The CGIAR Collaborative Research & Capacity Building Program for the Development of Sustainable and Resilient Agricultural Production Systems in Central Asia under the Conditions of Changing Climate

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(1) Introduction

Russian Federation supporting CGIAR Collaborative Research & Capacity Building in Central Asia

In 2013, the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Food Policy Research Institute (IFPRI) launched a four-year "CGIAR Collaborative Research & Capacity Building Program for the Development of Sustainable and Resilient Agricultural Production Systems in Central Asia under the Conditions of Changing Climate" in partnership with the Eurasian Center for Food Security at Moscow State University (ECFS). ECFS acts as the technical focal point on behalf of the Russian Federation, which provides the funding for the program to facilitate strategic collaborative research and capacity-building activities in Central Asia.

Based on the Four-Year Strategic Workplan, elaborated jointly by ICARDA and ECFS, support from the Russian Federation has been utilized to implement research on integrated land and water management in the framework of the CGIAR Research Program "Dryland Systems" (CRP DS), led by ICARDA (*www.drylandsystems.cgiar.org*). The purpose of the research is to attain sustainable growth in agricultural productivity in the dry areas in selected action sites. In addition, the initiative also aims at strengthening agricultural research and capacity-building efforts in Central Asia. It has built on an existing partnership – the consortium of eleven International Agricultural Research Centers, operating in the Region, and the National Agricultural Research Systems (*www.cac-program.org*). Linkages have been established with the Moscow State Lomonosov University and the relevant institutions of the Russian Academy of Agricultural Sciences.

The research outputs and activities listed in Section (3) of this report correspond to the strategic priorities developed and endorsed during the regional inception phase of the CGIAR Research Program "Dryland Systems". ECFS has been fully engaged with ICARDA and other partners in shaping the research agenda during the inception phase (see Sections 5, 6).

Establishing CGIAR Research Program on Dryland Systems

Central Asia is among five Regions where the global CGIAR Research Program "Dryland Systems" has been implemented since 2013. The first regional inception workshop held in June 2012 in Tashkent, Uzbekistan, endorsed an ambitious research framework to tackle the challenges of sustainable agricultural development under the severe environmental conditions characterized by drought, high soil salinity and extreme climatic conditions. The workshop was organized by ICARDA in partnership with the national research partners and other International Agricultural Research Centers. About 100 participants from international centers, national research institutes and universities, farmers' organizations, the private sector, international development and donor agencies, and an emerging civil society attended the workshop. The workshop built on the groundwork carried out by an Interdisciplinary Research Team (IRT), which collected and collated characterization data for selected Action Sites, prepared and formulated research hypotheses. The rationale and the research hypotheses developed at the time are listed in Section (2).

The establishment of the Research Program "Dryland Systems" enables the introduction, development and adoption of new, more water-use efficient technologies, facilitates exchange of knowledge and experience with other parts of the world and creates an innovation platform, bringing together all relevant partner groups from research, policy, education, private sector and practice. It is the first large-scale research program to use an integrated agro-ecosystems approach to improve productivity and livelihoods in the dry areas. It aims to enhance food security for the rural poor and ensure environmental sustainability in dryland agro-ecosystems while enhancing social and gender-equitable development. It focuses on target dryland systems, identified by two criteria: (i) those with the most vulnerable populations, and often associated with severe natural resource degradation; and (ii) those with the greatest potential to impact on food security in the short to medium term.

In Central Asia, the first type is represented by the upper reaches of Amudarya river (Rasht Valley in Tajikistan and neighboring Alay-Chong Alay district in Kyrgyzstan) and the lower reaches of Amudarya and Syrdarya rivers (Aral Sea Region stretching from Turkmenistan through Uzbekistan to Kazakhstan).

The fertile, trans-boundary Fergana Valley was chosen to represent the second type, with so-called satellite sites for future research identified in Azerbaijan. In 2013-2015, research activities have been conducted in the Aral Sea Action Site and the Fergana Valley Action Site (see Section 4). Whereas some preparatory work was completed for Rasht Valley Action Site (characterization data and hypotheses), it was agreed that research activities would be initiated in the second phase of the program.

Considerable deliberation and planning, in particular during the Target Region Implementation and Partnership (TRIP) workshop in Fergana, Uzbekistan, in August 2013, paved the way and set the pace for the collaborative research work. The 2nd International Conference on Arid Land Studies (ICAL 2) on 'Innovations for sustainability and food security in arid and semi-arid areas', an international conference, held in Samarkand, Uzbekistan, in September 2014, gave a renewed impetus to agricultural research cooperation in drylands. More than 220 experts, senior scientists from international research organizations, policymakers and other stakeholders from 24 countries paved the way for the launch of multi-country collaborative projects on salinity management with support from various donors. The DS CRP contributed to the Conference, and helped facilitate the first meeting of Eurasian Soil Partnership, a new chapter of the Global Soil Partnership (GSP) operating under the auspices of the Food and Agriculture Organization of the United Nations (FAO).

With clear priorities defined and a research agenda established for the short to medium term and beyond, the new program has emphasized the important principle of building upon many years of research and collaboration in agricultural pro-development research in the region (see Section 6). The agricultural livelihood systems were defined and their key constraints in meeting the broader Intermediate Development Objectives (IDOs) of the CGIAR identified.

Integrated research approach

An integrated approach is now at the heart of every research activity. The research portfolio aims to sustainably intensify production systems and mitigate risks and reduce vulnerability -- particularly of women and youth throughout Central Asia. But the research activities and outputs need to be put into the wider context of theory of change and impact pathways (see Section 8). Access to quality seed material, varieties, breeds, data and knowledge, advisory services, innovations, technologies, economic incentives, and institutional approaches are needed to enhance the resilience of smallholder farmers, livestock keepers, and rural communities throughout Central Asia. The new approach rests on participatory planning and multi-disciplinary research and work with end-users and beneficiaries to test and scale out innovations, technologies, and research methods, using innovation platforms, multi-stakeholders dialogue and foresight mechanisms. Innovation platforms were established in all Action Sites, and engage with international and national research partners, academia, extension services, farmer representatives, policy makers, development organizations and the private sector.

Linkages have been built with other relevant bilateral projects, which are already being implemented in Central Asia, notably “Knowledge Management in “Central Asian Countries Initiative for Land Management (CACILM) Phase II” and “Economics of Land Degradation”.

Since 2013, ICARDA has made significant progress in the implementation of the planned research and capacity-building activities. Highlights of the work conducted to date are described below, and detailed information on progress made and results produced by Output during 2014-2015 can be found in Sections (6, 7) of this report.

Highlights of progress made in 2013-2015

By some estimates, over 70 per cent of the lands in the region are arid and semi-arid. Salinity, frost, heat, drought, and diseases are major constraints to crop production in Central Asia, severely affecting the livelihoods of rural households. The activity on stress-tolerant varieties included an evaluation of more than 300 improved germplasm resources and varieties - of wheat, chickpea, mungbean, potato, sorghum, finger millet, alfalfa and perennial shrubs - which have the potential to meet the needs of multiple food crops for human consumption and livestock fodder. The program was successful in

identifying stress-tolerant, improved varieties of some of these crops, which are expected to play an important role in coming years.

Salinity in Central Asia affects 15-20 per cent of irrigated production systems. In 2014, a group of researchers and post-graduate students undertook salinity mapping, soil classification, description of plant communities and taxonomic and genetic analyses in selected areas in the Aral Sea Action Site (Khorezm and Karakalpakstan), contributing to the activity on marginal lands. The group of students came from Moscow Lomonosov State University, a partner in implementing the DS CRP in Central Asia.

The dominant cropping system in the irrigated lands of Central Asia is the wheat-cotton rotation, which leaves land fallow during the late summer-autumn period following the wheat harvest. In an effort to intensify land use during this usually crop-free period, cultivation of highly nutritious mungbean and potato were successfully tested as a second crop in 2014, which produced additional income for participating farmers. As mungbean is not a state-controlled crop, this practice could substantially improve farm income, human nutrition, and soil health, as well as generate additional on-farm employment. A serious constraint to up-scaling this intensification strategy is the lack of an adequate mungbean seed supply system. As a result, a set of farmers were subsequently engaged and trained in producing quality seed, a potentially highly profitable enterprise.

Seed supply is not only a constraint for mungbean producers. Newly developed high-yielding varieties of cereals, legumes, potato, and fodders are not reaching poor farmers due to a lack of improved seed in the CRP DS Action Sites in Central Asia. Farmers are therefore growing old varieties of these and other crops, and are unable to improve system productivity and income. To address this gap, the CRP DS activity launched a 'Seed System' activity, emphasizing production of high quality seed and associated capacity building in cooperation with national agricultural research systems and selected farmers, to ensure that quality improved seed becomes more widely available.

Meat, milk, fiber and pelts from small ruminants are key income sources for agro-pastoral communities living in mountainous regions in Tajikistan or on marginal salt-affected land in Uzbekistan. As their main source of fodder sheep and goats depend on rangelands, which occupy a large proportion of the total land area in Central Asia (approximately 260 million hectares or 65% of the total land area). The livestock research activity takes a comprehensive approach by combining value chain analysis with rangeland and livestock research. An artificial insemination campaign was completed in October 2014, building on the work of an earlier ICARDA project. A total of 196 selected goats belonging to the super-nucleus flock owned by the Tajik Livestock Research Institute (TLRI) and a private elite Tajik Angora goat flock were synchronized and inseminated. A toolkit for small ruminant value chain assessment was adapted to Tajikistan and Uzbekistan conditions, and value chain analysis in four villages was completed.

Research was conducted to test and demonstrate the use of Evapotranspiration-based irrigation scheduling for improving water-use efficiency Fergana Valley. Prior to this demonstration experiment, a comprehensive investigation into efficiency of prescribed irrigation scheduling against widely used ET-based irrigation scheduling had been limited. This experiment, while demonstrating the efficiency of ET-based irrigation scheduling, provides crop coefficients for cotton and winter wheat grown in predominant Hydro Module Zones. In addition, the data collected as part of this experiment can be used to conduct crop modelling to evaluate the effects of climate change on water availability and water demand in the Fergana Valley.

Crop diversification and fodder production go hand in hand to support livestock feed security In Aral Sea Region, where wheat, cotton and livestock are the most important agricultural commodities. With a trend to diversification, crops such as sorghum, corn, pearl millet, proso millet, sudan grass, sweet clover, alfalfa, winter field pea and winter rye, can become important fodder crops. Crop rotation, one of the principles of conservation agriculture, with dual purpose grain and legume crops, can be good for farmers and for the environment alike. Two demonstration sites were established with 9 forage crops, and evaluated, under no-till and conventional till, for both dry

fodder and grain in Karakalpakstan. Some of the newly introduced forages are performing well under no-till and conventional till in spite of extreme drought and salinity conditions.

Geoinformatics resources namely maps of the Action Sites, field research sites and related database of the biophysical and climatic attributes were developed, and are available online.

(2) Rationale and key research hypotheses

Central Asia and the Caucasus (Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) (CAC) occupy a land area of about 4.1 million km^2, of which 14% is under arable and permanent crops. The region is known for its vast area covered by deserts, mountains and steppes. About two-thirds are drylands with low rainfall. Climate is strongly continental and subject to extremes of cold winters and very hot dry summers. About 30% of the cultivated area is irrigated, and irrigated agriculture sustains the livelihoods of a significant proportion of the population of CAC and has done this for millennia.

In recent history, the eight CAC countries gained independence from the former Soviet Union more than 20 years ago. They adopted a new course in development by moving towards a market-based economic growth, with different models – and experiences – of socio-economic development. The state policy of each of the countries includes as a strategic goal food security associated with self-sufficiency in wheat production to secure the economic sovereignty. During the past ten years, overall productivity in wheat and other major crops (cotton) increased in almost all countries as a result of innovations introduced in agriculture.

Agriculture employs between 20-50% of the population and farming is the primary source of income in rural areas, with a significant dependence on remittances. Growing and predominantly rural populations expect secure income options, stable and healthy food supply under changing environmental and socio-economic conditions.

