



RESEARCH
PROGRAM ON
Dryland Systems

International Crops Research Institute for the
Semi-Arid Tropics
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Food security and better livelihoods
for rural dryland communities

The CGIAR Research Program on Dryland Systems aims to improve the lives of 1.6 billion people and mitigate land and resource degradation in 3 billion hectares covering the world's dry areas. Dryland Systems engages in integrated agricultural systems research to address key socioeconomic and biophysical constraints that affect food security, equitable and sustainable land and natural resource management, and the livelihoods of poor and marginalized dryland communities. The program unifies eight CGIAR Centres and uses unique partnership platforms to bind together scientific research results with the skills and capacities of national agricultural research systems (NARS), advanced research institutes (ARIs), non-governmental and civil society organizations, the private sector, and other actors to test and develop practical innovative solutions for rural dryland communities.

The program is led by the International Centre for Agricultural Research in the Dry Areas (ICARDA), a member of the CGIAR Consortium. CGIAR is a global agriculture research partnership for a food secure future.

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Table of Contents

Table of Contents	2
SECTION I – Key MESSAGES	6
a. Synthesis of Progress and Challenges	6
b. Significant Research Achievements	7
c. Financial Summary.....	8
SECTION II– IMPACT PATHWAY AND INTERMEDIATE DEVELOPMENT OUTCOMES (IDOS)...	9
a. Progress along the Impact Pathway	9
b. Progress in WAS/Rainfed	9
I. Progress towards outputs.....	9
II. Progress towards the achievement of research outcomes and IDOs.....	12
III. Progress towards Impact	12
IV. Unexpected Outputs, Outcomes and or Impact	13
c. Progress in South Asia/Rainfed.....	13
I. Progress towards outputs.....	13
II. Progress towards the achievement of research outcomes and IDOs.....	15
III. Progress towards Impact	16
IV. Unexpected Outputs, Outcomes and or Impact	16
d. ESA/Rainfed	16
I. Progress towards outputs.....	17
II. Progress towards the achievement of research outcomes and IDOs.....	19
III. Progress towards Impact	19
IV. Unexpected Outputs, Outcomes and or Impact	20
SECTION III – CROSS-CUTTING ISSUES a. Gender Research Achievements	20
b. Partnerships Building Achievements	21
c. Capacity Building Achievements	22
d. Risk Management.....	24
e. Lessons Learned	24
SECTION IV - RESEARCH OUTCOME STORIES	26
OUTCOME STORY 1	26
1. Outcome Story Headline	26
2. Outcome Story Abstract.....	26
3. Problem/Challenge Overview	27
4. What are the main research activities?	27
5. What are the main Outcomes of your research?.....	28
6. What are the main research Outputs that resulted in the outcome(s)?.....	28
7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?	28
8. How were your research outputs used (will be used in the future)?	28

9.	What is the Evidence of Your Research Outcomes?	29
10.	Testimonials.....	29
11.	Lessons Learned	29
12.	Full reference citations and URL link to published research work	29
	OUTCOME STORY 2	30
1.	Outcome Story Headline	30
2.	Outcome Story Abstract.....	30
3.	Problem/Challenge Overview	30
4.	What are the main research activities?	31
5.	What are the main Outcomes of your research?.....	31
6.	What are the main research Outputs that resulted in the outcome(s)?.....	31
7.	Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?	31
8.	How were your research outputs used (will be used in the future)?	31
9.	What is the Evidence of Your Research Outcomes?	32
10.	Testimonials.....	32
11.	Lessons Learned	32
12.	Full reference citations and URL link to published research work	32
	OUTCOME STORY 3	32
1.	Outcome Story Headline	33
2.	Outcome Story Abstract.....	33
3.	Problem/Challenge Overview	33
4.	What are the main research activities?	34
5.	What are the main Outcomes of your research?.....	34
6.	What are the main research Outputs that resulted in the outcome(s)?.....	34
7.	Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?	34
8.	How were your research outputs used (will be used in the future)?	34
9.	What is the evidence of your research outcomes?.....	35
10.	Testimonials.....	35
11.	Lessons Learned	35
12.	Full reference citations and URL link to published research work.	35

OUTCOME STORY 4	36
1. Outcome Story Headline	36
2. Outcome Story Abstract.....	36
3. Problem/Challenge Overview	37
4. What are the main research activities?	37
5. What are the main Outcomes of your research?.....	38
6. What are the main research Outputs that resulted in the outcome(s)?.....	38
7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?	38
8. How were your research outputs used (will be used in the future)?	38
9. What is the Evidence of Your Research Outcomes?	39
10. Testimonials.....	39
11. Lessons Learned	39
12. Full reference citations and URL link to published research work.	39
SECTION V – LIST OF 2015 PUBLICATIONS AND SCIENTIFIC OUTPUTS.....	39
Table 1. Summary of all ISI publications	40
Table 2. Summary of Non-ISI Publications	40
ISI Journal Articles (13).....	40
Non-ISI Journal Articles and Theses (6).....	42
Book Chapters (4).....	42
Technical Reports and Working Papers (6).....	43
Proceedings (13)	43
Data sets (8)	45
Other publications (18)	45
Annex 1: CRP indicators of progress, with glossary and targets.....	47
Annex 2: Performance indicators for gender mainstreaming with targets defined	53
Annex 3: List of ICRISAT Research Staff contributing to Dryland Systems	53

List of Acronyms

AFRI	Arid Forest Research Institute
AP	Andhra Pradesh
AFEC	Accion Fraterna Ecology Center Anantapur
ANGRAU	Acharya NG Ranga Agricultural University, Andhra Pradesh
AMMED	Association Malienne d'Éveil au Développement Durable
B	Boron
Cu	Copper
CRP	CGIAR Research Program
CPRs	Common Property Resources
CCAFS	Climate Change, Agriculture and Food Security
CIP	International Potato Centre
CORUS	Community Organizing for Rural Upliftment Society
CHC	Custom Hiring Center
CAZRI	Central Arid Zone Research Institute
CIAH	Central Institute for Arid Horticulture
DS	Dryland Systems
E&RAS	Extension and rural advisory services
FYM	Farm yard manure
GRAVIS	Gramin Vigyan Vikas Samiti
IDOs	Intermediate Development Outcomes
INM	Integrated nutrient Management
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ISFM	Integrated Soil Fertility Management
IWMI	International Water Management Institute
IRR	Internal rate of return
KVK	Krishi Vigyan Kendra (Farm science center)
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NGOs	Non-Government Organizations
N	Nitrogen
NARS	National Agricultural Research System
NRM	Natural Resource Management
NSC	National Seed Corporation
P	Phosphorus
RSDS	Rural Studies and Developmental Society
RAU	Rajasthan Agricultural University
S	Sulphur
SAT	Semi-Arid Tropics
SBMMAS	Shri Banashankari Mahila Mattu Makkala Abhivruddhi Samsthe
SHG	Self-Help Group
UASD	University of Agricultural Sciences Dharwad
VDC	Village development committee
Zn	Zinc

SECTION I – Key MESSAGES

a. Synthesis of Progress and Challenges

- The impacts of systems research undertaken in these complex dryland environments require the development of long term partnerships with the local stakeholders and constructive dialogue with the policy makers. A one-year funding cycle, constant reductions in funding from 2014 and the sudden cessation of funding at the end of 2015 has made such a systems program difficult to implement. Despite this, a dedicated team of scientists and partners has delivered some remarkable outcomes:
- In WAS, operating across the transects Katsina Kano-Maradi (KKM) and Wa-Bobo-Sokasso (WBS) there were many integrated activities to upscale promising technologies: Demonstration of 2 new varieties (Caufa and Fadda) in two countries (Burkina and Mali) of multipurpose crops (grain and fodder); promotion of contour bunding technology in Mali in technology parks near Koutiala and Bougouni; scaling of ISFM technologies, coupled with participative selection of varieties by farmers in Niger, leading to high improvement of crop yields. Combining hill placement of manure, mineral fertilizer microdose and seed treatment doubled grain yield and was the preferred technology by > 88% of farmers of both gender; demonstration of the use of locally available wood ash from the daily kitchen activities increased pod and haulm yields of groundnut; A field study initiated in 2015 to investigate an intercropping system with millet, cowpea and trees (Ziziphus) combined with micro dosing of small dose of fertilizer through the Zaï technology (6 g NPK fertilizer/zaï pit) on millet has produced highly novel results and journal papers; an 18 year old long-term fertility experiment is conducted as a reference tool for researches on sustainable management of soil fertility and modelling.
- In Niger, ISFM technologies were demonstrated, coupled with participative selection of varieties by farmers in 3 zones of Niger, ISFM technologies were demonstrated with improved varieties of millet (ICMV IS 99001), sorghum (Mota Maradi and SSD-35) and groundnut (55-437 and RRB) compared to local varieties. Two hundred and forty-eight (248) demonstration tests kits were prepared (seed and fertilizers) in addition to 24 Farmer Field school kits. A total of 124 demonstration tests in integrated soil fertility management and 124 participatory variety selections was implemented during the past rainy season.
- In South Asia, across 3 action sites [Western Rajasthan (Barmer, Jodhpur, and Jaisalmer Districts), Andhra Pradesh (Anantapur, Kurnool Districts) and in Karnataka (Bijapur District) in India] an integrated systems approach that targeted climate resilience, strengthened value chains and enhanced local capacity through innovation platforms and self-organization was implemented. Building on outcomes of 2014, >700 on-farm trials demonstrated suitable cultivars of cereals and legumes for cropping systems intensification and diversification, soil & water conservation, dual purpose crops, agro-horti-forestry systems and high value commodities (fruits, vegetables, medicinal plants) resulting in increased crop productivity by 18% to 150% over existing practices. In the driest of areas (<150 mm rainfall) Khadin water conservation systems, common silvi-pasture systems, agro-horti kitchen gardens, value chains of medicinal crops and small ruminant created enthusiasm and market led opportunities among the local stakeholders.
- As part of CRP Dryland Systems we have successfully demonstrated participatory approaches for rehabilitation of severely degraded pastures in 5 locations achieving increased productivity, equity, resource conservation and value for investment in CPRs. The management of common property resources (CPRs) and their synergistic linkages with farm systems was demonstrated and created awareness amongst key stakeholders on their sustainable management. An integrated ecosystems approach for the rehabilitation of severely degraded community based silvi-pasture systems resulted in many fold increase in biomass yield (0.25-0.40 t/ha to 1.6 – 4.6 t/ha in 2 years). The proportion of edible species also increased from a baseline of 15 - 24% desirable spp. to > 55%. The ex-ante analysis for 10 years' time horizon indicates payback period of about three years and over 30% IRR. Critical to sustainability of such systems are the institutions managing common pool resources (CPR).

- The women farmers in 15 villages adopted farming methods which show, there is hope to combat climate change impact in the drylands and move out of poverty. By facilitating leadership among rural women, innovations such as improved cereal varieties, fruit trees to provide nutrition and income, constructing embankments to improve the water table and prevent runoff and soil erosion, planting grasses and fodder trees to provide fodder for cattle were experimented with. The partnership with major stakeholders was the key to the success of the program and featured in Al Jazeera and the Third Pole (see “other” publications section).
- In collaboration with CCAFS climate smart villages, we communicated seasonal rainfall forecast and model-based crop management scenarios to smallholder farmers (4 villages in Anantapuram and 3 villages in Bijapur district) in order to assist in informed crop planning for 2015. The CRP DS activities were able to provide alternative options for intercropping and short duration cultivars of cereals and legumes to help farmers cope with the difficult el Nino conditions of 2015
- Institutions for structuring and strengthening local initiatives, stakeholder convergence and inclusive value chains are important features of our work. In this regard three Innovation platforms-IP (Rajasthan, Karnataka, Andhra Pradesh); 12 village development committees (VDCs) and 3 women livestock keepers sub-committees for management of CPRs were actively functional in India (4 workshops of IP and 12 meetings of VDCs). More than 250 farmers in Rajasthan participating in IP on medicinal plant value chain could enhance household annual income by INR 5000 to 50000. The importance and potential of multiple stakeholder engagement in addressing key developmental challenges was well demonstrated by the three IPs operated in ESA as well. Through participation in IPs, more than 1,500 farmers in Manica, Central Mozambique achieved greater income by making better decisions regarding production, storage, marketing and selling of their common bean produce in local and distant markets. About 300 farmers in East Shewa, Ethiopia were able to get greater income by intensifying their systems with legume intercropping, improved management of small ruminants (mainly goats), water harvesting and better management of common lands.
- Workshop on systems analysis for smallholder farmers Niger 21-25 Sept 2015: Twenty participants (2 female) from 5 National Agricultural Research Institutions of countries (Burkina, Ghana, Mali, Niger, Nigeria) and staff from ICRISAT, ICARDA, ICRAF and CIRAD learned to use tools for systems analysis: (i) an advanced course on crop modelling with the Agricultural Production Systems simulator (APSIM); and (ii) an advanced course on bio-economic modelling Integrated Assessment tool (IAT) which combines outputs from a range of models and expert knowledge to gain enhanced understanding of bio-economic behaviour of mixed smallholder systems.

b. Significant Research Achievements

In 2015, 13 ISI and 6 non-ISI journal papers were published by authors from the CRP that represent the culmination of work over the last 3 years and attributed to work funded by W1/W2 and W3/bilateral funds aligned with CRP DS. Much other evidence of scientific achievement are demonstrated in the listed book chapters, conference proceedings, open access databases. The highlights of this work are as follows:

- i. Well-designed household surveys (In India >1000 households in the 3 actions sites of India; a seventeen-year panel dataset of farms in Koutiala, Mali) provided socio-economic and agro-ecological basis to categorize households into farm typologies (Falconnier et al. 2015; Kumar et al. 2015). Livelihood assets, access to institutional support, amongst other factors determined farm ‘trajectory,’ land use patterns, agricultural management practices. Systems analysis and participatory approach led to on-farm assessment and integration of farm typology specific most appropriate interventions in the action villages. Further the estimation of composite sustainability indices (CSI) of each farm type guides investment decisions (Haileslassie et al. 2015). Such studies identify the livelihood factors influencing household resilience. A resilience capacity index was generated which includes variables on household expenditure on food and non-food, savings, food and feed reserves from a comprehensive socio economic panel data set. We then identified livelihood strategies through multi-factor analysis. The livelihood strategies reflect the heterogeneity in household characteristics. The newly

- developed resilience capacity index and derived livelihood strategies are a simple but promising way to understand the complexity of household level resilience (Ramilan et al., 2015).
- ii. Climate information services coupled with crop management options scenarios was useful in delivery of location specific information to help farmers make informed decisions on crop planning. For example, during the 2015-16 cropping season, the strong El Nino event forecasts of rainfall deficit enabled farmers to use low input investment cropping systems with hardy crops like short season legume (mung bean) intercropped with pigeon pea. These systems which have been proved to be much resilient with supplemental irrigation provided from stored water from farm ponds, resulted in good economic returns to the farmers (NageswaraRao et al. 2015) In related work from low rainfall regions in Australia, McBeath et al. (2015) and Whitbread et al. (2015) show the importance of low risk management strategies (fallow management, rotations, timing of break crops) in determining WUE and profitability- such strategies are being tested for their application to SA and SSA farming systems.
 - iii. Multi-stakeholders innovation platforms (IP) are a unique approach bringing together stakeholders from across a wide range of sectors along the value chain, with complementing objectives and interests. The stakeholders include a mix from farming communities, NARS, policy-makers, NGO's and the private sector (Issa et al; Kumar et al. Rana et al; Sapna et al. 2015).
 - vi. In the Sahel, finding technologies addressing low fertility and crop nutrition in cereals that have been adopted widely is rare. Fertiliser micro-dosing is one such example of a farmer acceptable practice that has been moderately successful. Ibrahim et al. (2015b; c) utilises on station trials to test the best combination of the technology with other practices and devise the mechanisms that support improved crop growth. Ibrahim et al. (2015a) suggests how leaf litter from local shrubs might be used in combination with micro-dosing to increase crop response. In similar work at scale in central India, Wani et al. (2015) reported that soil based nutrition recommendations twinned with soil management led to significant productivity enhancements which could be scaled up.
 - vii. In traditional crop-livestock systems of Zimbabwe, co-designing (with stakeholder) farming systems towards integrated market oriented mixed farming systems was a successful method for finding options in highly vulnerable systems (Homann-Kee Tui et al. 2015). The work showed that in such constrained systems, technology interventions such as improved forages or conservation agriculture improved the systems and the incomes of farmers to some extent, but without outside interventions in the forms of subsidies, farmers would remain in poverty. The maize-mucuna rotation was found to reduce trade-offs between CR uses for feed and mulch, providing locally available organic soil enhancement, supplementary feed and a potential source of income. Valbuena et al. (2015) demonstrated such trade-offs for the use of crop residues depends on the context, but efficiencies in the use of common lands, off farm income sources and technologies should all be considered.
 - viii. The comprehensive understanding of the social-ecological systems around common property resources in dry areas of India focused on both the biophysical conditions and the socio-economic attributes of the community, the rules determining use of common resources, and the patterns of interactions among various actors which seemed to produce different outcomes in different scenarios. The integrated ecosystems approach for rehabilitation of severely degraded community based silvi-pasture systems resulted in many fold increase in biomass yield and increased cooperation among the community, Kumar et al., (2015).

c. Financial Summary

ICRISAT's 2015 CRP Dryland Systems Final Financial Report is available on [CGXchange](#).

