and integrated weed management were the interventions.

Encouraging direct-seeding method of rice establishment by the farmers: The advantages of direct-seeding are being popularized among the farmers during the field visits by IRRI scientists. The area under direct-seeding in Raichur district was around 40,000 acres in kharif 2014. As the rainfall was erratic and less, seed germination in direct-seeded rice was not uniform and the farmers preferred transplanting after the release of assured water from the dam. Several demonstrations were undertaken along with DoA on improved management practices for direct-seeded rice.

Collaborated with ICRISAT to estimate direct-seeded rice area in Raichur district: IRRI was involved in a collaborative effort to estimate the area under direct-seeded rice in Raichur district using remote sensing data. The efforts are in progress.

Demonstrating improved rice varieties in farmers' fields: As a part of efforts to evaluate the performance of released rice varieties in farmers' fields, demonstrations were conducted in farmers' fields in Raichur district and Chikkamagaluru district. In Raichur, rice varieties Prathyumna, Jagityala mashuri, Krishna, JGL 15048 (Figure 71) are being demonstrated under direct-seeded method of rice establishment and the demonstrations are in progress. The rice variety JGL 17004 was harvested in farmers' fields and farmers reported a yield of around 7 t/ha in 100 days duration of the crop.

Figure 71. RNR 15048 variety direct-seeded in farmers' fields.

In Chikkamagaluru district, one demonstration was on DSR and the rest were of transplanted rice. The rice varieties evaluated in farmers' fields include: KHP2, KHP 5, KHP10, Sharavati, IET21478, IET21479. Thunga and Intan. The demonstrations are in progress. The londax power (Bensulfuron + pretilachlor granular formulation) herbicide was recommended for use in the transplanted rice demonstrations and the herbicide performed well in managing weeds.

Figure 72. Direct-seeded rice demonstration fields at Chikkamagaluru district.

In aerobic rice demonstrations in Tumkur district, seed of short duration rice variety Raksha was provided to farmers, as the monsoon rains were less than average. Sowing was delayed due to lack of rainfall and irrigation facility, and consequently farmers were reluctant to follow the management practices suggested. Iron deficiency was observed for which ferrous sulphate (0.5%) at weekly intervals was suggested. The transplanted rice demonstration that used the short duration variety Raksha was good as the farmers adopted all the best management practices suggested. All the demonstrations are in progress.

Providing technological inputs to farmers/department officials during the cropping season: Several farmer field visits were made in Raichur, Chikkamagaluru and Tumkur districts. During field visits to farmers' fields, technological information on available RRI technologies is being passed on to farmers based on their location specific needs. A few of the observations made and suggestions given include: **a)** Leaf folder was observed in some of the fields. IRRI recommended application of acephate or caratap hydro chloride (caldan) (1.5 grams per liter of water); **b)** Sucking insect pests viz. mites, were observed and application of Phasolone or dicofol at recommended rates was suggested to manage them; **c)** Farmers were using three to four times more fertilizers than recommended. The use of leaf color chart and need based fertilizer use was suggested; **d)** Iron deficiency was observed in several fields. Application of 1% ferrous sulphate (1 kg ferrous sulphate in 100 litres of water) twice at weekly intervals was suggested to farmers. The addition of citric acid (0.5 to 1.0 gram per litre of water) to the ferrous sulphate was recommended; **e)** Farmers were observed using pesticides even without minimal safety measures, a factor that is of major concern on which awareness campaign needs to be undertaken. On-farm training was conducted to farm facilitators, AOs, AAOs on safe use of herbicides to enable them to pass on the message to farming community.

Integration of mechanical weeders with other management practices has a key role to play, especially in holdings less than 2 acres. Inclusion of mechanical weeders and power weeders in DoA's subsidy program next year was suggested.

Weedy rice observed and awareness created: Weedy rice was observed in Tumkur and Chikkamagaluru districts. Awareness was created among the field staff and farmers on the need to take preventive measures to curtail the spread of weedy rice.

Training the field staff: At the meetings of action plan formulation at Tumkur and Chikmagalur districts, the DoA staff was trained on best management practices of DSR, integrated nutrient management using leaf color chart and integrated crop and weed management. In addition on-farm, on-village, training was extended to field staff and farmers on various aspects of best management practices and proper use of inputs. The administrators were also kept informed of the technologies based on farmers' needs.

Understanding farmers' DSR management practices: A detailed survey was conducted in collaboration with the Department of Agronomy, UAS-Raichur. The survey data is being processed.

Figure 73. Excellent rice crop of a farmer who followed all the suggested recommendations, in Chikkamagaluru district (Rabi, 2014).