In addition to the necessary policy, technological and institutional factors in the CAC Region, in order to generate dynamic development, including agricultural innovations systems, it is necessary that it becomes better connected to global markets as well as to most advanced education, research and innovation centers. Strong international trade and market access, development of science, and mutual cross-fertilization of ideas with other regions of the world had been the basis for the prosperity and eminence in CAC s in the past.

Land degradation occurs widely and is associated with soil erosion, low soil fertility and high salinity of soils. In the lower Amudarya basin, the specific problems of waterlogging and salinity cover almost 90% of the area that is under irrigation. The yields of wheat, the main food crop, are very low due to the secondary salinization of the soils, caused by seepage losses from earthen canals, very low permeability of the sub-soils, poor natural drainage of excess water, and inadequate artificial drainage infrastructure. Over-irrigation leads to almost 50% of the water lost to either open drainage system or the shallow water tables.

Under these harsh conditions, the application of water-use efficient techniques and appropriate soil and crop management practices is essential. It is also necessary to use highly productive crop varieties that can be grown under local production systems, are tolerant to biotic and abiotic stress that meet market requirements of the local population. An enabling policy and institutional environment is a key factor for their implementation.

The CRP “Dryland Systems” (CRP DS) prime objective is to study and provide options for reducing vulnerability and managing risk in the production systems characterized by land degradation, severe socio-economic conditions, health risks and with no viable development alternatives. Two trans-boundary Action Sites meeting the conditions of Strategic Research Theme 2 (SRT-2 “Reducing vulnerability”) were identified, namely the Aral Sea Region and the Rasht Valley. They constitute the upper reaches of Amudarya River (Rasht Valley in Tajikistan and to a lesser extent Kyrgyzstan) and the lower reaches of both Amudarya and Syrdarya rivers (Aral Sea Region stretching from Turkmenistan through Uzbekistan to Kazakhstan).

Participatory approaches incorporating local knowledge into a given technology have demonstrated their effectiveness in previous research. Therefore, development and adoption of an innovative

knowledge platform for integrated land conservation, watersheds management in upper and lower reaches of the Amudarya and the lower reaches of Syrdarya will lead to improved institutional function and responses in addressing agricultural constraints, for rangelands and irrigated agriculture (Research Hypothesis 1).

Improved options and practices for integrated water and land resources management, increased diversity portfolios (including neglected and underutilized species) adapted to soil salinity in target cotton-wheat-rice-livestock production system will increase soil and environmental health, sustainable agriculture productivity, improve diets and food nutrition, and increased employment in the Aral Sea Region (Research Hypothesis 2).

Increased diversification of the mixed production system integrating horticulture, agroforestry, value addition and market access will enhance water productivity, human nutrition and livelihoods of rural women and men, thus increasing employment in Rasht Valley and in neighboring areas (Research Hypothesis 3).

In addition, a system analysis integrating bio-economic modeling for optimum scenarios will enable out-scaling for agro-pastoral and mixed most vulnerable production systems. This will be tackled by developing crop modeling for major crops at the first stage, and then integrate results into bio-economic modeling which is foreseen in next stages (Research Hypothesis 4).

The CRP DS will also seek effective ways of improving the competitiveness of smallholder production systems by sustainable intensification and by diversification to higher-value crops. In the process, it will consider the opportunities for woman in these transitions. The Fergana Valley was identified as the Action Site where most impact can be achieved in terms of sustainable intensification. It represents a trans-boundary area between Kyrgyzstan, Tajikistan and Uzbekistan, characterized by environmental and socioeconomic conditions that could lead to generating significant income for the local population. Water available for irrigation, the potential to diversify cotton-wheat-livestock production system with vegetable and fruit growing characterized by high and unique agrobiodiversity, along with good research infrastructures and transport facilities are some of the factors that could lead to increasing livelihoods of the local population.

Development and adaptation of an innovative knowledge platform for addressing constraints in agricultural production will increase institutional function and livelihoods in Fergana Valley (Research Hypothesis 5). In addition, a policy framework ensuring land security of agricultural producers, improved access to market, information, technologies will promote sustainable agriculture and improve rural welfare (Research Hypothesis 6).

Innovative and combined policy, institutional and technological approaches to optimize water productivity and equitable allocation will lead to sustainable intensification of cotton-wheat-livestock production system in Fergana Valley (Research Hypothesis 7).

Diversification of vegetable-horticultural-potato production systems through Integrated Pest Management (IPM), improved seed and processing systems, marketing and adequate policies will increase nutrition and livelihoods of rural women and men and reduce environmental and social risks in Fergana Valley (Research Hypothesis 8).

Finally, integrating environmental and socio-economic analysis will help to develop optimal scenarios for trade-off resolution and up- and out-scaling in similar production systems in the CAC Region (Research Hypothesis 9).

The Research Hypotheses were based on an analysis of constraints identified for the three Action Sites. They have been translated into a number of Outputs and Activities with deliverables (milestones) agreed at the regional inception workshop, in June 2012.

The three Action Sites are not only trans-boundary, but they also include gradients ranging from the most vulnerable conditions to those more favorable, having the potential for sustainable intensification. These two situations cannot be entirely separated from each other in a geographic sense. Central command planning combined with the vast, often unsustainable efforts to intensify agricultural production in the former Soviet Union has led to degradation of land and water resources in many areas (*i.e.*, a conversion on large scale).

Establishing a solid baseline with inventory of stakeholders and institutions, market systems, database of natural resources, geoinformatics, watersheds, maps of WUAs, vegetation phenology, land use and land cover dynamics, and rangeland boundaries as well as analyses of the baseline data and impact studies will be essential for the CRP DS implementation.

(3) Research outputs and activities

The outputs and activities of Collaborative Research on Natural Resources Management and Capacity-Building as per the Four Year Strategic Workplan, are listed below:

Output 1: Improved practices for integrated water and land resources management are adopted to mitigate soil salinity and waterlogging in cotton-wheat-rice livestock production system in Aral Sea Region

Activity 1.1: Evaluate and adopt water saving irrigation technologies on salinity management and increasing crop yields -- Improving Water Use Efficiency through Innovative Technologies

Activity 1.2: Identify and introduce stress-tolerant, high-yielding and improved quality varieties of cereals, potato, vegetable, horticultural and fodder crops in pure and mixed plantations through on-farm adaptive trials

Output 2: Options for integrated water and land resources management to mitigate inequity in resource use are established and implemented with users

Activity 2.1: Increase sustainability of marginal lands by using non-conventional water for innovative small-scale irrigation technologies and introduction of crop and pasture diversity adapted to soil salinity, heat and drought

Activity 2.2: Evaluate the effect of conjunctive use of canal and drainage waters, different cropping patterns, and improved irrigation practices on control of salinity and waterlogging in the lower Amudarya, and delineate most efficient water management and agronomic practices

Output 3: Improved options for mixed production system integrating cereals, potato, vegetable, horticultural and fodder crops, medicinal and aromatic species, agroforestry, livestock and bee-keeping

Activity 3.1 Increase livestock productivity to improve availability of animal protein to the households and increased revenues and well-being of livestock keepers

Output 4: System analysis of trade-offs of different scenarios and optimal use of farm and rangeland resources

Activity 4.1: Evaluate the impacts of collective action, land tenure and property rights (policies) on pastoralists livelihoods and rangeland ecosystem maintenance

Activity 4.2: Modeling to understand soil erosion, landslides, mud-flows and floods in marginal croplands and to evaluate watershed management and crop production stability in view to establish an Early Warning System for risk reduction

Activity 4.3: Develop strategies for sustainable management of land and water, based on study and identification of social, technical and economic factors influencing success of multiple land use (crops, trees, pasturelands) for the benefit of all users

Activity 4.4: Bio-economic modeling of farming systems, technological options for natural resource management under different scenarios of the state of natural resource base, market conditions and policies for determining optimal use of resources, and assessing the economic, social and environmental consequences on target population -- Crop Modeling to Determine SLM Options

Output 5: Improved production options for diversifying cotton-wheat-livestock and vegetable-horticultural-potato production systems of Fergana Valley developed and promoted

Activity 5.1: Identify new improved varieties of cereals (wheat and barley) legumes (chickpea, lentil) and fodder (alfalfa) to fit into the prevalent cropping pattern on the basis of adaptive trials

Activity 5.2: Increase year-round (greenhouse and open field) vegetable production and market supply that lead to improved diets of the local population

Output 6: Strategic Innovation Platform for integrated land conservation and watersheds management leading to improved access to irrigation, enhanced cultivation practices and pasture management for sustainable agriculture and livelihoods is established and operational in Action Sites

Activity 6.1: Establish innovation platform for integrated land conservation and watersheds managements leading to improved access to water, enhanced agricultural practices and pasture ecosystem services and management

Activity 6.2: Build capacity of men and women farmers and other stakeholders in cultivation and post-harvest practices for improved quality of commercial crops

Activity 6.3: Establish public private partnership to develop, advice on and support seed multiplication of cereals, potato, vegetable and horticultural crops

Output 7: Improved institutional functioning to address constraints for enhanced performance of rangelands and irrigated agriculture in the upper reaches of Amudarya River (Rasht and Kyzyl Suu Valleys) and lower reaches of Amudarya and Syrdarya rivers (Aral Sea Region)

Activity 7.1: Improve access of farmers to inputs and quality seeds of agricultural crops (cereals, potato, vegetable, horticultural and fodder crops) adapted to stress-prone environments

Output 8: Strengthened capacities in the application of Geoinformatics in assessment and sustainable management of natural resources in Central Asia

Activity 8.1: Mapping CRP DS activities in Action Sites, and related RS/GIS data streamlining, on-line visualization and map servers, coordination activities with CGIAR mapping tools

Activity 8.2: Development of satellite based algorithms, methods, datasets for mapping, monitoring and assessment of agro-ecosystems at farm to landscape scales in Central Asia (beta version)

The Section (7) provides a summary of each output and describes the activities completed to date towards achieving the outputs that are being implemented as of 10 August 2015.

(4) Action Sites

The **Aral Sea Action Site**, located in the lowest part of Amudarya and Syrdarya, the two principal Central Asian rivers, stretches from North Turkmenistan (Dashoguz province) through Karakalpakstan and Khorezm in Uzbekistan to Kyzylorda province in Kazakhstan. Integrated research activities as part of the CRP DS are being implemented in several field sites called "Cooperative 40 years of Karakalpakstan", seven rural communities in Karauzyak district and Karabuga village in Karakalpakstan; Dashoguz province in Turkmenistan; and a cluster of villages in Kazalinsk in Kazakhstan.

Altogether these field research sites are part of a much larger watershed at the borderline of a transition zone between irrigated agriculture and sandy desert. They host a population of at least 1.6 mln people, mostly living in remote rural areas. In the long term, up-scaling of technology options can achieve impact in a large transect of about 24,000 km^2, with a population of more than 6.5 mln people, representing 9% of the total population of the Aral Sea Basin. Climate variability (index of aridity 0.065-0.18), low annual rainfall (90-150 mm) induces serial droughts and temperature extremes, which exacerbate the already high degree of degradation of arable lands as well as and rangelands. The area embedding the field sites faces the challenges associated with rising saline water tables. Dryland salinity and associated water quality are recognized to be among the most severe natural resource degradation problems in these marginal areas. Salt-affected irrigated lands in the lower Amudarya increased at average from 1.16 mln ha in 1990 to 4.43 mln ha in 2012. Access to irrigation water has drastically decreased in recent years, which has caused additional obstacles to rangelands productivity and agricultural production alike. During the past decade, the yields of cotton, wheat and rice have been decreasing steadily, and annual cotton yield does not exceed 1.6 t ha^{-1}. Increasing deterioration in soil and water conditions bring the risk of poverty and out-migration associated with loss of local traditional knowledge and experience of land and water use. Reducing livestock numbers due to lack of good quality forage and low grazing capacity of desert pastures negatively reflect on the incomes of local people, despite of adequate access to local markets. Unemployment exceeding 30% coupled with a weak capacity to regulate and monitor sustainable use of natural resources and limited access to decision-making aggravate livelihoods of rural poor in the Action Site.