SECTION II– IMPACT PATHWAY AND INTERMEDIATE DEVELOPMENT OUTCOMES (IDOS)

a. Progress along the Impact Pathway

The research for development efforts at DS sites in India used multi-disciplinary and systems approaches that build on the indigenous coping and adaptation strategies to achieve enhanced resilient and sustainable intensification in dryland farming systems. The program worked to enhance biomass productivity and systems resilience through appropriate integration of crops, tree and livestock using improved technologies, climate information and natural resource management and markets. Of particular focus was to better understand temporal and spatial dynamics and therefore risk. Strengthening formal and informal institutions and social capital especially women and youth and stakeholders convergence for equitable and sustainable use of natural resources and improve delivery system & value chains for future trajectory development.

b. Progress in WAS/Rainfed

1. Progress towards outputs

Multipurpose crops (production of both grain for human nutrition and fodder for animal feeding and domestic usage) are of high interest for farmers in WAS/rainfed systems. ICRISAT is working to demonstrate new improved varieties of dual-purpose sorghum. Thirty-eight (38) field tests of dual-purpose sorghum varieties were implemented in Burkina Faso (29) and Mali (8). The main objective was to assess the grain and stover yields of promising dual purpose sorghum in farmers' conditions. The first data show high variation with locations, indicating that the most adapted variety will depend of the biophysical and climatic conditions. But the variety Caufa seems to be best one on many sites.

Ten (10) farmers in Burkina Faso (selected with partners) tested the promising dual-purpose sorghum we selected from the varietal test. The main objective was both to make an extensive evaluation of the material in farmers' conditions and allow farmers to produce enough biomass for their animals. The stover production is kept by the farmers to be part to participate feeding trial during the dry season early 2016 (as done in 2015 in Cercle de Koutiala), and a small part of it was collected to assess grain and stover yield and quality. The quantity and quality of stover of the dual-purpose sorghum varieties were evaluated. Samples are collected for Near Infrared Spectrum analysis to define the main characteristics of the stover. Even most of the samples are still under analysis, the first data showed a correlation among plant traits (such as grain yield or stover yield -Tbio) with quality trait (such as lignin content ADL or fiber content ADF). This should help us to identify relevant plant traits for breeder to focus on their selection.

The effect of different management practices on the promising dual-purpose crop was evaluated through an agronomic field experiments implemented. The effect of of organo-mineral fertilizers, plant density on stover and grain yield and associations with legume crops (cowpea, groundnut and soybean) were evaluated. The primary results suggested to recommend farmers to use variety 2 (Fadda also tested on farm) with 2 t/ha of compost and his/her normal plant density (0.4*0.8m, as plant density as not significant effect). First data indicated that the Fada variety responds better in association with soybean while the other more with cowpea. This indicates that better management options of dual-purpose sorghum varieties in association with legume crops (cowpea, groundnut and soybean) could be identified to increase food and fodder production at farmer's levels.

In line with the work on improving fodder production for animal with dual-purpose sorghum, a feeding trial was carried out to compare intake and body weight change for a sheep fed with

chopped stover and a sheep fed as residues (unchopped) from the field. A total of 17 trials (with 2 animals per trial) were conducted in 6 villages. The trials were carried out during the dry season from March to May. Each farmer had at least 2 animals – one for farmer's practice and one for chopped crop-treatment. The animals under the farmer's practice had weight gain varying from -1 kg to + 8kg while the ones with the chopped residues varied from -4kg to +4kg, with an average intake of the chopped of chopped stems of about 25% of the given stover. The final data of this work are expected for May-June 2016.

The scaling process of the contour bunding technology was undertaken in Mali (site of Kani village). Farmers' field selection, meetings and installation of agronomic and hydrologic equipment constituted the progress towards outputs. To facilitate community mobilization ICRISAT signed agreement with the local NGO, AMEDD who facilitated meetings and distributed agronomic inputs i.e seeds, fertilizers and etc. AMEDD assigned two technicians to monitor the day-to-day activities and data collection along with farmers. ICRISAT also signed agreement with the national research institute, IER. The main role of IER was to supervise implemented activities delivery of high quality data. Sediment quality data and grain and biomass data were tested in the laboratory of IER. Volunteered farmers agreed to offer a 10x10 m of plot for research experimentation. The in-field soil and water conservation technology experimented was contour bunding. Four crops were grown in the experimental field; maize, cotton, millet and sorghum. Main activities conducted in Kani Dryland site in the year 2015 include: i) Facilitated meetings with local farmers; ii) Farmers' field selection, land preparation and geo-referencing; iii) Soil data analysis and; iv) Establishing monitoring station; Rain gauges, weather stations, runoff gauges, soil moisture monitoring devices, and piezometers to monitor shallow wells recharge.

A field study is initiated in 2015 to investigate different management options of cropping systems with cereal (millet), N₂-fixing legume crops (cowpea) and trees (*Ziziphus m.*) intercropping combined with micro dosing of small dose of fertilizer through the Zaï technology (6 g NPK fertilizer/zaï pit) on millet. The main objective is to develop an integrated and affordable management options of cropping systems to improve soil fertility, crop production and production while providing more biomass and good quality fodder for animal feeding. The first data indicate that intercropping of millet with cowpea associated with *Ziziphus* tree at 50 plants of tree per hectare could be the most performing cropping system.

An 18 years old long-term fertility experiment is conducted as a reference tool for researches on sustainable management of soil fertility and modelling. The experiment is a factorial of 4 cropping systems (millet and cowpea alone, millet/cowpea associated or in rotation) and 4 fertilization treatments. Cropping systems were used as first factor in the main plots. This long-term experiment provides the needed data for modelling work and follow up of soil fertility under different management options of fertilizer and cropping systems.

To improve the adaption of new technologies, Integrated Soil Fertility Management (ISFM) technologies were demonstrated, coupled with participative selection of varieties by farmers in 2 zones of Niger (Maradi and Zinder). ISFM technologies were demonstrated with improved varieties of millet (ICMV IS 99001), sorghum (Mota Maradi and SSD-35) and groundnut (55-437 and RRB) compared to local varieties. Two hundred and forty-eight (248) demonstration tests kits were prepared (seed and fertilizers) in addition to 24 Farmer Field school kits. Protocols and data collection books were also provided detailed explanation of which was done during the training course conducted. The demonstrations and farmer field schools cover 25 ha. A total of 124 demonstration tests in integrated soil fertility management and 124 participatory variety selections was implemented during the past rainy season. These demonstrations were implemented with the direct implication of 248 farmers across the program sites. In the course of the season, those demonstrations were visited by 18,331 farmers of whom 51.45% of women famers. Twenty farmer

students were involved in each farmer field school indicating a total of 480 resource person trained in the communities of the program sites.

Millet grain yields as high as 1,722 kg/ha were obtained with the seed treatment, Apron Star, showing the potential of yield increase existing in the Zone of Matameye if appropriate management is put in place. For this comparison we have equated the zones to the clusters. This was done to facilitate comparison due to lack of data related to the cause mentioned above. In the same zone, combining hill placement of manure, mineral fertilizer micro dose and seed treatment double the grain yield of 500 kg/ha reported as country level average. This combination appeared as the most preferred by both gender of farmers with 88% and 98% respectively in the zone of Kantche. The improved variety of millet performed better than the local varieties. Considering potential access of farmer to improved varieties and the open pollinated nature of millet, the probability of the farmers' variety acquiring improved trait is high, which may have resulted in the trend observed. In addition the data reported are averaged over all soil fertility management treatments. All soil fertility improvement options on sorghum have resulted in grain yield increase compared to the control in all localities of intervention as per the data collected so far. The most important grain yield increase in comparison with the control was obtained with the combination of Apron Star and application of farmyard manure with 900 kg/ha grain yield. It appeared from the data that seed treatment with Apron Star was highly appreciated.

On groundnut, low plant available soil P limits crop root growth a key factor influencing crop nutrient and water uptake. In addition for groundnut, Ca is key factor in pod formation and filling. Seed treatment is important to protect seedlings against soil borne diseases. Combining appropriate soil nutrient source, pod filling treatment and seed treatment result in good production. The objective of the groundnut demonstration test is to raise the awareness of farmer about existing options to improve groundnut production including the use of locally available material such as wood ash they can gather in the daily kitchen activities. In the three zones, substantial pod yield increase was obtained with application of wood ash alone compared to the control but also compared to other combinations indicating the potential of this option in increasing pod yield. We collected samples of the different nutrient sources used in these demonstrations, which will be analysed to determine their chemical status. However, wood ash as source of mineral significantly contributed to pod as well as haulm production. From their observation the farmers' preference is oriented toward application of mineral fertilizer, which is not confirmed with the yield produced. We hope to make them change their mind during the feedback session we planned to organize in the coming months. The varieties tested are similar in terms of pod production in all the three zones. However, the improved variety was more preferred than the farmer's variety (Table 11). Gender differences were not observed.

To understand the social, economic and environmental dynamics coupled with analysis of crop and livestock biodiversity including gender preferences, practices and producers' knowledge along with an analysis of the performance of the favourite main crops at farm level and evidence from the laboratory on Iron content of grains and fodder quality traits using multidisciplinary methodology a study was conducted in purposively selected Milli and Gourjia villages in Niger, in KKM transect. The methodology utilized 23 tools of qualitative and quantitative methods for socio-economic gender analysis. Agronomic data was collected for non-destructive and destructive observations like grain and fodder yield. Further a total of 72 pearl millet and 72 cowpea crop samples were analysed for fodder quality at ILRI Laboratory by Near Infrared Spectroscopy for nitrogen, neutral (NDF) and acid (ADF) detergent fiber, acid detergent lignin (ADL), in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) content. A total of 32 grain samples of pearl millet and cowpea were prepared for X-Ray Fluorescence analyzer (XRF) for non-destructive method for analysing mineral nutrient in grains in ICRISAT Niger Lab. Data was analysed using ANOVA. Rank based quotient on constraints by women in Milli were: low yield (63.89), insufficient rainfall (61.11) and crop diseases (50) while men reported: low rainfall (81), no access to fertiliser (57.14) and crop diseases (37). Gourjia women farmers main issues were lack of feeding

resources for animals (80.95), while men farmers reported low rainfall (63.5). Four square analysis showed in Gourjia that women and men farmers planted cowpea varieties- IT 90 and El Dakar. *El Masara* groundnut variety was preferred by men and women in two villages, while in case of cowpea men in Gourjia preferred *Mai Hutila* while Jan wake by women for taste. The cattle breeds preferred by men and women of two villages were *Ba haouche*, *Bar haje*. Women had lesser role in decisions making, ownership and marketing of cowpea and groundnut crop than men farmers. Farmer trials revealed that in cowpea varieties – *Mai Hutila* and *IT90* significant location effects ($p < 0.05$) were observed in fodder quality traits such as ndf (0.00), afdm (0.00), adl (< 0.001), and ME (0.01). While in case of pearl millet varieties- *Dan Eka* & *HKP* for fodder quality traits- significant ($p < 0.05$) effects of location (0.01), varieties (0.0006), location* varieties (< 0.0001) were reported. The XRF results indicated that local varieties of millet (Dan Eka) and cowpea (Mai Hutila) had more availability of Fe in the grains than improved varieties. A total of 29 crop germplasm was collected from the selected sites for ex-situ conservation.

II. Progress towards the achievement of research outcomes and IDOs

Through the demonstrations with farmers and partners, the multipurpose sorghum varieties are more known by farmers as source of food both for human and animal feeding. The scaling process is engaged in Mali and Burkina with two varieties (Fadda and Caufa), which seems to be the most appreciated. The development of appropriate management practices for the promising dual-purpose variety will help improving its adoption and better use of these technologies by farmers.

The scaling process of the contour bunding technology involving the local community (NGO and AMEDD) and the NARI through the agreement with ICRISAT will facilitate the scaling up/out this in-field soil and water conservation technology. Farmers were trained on the best possible use of available technologies that ranged from agronomic inputs (hybrids, and fertilizers) to soil and water management conservations practices. It is expected that 70% of farmers who received training on the best use of technologies in the year 2015 continue the implementation in 2016 and beyond. In addition other farmers who witnessed better agricultural productivity and land and water management technologies in the farm fields of volunteered farmers in the year 2015 would implement the technologies in their farm fields. The involvement of the local NGO, AMEDD, and the national research institute, IER, in the research program help to disseminate research outputs widely to the benefit of local farmers and national policy programs.

The identification of improve management options of cropping systems with cereal (millet), N_2 -fixing legume crops (cowpea) and trees (*Ziziphus m.*) intercropping combined with micro dosing of small dose of fertilizer through the Zaï technology (6 g NPK fertilizer/zaï pit) on millet will provide options to improve and diversify the livelihoods of small poor farmers. Including trees in the cropping is an opportunity for production of fruits and wood as source of energy.

The scaling of Integrated Soil Fertility Management (ISFM) technologies with improved varieties of millet (ICMV IS 99001), sorghum (Mota Maradi and SSD-35) and groundnut (55-437 and RRB) compared to local varieties through 248 will contribute to improve the adoption of these technologies but also the approach of integrated management of cropping systems by farmers. The field demonstration of the performances of ISFM technologies with improved varieties will certainly stimulate the dissemination of these technologies

The work on long-term fertility experiment and modelling work are tools for research on sustainable management of soil fertility and cropping systems. They provide the needed reference to develop, test and validate management options to improve agricultural production under different conditions.

III. Progress towards Impact

Farmers benefit from better agricultural productivity that would improve their livelihood. Diversification of agricultural practices and implementation of off-season farming practices are expected in the near future. By offering alternatives for diversification of livelihoods for food security, there are opportunities to stimulate the adoption of the improved and integrated cropping systems combining cereal, dual-purpose crops, legume crops (cowpea, groundnut, soybean) and trees. Farmers are encouraged to see crop establishments in treated farm fields performed better than the untreated ones. In addition more organic matter and applied fertilizer retained in treated fields according to farmers' perspective.

IV. Unexpected Outputs, Outcomes and or Impact

At the dryland site of Kani there was some initial reluctance by the farmers to make land available for experimentation. This remains a sensitive topic in many families because even if the land belongs to the family head, he does not decide alone on the use of the land. All men of the family must agree and decide together whether it is appropriate or not to participate in the research project. So often we have the agreement of farmers who fail to convince their head of household or other family members.

c. Progress in South Asia/Rainfed

I. Progress towards outputs

Based on the systems characterization, ex-ante assessment and participatory prioritization in the context of resources, preferences and market, a number of activities related to options for resilience building and intensification were assessed. Based on above analysis >700 on farm trials on high yielding and climate ready cultivars of millet, sorghum, chickpea, cluster bean, moong bean, moth bean, maize, pigeon pea (sole as well as intercrop), balanced nutrition and soil & water conservation and rainwater harvesting together with introduction of high value crops fruits, vegetables (agri-horticulture system) and herbal medicines were demonstrated on about 200 ha in dryland systems action villages by ICRISAT. The cropping systems were diversified by appropriately integrating legumes like moong bean, cluster bean, chick pea, pigeon pea, ground nut and foxtail millet, fruits, vegetables and medicinal plants in three sites. The analysis showed a significantly higher yield compared to farmer practices. Productivity enhanced on participating farmers' fields by 18% to >150% for different crops. The increment was much greater in Rajasthan and AP. Soil test-based application of deficient secondary and micronutrients under the Bhoochetana initiative was scaled-up to across 13 districts of Andhra Pradesh and 30 districts of Karnataka.