The Aral Sea Action Site activities focus on crop/livestock diversification and sustainable management of marginal lands through the up-scaling and dissemination of high-yielding forage production packages that are better adapted to the saline and marginal environmental conditions. Identification and training of progressive clusters of farmers and animal keepers, facilitated by the consortium of the international centers in partnership with local stakeholders, could stimulate crop diversification and seed production programs to enhance the productivity of salt affected lands. Farmer-participatory research at village (*kishlak*) level is crucial in transferring the technology of cultivation of salt tolerant crops for rapid adoption. Institutional framework conditions are essential since a change in land use policies of marginal land may be necessary to implement some options that are emerging from this research. The institutional arrangements are assessed for their role in providing direct economic benefits to rural farmers, income for the government via taxes, and improvement of ecological conditions in the Sites.

Various studies conducted in the Action Site have already demonstrated the potential of technology and institutional options in improving the livelihood conditions on salt-affected marginal lands. An accurate mapping (location, salinity, irrigation network, water supply, cropping practices) with the help of remote sensing (RS) and Geographic Information System (GIS) of marginal lands in the irrigated areas was conducted. Several hundred farmers were trained on using marginal water in their farms, improving water productivity, and using modern agricultural technology options. The results showed, for instance, that sorghum, pearl millet, mungbean and potato can be recommended as second crop after wheat harvest in mid-June to early July. Dual-purpose promising varieties of sorghum and pearl millet can play significant role to fill gaps in the farm productivity and crop-livestock systems in all three countries. Results obtained on salinity management showed that with appropriate plant genotypes, productive agriculture is possible across a wide range of Aral Sea salt-affected lands. On moderately affected land, winter wheat had grain yields of 5–7 t ha^{1}, spring planted wheat 3-5 t ha^{1}, chickpea 1-2 t ha^{1} and

summer forages had biomass yields of 5–12 t ha^{1} dry matter. On more salinized land, barley had grain yields of 0.8–1.3 t ha^{1} and halophytic grasses produced 7–12 t ha^{1} dry material. Preliminarily evaluation of green forage seed harvesting showed promising results for pearl millet, sorghum, indigofera, amaranthus, sesame, mungbean, topinambur, licorice, kochia and other crops. A review was undertaken to look at the halophytic plants widely recognized as a means for forage using saline land and water; and factors affecting the use of this biomass by small ruminants. About 24 halophytic species (mostly grasses and shrubs) are grown for livestock fodder. This review focused on three factors that affect livestock production using these plants – biomass production, nutritive value of the biomass and voluntary feed intake.

An agro-silvicultural model of trees intercropped with complementary crops, especially deep-rooted, early-maturing and frost tolerant legumes and graminous crops were evaluated on marginal lands at the Akdepe experimental site in Dashoguz province, Turkmenistan. Herbaceous fodder crops planted within the inter-spaces of salt-tolerant trees/shrubs plantations improve productivity of saline prone soils, improved animal feed, and increase farmers' incomes. Low yields are due in part to low levels of technical knowledge of farmers, inappropriate varieties and poor quality seed. Therefore, two seed multiplication trials with participatory work of women to generate additional income were established at farms in several of the field sites. A field training course was held for local communities in seedling establishment of wild forage shrubs and seed multiplication of dual purpose crops with the female headed households as the main target group. The impact of planting herbaceous fodder crops within inter-spaces of salt-tolerant trees/shrubs improved the productivity of saline prone soils.

In conclusion, in Aral Sea Action Site, the consortium of the international centers in partnership with local stakeholders aims to increase resilience and productivity of farming and pastoral communities through a more integrated use of existing technology, institutional options and innovative approaches for better livelihoods and diversification of income in remote desert rural communities.

The **Fergana Valley** represents an intermountain depression in Central Asia, located between the mountain systems of the Tien-Shan in the north and the Gissar-Alai in the south. The Valley is approximately 300 km long and up to 70 km wide, forming an area of 22,000 km^2. Its position makes it a separate geographic zone. The Valley owes its fertility to two rivers, the Naryn and the Kara Darya, which unite near Namangan, to form the Syrdarya. Numerous other tributaries not only supply water for irrigation, but also bring down vast quantities of sand, which is deposited alongside their courses, especially alongside the Syrdarya where it cuts its way through the Khujand-Ajar ridge. This expanse of moving sand, covering an area of 1,900 km^2, under the influence of south-west winds, encroaches upon the agricultural districts. The Valley is divided between Kyrgyzstan, Tajikistan and Uzbekistan. In Tajikistan, it is part of Sogd Province or *vilayat*. In Uzbekistan it is divided between the Namangan, Andijan and Fergana *viloyati*, while in Kyrgyzstan it contains parts of Batken, Jalal-abad and Osh *oblasts*. Total population of this region is approximately 13 million.

After collapse of the Soviet Union, the newly formed three republics began to privatize state farms, and private farms are of utmost importance as they now represent the only reliable source of family income or at least subsistence farming. The agricultural activities in the Valley traditionally concentrated on main staple crop commodities of cotton, wheat, rice (marginally) and cattle breeding. Soon after the collapse of the Soviet system in the early 1990s, these shifted to subsistence farming. Individual demand for irrigation water on small fields rose sharply.

Favorable conditions for agriculture have made Fergana Valley the most densely populated part of Central Asia; almost a quarter of the Region's total population lives on less than 5% of the total land area. While the population density of Central Asia as a whole is 40.8 people per square km, in the Fergana Valley it is 1,600 people per square km. It is also one of the fastest growing areas within Central Asia, experiencing a population growth of over thirty per cent in the last 10 years.

The Valley is the backbone of Central Asia's agriculture. It is a major producer of cotton, wheat, fruits and raw silk. Owing to local demand, many other crops are grown on a smaller scale. In the Uzbekistan part,

these include carrot, maize, melon, mungbean and rice, as well as groundnut and vegetables. Rice is double-cropped using drainage water if salinity is not too high. In southern areas, maize and mungbean are also double-cropped. In Tajikistan part of the Valley, small-scale farmers also practice double-cropping. Maize and mungbean are grown widely, followed by buckwheat, common bean, groundnut, millet, sesame, soybean, tobacco, and vegetables. When water availability is adequate, rice is also grown. In addition to annual crops, the area is covered with orchards, vineyards, walnut groves, and mulberry tree plantations (including for silk production). Unfortunately, increasing population, poor land management, and industrialization have taken a toll on this verdant region. Deforestation and overgrazing, salinization of agricultural soils, erosion on mountain slopes are observed, resulting from recent human activities and agricultural development.

The climate is dry and warm. In March, the temperature reaches 20°C, and then rapidly rises to 35°C in May, June, July and August. During the five months following April precipitation is rare, but increases in frequency starting in October. Snow and frost, and temperatures down to -20°C occur in December and January. It is reported that over the past 30 years the average regional surface temperature in the Fergana Valley has increased significantly. It is likely that climate change will affect agriculture, and that shortages of water associated with a significant increase in air surface temperatures could occur.

In the Fergana Valley Action Site, CRP DS work started with a research activity on improving water use efficiency through innovative technologies in irrigation and farming in cereals, potatoes, vegetables, horticultural and fodder crops. It provides the opportunity to evaluate innovative approaches and tools for the planning and use of irrigation water in several field research sites in Uzbekistan and Tajikistan (see Output 1 summary in Section 7).

Following disintegration of collective farms, the water distribution system delivery of irrigation water to water users has changed significantly. Many small water users have emerged replacing the large collective farms. Planning of water use and allocation, based on the previously approved irrigation schedules has become complex with poor levels of efficiency and inadequate distribution. Old planning approaches for water use that were appropriate for large collective farms, are not suitable for water allocation to the small farms. This has led to poor water allocation that can result in conflicts between farmers. WUAs and district water organizations have faced the problem of irrigation water supply to farmers, but often lack the knowledge of technological options.

The first survey of farmer households has indicated the lack of water use planning, which leads to opportunistic water use by farmers throughout the vegetation period. Incorrect irrigation scheduling leads to overuse of water in some months and insufficient water supply in most critical periods. This leads to a very lower crop yields and associated productivity.

The pilot Water Users Associations (WUAs) with field research sites (farms) were selected in Fergana and Andijan provinces in Uzbekistan and in Sogd province in Tajikistan. Demonstration fields were identified and established to assess alternative technology options for water use efficiency. The territory of each WUA is on average composed of 40-45 farmers. The population within the WUA is on average 25,000-30,000. The predominant occupation of the population is agriculture. Agriculture in the area can develop only with irrigation, and so water use efficiency is key for increasing agricultural productivity.

Atlas of the Action Sites can be found at *http://issuu.com/crpds/docs/atlas_crpds_sites_ca*

(5) Partnerships

The inception phase and implementation of the CRP DS in Central Asia has been spearheaded by an Integrated Research Team composed of members from the different Centers co-located in Tashkent under the leadership of ICARDA. The mix of different scientific backgrounds, access to specific knowledge and technologies from the Centers and well-established local partnerships resulted in a set of coherent activity clusters leading to outputs and geographic priority areas (Action Sites) clearly defined and described.

The multi-stakeholder consultation process engaged the Central Asia and the Caucasus Association of Agricultural Research Institutions (CACAARI), which represents an open platform for dialogue on issues related to agricultural research through national, regional and international partnerships to reach stakeholders ranging from policy makers to grassroots researchers and practitioners.

Initial partnerships established with national and local organizations in the Action Sites included: Khorezm Rural Advisory Support Service (KRASS) to undertake accurate mapping of the marginal lands in the irrigated areas in the Aral Sea Action Site; and Scientific-Information Centre of the Interstate Coordination Water Commission (SIC-ICWC) to undertake activities in relation to improving water use efficiency through the introduction of innovative technologies in irrigation and cultivation of cereals, potatoes, vegetables, fruits and forage crops in the Fergana Valley Action Site; and with the Institute of Farming of Tajik Academy of Agricultural Sciences in Sogd province (Fergana Valley).

The partnerships have expanded with full implementation of the research activities in field research sites in 2014-2015. Key partners currently include:

Kazakhstan:
KazAgroInnovation
Kazakh Institute of Rice Production in Kyzylorda

Kyrgyz Republic:
Kyrgyz National Agrarian University n.a. Skryabin

Tajikistan:
Institute of Farming (IF) of Tajik Academy of Agricultural Sciences
Tajik Livestock Research Institute (TLRI)
NGO Zilola, Khujand
Farm “Istiklol - S” Sartukay Village

Turkmenistan:
Turkmenistan Academy of Sciences
Farming Institute of Ministry of Agriculture, Research Station in Dashoguz

Uzbekistan:
Hokimyat (local government), Karauzyak District, Karakalpakstan
Hokimyat (local government), Fergana and Andijan Provinces
Uzbek Scientific Production Center for Agriculture (UZSPC)
Uzbek Research Institute of Plant Industry (UZRIPI)
Kashkadarya Research Institute of Breeding and Seed Production of Cereal Crops (KRIGBSP)
Khorezm Rural Advisory Support Service (KRASS)
Scientific-Information Centre of the Interstate Coordination Water Commission (SIC-ICWC)
Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology
Tashkent State Agrarian University
Samarkand State University
Andijan Experimental Station
Karakalpak Branch of Tashkent State Agrarian University

Nukus Forestry Department
Karakalpak Research Institute of Crop Husbandry (KRICH)

International Agricultural Research Centers
International Center for Agricultural Research in the Dry Areas (ICARDA) as the lead organization
AVRDC - the World Vegetable Centre
Bioversity International
International Potato Centre (CIP)
International Water Management Institute (IWMI)
International Centre for Biosaline Agriculture (ICBA)
International Food Policy Research Institute (IFPRI)
World Agroforestry Center (ICRAF)

Other international partners
Eurasian Center for Food Security (ECFS) at Moscow Lomonosov State University
Michigan State University (MSU), USA
Center for Development Research (ZEF) at Bonn University
Statistical Services Center, University of Reading
Food and Agriculture Organization of the United Nations (FAO)
University of Oklahoma, USA
University of Wuerzburg, Germany
International Winter Wheat Improvement Program (IWWIP)

(6) Inception phase and progress in 2013

Recognizing that the CRP DS is implemented through a multi-stakeholder, bottom-up process, innovation platforms were established encompassing all three Action Sites. They engage with international and national research partners, academia, extension services, farmer representatives, policy makers, development organizations and the private sector. Approximately 100 key representatives of these groups were identified and are directly involved in the innovation platforms. The Action Sites were characterized for a comprehensive set of bio-physical and socio-economic indicators[1]. As a result of the inception phase, research activity clusters were developed and mapped into the regional logframe[2]. Five activities namely marginal lands survey, water use efficiency, on-farm adaptive trials of varieties, seed systems, and the innovation platforms started to be implemented in last quarter of 2013. Field research areas for community development within the Action Sites were identified on the basis of agreed criteria.

Launch of the program in 2013

A baseline survey (bio-physical parameters) with soil and water samples collected along a gradient of landscape salinity was carried out from the Kyzylkum desert throughout agricultural zones in Aral Sea Action Site (marginal lands activity). Socio-economic survey and analysis of economic feasibility of using halophytes for land reclamation, forage and biofuel production was conducted and included data collection (structured interviews); data management (cleaning/entry); data processing (statistical and graphical analyses); and description of findings in selected areas of the Action Site[3]. The baseline survey generated policy recommendations using a participatory approach, which included: (i) activities for up- and out-scaling in which resource users are involved, namely beneficiaries to ensure better impacts of research; (ii) capacity strengthening needs to harness sustainable use of water and land resources; (iii) resource viability and relative importance of small-scale resource users; (iv) effects of activities on resource sustainability and the environment; (v) further interventions to enhance community livelihoods in marginal areas; (vi) proposals for implementation of the identified options for sustainable management of the selected research areas.

Tolerant, high-yielding and improved quality varieties of cereals, legumes, potato, vegetable, horticultural, fodder crops were identified and introduced through on-farm adaptive trials. This activity supplied smallholder farmers with high quality seed and planting materials: (i) winter wheat varieties were planted on farmers' fields on 60 ha, in Uzbekistan; (ii) seed varieties of wheat, barley and chickpea were planted in the farmers' fields, and in total, 3066 kg of wheat, 268 kg of barley and 140 kg of chickpea were planted covering areas of 15.3 ha; 1.64 and 1.38 ha, respectively in Tajikistan.

In Aral Sea Action Site, advanced lines identified as tolerant to salinity, frost and heat along with local checks were planted in Karakalpakstan and Khorezm in replicated yield trials to identify new varieties. The crop germinated and established well prior to the onset of winter. Small-scale seed multiplication of a new candidate cultivar of winter wheat, identified salinity and frost tolerant in Turkmenistan over 2011-2013, was planted in the season 2013-2014 for demonstration trials. This activity was conducted in close collaboration with the CGIAR Research Program on Wheat[4].

In Fergana Valley Site, 11 high yielding, yellow rust resistant winter wheat lines along with 4 checks were planted in yield trial in Sogd, Tajikistan to identify new varieties for the Action Site. These lines were tested in yield trials in Uzbekistan the previous years. Demonstration trials using 8 released and

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[1] *http://www.cac-program.org/files/crp/crp_1_1_scd_ru.pdf*

[2] *http://www.cac-program.org/crpds*

[3] *Toderich, K. N., Shuyskaya, E. V., Rajabov, T. F., Ismail, Sh., Shaumarov, M., Yoshiko, K. and Li, E. V. 2013. Uzbekistan: Rehabilitation of Desert Rangelands Affected by Salinity, to Improve Food Security, Combat Desertification and Maintain the Natural Resource Base. In: Ali Heshmati, G. and Squires, V. eds. Combating Desertification in Asia, Africa and the Middle East (proven practices). Springer. pp. 249-279.*

[4] *Sharma, R. C., Rajaram, S., Alikulov, S., Ziyaev, Z., Hazratkulova, S., Khodarahami, M., Nazeri, S. M., Belen, S., Khalikulov, Z., Mosaad, M., Kaya, Y., Keser, M., Eshonova, Z., Kokhmetova, A., Ahmedov, M. G., Jalal Kamali, M. R., Morgounov, A. I. 2013. Improved winter wheat genotypes for Central and West Asia. Euphytica, 190 (1). pp 19-31.*

pre-released winter wheat varieties were planted in two farmers' fields in Uzbekistan. Demonstration plots using 4 wheat, 3 chickpea and 2 barley varieties were planted in Sogd. Small scale seed multiplication of chickpea, barley and winter wheat was planted in same location. More than 80 men and women farmers, seed producers, researchers and policy makers learned about new, improved varieties of wheat, barley, chickpea, lentil, faba bean, potato and vegetables, fodders and fruits introduced in the system that will result in immediate benefit through adaptive trials in Aral Sea Action Site.

Within adaptive trials to improve access of both intensifiable and vulnerable households to food sources, eight varieties of vegetable legumes were evaluated at Andijan Experimental Station of Uzbek Research Institute of Plant Industry. As a result, superior varieties were identified. These varieties were most promising for cultivation by farmers. Seed multiplication of soybean and mungbean for the production of 1350 kg of seeds was organized for promoting farmer to farmer seed exchange of improved material.

Outcomes and impact of other bilateral projects

Besides these new activities, several ongoing bilateral projects contributed towards the CRP DS progress and impact in Central Asia. In particular, conservation agriculture research and demonstration activities were carried out in selected irrigated areas in Kazakhstan and Uzbekistan, including the Aral Sea Action Site. They demonstrated significantly higher water use efficiency in the plots. The project also identified new crop rotations and studied their potential impacts for use in conservation agriculture. A prototype of a no-till drill implement was produced locally in a factory in Karshi, Uzbekistan. A total of 540 participants were trained in conservation agriculture approaches[5]. In the wider context of bilateral projects, convincing evidence for adoption of conservation agriculture practices in the irrigated areas of Kazakhstan and Uzbekistan was delivered through research and demonstration trials. As a result, irrigated areas under conservation agriculture practices reached 1100 ha in Kazakhstan and 2050 ha in Uzbekistan in 2013.

Model-based assessment of the impacts of climate change and the effects of adaptation technologies on crop productivity and farmers' assessment has been undertaken in close collaboration with the CRP Climate Change[6].

Two water management projects in the trans-boundary Fergana Valley pioneered a framework for scaling up cooperation mechanisms on small transboundary tributaries. The concept of Innovation Cycle was introduced, which makes knowledge produced at the research centers easier accessible to farmers. The projects provided farmers in six WUAs with information and training resources, trained them in improved water accounting methods, constructed flow measurement structures, purchased equipment and set up demonstration plots for new technologies[7][8]. The work continued to be supported through the CRP DS in several communities in the Fergana Valley. As a result of the trans-boundary water management projects in Fergana Valley, transparency in water use increased, while potential conflicts over water in WUAs was reduced. This assisted farmers to improve water productivity at field level (proportion of supplied irrigation water used directly in the field from 42 to 70%), and consequently increased their profit margins.

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[5] *Nurbekov, A., Suleimenov, M., Friedrich, T., Taher, F., Ikramov, R. and Nurjanov, N. 2012. Effect of tillage methods on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. Journal of Arid Land Studies, Vol. 22-1 pp. 255-258.*

[6] *Sommer, R., Glazirina, M., Yuldashev, T., Otarov, A., Ibraeva, M., Martynova, L., Bekenov, M., Kholov, B., Ibragimov, N., Kobilov, R., Karaev, S., Sultonov, M., Khasanova, F., Esanbekov, M., Mavlyanov, D., Isaev, S., Abdurahimov, S., Ikramov, R., Shezdyukova, L. and De Pauw, E. 2013. Impact of climate change on wheat productivity in Central Asia. Agriculture, Ecosystems and Environment, Vol. 178. pp. 78-99.*

[7] *Comprehensive Hydrographic Study of the Fergana Valley, by Scientific Information Center ICWC, 2012.*

[8] *Jumaboev, K., Reddy, J. M., Mukhamedjanov, S., Anarbekov, O. and Eshmuratov, D. 2013. Public-Private Partnership for Irrigation Extension in Fergana Valley of Central Asia. International Journal of Agricultural Extension and Rural Development, Vol. 5-1. pp. 21-30.*

A four-year initiative on value-added processing of cashmere, wool and mohair targeted rural women artisans and small livestock breeders, through improved production, processing and export of value-added fiber in Kyrgyzstan and Tajikistan[9] has been completed. The project increased employment opportunities and income options for poor rural populations, particularly vulnerable women in the mountainous areas. Employment opportunities were secured for several hundred households.

Finally, a knowledge management project undertaken in the context of the Central Asian Countries Initiative for Land Management (CACILM) streamlines the use of approaches and practices of sustainable land management. A knowledge platform has been established, which provides up-to-date information on best practices, monitors and assesses the rate of their adoption, and provides support for evidence-based policy formulation. A set of over one hundred approaches and technologies was collected and disseminated in the five countries of Central Asia[10].

[9] *http://www.cgiar.org/consortium-news/helping-to-tap-missed-opportunities-for-women-in-central-asia/*

[10] *http://www.cacilm.org*

(7) Implementation in 2014-2015: results achieved to date

Output 1: Improved practices for integrated water and land resources management are adopted to mitigate soil salinity and waterlogging in cotton-wheat-rice-livestock production system in Aral Sea Region

Activity 1.1 Evaluate and adopt water saving irrigation technologies on salinity management and increasing crop yields -- Improving Water Use Efficiency through Innovative Technologies

Irrigated agriculture is the backbone of Uzbekistan's economy. Therefore, efficient irrigation water management is of crucial importance to the sustainable crop production in the country. Since independence, Uzbekistan has made significant, efforts including institutional reforms, to implement integrated water resources management (IWRM) to maintain and improve irrigation capacity. As per IWRM guidelines, (WUAs) were formed at secondary canal levels to manage allocated bulk water locally and equitably. Major irrigated crops in Uzbekistan are cotton, winter wheat and rice. Most of the state-funded efforts are on improving and modernizing hydraulic structures and canals. Although, these efforts are much needed for better water management at a regional scale, there is a need for equal and simultaneous efforts to improve irrigation water management at field and farm levels through adoption of water-saving technologies that include evapotranspiration (ET)-based irrigation scheduling, drip irrigation and crop monitoring sensors. At present, Fergana Valley farmers use the Soviet period-developed method of irrigation which divides the irrigated areas in Hydro Module Zones (HMZ). Each HMZ has a set of crop-specific recommendations for irrigation based on the soil characteristics (thickness of soil layers, soil texture) and depth of groundwater table. These recommendations have not been revised against changes in cultivars and fluctuations in groundwater table during the past decades. The ET-based irrigation scheduling method has the potential to replace subjective daily water management decisions at the WUA level with crop water demand-based decisions to improve water use efficiency while reducing salinity and waterlogging problems.

Goal and objectives

Research was conducted to test and demonstrate the use of ET-based irrigation scheduling for improving water-use efficiency in Uzbekistan. This can be achieved by: (i) measuring water use, its yield, and its water use efficiency (WUE) under full irrigation, and (ii) compare these for ET-based irrigation and WUA-prescribed irrigation scheduling methods.

Materials and methods

Study area

Field experiments were established in two provinces of Uzbekistan (Fergana and Andijan) and one province of Tajikistan (Sogd), all within the Fergana Valley where winter wheat and cotton crops are predominantly grown. Within each province, one WUA was selected. In Uzbekistan, within each WUA boundary, six dominant HMZs were identified for conducting irrigation experiments with wheat and cotton.

Table 1. Characterization of selected fields for irrigation demonstration experiment during 2015 growing season.