Climate information services coupled with crop management options scenarios in advance of the season helped farmers to take appropriate cropping decisions even in a strong El Nino event and harsh rainfall situation during 2015-16 crop seasons. Farmers opted to low input investment cropping systems with hardy crops like short season legume (mung bean) intercropped with pigeon pea. These systems which have been proved to be much resilient with supplemental irrigation provided from stored water from farm ponds, resulted in good economic returns to the farmers.

Gender role, in agriculture and animal husbandry in target villages, and vulnerability of women and men engaged in agriculture and allied enterprises assessed in Rajasthan. Negative and high correlation coefficients (r value ranging from -0.64 to -0.96) for sets of male and female genders indicated that gender roles were clearly segregated in case of crop and animal husbandry activities. Data indicated that women were engaged in unpaid and unaccounted labour work involving drudgery. Vulnerability scale consisting of 20 statements revealed that women were highly vulnerable to livelihood insecurity in all target villages. Gender mainstreaming was the integral part of the systems approach to empower women in agriculture. Formation of women's

self-help groups (SHG), encouraging them to participate in decision making and lead the activities like small ruminant production and marketing, agri-horti kitchen gardening, seed production and managing common pastures helped women farmers take leadership role and enhanced food and nutrition security for their families. More than 150 farm women in [Rajasthan](#) and [Andhra Pradesh](#) led the diversification through kitchen gardens, fodder development through CPRs, improving small ruminant productivity and selling them on weigh basis. Regular interactions with SHG members facilitated a platform for women to mobilize themselves and discuss issues that concern them. Gender responsive integrated approach has informed the initiatives and the impact of such interventions also has begun to manifest in increased [participation of women](#). The strategic research on identifying leverage point for mainstreaming gender and gender sensitive extension services generates useful information for policy and development actors.

Sodicity /salinity build-up is noticed due to irrigation/ over irrigation by groundwater in Rajasthan. This calls for immediate actions towards non-consumptive use of ground water irrigation. Soil Moisture dynamics in Khadins in Jaisalmer revealed that the rate of moisture loss was higher in upper ridge profiles and therefore, low water requiring crops can be grown in upper region, high water requiring crops (Wheat and Mustard) can be grown in middle and lower region. Leguminous crops are not recommended because sodicity was noticed in middle and lower parts of Khadin. For sensitizing farmers/ stakeholders about the soil health of their agricultural fields and ground water quality of their tube wells, 321 soil health cards and 59 water quality report cards were distributed with appropriate recommendations, respectively. Over 15 mm rainfall events resulted in runoff. In constructed Khadins of Barmer, siltation ranged from 10.8 to 509.3 t and in Khadins of Jaisalmer it ranged from 8.9 to 627.52 t. To enhance the crop production timely de-siltation of Khadins should be given priority.

In the silvi-pasture agroforestry demonstrations established on 10ha commons, diversity patterns of tree vegetation exhibited adequate degree of stability. Maximum total available woody biomass was contributed by tree vegetation followed by shrubs. As far as edible biomass is concerned, maximum was contributed by crops. Total fodder base which included tree leaf fodder, grasses and crop straw was maximum in Mansagar followed by Govindpura. The minimum fodder base was worked out for Dhirasar. On an average across all the target villages 85% fodder was contributed by crop straw (Rabi + Kharif crop) followed by grasses (12%) and tree leaves (2.4%). The fodder demand and supply scenarios could be worked out using these data sets.

Agro-horticulture system and creating/strengthening value chain of medicinal plants were implemented in targeted households based on typology; 10 unit of 50 to 100 plants of most suitable arid fruit + legumes intercrop together with rainwater harvesting structure (Tanka/farm pond) of 25000 to 50000 liter capacity assessed through participatory approach has encourages many farmers to adopt such integrated approaches. This model was assessed successfully in the 2nd year. Started with pitcher-irrigation technique of watering for establishing of horticulture plants (lemon, pomegranate, *Ziziphus mauritiana*, *Cordia myxa*) was moved to drip systems irrigation using gravity. Another 80 units of agro-horti kitchen gardening with 10-20 multiple fruit plants for poor women farmers were implemented in Rajasthan. Participatory trials for diversification to vegetables as kitchen gardens with about 100 women farmers were conducted in Andhra Pradesh. An economically important and naturally occurring medicinal plant Sankhpushpi (*Convolvulus pluricaulis*) was successfully introduced last year adopted by 250 farmers in Barmer facilitated by ICRISAT and KVK-Barmer. To develop the value chain an MOU was signed with a major private herbal company- Dabur India Ltd to buy back from the farmers. The introduction of Sankhpushpi could generate additional about US\$ 500 per ha, thus farmers are quite motivated. The [process of organizing](#) these farmers into shankhpushpi growers association has been initiated.

Custom hire service center: In dryland villages most of the farmers are economically poor and they don't have farm implements/equipment which can reduce their drudgery and some time

they are even not aware of many implements also. Purchasing implements is difficult to individual farmer. In such cases a group of farmers can have all necessary implements and can be given to farmers on rent basis. We have established two such farm machinery custom hiring centers (CHCs) in Manur and Balaganur villages of Bijapur district and CHCs in Anantapur district. The farmers were trained to maintain and manage the CHC as community institution. CHCs have enhanced the labour productivity and adoption of NRM as well as regards scaling-out balanced nutrition in Andhra Pradesh (through Rythu Kosam initiative), farmer capacities were developed in soil test-based balanced fertilization through implementing balanced fertilization in about 0.4 million ha land across the AP state.

II. Progress towards the achievement of research outcomes and IDOs

- The outcomes of the interventions at DS sites were in terms of awareness creation and capacity building of the participating farmers and stakeholders integrating systems approaches across the value chains to enhance farming systems resilience and productivity and improve livelihoods. Integrated soil-water-crop management has enhanced soil and water resource use efficiency as well as higher yields. The technology of rainwater conservation through covered structure (tanka) in Rajasthan and low-cost farm ponds in AP and Karnataka was piloted which demonstrated increased resilience of smallholders to effectively cope with drought spells through life-saving watering. Access to water also facilitated strengthening alternate income sources through diversifying to dryland horticulture, vegetable cultivation and fodder promotion. Rehabilitation of community based silvi-pasture systems for fodder promotion on common lands has strengthened not only the livestock related livelihoods and income sources but also improved the ecosystems functions.
- Enhanced productivity through integrated soil-crop-water management interventions has enabled men and women farmers to spare more for the market. Piloting kitchen garden scale vegetable-fruits cultivation has enabled women-farmers to sell some produce in the market while enhancing family nutrition.
- The investments in piloted interventions are very low with high returns which have increased farmers' incomes. Strengthening natural resources along with introduction of science-led interventions has increased employment opportunities through intensification, contingent crop plans, diversification, boosting livestock activities.
- With enhanced productivity and diversification, farmers have access to more and diverse food. Need based soil nutrition have resulted in avoiding indiscriminate use of macronutrient fertilizers while applying deficient micronutrient fertilizers; consequently, food safety is also improved.
- Piloting community based on-farm mechanization has resulted in reduction of drudgery and economic on-farm operations with increased crop yields. Small farmers and stakeholders got awareness and capacity building in a model of sharing resources for on-farm mechanization through custom hiring centers. Farmers' capacity is strengthened in mechanized operations for sowing and, water conservation and utilization which reduce cost and increases resource use efficiency and climate adaptation.
- Water conservation in farm-scale ponds and tanka is demonstrated as an effective technology to mitigate and adapt to long dry spells experienced in three regions. This addresses the issue of extensive groundwater exploitation which is declining and also gives an access and control to farmer on water resource to effectively use for his/her livelihood improvement. A good learning of the initiative is that a micro-watershed catchment scale low-cost rainwater harvesting structures can effectively store 50 to 200 m³ water which can be used for life-saving watering of crops during drought spells which are frequently observed in these regions. Low cost makes it a scalable technology and enable to kick-start growth engine of agriculture in large number of farmers' fields. A great learning is that small investment in conserving water facilitates farmers to bring non-cultivable area under horticulture plantations leading to enhanced income and nutrition security.
- The soil-water-crop interventions are not only targeted on intensification, but also inclusion of women and opportunities for youth. Diversification through women based agri-horti kitchen gardens and small ruminant value chains in the action sites has empowered women through their increased income and bring in more diversity of food for family. Promoting quality and quantity

fodder resources on common lands has demonstrated nicely that women-centred livestock related livelihoods could be strengthened through better management of common lands.

- The institutional innovations such as village development committee (VDC), women self-help groups (SHGs) at village level and innovation platform (IP) at sub regional level are key elements of the systems approach for enhancing technology adoption, sustainable resource management, reduction in transaction costs across value chain, value addition and market linkages. The IPs across three regions in India have successfully helped sensitize relevant stakeholders on benefits of convergence and on harnessing synergies in implementing interventions to improve farm-based livelihoods and ecosystems services and consequently upscaling. IP is a unique approach bringing together stakeholders from across a wide range of sectors along the value chain, with complementing objectives and interests. It helps them to collectively address common challenges and opportunities and give a boost to dryland agriculture.
- Integration of high value commodities especially medicinal crops with suitable market linkages in Rajasthan as part of integrated farming systems has resulted in significant increase (more than double) in farm income for dryland farmers. Now >250 farmers have been integrated into the shankhpushpi value chain and got additional benefit of INR 5000 to 45000 each. Now the state government has shown keen interest to upscale this initiative.
- Bhoochetana in Karnataka and Andhra Pradesh has created a learning platform for the overall process of innovation and out scaling and impact of technologies on livelihood of smallholders. The benefits of soil-test based nutrient recommendations at sub-district level and seeds of improved cultivars, seed treatment, and integrated pest management options with soil and water conservation were evident in improved crop yields over farmers' practice varying from 19-57% (Wani et al. 2015). Achieving research outcomes for systems depend on action sites database establishment, engaging the community and building trust. Bhoochetana initiative was scaled-up across 13 districts of Andhra Pradesh and 30 districts of Karnataka. The participatory trials under Bhoochetana in Andhra Pradesh showed productivity improvement of 10% to 50% on participating farmers' fields.
- Gender mainstreaming has been one of the key strategies in the project and accordingly a number of interventions have been designed with a view to empower women in agriculture. These include formation of women's self-help groups (SHG), trainings of farmers including women farmers on innovative farming techniques, water harvesting techniques, crop demonstrations, establishing kitchen garden with fruit and vegetables that have helped them in enhancing their food and nutrition security.
- The capacity of farmers, NGOs, NARS and industry partners has been strengthened for enhancing dryland systems resilience and sustainable agricultural intensification. The CRP Dryland System action sites are developed as good learning sites for other farmers and development organization. The protocols of individual interventions are nicely validated.

III. Progress towards Impact

The project has created significant impact on the ground not only benefiting directly the farmers but also has been able to influence the major local stakeholders to integrate the systems approach into their agenda. Farm typology specific targeting of interventions, rainwater harvesting linked to high value commodities, rehabilitation of community based silvi-pasture systems, development of value chains on medicinal plant and small ruminants, mainstreaming gender and using climate information to minimise risk have been the key interventions creating impact on the ground.

IV. Unexpected Outputs, Outcomes and or Impact

The success of rainfed agri-horti systems, common silvi-pasture systems as part of integrated approach, creation of women leadership/ empowerment as well as development of value chain of medicinal plant has been more than expected.

d. ESA/Rainfed

I. Progress towards outputs

The overall focus of the work in ESA is on identifying, evaluating and promoting interventions for sustainable intensification of smallholder agricultural systems in the Marsabit-Yebello-East Shewa action transect in East Africa and in Chinyanja Triangle action site in Southern Africa. The intervention areas included bringing together relevant stakeholders to plan and work collaboratively by establishing and operating “Innovation Platforms” (IPs) and identifying, testing and promoting locally relevant interventions for sustainable intensification.

Innovation platforms: Three IPs, two in Chinyanja Triangle (CT) and one in East Shewa action site that were formed in 2014 to facilitate sustainable intensification efforts were further strengthened with various research for development activities. The IPs focussed on and advanced on building social capital, the capacity to self-organize at community level and strengthening collaborations with provincial and district level extension services and NGOs in meeting the site specific needs. Key benefits observed include better coordination and cooperation leading to faster decision making, more efficient utilization of resources, better access to extension services, stronger links to partners such as local governments and financial institutions for timely financial and technical support, improved marketing to realise better prices and increased effectiveness of the investments by participating organizations.

The development goal of Marara, Tete, CT, IP was to promote market oriented livestock production for improved income and that of Manica was to facilitate crop livestock integration and commercialization of common beans. At both locations, farmers acknowledged progress made in promoting food feed crop technologies, but saw fodder technology, market development and links to buyers as insufficient. Strong progress was documented on communities gaining knowledge in social capital and self-organization. Farmers now achieved increased production, as they expanded land and increased yields through improved soil fertility enhancement and crop management, realized better prices by assembling and selling common beans collectively and improved livestock and draft power animal feeding management. The collective efforts have also attracted new partners and support, e.g. training by FAO on post-harvest management and CARITAS on sustainable agriculture and sanitation and support by ODEMA to build grain storage facilities. The Manica IP influenced about 1500 other farmers. The Adamitullu IP, East Shewa, Ethiopia focused on sustainable intensification by bringing together ten different organizations to collectively plan and implement interventions that conserve resources and improve profitability. Through these efforts, nearly 300 farmers in two kebeles were benefitted by increasing their farm productivity through use of improved crop varieties, increased cropping intensity by intercropping with pigeonpea, more efficient soil fertility management, water harvesting and vegetable production using drip system, greater access to credit through microfinancing and women thrift groups and better management of common areas through tree planting and area enclosures. Guideline on Implementing Innovation Platforms illustrates how Dryland Systems Research can use innovation platforms (IPs) as a powerful vehicle for implementing and coordinating systems research and for sharing lessons with the wider research for development community (Homann-Kee Tui et al., 2015)

Key lessons learnt:

- IPs with relevant stakeholders served as excellent venues to collectively identify challenges and opportunities that reflect the realities and to co-create practical solutions
- IPS served as an important mechanism to create awareness and stimulate actors to take actions and have contributed to a clear change in mind-sets of those involved
- IPs encouraged stakeholders to take ownership of planned activities and ensure their success generating more benefits in short time
- IPs motivated the partners to pool their resources and work together to achieve more than what they can achieve in isolation. This made it possible to promote diverse set of

innovations aimed at conserving natural resources, diversification and intensification of farming systems, collective marketing, better use of common properties and promoting income generating activities as one single program

- IPs made significant contribution to more equitable access to services and sharing of benefits among the gender groups
- Tools are being developed for stakeholder network analyses, participatory pathways development, group dynamic interventions that enhance innovation, market orientation and collaboration for market oriented crop livestock systems
- This is a short period (24 months) and requires more time to reach a tipping point in the shift in mind sets and spread the results to other regions

Sustainable intensification: The work on sustainable intensification considered three key intervention areas viz., better conservation and utilization of available resources, achieving greater productivity and profitability and generating more income. A number of interventions that contribute to achieve the same were identified, tested and promoted by involving relevant stakeholders through IPs.

In Adamitullu, Ethiopia, farmers adopted pigeon pea as intercrop, constructed farm ponds to harvest water with help from Bureau of Agriculture, Government of Ethiopia, installed drip irrigation systems to grow vegetable and other high values crops with assistance from an NGO IDE, adopted improved varieties of haricot beans by establishing a revolving seed, accessed credit from a micro-finance company to buy inputs and services, taken up common property development work with tree plantation and area enclosures, and received better extension services from Bureau of Agriculture, Farmer Training Centre (FTC) and local research station all of which contributed significantly for improved profitability and sustainability. All interventions were identified through IPs. The IP deliberations have identified options to address the identified challenges under three categories- those that are readily available for promotion, that need adaptation to local conditions and that need additional research. The readily available options such as improved varieties, water harvesting and small scale irrigation, afforestation, area enclosure and common property management and thrift and credit programs were taken up by Government agencies and NGOs for promotion while those that require adaptation such as intercropping with pigeon pea, screening of potential new crops such as chickpea, mung bean and cowpea for their productive potential and identifying mechanization options for timely conduct of operations were taken up by the research organizations for further development to meet local requirements.