* HMZ: Hydro Module Zone

Irrigation experiment design

At each location, irrigation experiments have been established in three replicates and two irrigation scheduling methods: (i) evapotranspiration-based irrigation scheduling and (ii) WUA-prescribed irrigation scheduling. Both irrigation scheduling methods are designed to apply full irrigation with furrow method. For implementing ET-based irrigation scheduling, field capacity (FC) of soils in the experiment plots were measured. Irrigation will be scheduled when soil-water content in the root zone is depleted by the crop

Farm	HMZ*	Soil characteristics (soil depth and texture)	Ground Water Table	Crop	
				Type	Area (ha)
WUA "Tomchikuli", Marhamat District, Andijan Province, Uzbekistan					
Davlat Ganimat	I	Shallow (0.2-0.5 m) loamy and clay on sandy gravel deposits and deep sandy loam and light loam	≥ 3m	Cotton	32
				Wheat	34
Mirzahmat Sahovati	VI	Deep (≥ 1 m) heavy loam and clay, homogeneous, different-texture, stratified	2-3m	Cotton	31
				Wheat	43
E. Ergashev	IX	Deep (≥ 1 m) heavy loam and clay, dense, homogeneous, different-texture, stratified	1-2m	Cotton	40
				Wheat	30
WUA "Qodirjon Azamjon", Kuva district, Fergana Province, Uzbekistan					
Qahramon Davlat Sahovati	II	Medium (0.5-1.0 m) depth, loamy and clay on sandy gravel deposits and gypsum, deep sandy loam and light loam	≥3m	Cotton	32
				Wheat	33
Qurbonov Temur	IV	Deep (≥ 1 m) sandy and sandy loam, and shallow- and medium-loam and clay	2-3m	Cotton	25
				Wheat	22
Toshpulatov Ganijon Shuhrat	VIII	Deep (≥ 1 m) light- and medium-loam, homogeneous, heavy loam, lightened texture (transient to coarser texture) to the bottom	1-2m	Cotton	14
				Wheat	13
WUA "Chashma", J. Rasulov district, Sogd Province, Tajikistan					
Parij Kammuna	III	Deep (≥ 1 m) medium, heavy loam and clay	≥ 3m	Cotton	8
				Wheat	1

to 70% of FC. The amount of irrigation applied is measured using flow meter at both supply and tail ends of the furrow.

Daily grass reference ET (ET_o) required for estimating crop water use is calculated using the ASCE Standardized ET equation (Allen et al. 2005). Three weather stations have been established, one each installed within the three selected WUAs (Table 1). Efforts were made to find a suitable location that represents weather conditions with the WUA boundary and near one of the fields selected for irrigation experiment for ease of maintenance. The weather data required for calculating ET_o is being obtained from a weather station installed at each experiment location. Crop coefficients for different stages of cotton, developed by KRASS (a national partner in this activity), is being used in the Equation to estimate cotton water use. Crop water demand or ET calculated using grass reference ET and crop coefficients will be compared with ET derived using the soil water balance equation:

$$ETc = P + I + F - R - \Delta S \qquad (1)$$

where ET is the crop water use, P is the precipitation, I is the irrigation, F is flux across the lower boundary of the root zone, R is the sum of runoff and run-on, and ΔS is the change in soil water content in the soil profile. Precipitation data is obtained from a weather station installed specifically for this experiment. The ET value from equation will be adjusted if it is different from that calculated using Equation 1. The change in the storage volume is calculated using soil water content measured using TDR sensors installed at a depth of 30, 60, and 90 cm. Finally, each experiment site is also equipped with ET gauges for comparing their estimate of ET with the weather station-based equation method. Seasonal crop water use for cotton will be calculated by summing the daily crop water use. Finally, WUE will be calculated and compared between two irrigation scheduling methods.

Prior to this demonstration experiment, a comprehensive investigation into efficiency of WUA-prescribed irrigation scheduling against widely used ET-based irrigation scheduling in the Fergana Valley had been limited. This experiment, while demonstrating the efficiency of ET-based irrigation scheduling services, provides crop coefficients for cotton and winter wheat grown in seven predominant HMZs. In addition, the data collected as part of this experiment can be used to conduct crop modelling to evaluate the effects of climate change on water availability and water demand in the Valley. Irrigation and water use

efficiencies calculated using this experiment can be used to compare their relative performance with other cotton and wheat producing nations in Central Asia and around the world.

Capacity development events

- Conducted a 2-week training on crop modelling
- Conducted field soil sampling methods training in the Fergana Valley
- Conducted training on installation and use of scientific equipment

Activity 1.2 Identify and introduce stress-tolerant, high-yielding and improved quality varieties of cereals, potato, vegetable, horticultural and fodder crops in pure and mixed plantations through on-farm adaptive trials

Multiple stress-tolerant varieties of wheat, chickpea, mungbean and potato offer options for crop diversification, food diversification, and higher income and employment for both vulnerable areas and sustainable intensive agro-ecosystems: In 2014-2015, the salinity- and frost-tolerant winter wheat varieties were successfully identified through on-farm adaptive trials established in the Action Sites.

Salinity and heat-tolerant highly productive spring wheat, chickpea, mungbean varieties, and clones of potato were also identified. Using early maturing varieties of different crops winter wheat - potato annual crop rotations were successfully demonstrated in both vulnerable field research areas (Aral Sea Region) and sustainable intensive systems (Fergana Valley). Four participating farmers in the Fergana Valley of Uzbekistan were able to improve farm income considerably from field demonstrations of winter wheat - mungbean crop rotations. This was also implemented in the Aral Sea Action Site in Uzbekistan and Sogd Region in Tajikistan. Cultivation of mungbean as an additional heat-tolerant crop during the hot summer season after wheat harvest not only increases farm productivity, but also improves soil health, family nutrition, and on-farm employment.

Wheat and mungbean seed production: Approximately 451 tons of quality seed of eight new varieties of winter wheat, and around 80 tons of seed of six varieties of mungbean were produced by the farmers. Considering that wheat seed costs 0.15 USD per kg more than wheat grain, farmers earned about 67,000 USD by producing 451 tons of wheat seed. This figure could be much higher if the farmers had been able to produce higher quality grades of seed such as super elite and elite. Similarly, considering that mungbean seed costs 0.50 USD per kg more than mungbean grain after harvest, participating farmers earned approximately 40,000 USD by producing 80 tons of mungbean seed. In addition, mungbean offers an excellent option to all wheat farmers as a second crop during summer after the wheat harvest. As a result, farmers could earn much higher profits from the adoption of wheat-mungbean rotations.

Farmers training in wheat seed production: Capacity development of farmers in quality seed production is vital if producers are to benefit from seed production. Since rural farmers lack proper technical knowledge of quality seed production, CRP DS organized training courses on quality wheat seed production in four farming communities within the two Action Sites. This helped in the capacity development of 208 farmers (194 men and 14 women) from the Action Sites in the production of quality wheat seed. The new skills acquired by the farmers are expected to improve production and availability of quality wheat seed in 2015, thereby contributing to higher income among seed-producing farmers, as well as helping to improve overall wheat productivity and food security in both Action Sites.

Summary of technology options:

- More than 300 germplasm accessions of winter wheat were evaluated for tolerance to the prevalent stresses, in particular salinity and frost and for superior performance against the locally grown varieties. As a result, twenty improved varieties, superior to local checks were identified. Two stress-tolerant varieties are being considered for submission to the State Variety Testing Commission in Uzbekistan.
- Shallow (2-cm) and deep (4-cm) planting depths were evaluated as a mechanism to avoid frost damage. As a result, the option of 4-cm seeding depth protected winter wheat better against frost compared to 2-cm depth. This technology is under consideration for recommendation by the local administration to the farmers in Karakalpakstan in Uzbekistan.
- 25 spring wheat and 10 chickpea varieties were compared as options for heat-tolerant crops to maximize profit from fields not cultivated with winter wheat. Three heat-tolerant spring wheat varieties were identified, which is a new promising option for wheat farmers in the Aral Sea Region where winter wheat can't be planted due to severe cold or frost. Four superior chickpea varieties were identified for further evaluation.

- Ten improved clones of potato were evaluated after wheat harvest under high temperatures in Aral Sea Region. Two heat tolerant potato clones were identified. This was first time demonstration of potato as a catch crop in wheat-wheat and wheat=cotton rotations in Aral Sea Action Site.

Capacity building:

- Two farmers' field days were organized to demonstrate performance of improved germplasm of wheat and chickpea and frost management techniques and allow farmers to evaluate them through observations. Knowledge of more than 60 farmers and seed growers on availability of new wheat varieties and frost crop management technology was strengthened. Besides, the farmers, seed growers, and policy makers could observe demonstration of high yielding heat tolerant spring wheat and chickpea varieties.
- 208 farmers (194 men and 14 women) were trained in production of high quality wheat seed.

Output 2: Options for integrated water and land resources management to mitigate inequity in resource use are established and implemented with users

Activity 2.1: Increase sustainability of marginal lands by using non-conventional water for innovative small-scale irrigation technologies and introduction of crop and pasture diversity adapted to soil salinity, heat and drought

A number of exploratory field missions were undertaken to Karakalpakstan to collect baseline data for potential target research areas. Intensive discussions were held with district authorities and livestock farmers, women leaders, households, and other stakeholders. Nine villages in Karauzyak district were selected, and target plots for feed production and rangeland rehabilitation are currently were identified.

The field missions, and the sampling and chemical analysis of water, soils and plants along a salinity gradient, have helped to categorize marginal lands and identify 'hot spots' of high vulnerability in Karakalpakstan and Khorezm. GIS/RS-based mapping of degraded lands (location, extent, salinity levels at the borderline of old agricultural and sandy desert zones were completed for Khorezm in close collaboration with KRASS; shape files and benchmark site selection and characterization was also completed for Karauzyak district (a report is being prepared)). Maps were developed for marginalndegraded lands in Khorezm by KRASS (*http://krass.uz/ICARDA/CRP11/*).

A rapid-appraisal socio-economic household surveys and the needs assessment of rural communities in Karauzyak district have also been completed (three groups of target communities on the Karabuga farm; seven villages adjacent to a pastoral cooperative, one village within a private livestock farm, and one village near the forestry pastures, as well as in Khorezm Region: Yangiarik, Urgench and Kushkupir districts). In addition, 70 rural households were interviewed.

Biological approaches for reclaiming root zone areas with legumes on saline soil with shallow water tables in order to sustain economic productivities were established at Karabuga. The testing and rapid adoption of best biosaline practices and interventions for integrated salinity management and value chains of non-conventional crops (halophytes inclusive) were also started in the Karabuga village. Farmers benefit from the introduction of mixed farming practices on highly saline abandoned lands through the introduction of a range of deep-rooted annual and perennial species. Legumes, chenopod and tree species were combined into an agroforestry and/or alley-cropping farming model on the Kegeyli farm, Karakalpakstan, and Koshkupir in Khorezm Region of Uzbekistan. Technology packages on the cultivation of non-conventional crops are under preparation.

To advance research on vulnerable households' access to food sources, four released varieties of quinoa and vegetable legumes were evaluated on the Karabuga farm. As a result, superior varieties/improved cultivars of topinambur, fodder beet, sorghum, pearl millet, mungbean, cow pea, soybean and faba bean were identified. A new salt and drought-tolerant, early-maturing pearl millet variety was also released and seed multiplication started on the Kegeyli farm in Karakalpakstan.

Technology options -- seed production:

- 6.0 ha seed production of four varieties of sorghum;
- 2.5 ha seed production of one variety of alfalfa;
- 7.4 ha seed production of six species of perennial shrubs

Capacity development:

Training courses on seed production and seed quality of sorghum, pearl millet and fodder perennial shrubs were organized on the Azamat farm, Kegeyli (Karakalpakstan) and in Bukhara.

An additional study has been initiated, aiming to determine the trade-offs between the amounts of water used for leaching salts to control soil salinity but minimizing nutrient leaching and enhance soil fertility, control water table and increase agricultural water productivity and efficiency. Its expected outputs include (i) calibrated and validated HYDRUS model for water and nutrient leaching for entire Khorezm

Region; (ii) interactive simple software based on Hydrus results for optimum water and nutrient leaching requirements under soil-crop-water-climate matrix; and (iii) guidelines for water managers (public institutions), WUAs and farmers on the alternative soil-crop-water-climate matrix.