In Marara, Tete, a basket of 6 crops was evaluated by 30 farmers as dual purpose crops for achieving food security, mitigating effects of climate variability and for dry season feeding of livestock. Resource poor farmers preferred more drought tolerant food crops and preferred to combine sorghum with food legumes, whereas the better-off intensifying farmers with cattle went for maize, fodder and dual-purpose legumes. For all crops, farmers observed the benefits of improved crop management, especially early planting and increasing seed densities, and improved early maturing varieties. Farmers appreciated especially the short duration sorghum, groundnut and cowpea varieties for better drought resistance. Pigeon pea was introduced as a new crop; few livestock keepers opted to intercrop pigeon pea with maize; they saw benefits on maize, and the crop provided good biomass for livestock. Intercropping was identified as critical soil fertility management option, as with free grazing livestock manure is not sufficiently available and inorganic fertilizer seen as too risky. Pests and diseases remains a challenge especially on legumes.

In Manica district, commercialization of common beans (*Phaseolus vulgaris* L.) is one of the most important strategies for farmers to improve their livelihoods. Through demonstrations by 30 farmers IP members and participants, greater awareness about the benefits of integration

of legume crops (common beans and mucuna) and livestock through crop rotation and cover crops in improving soil fertility and reducing dependence on external inputs was created which when combined with draft power animal management has increased productivity and profitability of common beans.

II. Progress towards the achievement of research outcomes and IDOs

Improved access to data, knowledge and technologies to all stakeholders including farmers in the target area and greater benefits to smallholder farmers are the two major outcomes that were planned achieve and the progress made towards these outcomes is as given below.

- Nearly 120 farmers and about 20 organizations who have participated in the three IPs established in East and Southern Africa action sites have confirmed that the joint activities have improved the individual achievements (knowledge, capacity development, farmer organization) and Government representatives expressed their wish to continue the work on IPs (IDO 6)
- In Dororo, Manica, collective marketing efforts by farmers with support from local institutions have helped them 50% higher revenues than what they would get by selling individually (IDO 2)
- In Adamitullu, Ethiopia, 40 farmers practiced pigeon pea intercropping which stimulated 300 more who have expressed interest to adopt pigeon pea in 2016, About 20 farmers have dug farm ponds and installed drip irrigation system which helped in realizing an additional income of Ethiopian Birr 2,200 (equivalent to US\$ 110) from a 400 m² plot, Collective efforts also led to planting more than 5,000 trees by about 300 farmers in their homesteads and farm boundaries, About 70 farmers were benefitted by 25% increase in the productivity of haricot bean by replacing local variety with improved one (IDO 2)
- From self-assessment of IP members themselves, it is clear that farmers capacity to represent themselves and better organize in production to market processes has helped in realizing better prices to their crop and livestock products (Homann-Kee Tui et al., 2015) (IDO 6)
- The research has illustrated to government and national research that beyond the farm gate, adequate infrastructure and support services including seed quality control, and access to national and regional markets are critical for the new crops to take off as cash crops for smallholder farmers. (IDO 2)
- Stakeholders are able to access the data and messages online and use them for their own research and development work (links to various databases are given at the end of this section) (IDO 5)
- About 120 ha area in East Shewa action site was brought under area enclosure program through collective efforts and nearly 6,000 trees were planted to restore the lost biodiversity (IDO 1)
- In East Shewa resilience of about 40 farmers to climate shocks was improved through adoption of drought tolerant pigeon pea, construction of farm ponds with appropriate irrigation system and by establishing fruit trees (IDO 1)
- About 300 farmers have now improved access to credit through a local micro-finance company and through thrift and credit schemes operated by women in the area with support from iDE (Contribution to IDO 3)

III. Progress towards Impact

It will take time to realize the full impacts of the proposed interventions. However, nearly 120 farmers who have adopted the identified interventions were benefitted from the increased production, better prices for their products and more importantly enhanced resilience to climate shocks. The pigeon pea intercropping introduced in Adamitullu and tested by 20 farmers has

generated good interest among the community with more than 300 farmers coming forward to adopt the system in 2016. In Manica, the introduction and demonstration of common bean has generated interest among 1500 other farmers to take up commercial production of this crop. In addition to these direct benefits, the operation of IPs has generated a number of other benefits that include change in attitude, demonstration of benefits from collective actions in the production and marketing process and equity in access to and benefits from the interventions, it is expected that the full impacts of these will be realized over the next two years.

IV. Unexpected Outputs, Outcomes and or Impact

In Marara, Tete, CT, the IP was legalized as AAPACHIMA association, with about 42 farmers and a title to 13,000 ha of land

In case of Manica IP, two groups with about 40 farmers each, were able to attract new partners and support, e.g. training in postharvest management by FAO, training on sustainable agriculture and sanitation by CARITAS and assistance to build grain storage facilities by ODEMA

IP activities influenced non IP farmers. For example, the Manica IP has influenced about 1500 other farmers to take up commercial cultivation of beans

A new project on nudging sustainability transitions, aiming at more effective ways of facilitating desirable change in farming systems and enhance capacities of farmer-extension-NARs towards market-oriented farming was started at the Tete CT action site,

Regional Integrated Assessment and co-design of scenarios produced a series of results on ex-ante impact assessment for improving management technologies and market oriented farming, for near- and midterm scenarios and under climate change. The methods of the scenario development (RAP) and first phase results were published in two book chapters (Masikati et al., 2015; Valdivia et al., 2015). Stakeholders confirmed the results as meaningful for informing climate change adaptation processes and the broader socio-ecological context (Homann-Kee Tui et al., 2015).

SECTION III – CROSS-CUTTING ISSUES

a. Gender Research Achievements

Gender mainstreaming has been one of the key strategies in the project and accordingly a number of interventions have been designed with a view to empower women in agriculture. These include formation of women's self-help groups (SHG), trainings of farmers including women farmers on innovative farming techniques, water harvesting techniques, crop demonstrations, establishing kitchen garden with fruit and vegetables that have helped them in enhancing their food and nutrition security. More than 150 farm women in Rajasthan and AP led the diversification through kitchen gardens, fodder development through CPRs, improving small ruminant productivity and enhancing market integration through promoting sale of goats on weigh basis.

Data showed that kitchen garden scale vegetable cultivation not only strengthened 120 women farmers to improve household nutrition, but also increase their incomes through sale of extra produce. Similarly, five women sub-committees for managing common property resources (CPR) played a key role in enhancing fodder production through CPRs and strengthened the livestock-based activities which are in general in domain of women. The farmers are growing annuals like sorghum and horse gram and sharing on nominal price which has extended fodder availability period and quality and quantity also. Enhanced access to nutritious quality fodder has not only increased milk production but also reduced their drudgery in collecting forage. Similarly, forty-five women farmers were involved in establishing and evaluating role of seed banks in the action site villages. The interested women farmers have grouped themselves as a self-help group (SHG) and are being supported to manage seed bank as livelihood activity while helping disseminating

improved seed for sustainable intensification; data is being collected. About 80 women framers were engaged in seed production of moth bean, groundnut, pigeon pea and foxtail millet. In Rajasthan the seed production was taken up in convergence with national seed corporation (NSC).

A study to assess smallholder men, women and youth' to extension services and thereby identify gender responsive extension options contributes evidence and analysis on the difference in access to extension services from a gender perspective using data collected from 240 households from six villages of Karnataka and Rajasthan states in India. Preliminary results suggest that farm size plays an important role in access to information via the agricultural services and other sources, for both men and women. Large land holding farmers have more access to information via different sources. Compared to men, women have poor access to extension services. In relative order of importance, progressive farmers/relative/neighbor were the biggest source of information (90 out of 159 men; 110 out of 159 women interview), followed by NGO, input dealer and television were the sources of information. There is need to place women extension officers and also the male and female extension officers should be trained to have the capability to talk to both men and women farmers, should be equipped with knowledge and skills to address them equitably. Ultimately, gender-responsive techniques and methods are to be adapted to suit the local context – especially fitting in with the existing gender, social and cultural norms.

In East Shewa, Ethiopia, women took active role in forming thrift and credit groups with support from IDE. IDE in collaboration with an Indian NGO Kabil has trained these groups in keeping proper accounts and in managing the finances transparently. The four groups, each with 20 members, have now become highly successful models and currently efforts are on to establish similar groups in the region. Key benefits that these groups were able to achieve include greater access to cheaper credit on flexible terms with little or no paper work and reduced dependence on financial institutions whose lending rates are higher with little flexibility. The intensification of cropping systems with legumes has contributed to increased consumption of the same by the households and members of the household especially women and children are benefitted by the improvements in the nutritional value of the traditional food. About 40 households benefitted during the first year.

b. Partnerships Building Achievements

Across the 3 Indian action sites, significant partnerships were built with 5 CGIAR (ICARDA, Bioversity, IWMI, ILRI, CIP) and 5 NARS partners (Central Arid Zone Research Institute, Jodhpur; SAUs- ANGRAU and Horticulture University, AP; UASD, Karnataka and KVK, Barmer); 5 NGO partners (GRAVIS, Jodhpur; RSDS and CORUS, Karnool; AFEC Anantapur and SBMMAS, Bijapur and 2 industry partners namely Dabur India Ltd. and Jain irrigation systems. The related state line departments like agriculture, animal husbandry, watershed, micro-irrigation, horticulture, state and nation seed corporation, lead banks, were engaged as members of the regional Innovation Platform for synergies through collective working and aligning states and regional priorities in research for development at DS pilot sites. During the year 2015, Innovation Platform strengthening was focused on better targeting of systems interventions and up and out scaling of best practices. In the meetings the plan of action for 2015 along with role clarity for partners was also discussed. This year we also established close collaboration with CRP on CCAFS for effectively addressing the climate issues. During the ['Innovation Platform'](#) meeting, the partners were briefed about the progress made and approach followed during 2014-15. The broad framework of 2015 activities in the systems context was shared - which are targeted at productivity enhancement through balanced fertilizer management; recycling of farm wastes from soil fertility point of view; mechanization; women-centred small-scale vegetable cultivation; conserving green and blue water resources and efficient management; fostering institutions for water management; fodder development to strengthen livestock related activities; insurance; and capacity building. The activities for 2015-16 were agreed on by one and all. A good discussion was held on management issues and suggested protocols related to – common property resources (CPRs), community seed banks and farm machinery custom hiring centers (CHCs) for mechanization and operational

guidelines were agreed on. The representatives of line-departments agreed to focus on pilot sites for developing as sites of learning/bright spots through bringing in more of departmental schemes and programs. The linkages established through IPs led to continuous interactions with the relevant state line departments and SAUs and ICAR institutes.

These new partnerships were developed with Rajasthan state seeds corporation (RSSC) and national seed corporation (NSC) for community level seed production of moth bean, wherein 65 farm women and men participated, the breeder seed was supplied by NSC/RSSC and they seeds from farmers bought back. This initiative was very successful and led to creation of seed grower farmers group and seed bank at village level. Another new and important partnership developed was with Cattle breeding farm, Jaisalmer of the Rajasthan Veterinary University, Bikaner for purchasing/ supply of superior quality breeding males of high yielding cattle (Tharparkar) to farmers. Such bulls were supplied to four villages on subsidised payment basis and center gets the data on performance of the bulls (Proceedings of the IP meeting available).

In ESA, one of the major achievements of the work under dryland systems is in building partnerships. The three IPs that were formed and operated successfully over the past two years with significant achievements provide a clear evidence of this. A total of more than 20 research, development, government and non-government organizations have participated in these IPs. The interest and commitment they showed in IP activities as evidenced by their regular attendance and successful implementation of mutually agreed work plans. These partnerships helped achieve much greater impacts than otherwise possible. For example, the afforestation work in Adamitullu is a combined effort between Bureau of Agriculture which supplied the seedlings, Adamitullu Research Station which provided the transportation of seedlings, IDE which provided some implements, research organization which identified appropriate species that can give good economic and environmental benefits and farmers who have contributed labour to plant and manage the area.

c. Capacity Building Achievements

Capacity development was undertaken with farmers, youth, local NARS staff and private industries over many occasions in a range of settings. In SA, a total of 2127 farmers including 478 women farmers were trained on various aspects of agriculture for sustainable intensification and resilience building of dryland systems through many workshops. Ten farmers from Rajasthan also had exposure in an international grassland congress held at New Delhi in November 2015. Innovation platform meetings at the action sites engaged >200 to create awareness and provide incentives to communities for CPRs management, identifying specific areas of convergence among stakeholders e.g. Seed Bank: NSC, RSSC, RAU etc., livelihood strategies linked with marketing and financial institutions and Grain and fodder storage systems. In Ethiopia, a farmer training centre (FTC) at Adamitullu established demonstrations with pigeon pea and other short duration legumes cowpea, lentil and chickpea with many visitors regularly. Field days were organized for interested farmers and DAs to visit these demonstrations and also the Adamitullu research station where a number of other experiments are in progress. A total of about 150 farmers have attended the field day. Capacity building was also done in efficient and transparent management of thrift societies. Four societies with 20 members each were benefitted. The other training programs planned were not held due to budgetary limitations

Workshop on systems analysis for smallholder farmers Niger 21-25 Sept 2015: In the resource constrained mixed farming systems prevalent in the semi-arid tropics, understanding what interventions result in benefits to farm households, i.e. improvements in food security and income, is not straight-forward. Farm households are highly heterogeneous with multiple constraints of labour, capital and access to resources and operating in highly climatically variable environments. The use of systems analysis, encompassing the biophysical and socio-economic makeup of farm

households, requires a range of computer based tools that can capture some of these complexities and lead researchers to devising robust intervention strategies which more effectively lead smallholders out of poverty. Twenty participants (2 female) from 5 National Agricultural Research Institutions of countries (Burkina, Ghana, Mali, Niger, Nigeria) and staff from ICRISAT, ICARDA, ICRAF and CIRAD were trained to learn and apply their systems analytical skills through:

- (i) an advanced course on crop modelling with the Agricultural Production Systems simulator (APSIM) and,
- (ii) an advanced course on bio-economic modelling Integrated Assessment tool (IAT) which combines outputs from a range of models and expert knowledge to gain enhanced understanding of bio-economic behaviour of mixed smallholder systems.

Trainings activities have been conducted in Niger to improve the farmer’s skills and adoption of new integrated management technologies (IMT). The training covered 7 topics as indicated on table 1 below. A total of 425 farmers comprising 409 males and 16 females were trained.

Table 1: Training topics, number and gender structure of the participants

Training topics	Male	Female	Total
Survey design and data collection, PRA method and small agribusiness and market development	55	2	57
Participatory variety selection and demonstration approach	45	2	47
Technology of crop growth in the Bio-reclamation of degraded land field	47	2	49
Integrated soil fertility and Striga management and Farmer Field school approach	47	2	49
Monitoring and management of direct reading rain gauge	116	4	120
Integrated Millet and cowpea pest management	47	2	49
Farmer Field School activities - Agro-Eco-System Activities	52	2	54
Total	409	16	425

Workshop on systems analysis for smallholder farmers Niger 21-25 Sept 2015: In the resource constrained mixed farming systems prevalent in the semi-arid tropics, understanding what interventions result in benefits to farm households, i.e. improvements in food security and income, is not straight-forward. Farm households are highly heterogeneous with multiple constraints of labour, capital and access to resources and operating in highly climatically variable environments. The use of systems analysis, encompassing the biophysical and socio-economic makeup of farm households, requires a range of computer based tools that can capture some of these complexities and lead researchers to devising robust intervention strategies which more effectively lead smallholders out of poverty. Twenty participants (2 female) from 5 National Agricultural Research Institutions of countries (Burkina, Ghana, Mali, Niger, Nigeria) and staff from ICRISAT, ICARDA, ICRAF and CIRAD were trained to learn and apply their systems analytical skills through:

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- (ii) an advanced course on bio-economic modelling Integrated Assessment tool (IAT) which combines outputs from a range of models and expert knowledge to gain enhanced understanding of bio-economic behaviour of mixed smallholder systems.

d. Risk Management

The biggest risk faced across all regions was due to funding and uncertainty. One of the activity on capacity building was dropped and data collection and progress monitoring were downscaled to match the resources made available. In addition to the negative impact on implementation of planned activities, it also affected the lead institute image and credibility adversely. Limited physical infrastructure and human capacity of local research and development organizations is constraining these institutions to deliver the outputs as planned in a timely manner. Efforts were made to support the partners by making additional resources available to them. Adamitullu Agricultural Research station under Oromia Agricultural Research Institute and IDE who have implemented a number of field based activities were supported with CRP funds.

Availability of required inputs is another major risk faced while promoting identified technologies. For example, interventions such as introduction of pigeon pea or introduction of improved varieties such a haricot bean are constrained by lack of seed and other inputs. Efforts were made to source from other countries but the process to get the varieties in the country will take time. Efforts were also made to address the problem related access to finance by farming thrift and credit societies locally.

Lack of collective action: the effective delivery of results by outputs of the CRP DS initiative depends on strong partnerships and collective action by different knowledge-generating and knowledge-disseminating institutions to provide location specific holistic solutions. Belonging to different organizational cultures, working in a consortium mode is always a challenge and a major risk for effective delivery of results. For successfully managing the consortium, team building cum review & planning meetings are important to clearly define roles and responsibilities. Transparency in planning & actions, budget allocation, more communication, credit sharing are some of other mechanisms for effective working.

Conflicts in resource sharing/use by farmers: To avoid conflicts within farmers, a participatory mode of on-farm research is adopted where any intervention is planned in consultation with and as agreed by the farmers. There is need to allow sufficient time to encourage stakeholders to participate and take ownership of the initiative/project.

Extreme climate situations (severe drought in many regions of India) has affected outputs. We have focused on diversification of interventions including livestock, perennial component and value chains

e. Lessons Learned

- i. For planning and implementing systems research aimed at all round improvement in both productivity and sustainability requires active participation of several stakeholders and IPs were found to be the best means to facilitate the involvement of all stakeholders.
- ii. Legumes are vital for sustainable intensification and the baseline survey conducted in Adamitullu action site indicates that only 9% of the cropped area is under legumes. This is mostly driven by the growing demand for food from rapidly increasing population. Options such as intercropping with pigeon pea which increase the cropping intensity without affecting the cropping area under any crop are extremely important for sustainable intensification
- iii. Locally formed thrift and credit societies are extremely efficient in providing timely access to credit at affordable prices.

- iv. Greater attention to maintain common lands and equitable sharing of the benefits is required. Lack of interest in agriculture amongst the youth and increasing scarcity of labour requires special attention.
- v. Managing rainwater efficiently is a challenging task and managing both green and blue water resources in an integrated manner to use it efficiently for high value crops is the need of the day. Water conservation at micro-watershed in individual farm scale along with looking at bigger catchment which brings command to smallholders to use water as per their demands. Rainwater harvesting need to be promoted at farm-scale as a drought proofing strategy through low-cost farm-ponds which can kick-start the stagnant growth of agriculture and make it sustainable thereafter.
- vi. Due to lack of land rights, mainstreaming women farmers is a big challenge. Participatory research at DS sites showed that through promotion of kitchen garden scale fruit-vegetable cultivation, women can be strengthened to improve family nutrition as well improve income through sale of additional produce. Encouraging self-organization, training, involving them in fodder production augmentation through common lands and small ruminant marketing are effective ways to empower women-farmers.
- vii. Similarly, the interventions on integrated farming systems along with rainwater harvesting systems, management of CPRs are successfully implemented, but will need time to show outcome/impact and sustainability.
- viii. With current scenario of labour scarcity, and to develop agriculture on business lines, mechanization in modern agriculture is call of the day. Farm machinery custom hiring center (CHC) is a scalable model to improve productivity and incomes through efficiency in on-farm operations like water conservation, sowing, interculture, harvesting and threshing, while simultaneously reducing drudgery.
- ix. Innovation platforms could be important vehicle to encourage consortium of partners like line departments, universities, NGOs, farmers, national & international research organizations facilitate harnessing synergies of each other. The IPs developed around the high value commodities would be very effective in strengthening those value chains. Integrating high value crops and strengthening linkages with related industry is equally important for enhancing economic viability of dryland agriculture.
- x. For holistic and sustainable development of dryland systems, new skills about science-led management of resources need to be developed. Therefore, skill development of farmers and stakeholders is most important for sustainable intensification and rural livelihood improvement.

SECTION IV - RESEARCH OUTCOME STORIES

OUTCOME STORY 1

Name of research activity/project title:	Improving land and water productivity in arid regions for sustainable livelihoods
Flagship:	South Asia
Geographical region:	Rajasthan
Name and email of Activity & Outcome Story Lead:	Shalander Kumar (k.shalander@cgiar.org)
Activity Lead Center:	ICRISAT
Activity Partner Center(s):	Gramin Vikas Vigyan Samiti (GRAVIS), Jodhpur Central Arid Zone Research Institute (CAZRI), Jodhpur
Activity Partner CRPs:	CGIAR Research Program on Dryland Systems

1. Outcome Story Headline

Community-driven Solutions for India's Drylands: Integrated ecosystems approach for sustainable intensification of community based silvi-pasture systems

2. Outcome Story Abstract

The common (silvo) pasture systems in arid western Rajasthan, India though are critically important for sustaining livestock dominant smallholder rural livelihoods and ecosystems services, but these have severely degraded due to several factors. The case study analyses and the group discussions were used as a starting point for facilitated community elaborations on how to adopt appropriate by-laws and identify opportunities and challenges of sustainable intensification of community based pasture systems. Facilitating appropriate institutional mechanism based on the understanding of social ecological systems (was a critical component of the rehabilitation strategy. The integrated ecosystems approach for rehabilitation of severely degraded community based silvi-pasture systems under extreme dry rainfed region resulted in many fold increase in biomass yield from 0.25-0.40 t/ha to 1.6 – 4.6 t/ha in the second year. Local communities, especially smallholder farmers, are benefitting directly from increased access to fodder resources, which invariably affects their food security and incomes. The local partner GRAVIS has already started to out scale this inclusive research-in-development intervention to 20 other locations in western Rajasthan that face similar challenges of water and fodder scarcity, and degraded lands. As our research results are shared with more and more major stakeholders through various innovation platforms, there is a greater likelihood that community-led solutions developed as a result of comprehensive systems research will be the new model for ensuring sustainable natural resource management in millions of hectares across this vast dry region where some of the world' poorest live.

3. Problem/Challenge Overview

Common property resources such as grazing pastures are the lifeline for rural dryland communities living in this area because they provide fodder, fuel, timber, water and medicinal plants. On the other hand, livestock in this region are heavily dependent on common pasturelands for grazing. However, these lands are severely degraded due to over-grazing, over extraction and lack of effective mechanisms for sustainable resource management. Moreover, increased grazing pressure has led to the disappearance of many species and a decline in biomass yield. The rural dryland communities are extremely poor and marginalized, and there are hardly any incentives provided to them for protecting common lands and managing resource sustainably. With very little opportunity to make a living in their rural communities, men are forced to migrate and look for jobs elsewhere in the urban areas, while women and children are left behind, struggling to survive in a harsh environment characterized by lack of water, food and constant threat of droughts or flash floods.

Lack of water and food for livestock and families are some of the biggest challenges poor rural women face in these dryland areas. Aside from the exorbitant financial cost in trying to secure water and food for their animals and families, the social costs are even higher. Families are forced to live apart due to economic hardship, and children are often left on their own and unsupervised by adults.

4. What are the main research activities?

A variety of data collection tools to solicit community participation were utilized, such as a field-survey (70 farmers), participatory rural appraisal (PRA) including transect walks, focus group discussions and key-informants interviewed in three villages. The [scientific findings](#) of this process were shared and discussed with the local community stakeholders in an innovation platform setting in order to fill data gaps and align scientific understanding with local priorities and needs. Extensive community consultations also organized in order to improve and advance equitable by-laws and institutional arrangements for the sustainable development and management of the silvopasture lands.

- Baseline characterization of farming systems
- Identification of Common Property Resources(CPRs) sites
- Receiving consent of local governance body (*Panchayat*)
- Facilitated establishment of Village Development Committee with equitable gender representation
- Focused group discussions with community to identify constraining factors and opportunities
- Analyses of social-ecological systems
- Community consultation and selection of appropriate grasses and plant species for plantation in CPR sites
- Community develops by-laws for management of CPRs and sharing of plan at innovation platform meeting
- Participatory implementation of soil and water conservation work and rainwater harvesting structures at the sites
- Preparation of seeding material (cakes, saplings) and planting saplings and sowing of grass
- Harvesting by the community
- Committee decides on sharing the produce (grass biomass and seed)

- Innovation platform meetings to share outcomes/gaps/solutions with stakeholders and to strengthen governance structure
- Participatory management and maintenance of CPRs

5. What are the main Outcomes of your research?

The integrated ecosystems approach for rehabilitation of severely degraded community based silvi-pasture systems under extreme dry rainfed region resulted in many fold increase in biomass yield from 0.25-0.40 t/ha to 1.6 – 4.6 t/ha in the second year. Local communities, especially smallholder farmers, are benefitting directly from increased access to fodder resources, which invariably affects their food security and incomes. The local partner GRAVIS has already started to out scale this inclusive research-in-development intervention to 20 other locations in western Rajasthan that face similar challenges of water and fodder scarcity, and degraded lands. As our research results are shared with more and more major stakeholders through various innovation platforms, there is a greater likelihood that community-led solutions developed as a result of comprehensive systems research will be the new model for ensuring sustainable natural resource management in millions of hectares across this vast dry region where some of the world' poorest live.

6. What are the main research Outputs that resulted in the outcome(s)?

- Understanding the social ecological systems around CPRs.
- Participatory and integrated ecosystems approach with greater focus on improving governance structure, profitability and sustainability of CPRs.

7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?

Gramin Vikas Vigyan Samiti (GRAVIS), Jodhpur, Central Arid Zone Research Institute (CAZRI), Jodhpur and state line departments and ICRISAT were the intermediary users of the research outputs for dissemination of the technology.

Three village communities in Western Rajasthan action sites are the direct users and 20 more communities are the indirect user of the technology.

8. How were your research outputs used (will be used in the future)?

The integrated ecosystems approach for rehabilitation of severely degraded community based silvi-pasture systems under extreme dry rainfed region has proved effective for enhancing dryland system resilience and improves livelihoods. With small investments and improving the governance structure, biomass productivity and incomes are increased significantly. DS action site in Rajasthan is established as site of learning for farmers and stakeholders including policy makers so as to disseminate the technology to large number of rural communities in the region. Policy makers at district level have visited the sites and are willing support these initiatives.

9. What is the Evidence of Your Research Outcomes?

The evidence has been collected through baseline survey, randomized biomass cutting experiments, species monitoring and data collection and farmers' responses by partners and ICRISAT staff.

10. Testimonials

The farmers Mr. DhudaRam, Govindpura village says 'working together for improving our village pasture has given us good quality fodder during lean season; we want now to rehabilitate the whole community land for fodder production'.

"In the new institutional arrangement, the involvement of women livestock keepers in operationalizing the cut-and-carry fodder system was critical and we expect it will contribute significantly to the sustainable management of common property resources", says Dr. Shalander Kumar, ICRISAT scientist.

11. Lessons Learned

- Institutional interventions are as important as biophysical interventions for improving productivity and managing common property resources in a sustainable way
- Governance structures should be inclusive of local stakeholders, especially vulnerable groups of livestock keepers.
- Institutional arrangements must ensure a fair representation of stakeholders.
- The small yearly benefits to users, especially smallholder livestock keepers, will accrue over several years – users must understand/share this long term view or may become disenchanted.
- There may be a need to have different by-laws to manage CPRs across villages in the same region depending on the differentiated local situations for example social norms, livestock composition, feed and fodder supplies.

12. Full reference citations and URL link to published research work

- <http://drylandsystems.cgiar.org/content/community-led-solutions-india's-drylands>
- <http://www.hindustantimes.com/jaipur/desert-farmers-on-the-path-to-economic-self-reliance/article1-1353429.aspx>
- <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1693.htm#1>



Rehabilitated community silvi-pastures in Dhok village, Barmer district, Rajasthan.

OUTCOME STORY 2

Name of research activity/project title:	Farm type specific sustainable intensification and strengthening value chains
Flagship:	South Asia
Geographical region:	Rajasthan
Name and email of Activity & Outcome Story Lead:	Shalander Kumar (k.shalander@cgiar.org)
Activity Lead Center:	ICRISAT
Activity Partner Center(s):	Krishi Vigyan Kendra (KVK), Barmer Dabur India Private Limited, New Delhi Gramin Vikas Vigyan Samiti (GRAVIS), Jodhpur
Activity Partner CRPs:	CGIAR Research Program on Dryland Systems

1. Outcome Story Headline

Integrating native high value medicinal plant (*Convolvulus pluricaulis*) into dryland systems and strengthening its value chain

2. Outcome Story Abstract

Identifying medicinal plants that grow wild in the region, motivating farmers to grow them as an intercrop that requires virtually no maintenance and linking them to a manufacturer of Ayurvedic (traditional Indian system of medicine) products has hugely benefited farmers. The profits earned by farmers who grew shankpushpi (*Convolvulus pluricaulis*) had attracted other farmers. Last year, 20 farmers in Barmer took up cultivation and this year, 250 farmers in five to six villages have joined them. Currently, shankpushpi is sold at Rs24 (US\$ 0.36) per kg and the seed is sold at Rs 1,500-1,600 (US\$ 22.7-24.2) per kg. A tripartite agreement with Dabur India Ltd, to buy back the produce is in place and technical backstopping in terms of training the farmers is being done by Krishi Vigyan Kendra, Barmer. Another medicinal plant, jeevanti (*Leptadenia reticulata*), was introduced this year and is being cultivated by 15 farmers. Jeevanti is a climber and planted as an intercrop with fruit trees. A farmer can earn around Rs 300-400 (US\$ 4.5-6) per plant. Another medicinal plant arna (*Clerodendrum phlomidis*) which is a very drought hairy plant and was used for fencing and roofing now has a buyback rate of Rs 15 (US\$ 0.23) per kg. This initiative has not only benefitted the farmers but has also sensitized the policy makers; the Principal Secretary government of Rajasthan for the department related to herbal medicines was encouraged to visit the field sites and offered support to upscale.

3. Problem/Challenge Overview

Sustainable intensification and enhancing farm income under the dryland systems has been a big challenge. Due to low productivity of traditional millets and legumes and crop losses due frequent droughts leading to poverty and migration from the dry regions. Identifying high value adapted crops/species, their on-farm assessment and integrating them into market value chain could help in stabilizing income and enhance resilience of dryland systems.

4. What are the main research activities?

- Baseline characterization of farming systems
- Participatory prioritization of constraints and potential interventions
- Identification of native medicinal plant shankpushpi (*Convolvulus pluricaulis*) and its introduction into farming systems
- Analyzing factors hindering its integration into farming systems
- Analyses of social-ecological systems and capacity building of stakeholders
- Market linkage: Tripartite agreement with industry Dabur India Ltd for back arrangements
- Facilitating farmers' self-organization into producers group
- Impact assessment and convergence with state government

5. What are the main Outcomes of your research?

The introduction of medicinal plant cultivation and facilitated linkages with the market has directly benefitted the 250 farmers from 6 villages and in Barmer. Individual farmers now earn additional income of about Rs 15000 to Rs 45000 per annum. It has generated a lot of interest among other farmers, NGOs and government departments.

6. What are the main research Outputs that resulted in the outcome(s)?

- Appropriate targeting of activity: farm type specific intervention
- Arrangement for quality seeds
- Successful on-farm assessment of the medicinal crop
- Hassle free direct linkage with the industry for marketing

7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?

KVK, Barmer; Gramin Vikas Vigyan Samiti (GRAVIS), Jodhpur; Dabur India Ltd; Central Arid Zone Research Institute (CAZRI), Jodhpur and state line departments and ICRISAT were the intermediary users of the research outputs for dissemination of the technology.

250 farmers from 6 villages and in Barmer directly benefitted. It has generated a lot of interest among other farmers, NGOs and government departments.

8. How were your research outputs used (will be used in the future)?

All stakeholders are looking for alternatives for sustainable intensification and enhancing farm income in dry areas. This intervention has proved very effective to achieve this objective. This initiative has not only benefitted the farmers but has sensitized the policy makers; the Principal Secretary government of Rajasthan for the department related to herbal medicines was encouraged to visit the field sites and offered support to upscale. Now the Rajasthan government is considering supporting the Shankhpushpi farmers. Now the farmers' producers group, horticulture department and NGOs are supporting this intervention

9. What is the Evidence of Your Research Outcomes?

The evidence is collected through crop cutting experiments, data collection and farmers responses by partners KVK, Barmer and ICRISAT field staff.