Activity 2.2 Evaluate the effect of conjunctive use of canal and drainage water, different cropping patterns, and improved irrigation practices on control of salinity and waterlogging and delineate most efficient water management and agronomic practices

An extensive irrigation network exists in irrigated areas of Uzbekistan to convey freshwater mainly from the Syrdarya and Amudarya rivers to farmer fields. Losses from unlined irrigation conveyance infrastructure and over irrigation during field application led to shallow groundwater levels. These shallow groundwater levels are threatening the menace of waterlogging and soil salinity. To control waterlogging and salinity, an extensive network of mainly open surface drains exists in the region. It has been observed during the last decades that the tendency of dry years is increasing in Uzbekistan. Moreover farmers are not getting adequate canal water supplies especially located at tail end reaches of the irrigation network. To combat water scarcity, farmers apply conjunctive use of canal and drainage water to achieve their yield targets. However continuous use of canal water and drainage water can build soil salinity in root zone, degrade fertile agriculture lands and eventually reduce crop yields. Hydrological models exists to simulate scenarios for proper management of canal water and drainage water in a more sustainable way. Moreover cropping patterns and improved irrigation practices can reduce the adverse impacts of soil salinity.

Several models for simulating soil moisture and soil salinity in vadose zone exists. These models can simulate the impact of conjunctive use of canal water and groundwater, cropping strategies and irrigation practices on soil salinity and root water uptake and eventually crop production. Two spatial scales were selected to conduct this study i.e., field level and WUA level. At field level, two sites were selected, one in Khorezm and one in Fergana Valley. Different quality of canal water and drainage water are being used to study the impact of conjunctive water management strategies on soil salinity build-up and soil moisture regimes under different cropping patterns. Data regarding soil moisture, soil salinity, soil texture, soil organic matter, hydraulic conductivity, pF curves, irrigation depths, irrigation water salinity, groundwater depth and salinity, crop height and rooting depth, yield, fertilizer, pesticides and other inputs are being collected at high spatial and temporal resolution. These data sets will be used to calibrate and validate the HYDRUS model to simulate scenarios for conjunctive water management in the long term. To up-scale the results of this study, it is of paramount importance to analyze the irrigation and drainage systems in context of potential for conjunctive water management, optimum cropping patterns and improved irrigation practices for larger irrigated areas of Uzbekistan. Therefore a WUA level is selected. Ten years of historical data along with other parameters including farms in selected WUA, cropping patterns, channels, collectors, area irrigated from each of water source, soil texture, soil salinity, Hydro Module Zoning, min and max temperature, wind speed, solar radiation, relative humidity, groundwater depth and salinity, irrigation, and cropping patterns have been collected to date. This data are being analyzed and potential for up-scaling the resulting model will be assessed.

Output 3: Improved options for mixed production system integrating cereals, potato, vegetable, horticultural and fodder crops, medicinal and aromatic species, agroforestry, livestock and bee-keeping

Activity 3.1 Increase livestock productivity to improve availability of animal proteins to the households and increased revenues and well-being of livestock keepers

Meat, milk, fiber and pelts from small ruminants are key income sources for agro-pastoral communities living in mountainous regions in Tajikistan or on marginal salt-affected land in Uzbekistan. As their main source of fodder sheep and goats depend on rangelands, which occupy a large proportion of the total land area in Central Asia (approximately 260 million hectares or 65% of the total land area). The livestock research activity takes a comprehensive approach by combining value chain analysis with rangeland and livestock research.

The main objective is to increase the returns from keeping sheep and goats on marginal lands in the Aral Sea Region and Fergana Valley Action Sites through integrated livestock and rangeland management.

Materials and Methods
The activity was initiated with a planning meeting in Dushanbe, held in May 2014. The objective was to establish partnerships, define criteria for selecting field research areas within the larger CRP DS Action Sites and identify major intervention needs and opportunities.

Field research areas
To build on ICARDA's expertise and to achieve impact through livestock related interventions, it was agreed in the planning workshop to focus on small ruminant production in agropastoral livelihood systems. In the Aral Sea Action Site, the Karauzyak district in Karakalpakstan was confirmed as target site. Within the Fergana Valley, Asht and Gafurov districts in Sogd Province were selected to build on Angora goat breeding program, which had been established by ICARDA in 2009.

Research approaches
A qualitative small ruminant meat value chain assessment (VCA) has been conducted at the target field research sites in Tajikistan and Uzbekistan, which describe opportunities and constraints of production but also of input supplies, marketing and processing to address all constraints along the meat value chain and target other value chain actors in addition to sheep and goat producers. Based on known constraints and on demands by stakeholders, specific research activities have been initiated in each country which will be reviewed once both VCA reports are available.

The livestock oriented "Cooperative 40 years of Karakalpakstan" in Karauzyak District is interested in a genetic improvement program of their Karakul flocks in order to produce higher quantities of Sur Karakul pelts, which are in high demand and achieve high prices. Thus, the feasibility of establishing a Sur Karakul elite flock in the cooperative is currently being assessed. If the genetic potential is considered sufficient, a program will be established with support from the Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology.

In Tajikistan the genetic improvement program of Angora goats focuses on improving mohair fineness and reducing kemp fibers in nucleus herds. Two elite herds are being improved by crossing with Texas Angora while improved selection and herd management practices are being implemented in selected private Angora goat herds. The program aims at providing access to improved genetic material to all mohair producers in Sogd Province in the long term. Based on the interest voiced by the women groups in the target villages in community meetings in Asht and Gafurov districts in April 2015, improved value addition options for goat milk will be assessed and low cost interventions developed and implemented.

The rangeland research aims at a comprehensive assessment of the current situation in both Action Sites, including:
- Assessment of dynamics in rangeland tenure and related governmental and donor activities,

- Current access to rangeland by different stakeholders,
- Monitoring of rangeland status including fine tuning/developing a toolkit for monitoring and assessing rangeland vegetation at the landscape level using up-to-date technology,
- Monitoring of current utilization patterns,
- Monitoring nutritional status and productivity of grazing sheep and goats in relation to rangeland status and utilization patterns.

Based on the assessment, improved utilization strategies including watering points and rehabilitation measures will be developed and available for out-scaling in the Action Sites.

Research results achieved so far

A literature review on Central Asian rangelands was completed and will be published in a forthcoming paper. Rangeland vegetation monitoring for the spring/summer season was completed on 1-5 May 2015 in Karakalpakstan and on 15-20 May 2015 in Tajikistan. The vegetation measurements included biomass, cover and density of perennial plants, biomass and density of annuals.

In target field research site in Karauzyak district, namely the "Cooperative 40 years of Karakalpakstan", two herds composed of sheep owned by the cooperative, the herder and village households were selected to be equipped with GPS collars for year-round monitoring of the grazing patterns and for taking blood samples to determine the nutritional status of the animals. Two Karakul sheep experts from the Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology conducted a feasibility study for creating an Elite Karakul Sur flock in the livestock cooperative in May 2015.

In Tajikistan, an artificial insemination campaign with frozen semen from Texas Angora bucks was conducted in October 2014 to continue the Angora goat breeding program initiated by an earlier ICARDA project. A total of 196 selected goats belonging to the super-nucleus flock owned by the Tajik Livestock Research Institute (TLRI) and a private elite Tajik Angora goat flock were synchronized and inseminated. The data collection for a first comparison of 'crossbred' with local offspring was completed in 2014 (*paper submitted to Small Ruminant Research*).

The toolkit for small ruminant value chain assessment (SR VCA) developed by the CGIAR Research Program on Livestock and Fish was adapted to Tajikistan and Uzbekistan conditions ("*Toolkit for rapid assessment of small ruminant value chains in Central Asia"*) and translated into Russian language. The value chain analysis in four villages of the two target districts was completed, and the VCA toolkit will be used to conduct the VCA in Karauzyak, in August 2015.

ICARDA's dairy technologist studied local goat milk processing methods in three villages in Tajikistan in May 2015. The objective of the assessment was to determine entry points for low-cost interventions to improve product quality and safety and identify options for additional dairy products. The assessment will be followed up with training on improved processing methods for the women groups next year.

Capacity development

The activity supports on-the-job training approach for scientists from the national partner institutes in Tajikistan and Uzbekistan. ICARDA's reproduction specialist provided technical backstopping for the Artificial Insemination campaign to the scientists from the Sogd branch of TLRI through detailed instructions for goat synchronization and procuring appropriate equipment and supplies. The project also facilitated support for the team in Tajikistan during the actual insemination of the goats with frozen semen by an AI specialist from the Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology, in October 2014.

Output 4: System analysis of trade-offs of different scenarios and optimal use of farm and rangeland resources

Activity 4.4: Bio-economic modeling of farming systems, technological options for natural resource management under different scenarios of the state of natural resource base, market conditions and policies for determining optimal use of resources, and assessing the economic, social and environmental consequences on target population -- Crop Modeling to Determine SLM Options

The objective of this research was to produce a model-based assessment of the impacts of climate change and the effects of adaptation of sustainable land management practices on crop productivity. It has been conducted in close coordination with the Knowledge Management in CACILM Phase II project.

Expected outputs include:

- Calibrated crop model for cotton and wheat for conditions of Uzbekistan (2015) and Tajikistan (2016);
- The manual on processing and using CORDEX[11] climate change data and crop models for assessment of climate change impact on crop productivity published and disseminated (2015);
- Quantified climate change impact on crop production (2016);
- Capacity building, the number of scientists (total of 5, including 2 female) from national institutions trained in processing and using CORDEX climate change data and crop models (2016).

This activity started by making assessments based on previous modelling work, including crop modelling to calibrate major crops in the region, extracting downscaled climate change data for the region to input as future scenario for crop productivity, bias correction of extracted climate change data to match observed and modelled climate parameters for the region, and studying effects of adaptation sustainable land management technologies on crop productivity. Ultimately, outputs generated under this activity could be taken further for systems modelling.

The research implemented in 2014-2015, and the following tasks were performed by mid- 2015:

- CropSyst model was re-calibrated for selected cotton and wheat varieties grown in Uzbekistan using newest version of the model with advanced nitrogen-uptake sub-model;
- CORDEX climate change data for Central Asia was extracted from the regional downscaled database of South Asia. Separate downscaled climate change data for Central Asia region is not yet available. Therefore, extracted data for Central Asia has significant biases since it is located close to the border of an area covered for South Asia. However, data are suitable for familiarizing with processing and bias correction;
- Long-term data from key meteorological stations of Uzbekistan was collected and used for testing of the tool developed at Texas A&M University for extraction and bias correction of CORDEX data;
- The tool was used for extraction and bias correction of data on temperature and precipitation. It was tested, documented and manual was distributed during "Knowledge Management in CACILM Phase II" Project Annual Planning Workshop. Additionally video-course on CORDEX data downloading and processing was recorded and made available through internet;
- New advanced version of the tool including additional methods for bias correction of temperature and precipitation, as well as additional meteorological parameters used for crop modeling, such as solar radiation, wind speed and relative humidity, is tested and described on the base of available information.

[11] CORDEX - the Coordinated Regional Climate Downscaling Experiment is a World Climate Research Program backed framework to produce ensembles of regional climate projections for all continents globally (*http://wcrp.ipsl.jussieu.fr/SF_RCD_CORDEX.html*). The climate projection framework within CORDEX is based on the set of new GCM simulations currently underway in support of the IPCC Fifth Assessment Report, referred to as CMIP5.