10. Testimonials

'Shankhpushpi acted as a lifeline for my family as I earned Rs 80, 000 in the drought-like situation last year when other farmers end up earning nothing' said Mr GainaRam, a farmer from Dhirasar Village in Barmer, Rajasthan.

"The revenue can increase significantly by cultivating a high value commodity crop like Shankhpushpi together with traditional crops like Bajra and Gaur. The Shankhpushpi crop requires water during sowing and once the seed germinates, it requires the same quantity of water as is needed for any dry land crop," said Shalander Kumar, scientist at ICRISAT.

11. Lessons Learned

Capacity building of farmers, availability of seed and market linkages is important preconditions to promote production of such exclusive high value commodities.

12. Full reference citations and URL link to published research work

- <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1693.htm#1>
- <http://timesofindia.indiatimes.com/city/jaipur/Herb-cultivation-benefits-western-Rajasthan-farmers/articleshow/48417637.cms>



Shankhpushpi with as part agri-horti system in Mr ShriRam's farm in Dhirasar, Barmer.

OUTCOME STORY 3

Name of research activity/project title:	Dryland Systems - Integrated Agricultural Production Systems for Improved Food Security and Livelihoods in Dry Areas
Flagship:	South Asia
Geographical region:	Andhra Pradesh
Name and email of Activity & Outcome Story Lead:	Girish Chander (g.chander@cgiar.org)
Activity Lead Center:	ICRISAT
Activity Partner Center(s):	Acharya NG Ranga Agricultural University (ANGRAU); AF Ecology Centre (AFEC); Rural Studies Development Society (RSDS); Community Organising for Rural Upliftment Society (CORUS)
Activity Partner CRPs:	CGIAR Research Program on Dryland Systems

1. Outcome Story Headline

Micro-catchment scale low-cost farm ponds facilitated intensification and diversification for smallholders

2. Outcome Story Abstract

Water scarcity is one of the major factor for low crop productivity in Dryland System (DS) action sites in Andhra Pradesh (AP). The consortium in AP adopted a strategy to promote participatory construction of micro-catchment scale low-cost cement-lined farm ponds for conserving rainwater. During 2014 and 2015, 40 smallholders volunteered for ponds in their farms. These ponds empowered the farmers to effectively cope with the long dry spells during 2015 and check yield losses up to 20% to 30% in crops like groundnut, foxtail millet and pigeon pea. These ponds enabled to establish fruit plants on adjoining 1-2 ha marginal lands, which is crucial in enhancing resilience through developing diverse income sources. Ponds also enhanced risk-taking abilities to diversify some small area under vegetables to enhance family nutrition and incomes and also fodder production for strengthening women-centered livestock enterprises. The construction of a small farm pond (10 m × 10 m × 2.5 m) with about one-centimeter thick concrete lining costs only \$300 and is an effective scalable technology for storing water even in red soil with a high percolation rate. This has shown a model about how small investment can kick-start the stagnant growth engine of agriculture in dryland systems.

3. Problem/Challenge Overview

Water scarcity is one of the major factor for low crop productivity in rainfed dryland systems in Andhra Pradesh. Studies have indicated that one or two lifesaving irrigations can substantially enhance crop productivity. Enhancing on-farm water availability, therefore, cannot only enable farmers to go for crop intensification, but can also open options for diversification and other livelihoods. Along with community-scale water management, focus on construction of small farm-ponds by smallholders in the rainfed tropics will effectively

conserve rainwater and provide strong handle to effectively explore options for intensification and diversification.

4. What are the main research activities?

The consortium in Dryland Systems action sites in Andhra Pradesh adopted a strategy to promote participatory construction of small-scale farm ponds for conserving rainwater. Farmers contributed their share through participating in digging farm pond; and were supported through this initiative in machine work for digging, properly levelling the walls, lining with cement (to check percolation losses). During 2014 and 2015, 40 smallholders volunteered for ponds in their farms. The year 2015 experienced a poor rainfall scenario and the role of farm-ponds in mitigating long dry spells through life-saving watering was evaluated in participatory trials with crops like groundnut, foxtail millet and pigeon pea. The pond farmers were supported to diversify marginal lands into fruit plantations and also bring in some area under vegetables and fodder production. Data was recorded from pond farmers and synthesized the results to assess the benefits.

5. What are the main Outcomes of your research?

During 2015 which was a poor rainfall year, the yield losses up to 20% to 30% were saved through life-saving watering in crops like groundnut, foxtail millet and pigeon pea. These ponds enabled to establish fruit plants on adjoining 1-2 ha marginal lands, which is crucial in enhancing resilience through developing diverse income sources. Ponds also enhanced risk-taking abilities to diversify some small area under vegetables to enhance family nutrition and incomes and also fodder production for strengthening women-centered livestock enterprises.

6. What are the main research Outputs that resulted in the outcome(s)?

This success story has demonstrated a low cost scalable technology of harvesting rainwater through construction of a small farm pond (10 m × 10 m × 2.5 m) with about one-centimeter thick concrete lining which costs only \$300 and is an effective for storing water even in red soil with a high percolation rate. This has shown a model about how small investment can kick-start the stagnant growth engine of agriculture in dryland systems.

7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?

AF Ecology Centre (AFEC), Rural Studies Development Society (RSDS), Community Organising for Rural Upliftment Society (CORUS), Acharya NG Ranga Agricultural University (ANGRAU) and ICRISAT were the intermediary users of the research outputs for dissemination of the technology.

40 farmers in Andhra Pradesh action sites were the direct users of the technology.

8. How were your research outputs used (will be used in the future)?

A micro-catchment scale low-cost cement-lined farm pond for conserving rainwater has proved effective for system intensification and diversification of dryland systems. With small investments, productivity and incomes are increased significantly which enhances farmers' capacity to invest in and sustain in future. DS action site in AP is established as site of learning for farmers and stakeholders including policy makers so as to disseminate the technology to large number of smallholders in the region. Policy makers at district level have visited the farm pond sites and supported through policy the construction of demand-driven large number of ponds in the target districts.

9. What is the evidence of your research outcomes?

The evidence was collected through crop cutting experiments, data collection and farmers responses by partners like AF Ecology Centre (AFEC), Rural Studies Development Society (RSDS), Community Organising for Rural Upliftment Society (CORUS) and ICRISAT line-staff.

10. Testimonials

Farmers Ms. Hemlatha and Mr. Ramanjeyulu in Mallapuram village expressed happiness on seeing how micro-catchment scale low-cost cement-lined farm ponds in fellow farmers' fields has empowered them to effectively cope with the long dry spells while enhancing risk-taking abilities to intensify and diversify the production system.

Dr. Y Reddy of AF Ecology Centre (AFEC) says that water conservation in individual farmer scale small low cost ponds can change the face of dryland production systems and smallholder livelihoods,

Dr. Girish Chander, Senior scientist – Natural Resource Management, ICRISAT, in a field day told fellow farmers that the construction of a small farm pond (10 m × 10 m × 2.5 m) with about one-centimeter thick concrete lining costs only \$300 and is an effective scalable technology for storing water even in red soil with a high percolation rate.

See: Drylands get greener with low-cost agri-interventions and shared resources in Andhra Pradesh, India. 2015. ICRISAT Happenings Newsletter 1699: 1-2. Available at:

<http://www.icrisat.org/newsroom/latest-news/happenings/happenings1699.htm>

11. Lessons Learned

Micro-catchment scale low-cost cement-lined farm ponds is a scalable technology which empower farmers to improve livelihoods through intensification and diversification.

The Challenge is to disseminate it to large number of smallholders.

There is a need for collective working of knowledge generating and knowledge disseminating institutions.

12. Full reference citations and URL link to published research work.

- Drylands get greener with low-cost agri interventions and shared resources in Andhra Pradesh, India. 2015. ICRISAT Happenings Newsletter 1699: 1-2. Available at: <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1699.htm>



A low-cost farm pond in Mr Gopal's farm in Mallapuram, Andhra Pradesh.

OUTCOME STORY 4

Name of research activity/project title:	Dryland Systems – Sustainable intensification of farming systems in East Shewa, Ethiopia
Flagship:	ESA
Geographical region:	Ethiopia
Name and email of Activity & Outcome Story Lead:	K.P.C. Rao (k.p.rao@cgiar.org)
Activity Lead Center:	ICRISAT
Activity Partner Center(s):	International Development Enterprise (iDE) Oromia Agricultural Research Institute (OARI) Bureau of Agriculture (BoA) ICARDA
Activity Partner CRPs:	CGIAR Research Program on Dryland Systems

1. Outcome Story Headline

Sustainable intensification of rainfed agricultural systems of East Shewa, Ethiopia

2. Outcome Story Abstract

Low and declining productivity is a major concern in East Shewa zone of Ethiopia where maize and wheat based cropping systems dominates the crop production activities. Interventions identified to reverse this trend include arresting erosion and conserving water through construction of trenches, promoting legumes as intercrops as well as cover crops, water harvesting and utilization of rain water, improved integration with livestock and improved management of community land resources. These interventions made significant contribution to reduce erosion, improve soil fertility, improve resilience to droughts and increase economic benefits while enhancing sustainability. A total of 150 ha was covered by these interventions benefitting more than 100 households. Intercropping with pigeon pea is now taken up for promotion by the local extension system and NGOs to cover more than 300 farmers in 2016. The 20 farm ponds along with drip irrigation system helped

farmers get an additional EBr 2000/yr (US\$ 100) from the 400 m² area under irrigation. Introduction of legumes as cover crops during short belg season which traditionally is not cropped helped farmers in getting a benefit equivalent to 20 kg N/ha and improved the quality and availability of fodder to cattle. Increased production and consumption has also improved the nutritional status of the households. Access to credit is improved with the increasing operations of thrift societies and lending by micro-finance company.

3. Problem/Challenge Overview

High levels of land degradation have been one of the major areas of concern in Ethiopia. Among the key processes contributing to degradation and thereby loss in productive potential are erosion and loss of fertile top soil, continuous nutrient mining leading to decline in soil fertility and practice of poor crop management practices resulting in soil organic matter depletion and associated changes in the soil physical characteristics. Uncertainty and risk associated with variable rainfall and occurrence of frequent droughts are further contributing factors. While the systems productivity is declining, there is a growing demand for food and fodder from increasing population. Sustaining productivity of the system while meeting the demands for food and fodder is the greatest challenge that the farmers in the dryland areas are confronted with. The predicted changes in climate are expected to further exacerbate the situation. Hence, there is an urgent need to intensify the production without degrading the resource base. The proposed interventions are aimed at achieving this by developing scalable models of sustainable intensification.

4. What are the main research activities?

Efforts to intensify the system require several interventions that address the identified constraints. Such interventions can only be implemented through effective and efficient participation of various developmental and research organizations. To achieve these following activities were implemented.

1. Formation and operation of IP with key partners that include research, government and non-government development agencies and private sector – An IP with 3 CG centers, 3 NGOs, 2 NARS, 2 private sector and local government and farmer associations was formed and operated successfully
2. Constraint analysis and ex-ante analysis of potential options for their productivity, profitability and end user acceptability – Ex-ante analysis of potential interventions was carried out using long-term climate data and local costs of inputs and outputs and their adaptability by local farmers was evaluated through IP deliberations
3. Intensification of the system with appropriate crops and systems – Among the interventions promoted are intercropping with pigeon pea, improved varieties of major crops maize, wheat and haricot beans combined with in situ water harvesting techniques and good agronomy.
4. Enhancing soil fertility with low cost locally relevant options – Interventions included use of belg rains for growing legume cover crops, improved methods of composting, greater use of organic amendments, increased area under legumes especially with Haricot beans
5. Promoting water harvesting and drip irrigation systems for improved resilience and income – 20 farm ponds were constructed with support of local government and farmer contributions and equipped with drip irrigation systems to irrigate 400 m² area with assistance of a local NGO and promoted planting of mango and other trees

6. Arresting degradation and improved management of common lands – Constructed contour bunds over 50 ha area, strengthened bunds with pigeon pea and Napier grass, rehabilitated 100 ha degraded communal land with area enclosure program of Government of Ethiopia, planted 6000 multi-purpose trees
7. Improved access to inputs – promoted access to credit by linking with a micro-finance company and by forming women thrift groups, established revolving seed systems for distribution of improved seed
8. Harnessing synergies with livestock – Promoted improved breeding and feeding practices and increased fodder availability practices

5. What are the main Outcomes of your research?

Among the participating farmers, cropping intensity is increased by up to 60%, total production increased by 35%, fodder availability increased by 20%, and the income of farmers who have constructed farm ponds has gone up by about US\$ 100. Area under legumes increased by 20% with benefits to household nutrition and soil health. During 2015, a drought year in Ethiopia the farmers who have adopted the interventions had better access to food. The collective efforts helped farmers access about EBr 5.1 m annually from Micro-finance company to invest in irrigation systems and inputs with 100% repayments. About 100 ha degraded communal land is rehabilitated for use by local communities by planting 6000 multipurpose trees which increased the fodder availability.

6. What are the main research Outputs that resulted in the outcome(s)?

Important research outputs are formation and operation of IP which helped in harnessing synergies between various developmental initiatives leading to bigger impacts, Knowledge on contributions by various management options to sustainable intensification, database on soil, climate and crop and quantified information on role of pigeon pea in intensification of the maize and wheat based cropping systems. Crop simulation model calibrated for locally relevant crop varieties is a tool that researchers can use to assess the trends in productivity, profitability and sustainability of various management options.

7. Who were the intermediary and direct users of your research outputs and what role did they play in achieving the outcome?

Bureau of Agriculture
 Oromia Agricultural Research institute
 Ethiopian Institute of Agricultural Research
 Non-Government developmental agencies
 Research community
 Farming community

8. How were your research outputs used (will be used in the future)?

Forming an IP around a development challenge and addressing the problem collectively was found to be a very effective way of addressing the multiple challenges faced by dryland systems. The government and non-governmental developmental agencies can adopt this model. Till now there is no information on the long-term performance of many locally adopted and recommended technologies. The information generated by the project will help researchers and extension agencies in better understanding the consequences of various practices while recommending for end user adoption. The database and calibrated APSIM model will help the research community in various studies in the target area. Farmers are

benefitted with the introduction of pigeon pea as intercrop without any need to reduce the area under cultivation of their preferred crops. This not only improved the overall productivity but also contributed to the improved nutrition at household level. Over the next few years, it has the potential to become a common practice with the farmers in the target area.

9. What is the Evidence of Your Research Outcomes?

Data collected from both on-farm and on-station trials is the primary evidence in support of the outcomes. The local Bureau of Agriculture is now actively promoting production of sorghum. Opinions expressed by the participant farmers and the growing interest among farmers to adopt some of the tested options like intercropping with pigeon pea and construction of farm ponds is an indication that the practices are profitable and acceptable to farmers. With little support such as providing access to seed, support for making farm ponds these interventions can be scaled up effectively. All the IP partners have adopted the approach used in this study.

10. Testimonials

ICARDA and ICRAF scientists who participated in the IP for first time commented that “bringing different stakeholders together and working collectively towards a common goal is the most effective way to develop locally relevant interventions with a high chance of adoption by smallholder farmers”

Abu Tona, a 39-year old farmer is one of the 50 farmers from Haleku Gulenta Kebele of Adami Tulu district of Ethiopia who has adopted intercropping with pigeon pea and also dug farm pond the water from which he used to cultivate onions and tomatoes. He testified that these approaches have really changed the way he was farming and helped him to become food secure and improve his income.

Dr. Chandra A. Madramootoo, Chair, ICRISAT Governing Board has commended the efforts which helped farmers improve their production and income.

11. Lessons Learned

Several technological options for sustainably intensify the smallholder cropping systems are available. It is possible to promote their adoption at scale by evaluating their suitability into local farming systems.

For sustainable uptake, there is a need to involve the local extension agents and create necessary support mechanisms such as access to seed, finance and other inputs.

12. Full reference citations and URL link to published research work.

Homann-Kee Tui S, Hendrickx S, Manyawu GJ, Rao KPC and Robinson L 2015
Implementing Innovation Platforms: a guideline for Dryland Systems Research. Manual.
CGIAR Research Program on Dryland Systems.

SECTION V – LIST OF 2015 PUBLICATIONS AND SCIENTIFIC OUTPUTS

In 2015, ICRISAT produced under the framework of the CGIAR Research Program on Dryland Systems a total of 69 published articles (13 indexed by ISI), 9 book chapters and several technical briefs, abstracts in conference proceedings, open access data. This extensive body of scientific work demonstrates that significant outputs around systems work requires 3-4 years of well planned and executed R4D. While outcomes at the farm level have been mainly at a pilot scale, significant outcomes in institutional capability (i.e. in the capabilities of our NARS and NGO partners to undertake systems R4D) are evident and long term. The success of such work relies on well-established partnerships and consistency in funding – continuous cuts in funding from 2014 and no funds in 2016 has resulted in the collapse of much of this work and reallocation or retrenchments of the key scientists.

The following represents a summary of all 2015 publications and research outputs produced by ICRISAT under Dryland Systems by SA, ESA and WAS regions, including full and correct citation of all publications, web link and categories of scientific output marked with the following codes to indicate:

- (S) = multidisciplinary/system research
- (M) = mono-disciplinary research
- [X.XX]= ISI Impact Factor¹
- (O) = Open Access

Table 1. Summary of all ISI publications

Region/AL S	ISI Factor [range of ISI scores]	ISI Open (% of ISI articles)	ISI Monodisciplinary (% of ISI articles)	ISI Multidisciplinary (% of ISI articles)	
WAS/					5
NAWA/					
ESA/	2.91				1
CA/					
SA/					7
TOTAL					13

Table 2. Summary of Non-ISI Publications

Region/AL S	Non-ISI Articles	Book Chapters	Technical Reports & Working Papers	Proceedings	Datasets	Other
WAS/	3			5		
NAWA/						
ESA/		4	3	3	5	4
CA/						
SA/	3		3	6	3	14
TOTAL	6	4	6	14	8	18

ISI Journal Articles (13)

1. Falconnier GN, Descheemaeker K, Van Mourik TA, Sanogod OM, Giller KE. Understanding farm trajectories and development pathways: Two decades of change in southern Mali. *Agricultural Systems* 139 210–222.

¹ For ISI, the JCR Impact Factor List for 2013 has used (<https://www.360researchpapers.com/resources/impact-factor>, accessed 6 July 2015). For journals not listed, the website of that journal was checked and if it lists an Region ISI factor, this was recorded.

2. Haileslassie Amare, Craufurd P, Ramilan T, Kumar Shalander, Whitbread AM, Rathore A, Blummel M, Ericsson P, Krishna Reddy K. 2016. Empirical evaluation of sustainability of divergent farms in the dryland farming systems of India. *Ecological Indicators* 60: 710–723.
3. Homann-Kee Tui S., Valbuena D., Masikati P., Descheemaeker K., Nyamangara J., Claessens L., Erenstein O., Van Rooyen AF. & Nkomboni D. 2015. Economic trade-offs of biomass use in crop-livestock systems: exploring more sustainable options in semi-arid Zimbabwe. *Agricultural Systems* 134, 48-60.
4. Ibrahim A, Abaidoo RC, Fatondji D, Opoku A. 2015a. Integrated use of fertilizer micro-dosing and *Acacia tumida* mulching increases millet yield and water use efficiency in Sahelian semi-arid environment. *Nutrient Cycling in Agroecosystems* 103, 375-388. DOI 10.1007/s10705-015-9752-z
5. Ibrahim A, Abaidoo CR, Fatondji D, Opoku A. 2015b. Determinants of fertilizer microdose-induced yield increment of pearl millet on an acid sandy soil. *Experimental Agriculture* Doi:10.1017/S0014479715000241
6. Ibrahim A, Abaidoo CR, Fatondji D, Opoku A. 2015c. Hill placement of manure and fertilizer micro-dosing improves yield and water use efficiency in the Sahelian low input millet-based cropping system. *Field Crops Research* 180 29–36 <http://dx.doi.org/10.1016/j.fcr.2015.04.022>.
7. Kurai T, Morey SR, Wani SP and Watanabe T. 2015. Efficient rates of nitrogenous fertiliser for irrigated sweet sorghum cultivation during the post-rainy season in the semi-arid tropics. *European Journal of Agronomy* 71: 63–72.
8. McBeath TM, Llewellyn RS, Gupta VVSR, Davoren CW and Whitbread AM. 2015. Break Crop Effects on Wheat Production across Soils and Seasons in a Semi-Arid Environment. *Crop and Pasture Science* 66, 566-579. DOI10.1071/CP14166.
9. Nageswara Rao V, Meinke H, Craufurd PQ, Parsons D, Kropff MJ, Anten NPR, Wani SP and Rego TJ. 2015. Strategic double cropping on Vertisols: A viable rainfed cropping option in the Indian SAT to increase productivity and reduce risk. *European Journal of Agronomy* 62, 26-37
10. Valbuena D., Homann-Kee Tui S., Erenstein O., Teufel N., Duncan AJ., Abdoulaye T., Swain B., Mekonnen K., Germaine I. & Gérard B. 2015. Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South Asia. *Agricultural Systems* 134, 107-118 (DOI: 10.1016/j.agry.2014.05.013).
11. Wani SP., Chander G., Sahrawat KL., Pal DK., Pathak P. (2015). Sustainable use of natural resources for crop intensification and better livelihoods in the rainfed semi-arid tropics of Central India. *NJAS-Wageningen Journal of Life Sciences* <http://dx.doi.org/10.1016/j.njas.2015.12.002>
12. Whitbread AM, Davoren C, Gupta V.V.S.R. Llewellyn R, Roget D. 2015. Long-term cropping system studies support intensive and responsive cropping systems in the low rainfall Australian Mallee. *Crop and Pasture Science* 66, 553-565. DOI10.1071/CP14136
13. Yelemou B, Savadogo P, Traore S, Millogo-Rasolodimby J and Hien V. 2015. - Floristic diversity of Piliostigma associations in relation to latitudinal gradient, soil and climate variables in Burkina Faso, West Africa. *Tropical Ecology* 56 (1), 57-76.

Non-ISI Journal Articles and Theses (6)

1. Jarial, S. Hakeem A Ajeigbe, Shehu Yahaya, Salissou Issa, Mamman K Nouri. 2015. - Innovation Platform: method to engage crop-livestock stakeholders in West Africa. International Journal of Agricultural Extension. <http://escijournals.net/index.php/IJAE/article/view/1305>
2. Jarial S. 2015. Comparative Analysis of Fodder and Grain from Dual Purpose Barley vis-a-vis Local Variety in Hills of Uttarakhand, India. Volume 15 Number 3. Pages: 47-51. September 2015. Indian Research Journal of Extension Education. <http://seea.org.in/irjee/upload/v15309.pdf>
3. Kumar, S., Raju B M K, Ramarao C A and Ramilan T 2015a. Sensitivity of Livestock Production to Climatic Variability under Indian Drylands and Future Perspective. Current Agricultural Research, 3 (2): 142-149, <http://dx.doi.org/10.12944/CARJ.3.2.08>
4. Kumar S., Ramilan T and Ramana DVB 2015b. Supply Chain and Sustainability Issues of Graded Murrah Buffaloes: A Case Study of Urban Dairy Farms in Hyderabad, India. Indian Journal of Agricultural Marketing, 29: 21-30.
5. Rana RK, Arya S., Kumar Sanjay, Singh BP, Adinarayana G, Kumar Shalander and Kadian MS 2015. Analysis of pre-requisites and framework for introducing potato crop in non-traditional Anantapuram District of Andhra Pradesh. International Journal of Tropical Agriculture, 33 (2): 824-830.
6. Issa, S., Sapna Jarial, Nouri Brah, Labo Harouna, and Idrissa Soumana. October 2015. Use of sorghum on stepwise substitution of maize in broiler feeds in Niger. Paper accepted in the journal Livestock Research for Rural Development. <http://www.lrrd.org/lrrd27/10/issa27212.html>

Book Chapters (4)

1. Miriti JM, Esilaba AO, Rao KPC, Onyango JW, Kimani SK, Njeru PM and Lekasi JM. 2015. Adapting agriculture to climate change: An evaluation of yield potential of maize, sorghum, common bean and pigeon pea varieties in a very cool-wet region of Nyandarua county, Central Kenya In Filho WL, Esilaba AO, Rao KPC and Sridhar G. (Eds) 2014. Adapting African Agriculture to Climate Change: Transforming Rural Livelihoods. Springer, Switzerland, 97-108. Springer ISBN 978-3-319-12999-0 ISBN 978-3-319-13000-2 (eBook), DOI 10.1007/978-3-319-13000-2
2. NGUGI LW, Rao KPC, Oyoo A and Kwena K. 2015. Opportunities for coping with climate change and variability through adoption of soil and water conservation technologies in semi-arid eastern Kenya. In Filho WL, Esilaba AO, Rao KPC and Sridhar G. (Eds) 2014. Adapting African Agriculture to Climate Change: Transforming Rural Livelihoods. Springer, Switzerland, 149-158. Springer ISBN 978-3-319-12999-0 ISBN 978-3-319-13000-2 (eBook), DOI 10.1007/978-3-319-13000-2
3. Njeru PNM, Mugwe JMI, Mucheru-Muna M, Mugendi D, Lekasi JK, Kimani SK, Miriti J, Oeba VO, Esilaba AO, Mutuma E, Rao KPC and Muriithi F. 2015. Integrating farmers and scientific methods for evaluating climate change adaptation options in Embu county. In Filho WL, Esilaba AO, Rao KPC and Sridhar G. (Eds) 2014. Adapting African Agriculture to Climate Change: Transforming Rural Livelihoods. Springer, Switzerland, 185-198. Springer ISBN 978-3-319-12999-0 ISBN 978-3-319-13000-2 (eBook), DOI 10.1007/978-3-319-13000-2

4. De Trincheria J, Craufurd PQ, Harris D, Manneke F, Nyamangara J, Rao KPC and Leal FW. 2014. Adapting agriculture to climate change by developing promising strategies using analogue locations in eastern and southern Africa: a systematic approach to develop practical solutions. In Filho, W.L., Esilaba, A.O., Rao, K.P.C. and Sridhar, G. (Eds) 2015. Adapting African Agriculture to Climate Change: Transforming Rural Livelihoods. Springer, Switzerland, 1-24. Springer ISBN 978-3-319-12999-0 ISBN 978-3-319-13000-2 (eBook), DOI 10.1007/978-3-319-13000-2

Technical Reports and Working Papers (6)

1. Homann-Kee Tui S, Hendrickx S, Manyawu GJ, Rao KPC and Robinson L 2015 Implementing Innovation Platforms: a guideline for Dryland Systems Research. Manual. CGIAR Research Program on Dryland Systems.
2. Magalhaes M, Mwakiwa E, Sambule N, Homann-Kee Tui, S., Rainde JO, Coma GP, Manda. 2015 Common beans: Benefits for farmers engaging in market-oriented production. MOREP project information brief in English and Portuguese languages. ICRISAT. [http://oar.icrisat.org/9024/1/Flyer %20Common%20Beans English.pdf](http://oar.icrisat.org/9024/1/Flyer%20Common%20Beans%20English.pdf)
3. Rainde JO, Homann-Kee Tui, S, Vilela F, Quembo C, Assane F, Gule C, Senda T, Masikati P. 2015. Sustainable intensification of smallholder farming in central Mozambique: Benefits from better integration of crops and livestock. MOREP project information brief in English and Portuguese languages. ICRISAT. [http://oar.icrisat.org/9025/1/Flyer %20Sustainable%20intensification%20of%20smallholder English.pdf](http://oar.icrisat.org/9025/1/Flyer%20Sustainable%20intensification%20of%20smallholder%20English.pdf)
4. Palanisami K, Haileslassie A, Kakumanu Krishna Reddy, Ranganathan CR, Wani SP, Craufurd P and Kumar Shalander. 2015. Quantification of Risk Associated with Technology Adoption in Dryland Systems of South Asia. A Household Level Analysis in Andhra Pradesh, Karnataka and Rajasthan States of India. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 44 pp. [http://oar.icrisat.org/8979/1/Cvr Final.pdf](http://oar.icrisat.org/8979/1/Cvr%20Final.pdf)
5. Palanisami K, Haileslassie A, Kakumanu Krishna Reddy, Ranganathan CR, Wani SP, Craufurd P and Kumar Shalander. 2015. Climate Change, Gender and Adaptation Strategies in Dryland Systems of South Asia. A Household Level Analysis in Andhra Pradesh, Karnataka and Rajasthan States of India. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 36 pp. [http://oar.icrisat.org/8978/1/CCGender Report Cvr Final.pdf](http://oar.icrisat.org/8978/1/CCGender%20Report%20Cvr%20Final.pdf)
6. Palanisami K, Kakumanu KR, Ranganathan CR, Haileslassie A and Wani SP. 2015. Mapping of household vulnerability and identification of adaptation strategies in dryland systems of South Asia. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 60 pp. [http://oar.icrisat.org/9120/1/Vulnerability%20HHs%20report Final.pdf](http://oar.icrisat.org/9120/1/Vulnerability%20HHs%20report%20Final.pdf)

Proceedings (13)

1. Akinseye Folunso M, Madina D, Adam M, Traoré PS, Agele Samuel O, Whitbread AM. 2015. Assessing the vulnerability of sorghum to changing climate conditions in West Africa semi-arid tropics. P39. In: Building tomorrow's research agenda and bridging the science-policy gap. CIRAD, INRA, IRD, Agropolis International, Wageningen UR, CGIAR, UCDAVIS, FAO, Agreenium, GFAR. Montpellier: CIRAD, Résumé, 128. <http://csa2015.cirad.fr/var/csa2015/storage/fckeditor/file/L3%20Towards%20Climate->

[smart%20Solutions\(1\).pdf](#)

2. Adam M, Bertrand M, Traoré PS, Akinseye F, Malick N. 2015. Network of experiments to phenotype contrasted sorghum and to model its adaptability in West African environments. P40. In : Building tomorrow's research agenda and bridging the science-policy gap. CIRAD, INRA, IRD, Agropolis International, Wageningen UR, CGIAR, UCDAVIS, FAO, Agreenium, GFAR. Montpellier : CIRAD, Résumé, 129. [http://csa2015.cirad.fr/var/csa2015/storage/fckeditor/file/L3%20Towards%20Climate-smart%20Solutions\(1\).pdf](http://csa2015.cirad.fr/var/csa2015/storage/fckeditor/file/L3%20Towards%20Climate-smart%20Solutions(1).pdf)
3. Falconnier GN, Descheemaeker K, Van Mourik TA, Giller KE. 2015. Innovative participatory farming system design: combining on-farm crop/livestock trials with ex-ante trade-off analysis, in: Gritti ES, Wery J. (Eds.), Proceedings of the 5th International Symposium for Farming Systems Design. Montpellier, pp. 485–486, <http://fsd5.european-agronomy.org/documents/proceedings.pdf>
4. Farquharson RJ, Freebairn JW, Webb JA, Stewardson MJ, Ramilan T. 2015. Allocating limited water: linking ecology and economics, MODSIM 2015: 21st International Congress on Modelling and Simulation, Gold Coast, Queensland, Australia, 29 November - 4 December.
5. HOMANN-KEE TUI S, Masikati P, Dube T, de Voil P, Van Rooyen AF, Rodriguez D and Valdivia R. 2015. Co-designing the transitions towards integrated market oriented mixed farming systems in semi-arid Zimbabwe. Tropical Agriculture Conference. 16-18 November 2015. Brisbane Convention & Exhibition Centre.
6. Homann-Kee Tui S, Descheemaeker K, Masikati , Gama CA, Crespo O, Claessens L, Valdivia R. 2015. Re-designing smallholder farming futures for reduced vulnerability to climate change in semi-arid southern Africa. Oral presentation at 5th International Symposium for Farming Systems Design, 7-10 September, Montpellier.
7. Kumar Shalander, Whitbread A, Ramilan T, Bhati TK 2015. Institutional and technological options for sustainable intensification of community based Silvi-pasture systems in arid ecoregions. Conference paper November 2015, 23rd International Grassland Congress, New Delhi. DOI: 10.13140/RG.2.1.1990.2808
8. Kumar Shalander, Whitbread A, Ramilan T 2015. Institutionalizing Systems Approaches for Improving Agricultural Livelihoods in an Arid Ecoregion of South Asia. Conference paper September 2105, 5th International Symposium for Farming Systems Design, 7-10 September 2015, Montpellier, France: 497-498. <http://oar.icrisat.org/9338/>
9. Orr, A., Tsusaka, T., Homann- Kee-Tui, S. and Msere, H. (2015) What do we mean by 'women's crops'? Commercialisation, gender, and the power to name. In: International Conference of Agricultural Economists (ICAE), August 8-14, 2015, Milan, Italy.
10. Ramilan T, Kumar Shalander, Rao, VNR, Whitbread A 2015. Characterization of farming systems in drylands of South Asia for assessing resource constraints and technologies. Conference paper September 2105, 5th International Symposium for Farming Systems Design, 7-10 September 2015, Montpellier, France: 139-140.
11. Ramilan T, Kumar S, Whitbread AM. A bioeconomic household model for assessing the impact of technological interventions in dryland systems of South Asia By The Australian Agricultural and Resource Economics Society Inc. Feb 10-13, Rotorua, New Zealand.