Output 5: Improved production options for diversifying cotton-wheat-livestock and vegetable-horticultural-potato production systems of Fergana Valley developed and promoted

Activity 5.1 Identify new improved varieties of cereals (wheat and barley) legumes (chickpea, lentil) and fodder (alfalfa) to fit into the prevalent cropping pattern on the basis of adaptive trials

The following work was carried out at the Fergana Valley Action Site. It is closely linked to the research undertaken in Activity 1.2 “Identify and introduce stress-tolerant, high-yielding and improved quality varieties of cereals, potato, vegetable, horticultural and fodder crops in pure and mixed plantations through on-farm adaptive trials”

Summary of technology options:

- More than 50 high yielding winter wheat varieties, resistant to yellow rust were evaluated. As a result, five new high-yielding winter wheat varieties ('Bunyodkor', 'Shams', 'Yaksart', 'Hisorok', and 'Gozgon'), resistant to yellow rust were identified which yielded significantly higher than the locally grown yellow rust susceptible cultivars 'Krasnoddar-99' and 'Chillaki'. Early-maturing, yellow rust-tolerant new winter wheat variety 'Hazrati Bashir' yielded significantly higher than the early maturing, yellow rust susceptible local cultivar 'Chillaki'.
- Early maturing varieties of winter wheat and mungbean were evaluated in rotation for intensifying cropping system. Early-maturing varieties ('Hazrati Bashir', 'Yaksart', 'Bunyodkor', and 'Hisorok') of winter wheat and early maturing mungbean variety 'Durdona' proved suitable for successful winter wheat-mungbean rotation to intensify prevalent Wheat-Cotton rotation. Based on measured soil attributes, cultivation of mungbean enriched the soil, which resulted in better crop stand and 17% higher wheat yield compared to the adjacent field not planted with mungbean. Cultivation of mungbean as catch crop resulted in additional income to the farmers.

Capacity building:

- Two farmers' field days were organized to demonstrate performance of improved varieties of wheat, barley, chickpea and wheat-mungbean crop rotation. Knowledge of more than 50 farmers and seed growers on availability of new wheat and mungbean varieties and improved crop rotation was strengthened.
- One training was organized for home gardeners: more than 80 home gardeners (>80% female) received training on improved home-gardening practices as well as received seed samples of different crops. A brochure on improved production practices of home garden crops was also distributed to all participants.
- One week long training course on scientific management of field experiments was organized for young researchers: 22 (16 male and 6 female) researchers were trained.
- One two-week long training course on statistical design and data analysis of field experiment was organized: 13 (9 male and 3 female) young researchers were trained.

Output 6: Strategic Innovation Platform for integrated land conservation and watersheds management leading to improved access to irrigation, enhanced cultivation practices and pasture management for sustainable agriculture and livelihoods is established and operational in Action Sites

Activity 6.1 Establish innovation platform for integrated land conservation and watersheds managements leading to improved access to water, enhanced agricultural practices and pasture ecosystem services and management

Innovation platform is a tool for facilitation of the collective actions towards development impacts. It uses a combination of joint learning systems and approaches to catalyze the robust engagement of relevant stakeholders. Innovation platform is realized and used through:

- participatory approaches and collective action, such as participatory research and extension approaches, development management, gender analysis, learning, agro-ecosystem management, integrated production systems;
- dissemination pathways that include interactive learning between different innovation stakeholders, farmer collective action, market led technology adoption, and participatory market chain approach;
- functional learning through systemic joint analysis, system analysis, data management, research methods support, documentation, and experiential learning and information/knowledge sharing among platform participants.

This activity focuses on engaging different agricultural innovation system stakeholders in the integrated research conducted in the Aral Sea and Fergana Valley Action Sites.

Objectives of the activity:

- Coordinate technical advice to actors, including researchers, farmers and other users in facilitation of innovation (information support, demonstration of the practical applications, consulting and training);
- Assist rural/agricultural producers, involving extension/advisory service providers, on issues related to introduction of new technologies and approaches, and to increase the effectiveness of existing technologies and approaches;
- Establish links between scientific and educational organizations, other sources and triggers of innovation to develop best practices for innovative cooperation;
- Create and maintain a database on innovations developed by research institutions for transfer and scaling out to different types of users;
- Baseline survey in Action Sites for determining 'starting points' for monitoring and evaluation progress, determine the needs of field researchers, farmers and extension in the innovation and development of new projects;
- On-line consultations on agricultural productivity, research, extension and human capacity within Action Sites and in the broader Central Asia region.

The Innovation Platform (IP) approach is used to engage a range of stakeholders into collective actions to identify and alleviate the constraints affecting productivity growth, and create the conditions that enable sustainable intensification and diversification.

An IP workshop was held in Bishkek, Kyrgyzstan, on 8-11 December 2014 with 40 participants from research organizations, development organizations and farmers to agree on modalities for establishing IPs in Central Asian countries, opportunities and constraints for agricultural innovation in the different production/livelihood systems, and the development of a joint strategy and action plan.

The CRP DS 'Innovation Platform' approach in Central Asia was considered a key innovative model for strengthening Rural Advisory Systems (RAS) in the CAC region at the regional RAS conference, held in Bishkek in November 2014 (*www.egfar.org*). To improve the capacity of CAC organizations, to enable them to be more pro-active in setting the research and innovation agenda for food, agriculture and rural

development, and positioning research and innovation in the broader context of development, CACAARI, in cooperation with CRP DS in Central Asia, is taking the lead in the region in establishing a foresight platform as a systematic, participatory and multi-disciplinary approach to explore mid- to long-term futures and drivers of change. In this regard, a workshop on developing forward-thinking capacities in CAC was in conjunction with the regional RAS conference in November 2014, with the purpose to advocate and raise awareness of different stakeholders of Agricultural Innovation System (AIS). As a result of the foresight workshop, participants acknowledged the value of engaging in foresight, and urged CACAARI to promote the foresight academy, a forward-thinking platform in the CAC region.

A baseline survey was conducted in Kyrgyzstan part of the Fergana Valley, covering 120 households. Baseline data was collected on demographic characteristics of households; financial, physical, natural and social capital; agricultural production; access, quality, quantity, and management of water resources; livestock production and management; agricultural policy; food security and nutrition; borrowing and access to credit; system vulnerability and local coping mechanisms used by households (*http://cac-program.org/crpds/survey/baseline_data*).

Gap analysis in system approach will reveal niches that need to be addressed by solid and comprehensive set of measures, considering CRP DS theory of change. However, this gap analysis is not a one-time tool, but a continuous mechanism. It is to be based on four main pillars: (i) multi-stakeholders dialogue, (ii) data management, (iii) innovation platform, and (iv) foresight mechanism. All those four components are interlinked and overlapping and this ensure effectiveness, efficiency, relevance, sustainability and impacts of CRP DS for improving resilience and well-being in the region.

All this requires the creation of an enabling environment where scientists and partners are able to produce and share high quality data outputs, while at the same time supporting a variety of data management procedures and practices at the project level. This IP activity is facilitating the production of well-managed and documented datasets that are easy to use both now and in the future.

The goal of Data Management System is for data products to be archived and made available for long-term use by partners and the scientific community. To increase the capacity of staff involved in data management, several training opportunities were provided in collaboration with Statistical Services Centre (SSC) of the University of Reading, UK. This has led to improved skills in data management and a strengthened support in data management, IT and statistics for research projects.

Furthermore, in cooperation with the Forum on Food Security and Nutrition (FSN) in Europe and Central Asia of FAO, a five-week online discussion was organized and facilitated on "The role of Agricultural Innovation Systems in Central Asia and Caucasus countries and China towards more sustainable food security and nutrition". The online discussion has gathered 83 comments. In total, 48 experts from 18 countries joined the discussion and shared their views and experience. More than 500 experts from 73 countries have visited the discussion's webpage and over 10,000 people have been informed about the discussion. There was a near-perfect gender and age balance among the participants who took part in the discussion. The discussion was widely promoted by the FSN Forum through the FSN global and regional mailing lists, social networks.

Activity 6.2 Build capacity of men and women farmers and other stakeholders in cultivation and post-harvest practices for improved quality of commercial crops

The objective is to build capacity of men and women farmers through implementation of conservation agriculture approaches in particular no-till or minimum tillage, crop diversification, double cropping and post-harvest technologies. The work has started in the Aral Sea Action Site with the establishment of research and demonstration trials in the selected target areas.

Expected outputs:

- Evaluation of current status of cropping system in Aral Sea Region;
- Assessment of the status of forage crops seed production;
- Review and assess alternative crops for double cropping under no-till;
- Suitable forage crops for salt-drought affected areas of Karakalpakstan, through implementation of no-till practice, to be identified and recommended to the farmers;
- Options to increase land use efficiency and crop production developed and recommendations prepared for local farmers. The economic impact of the conventional till and no-till assessed;
- Locally produced seeds of forage crops distributed to farmers through established network of forage seed growers (linkage with Seed system platform activity), in order to increase area of forage crops under no-till in the Site.

The activity addresses crop diversification and fodder production to support livestock feed security. Wheat, cotton and livestock are the most important agricultural commodities, and with a trend to diversification, forage crops such as sorghum, corn, pearl millet, proso millet, sudan grass, sweet clover, alfalfa, winter field pea and winter rye, can become important fodder crops. This will reduce the feed gaps during the winter experienced by many smallholders and livestock farmers. In addition, introduction of perennial legume crops, cereal-legume mixtures will improve productivity and reduce grazing pressure.

Farmers grow a limited number of forage crops in agriculture; farmers who grow fodder crops use old varieties and poor agronomic practices (*i.e.*, sub-optimal seeding rate, fertilization) leading to low forage crop yields. Thus, crop rotation, one of the principles of conservation agriculture, with dual purpose grain and legume crops, can be good for farmers and for the environment alike.

Most of the activities were implemented in 2015, with the following highlights:

- Two demonstration sites established in the Action Site with 9 forage crops, provided from the material available at ICRISAT/ICARDA and Uzbekistan, Kazakhstan and Tajikistan. They have been evaluated, under no-till and conventional till, for dual purposes (dry fodder and grain) at demonstration site in Karauzyak district in Karakalpakstan. Some of the newly introduced forage species are performing well under both no-till and conventional till in spite of serious drought and salinity conditions in the experimental site.
- The research on double cropping with alternative crops under no-till was initiated in the experimental site in Korako'l settlement in Karauzyak district, in order to improve land use efficiency, save irrigation water, seed and reduce the cost of cultivation. The initial observations indicate that the double cropped mungbean, soybean and kidney bean crops under direct seeding germinate well, and savings in irrigation water are being monitored.
- Seed production of forage crops for salt-drought affected areas of Karakalpakstan, through implementation of no-till practice, was organized in May 2015.
- A field day was conducted on 30 June 2015 at the demonstration site which attracted 48 participants from Karauzyak district farmers, district authorities, researchers, local and national TV, and ICARDA. During the field day, the participants found an opportunity to see how to install and calibrate no-till drill to plant mungbean as second crop after winter wheat harvest. The participants also engaged in lively discussions with instructors on various alternative crops for double cropping under no-till, economic and environmental aspects of conservation agriculture farming in Karakalpakstan.

Output 7: Improved institutional functioning to address constraints for enhanced performance of rangelands and irrigated agriculture in the upper reaches of Amudarya river and lower reaches of Amudarya and Syrdarya rivers (Aral Sea Region)

Activity 7.1 Improve access of farmers to inputs and quality seeds of agricultural crops (cereals, potato, vegetable, horticultural and fodder crops) adapted to stress-prone environments

Seed supply is an important element of agricultural production. However, the system is often fragmented and disorganized. Without improving access to quality seed of improved and alternative crop varieties, it would be difficult to ensure sustainable agricultural production in the face of climate change. This activity is focused on establishing a seed systems platform compatible with existing agro-ecological environments to supply farmers with high-quality seed and planting materials so as to improve livelihoods, food security and incomes of smallholders. Research is conducted at the Fergana Valley and Aral Sea Action Sites.

The following work was carried out and results accomplished in 2014-2015:

Technology options:

- Expert report prepared on the analysis of seed system of Fergana Valley, Uzbekistan. Farmers produced approximately 300 t elite quality seed, which earned them 100 per cent more income compared to grain production.
- High quality (elite grade) seed of wheat of five new, yellow rust resistant winter wheat varieties produced by more than 50 farmers on more than 80 ha in Fergana Valley. Farmers produced more than 1 t quality seed of mungbean, which earned them 200 per cent higher income compared to grain production.
- Four farmers participated in production of elite grade seed of four new varieties of mung bean on 2 ha in Fergana Valley.