12. Verkaart S, Munyua B and Mausch K. 2015. The impact of improved chickpea adoption on poverty reduction in Ethiopia. Paper presented at PEGNet 2015, Berlin, Germany.
13. Whitbread, A.M. 2015. Understanding the importance of managing climate risk in the restoration and conservation of natural capital in the dryland cereal systems. Proceedings of the Transitioning Cereal Systems to Adapt to Climate Change, <http://aridcereals.org>

Data sets (8)

1. Rao, K.P.C.; Alemayehu Eshete; Kedir Wako; Gizachew Legesse; Ermias Alemu, 2015, "Baseline survey data covering 301 households in Haleku Gulenta and Dodicha kebeles in Adamitullu Woreda, Ethiopia", <http://dx.doi.org/10.7910/DVN/WVF9SD>, Harvard Dataverse, V1
2. Rao, K.P.C.; Kedir Wako; Gizachew Legesse; Ermias Alemu; Jemal Seid; Robel Tekele Miteku, 2015, "Daily rainfall, maximum and minimum temperatures and solar radiation records from 1982 to 2013 for Adamitullu, Ethiopia", <http://dx.doi.org/10.7910/DVN/IKMU6A>, Harvard Dataverse, V1
3. Rao, K.P.C.; Gizachew Legesse; Ermias Alemu, 2015, "Area, production and productivity of major cereal and pulse crops grown in East Shewa zone of Oromiya region, Ethiopia", <http://dx.doi.org/10.7910/DVN/30U2LU>, Harvard Dataverse, V1
4. Legesse Gizachew; Rao, K.P.C. 2015, "Landuse and land cover data of Haleku Gulenta and Dodicha Kebeles in Adamitullu Woreda, Ethiopia", <http://dx.doi.org/10.7910/DVN/WD7GCN>, Harvard Dataverse, V1
5. Rao, K.P.C; Kedir Wako; Alemayehu Eshete, 2015, "Soil properties of 40 farmer fields in Haleku Gulenta and Dodicha kebeles of Adamitullu woreda, Ethiopia", <http://dx.doi.org/10.7910/DVN/GM2YV0>, Harvard Dataverse, V1
6. <http://dataverse.icrisat.org/dvn/dv/crpds/faces/study/StudyPage.xhtml?globalId=hdl:11038/10143>
7. <http://dataverse.icrisat.org/dvn/dv/crpds/faces/study/StudyPage.xhtml?globalId=hdl:11038/10146>
8. <http://dataverse.icrisat.org/dvn/dv/crpds/faces/study/StudyPage.xhtml?globalId=hdl:11038/10152>

Other publications (18)

Success stories published in media

1. <http://drylandsystems.cgiar.org/content/community-led-solutions-india's-drylands>
2. <http://www.thethirdpole.net/2015/11/26/rajasthani-women-farmers-combat-climate-change-in-the-desert/>
3. <http://www.hindustantimes.com/jaipur/desert-farmers-on-the-path-to-economic-self-reliance/article1-1353429.aspx>
4. <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1693.htm#1>
5. <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1638.htm#5>

6. <http://timesofindia.indiatimes.com/city/jaipur/Herb-cultivation-benefits-western-Rajasthan-farmers/articleshow/48417637.cms>
7. <http://www.thehansindia.com/posts/index/2015-11-29/COP21-Indian-women-leading-the-fight-against-climate-change-189667>
8. <http://www.ruralmarketing.in/industry/case-studies/women-farmers-combating-climate-change-in-rajasthan>
9. <http://timesofindia.indiatimes.com/city/hyderabad/Rajasthans-women-farmers-beat-climate-change-global-warming/articleshow/49935536.cms>
10. <http://www.aljazeera.com/indepth/inpictures/2015/11/women-lead-poverty-indian-desert-151117123726261.html>
11. <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1625.htm#3>
12. <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1684.htm>
13. Rainde JO, HOMANN-KEE TUI S, Vilela F, Quembo C, Assane F, Gule C, Senda T, Masikati P. 2015. Sustainable intensification of smallholder farming in central Mozambique: Benefits from better integration of crops and livestock. MOREP project information brief in English and Portuguese languages. ICRISAT. [http://oar.icrisat.org/9025/1/Flyer %20Sustainable%20intensification%20of%20smallholder_English.pdf](http://oar.icrisat.org/9025/1/Flyer_%20Sustainable%20intensification%20of%20smallholder_English.pdf)
14. Shalander Kumar, Ramilan Thiagarajah and P ParthasarathyRao 'Potential of Small Ruminants in Andhra Pradesh for promoting rural livelihoods: Institutional and policy gaps to be addressed' prepared for Commission on Inclusive and sustainable agriculture development of Andhra Pradesh, Govt of Andhra Pradesh, India, pp.13.
15. <http://www.trust.org/item/20151214144138-670zj/>
16. <https://www.thestandard.co.zw/2015/12/20/can-farming-shift-save-stricken-zim/>
17. <http://www.icrisat.org/newsroom/latest-news/happenings/happenings1686.htm#2>
18. <http://drylandsystems.cgiar.org/content/farmers-central-mozambique-taste-success-commercialization-common-bean>

Annex 1: CRP indicators of progress, with glossary and targets

Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
KNOWLEDGE, TOOLS, DATA				
1. Number of “products” produced by the Center	Glossary: These are frameworks and concepts that are significant and complete enough to have been highlighted on web pages, publicized through blog stories, press releases and/or policy briefs. They are significant in that they should be likely to change the way stakeholders along the impact pathway allocate resources and/or implement activities. They should		5	5
2. Number of products produced that have explicit target of women farmers/NRM managers	Glossary: The web pages, blog stories, press releases and policy briefs supporting indicator #1 must have an explicit focus on women farmers/NRM managers to be counted Provide concrete examples of what you include in this indicator		5	5
3. Number of products produced that have been assessed for likely gender-disaggregated impact	Glossary; Reports/papers describing the products should include a focus on gender-disaggregated impacts if they are to be counted Provide concrete examples of what you include in this indicator		5	5
4. Number of “tools” produced by the Center	Glossary: These are significant decision-support tools, guidelines, and/or training manuals that are significant and complete enough to have been highlighted on web pages, publicized through blog stories, press releases and/or policy briefs. They are significant in that they should be likely to		2	2
5. Number of tools that have an explicit target of women farmers	Glossary: The web pages, blog stories, press releases and policy briefs supporting indicator #4 must have an explicit focus on women farmers/NRM managers to be counted		2	2
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
KNOWLEDGE, TOOLS, DATA				
6. Number of tools assessed for likely gender-disaggregated impact	Glossary: Reports/papers describing the products should include a focus on gender-disaggregated impacts if they are to be counted		8	8
7. Number of open access databases maintained by Center	Indicate the type of data bases (e.g., socio-economic survey data; crop yields in field experiments...) you are reporting on in the following columns		8	8
8. Total number of users of these open access databases			10	10
9. Number of publications in ISI journals produced by Center			56	56

10. Number of strategic value chains analyzed by Center	Clearly indicate the type of value chains you are reporting on in the next columns		4	4
11. Number of targeted agro-ecosystems analysed/ characterised by Center	Specify the type of system, using its main products as descriptors (e.g., mixed crop, livestock system; monoculture of XX; agroforestry with maize, beans, etc.; mixed cropping with upland rice, cassava, etc...)by geographical location and agroecological zones (FAO typology)		3	3
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
KNOWLEDGE, TOOLS, DATA				
12. Estimated population of above-mentioned agro-ecosystems				
CAPACITY ENHANCEMENT AND INNOVATION PLATFORMS				
13. Number of trainees in short-term programs facilitated by Centre (male)	Glossary: The number of individuals to whom significant knowledge or skills have been imparted through interactions that are intentional, structured, and purposed for imparting knowledge or skills should be counted. This includes farmers, ranchers, fishers, and other primary sector producers who receive training in a variety of best practices in productivity, post-harvest management, linking to markets, etc. It also includes rural entrepreneurs, processors, managers and traders receiving training in application of new technologies, business management, linking to markets, etc. and training to extension specialists. (see above, but for female)		500	500
14. Number of trainees in short-term programs facilitated by Centre (female)			250	50
15. Number of trainees in long-term programs facilitated by Center (male)	Glossary: The number of people who are currently enrolled in or graduated in the current fiscal year from a bachelor's, master's or Ph.D. program or are currently participating in or have completed in the current fiscal year a long term (degree-seeking) advanced training program such as a fellowship program or a post-doctoral studies program. A person completing one long term training program in the (see above, but for female)		250	450
16. Number of trainees in long-term programs facilitated by Center (female)			2	1
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target

CAPACITY ENHANCEMENT AND INNOVATION PLATFORMS				
17. Number of multi-stakeholder R4D innovation platforms established for the targeted agro-ecosystems by the Center	Glossary: To be counted, a multi-stakeholder platform has to have a clear purpose, generally to manage some type of tradeoff/conflict among the different interests of different stakeholders in the targeted agro-ecosystems, and inclusive and clear governance mechanisms, leading to decisions to manage the variety of perspectives of stakeholders in a manner		5	5
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT				
18. Number of technologies/NRM practices under research in the Center (Phase I)	Glossary: Technologies to be counted here are agriculture-related and NRM-related technologies and innovations including those that address climate change adaptation and mitigation. Relevant technologies include but are not limited to: <ul style="list-style-type: none"> • Mechanical and physical: New land preparation, harvesting, processing and product handling technologies, including biodegradable packaging • Biological: New germplasm (varieties, breeds, etc.) that could be higher-yielding or higher in nutritional content and/or more resilient to climate impacts; affordable food-based nutritional supplementation such as vitamin A-rich sweet potatoes or rice, or high-protein maize, or improved livestock breeds; soil management practices that increase biotic activity and soil organic matter levels; and livestock health services and products such as vaccines; • Chemical: 		25	25
19. Number of technologies under research that have an explicit target of women farmers	The papers, web pages, blog stories, press releases and policy briefs supporting indicator #x must have an explicit focus on women farmers/NRM managers to be counted		10	10
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT				
20. Number of technologies under research that have been assessed for likely gender-disaggregated impact	Reports/papers describing the products should include a focus on gender-disaggregated impacts if they are to be counted		10	10
21. Number of agro- ecosystems for which CRP has identified feasible approaches for improving ecosystem services and for establishing positive incentives for farmers to improve ecosystem functions as per the CRP's recommendations	Use the same classification of agro-ecosystem as for indicator 11 above, including geographical location and agro-ecological zone		0	0

22. Number of people who will potentially benefit from plans, once finalised, for the scaling up of strategies	Indicate the potential number of both women and men			
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT				
23. Number of technologies /NRM practices field tested (phase II)	Glossary; Under "field testing" means that research has moved from focused development to broader testing (pilot project phase) and this testing is underway under conditions intended to duplicate those encountered by potential users of the new technology. This might be in the actual facilities		25	25
24. Number of agro-ecosystems for which innovations (technologies, policies, practices, integrative approaches) and options for improvement at system level have been developed and are being field tested (Phase II)	Clearly identify in this cell the type of technology and the geographical location of the field testing/pilot projects, and use the same classification of agroecosystem as for indicator 11, specifying the type of agroecosystems in which field testing is taking place		3	3
25. Number of above innovations/approaches/options that are targeted at decreasing inequality between men and women			5	5
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT				

26. Number of published research outputs from CRP utilised in targeted agro-ecosystems			13	13
27. Number of technologies/NRM practices released by public and private sector partners globally (phase III)	Glossary: In the case of crop research that developed a new variety, e.g., the variety must have passed through any required approval process, and seed of the new variety should be available for multiplication. The technology should have proven benefits and be as ready for use as it can be as it emerges from the research and testing process. Technologies made available for transfer should be only those made available in the current reporting year. Any technology made available in a previous		2	2
POLICIES IN VARIOUS STAGES OF DEVELOPMENT				
28. Numbers of Policies/ Regulations/ Administrative Procedures Analyzed (Stage 1)	Number of agricultural enabling environment policies / regulations / administrative procedures in the areas of agricultural resource, food, market standards & regulation, public investment, natural resource or water management and climate change adaptation/mitigation as it relates to agriculture that underwent the first stage of the policy reform process i.e. analysis (review of existing policy / regulation / administrative procedure and/or proposal of new policy / regulations / administrative procedures). Please count the highest stage completed during the reporting year – don't double count for the same policy. Clearly identify in this cell the type of policy.		0	0
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
POLICIES IN VARIOUS STAGES OF DEVELOPMENT				
29. Number of policies / regulations / administrative procedures drafted and presented for public/stakeholder consultation (Stage 2) that underwent the second stage of the policy reform process. The second stage includes public debate and/or consultation with stakeholders on the proposed new or revised policy / regulation / administrative procedure. Clearly identify in this cell the type of policy, regulations and so on, and the geographical location of the consultations		0	0
30. Number of policies / regulations / administrative procedures presented for legislation (Stage 3)	: ... underwent the third stage of the policy reform process (policies were presented for legislation / decree to improve the policy environment for smallholder-based agriculture.) Clearly identify in this cell the type of policy and the country/region concerned		0	0

31. Number of policies / regulations / administrative procedures prepared passed/approved (Stage 4)	: ...underwent the fourth stage of the policy reform process (official approval (legislation/decreed) of new or revised policy / regulation / administrative procedure by relevant authority). Clearly identify in this cell the type of policy and the country/region concerned		0	0
Indicator	Description of Activities and Products measured by Indicator	Deviation narrative (+/- 10%)	2015 Actual	2016 Target
POLICIES IN VARIOUS STAGES OF DEVELOPMENT				
32. Number of policies / regulations / administrative procedures passed for which implementation has begun (Stage 5)	: ...completed the policy reform process (implementation of new or revised policy / regulation / administrative procedure by relevant authority) Clearly identify in this cell the type of policy and the country/region concerned			
OUTCOMES ON THE GROUND				
33. Number of hectares under improved technologies or management practices as a result of CRP research	Clearly identify in this cell the geographic locations where this is occurring and whether the application of technologies is on a new or continuing area	Karnataka India Niger Rajasthan Andhra Pradesh	4m 90k 5k 10k	4m 90k 5k 10k
34A. Number MALE of farmers and others who have applied new technologies or management practices as a result of CRP research	Clearly identify in this cell the geographic location of these farmers and whether the application of technologies is on a new or continuing area and indicate:	Karnataka India Niger Rajasthan Andhra Pradesh	3m 9k 5k 10k	3m 9k 5k 10k
34B. Number of FEMALE farmers and others who have applied new technologies or management practices as a result of CRP research	Clearly identify in this cell the geographic location of these farmers and whether the application of technologies is on a new or continuing area and indicate:	Karnataka India Niger Rajasthan Andhra Pradesh	1m 9k 5k 10k	1m 9k 5k 10k

Annex 2: Performance indicators for gender mainstreaming with targets defined

Performance Indicator	CRP performance approaches requirements	CRP performance meets requirements	CRP performance exceeds requirements
1. Gender equality targets defined	Sex-disaggregated social data is being collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations	Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations And The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs)	Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations And The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs) And CRP targets changes in levels of gender inequality to which the CRP is or plans to contribute, with related numbers of men and women beneficiaries in main target populations

Annex 3: List of ICRISAT Research Staff contributing to Dryland Systems

Bioversity's 2015 CRP Dryland Systems Final List of personnel and consultants contributing to CRP Dryland Systems in 2015 is available on [CGXchange](#).