Capacity building:

- Four one-day training courses on quality wheat seed production were organized jointly with CRP Wheat. Two each in two Action Sites capacity of more than 200 wheat farmers strengthened in production of quality wheat seed.
- One stakeholders meeting on seed system was organized in Aral Sea Action Site. Key constraints to seed system were discussed and identified.
- Two farmer field days on wheat, barley and chickpea seed production were organized in Fergana Valley, where farmers received published information on seed production of high yielding wheat, barley and chickpea varieties.

Output 8: Strengthened capacity in application of Geoinformatics in assessment and sustainable management of natural resources in Central Asia

Activity 8.1: Mapping CRP DS activities in Action Sites, and related RS/GIS data streamlining, on-line visualization and map servers, coordination activities with CGIAR mapping tools

Maps of the CRP DS Action Sites, field research sites and related database of the biophysical and climatic attributes were developed. All the maps and atlas of the Action Sites and field research sites are available online at *http://geoagro.icarda.org/* and *http://issuu.com/crpds/docs/atlas_crpds_sites_ca*

Activity 8.2: Development of satellite based algorithms, methods, datasets for mapping, monitoring and assessment of agro-ecosystems at farm to landscape scales in Central Asia (beta version)

Natural resources degradation and desertification in the Central Asia has been accelerated over the past few decades due to increasing demand for food, feed and fiber, livestock grazing intensity and climate variability (Berger et al. 2013; Chuluun and Ojima 2002; von Wehrden et al. 2010). To restore, maintain, and enhance grassland condition and productivity in the Central Asia is the goal of many research and development projects in the region. However, these efforts have been hampered by the lack of up-to-date, accurate information on croplands and grassland dynamics, conditions, and productivity as well as by the capacity to generate such information in timely manner.

Satellite remote sensing has been playing an increasing role in characterization and monitoring of croplands and grassland condition and productivity (Kariyeva and van Leeuwen 2011; Li and Yang 2014; Sternberg et al. 2011). Most previous studies have used Normalized Difference Vegetation Index (NDVI) data from optical images to evaluate grassland condition and productivity in the context of land degradation and desertification (Emerson et al. 2010; Sternberg et al. 2011; Wang et al. 2014). Recently, a few studies in North American grasslands and Mongolia grasslands show that Enhanced Vegetation Index (EVI) and Land Surface Water Index (LSWI) are better indicators of grassland condition and productivity (John et al. 2013; Wagle et al. 2014; Wang et al. 2010b). We obtained preliminary results from a pilot project that evaluated satellite-based three vegetation indices (NDVI, EVI and LSWI) and land surface temperature (LST) for characterization and monitoring of croplands and grassland degradation and desertification in the Central Asia. We used multi-scale and multi-temporal remote sensing data from MODIS, Landsat and rapid eye data from 2000-2014 to quantify the agro-ecosystems in Central Asia. Database online can be accessed at **Geospatial Database Visualization:** *http://geoagro.icarda.org/en/default/visualization/centralasia*.

In this pilot study, we analyzed seasonal dynamics of the three vegetation indices (NDVI, EVI and LSWI) in the study area, and proposed a new LSWI-based scheme to define and map (1) desert vegetation and barren lands, and (2) grassland degradation to desert vegetation over years. The resultant maps need to be further evaluated through in-situ data collected by the researchers in the area. Such evaluation task is beyond the scope of this pilot study, and we expect that it will be incorporated into the future research. We also carried out simulations of the satellite-based VPM to estimate gross primary production (GPP) of vegetation in the study area. The resultant GPP shows the spatial variation of GPP in the study area, but it still needs to be evaluated using the CO_2 flux data from the CO_2 flux tower sites. It is likely that the parameter values used in this initial simulations of VPM will be modified or revised, once a comparison between the VPM simulations and the CO_2 flux tower data is made in near future.

(8) Impact pathways

Below is a description of the impact pathway developed by the CRP DS for the Aral Sea Action Site, followed by indicators of progress in achieving the broader Intermediate Development Objectives (IDOs) of the CGIAR.

The CRP DS research agenda in Aral Sea Action Site aims to identify and alleviate the conditions that continue degradation of the natural resource base and vulnerability, and the constraints to agricultural productivity and growth. Research on alleviation of these constraints will be key element of the work envisaged. The predominant focus is on Resilience (IDO 1 – (n-level)) although options for diversification and intensification of existing farming systems are also being addressed and developed (IDO 2 – (n-level)). The most vulnerable part of this predominantly agro-pastoral ALS (Agricultural Livelihood System) of the Action Site will be addressed through (i) Marginal Lands cluster activity.(ii) Access to quality seed materials, varieties, breeds, data and knowledge, advisory services, innovations, technologies, economic incentives, and institutional approaches is necessary to enhance the resilience of smallholder farmers, livestock keepers, and rural communities. These are to be addressed within (iii) Livestock productivity, (iv) Varieties/on-farm trials), (v) Conservation agriculture practices and (vi) Seed system platform activities.

It is widely recognized that agricultural research for development in Central Asia must be accompanied with effective processes for inclusive participation in the development and out-scaling of technologies, moving away from linear approaches of technology development and dissemination, and thereby addressing priority needs for rural communities and farm households. An important role in this regard is given to “Innovation Platforms” (cluster activity (vii) and Central Asia Countries Initiative for Land Management (CACILM) (cluster activity viii), in order to catalyze joint action in a region that is experiencing a profound economic and institutional transition. The research needs to rely on the strengths of an agricultural innovation platform to deliver development outcomes, by expanding upon its accepted technologically driven role to one that is inclusive of social and institutional innovations, as well as in influencing relevant policy focusing on one of the Action Sites, namely the Aral Sea Region.

To ensure system approach throughout the impact pathway, the activities can be grouped into three inter-related clusters:

A. On-farm germplasm trials and seed systems;
B. Livestock and pasture management;
C. Sustainable water and land management

The system approach will be based on participatory planning and multi-disciplinary research and work with end-users and beneficiaries to test and scale out a range of interventions, technologies, and research methods, using innovation platforms, multi-stakeholders dialogue, and foresight mechanisms that also involve partners from the research, policy, development and civil-society sectors. Therefore cluster activities (n-2 level) and sub-activities (n-3 level) are implemented in different phases: (1) Discovery, (2) Proof of concept, (3) Pilot, and (4) Scaling up phases.

The ongoing and planned research activities together with those that will be revealed by gap analysis to ensure system approach, will gradually contribute to Capacity to Innovate (IDO 5 – (n-1-level) of farmers and households, up-take and application of sustainable natural resource management practices IDO 4 – (n-1-level), which will ultimately ensure that women and children/households have year round access to greater quantity and diversity of food sources (IDO 3 – (n-1-level).

Such approach will take into account strengthening gender equity in the CRP DS in Central Asia with its specific landscape, agro-ecological, socio-economic, cultural, and historical conditions. These include the legacy of Soviet centrally planned economy and it transition to market economy; currently high labor out-migration; high dependence of food and nutritional security on land and water use; diversity of livelihood and production systems, and cultural aspects. Therefore, Gender empowerment (IDO 5 – (n-1-level) is considered a cross cutting issue at all levels of the Impact pathway, from n-2 to n-levels, *i.e.*

Reducing vulnerability and managing risk through increased resilience (IDO1) and towards Sustainable intensification for more productive, profitable and diversified systems (IDO2).

This multi-stakeholder, multi-institutional process together with other development initiatives and joint efforts, proactive cooperation with policymaking/government institutions, diversity of national and regional organizations and thematic networks, international agricultural research centers operating in the region, and finally linkages and complementarities with other CGIAR Research Programs throughout the process of change will contribute to the System Level outcomes (SRF) of the CGIAR, namely:

- Reducing rural poverty;
- Increasing food security;
- Improving human nutrition and health;
- Sustainable management of natural resources.

Indicators of progress in achieving the broader Intermediate Development Objectives of the CGIAR by 2016:

1. For IDO 1: 15 per cent increase in productivity of winter wheat, potato, mungbean, chickpea, potato, forages maintained by establishing a functional seed system platform and access to quality planting material of varieties in the field sites; 10 % Increase in livestock performance ensured by participatory planning of interventions to increase feed production and value chain analysis in the field research area.
2. For IDO 2: One-hundred household increased their incomes through adoption of innovative technologies by farmers heading those households in the field site.
3. For IDO 3: One-hundred households improve their dietary scores in the field site through better access and availability of quality wheat, mungbean, chickpea, potato and other planting materials.
4. For IDO 4: 10% increase in water use efficiency through innovative technologies in irrigation and farming in the field site.
5. For IDO 5: One-hundred households improve their vital activity through enhancing their leadership skills in participatory planning and decision making within their community based interventions.
6. For IDO 6: At least one innovation platform established within Action Site for multi-stakeholder dialogue to address socio-economic, cultural, management and policy issues at farm/community level and congruent decision and participatory planning of interventions for development; 10% of farmers, rural advisory services agents, agronomists, representatives of local agricultural education and research institutions improve their understanding and application of Sustainable Land Management (SLM) through continued facilitation of dissemination and up-scaling of SLM technologies and approaches.

(9) Publications

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Mueller, J.P., Kosimov, M.A., Kosimov, F.F., Brent, L., Nishanov, N., Rischkowsky, B. 2015. Do Texas Angora bucks improve mohair of Tajik Angora goats? *Small Ruminant Research*. [Submitted]

Nurbekov, A., Akramkhanov, A., Kassam, A., Turok, J., Sydyk, D., Ziyadullaev, Z. and Lamers, J.P.A. 2015. Conservation agriculture for combating land degradation in Central Asia: a synthesis. *Japanese Journal of Soil Science and Plant Nutrition*. [Accepted for publication]

Sharma, R.C., A. Amanov, Z. Ziyaev, E. Sadykov, J. Turok, A. Morgounov, M. Keser, F. Ozdemir, and M. Baum. 2014. Frost tolerance in winter wheat genotypes evaluated in Aral Sea cold zone in Central Asia. Poster presented at the Annual Meetings of the Crop Science Society of America, 2-5 November 2014, Long Beach, USA. *https://scisoc.confex.com/scisoc/2014am/webprogram/Paper89212.html*

Sharma, R.C., Z. Ziyaev, E. Sadykov, Y. Djumaniyazova, J. Turok, and M. Baum. 2015. Agronomic performance of salinity and frost tolerant winter wheat genotypes in Central Asia. Accepted for presentation at the International Wheat Conference, 21-25 September 2015, Sydney, Australia.

Blogs:
Breeding Angora Goats for finer mohair: the power of genetics and artificial insemination (Blog story on Artificial Insemination

Blog on Evapotranspiration-based irrigation scheduling (Blog story)
http://cac-program.org/files/b99ffb2d611550c1373cbf96f3c661c6.pdf

Video resources:
Video Lesson on Climate Change. Lesson I. Registration on ESGF website.
https://youtu.be/Nmsbc8hQxb0

Video Lesson on Climate Change. Lesson II. Downloading prognostic meteorological data from ESGF website. *https://youtu.be/B_4s17TR_DA*

Video Lesson on Climate Change. Lesson III. Extracting data of CORDEX files from a region with specified coordinates. *https://youtu.be/hOu8FYcXqv4*

Video Lesson on Climate Change. Lesson IV. CORDEX data correction based on daily observations of meteorological stations (CORDEX2SWAT_bias program). *https://youtu.be/bD-ZOpWYRh4*

Video Lesson on Climate Change. Lesson V. CORDEX data correction based on a decade observations of meteorological stations. *https://youtu.be/zCp4xJI5qDw*

Geoinformatics applications:
http://issuu.com/crpds/docs/atlas_crpds_sites_ca
http://geoagro.icarda.org/en/default/visualization/centralasia
http://geoagro.icarda.org/ca/
http://geoagro.icarda.org/awsl8.html
http://geoagro.icarda.org/en/research/details/Pest+%26+Diseases+Risk

General resources and E-News:
http://www.drylandsystems.cgiar.org
http://www.cac-program.org/crpds
http://www.cac-program.org/news/enews