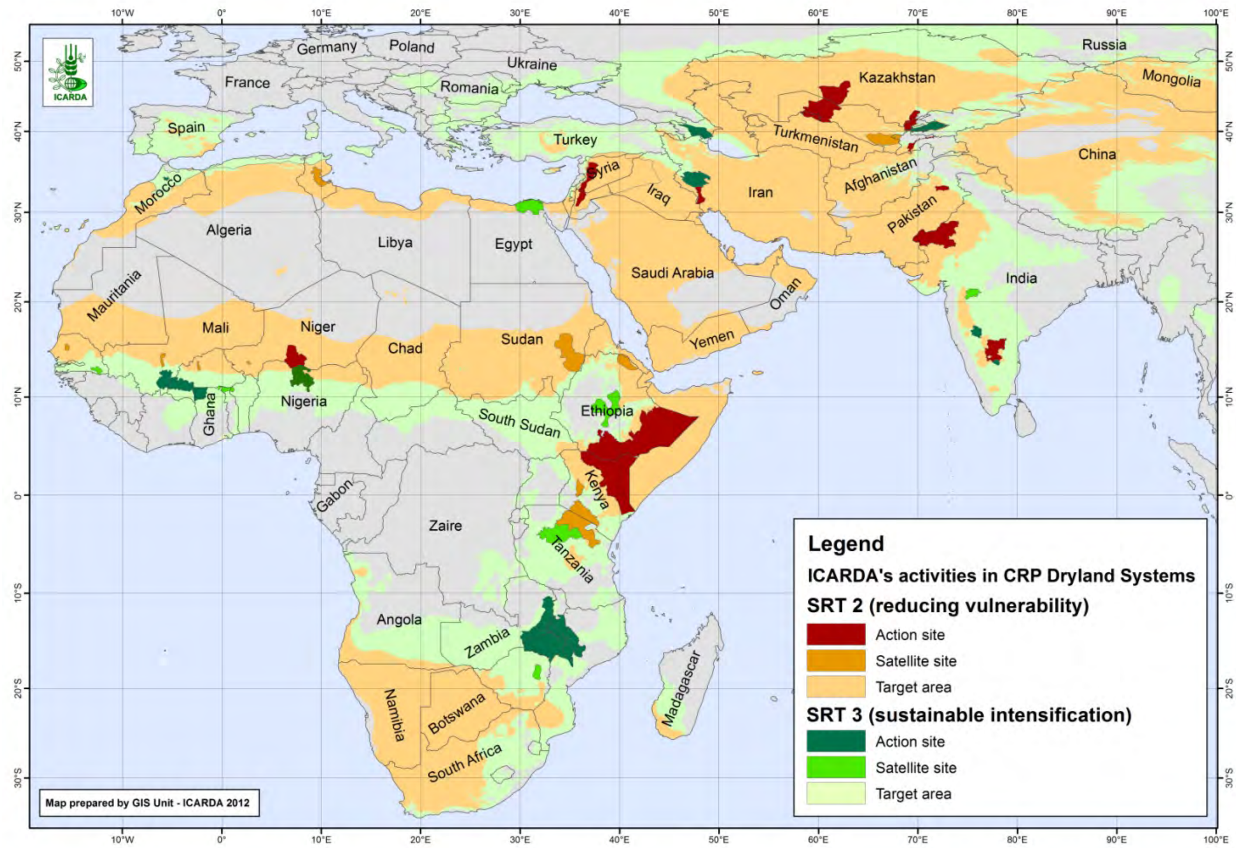
INTEGRATED AGRICULTURAL PRODUCTION SYSTEMS FOR IMPROVED FOOD SECURITY AND LIVELIHOODS IN DRY AREAS

Inception Phase Report



Multidisciplinary characterization and research prioritization for dryland systems of the West African Sahel and Dry Savannas, North Africa and West Asia, East and Southern Africa, Central Asia and the Caucasus, and South Asia

Contents

About this report

This report is the product of months of intensive groundwork that culminated in five regional inception workshops in which hundreds of scientists participated during an 11-month inception phase of the CGIAR Research Program on *"Integrated Agricultural Production Systems for Improved Food Security and Livelihoods in Dry Areas"* ("Dryland Systems"). Some US$10 million were invested in selecting and characterizing five target regions among the world's dry areas, and in creating targeted impact pathways to development using hypothesis-driven research. Inevitably, information from the five regions was imperfect, incomplete, and inconsistently gathered and reported.

The objective of this report is to summarize over 800 pages of characterization data and research planning in a standardized format that allows readers to compare and contrast characteristics among the areas in a way that has not previously been done. The report does not seek to disguise gaps or inconsistencies in site characterization, planning methodologies, and resulting priorities among regions.

Inception phase report: A multidisciplinary process of characterization and prioritization

The report on the inception phase of the CGIAR Research Program (CRP) on Dryland Systems covers a broad spectrum of socioeconomic and biophysical characteristics to show stakeholders why and how the Program chose its specific research-for-development (R4D) areas. This CRP relied on partners in each of the five target regions to gather data biophysical and socioeconomic data and review their research priorities. It brought together the foremost scientists from a multitude of disciplines to assess needs and formulate hypotheses, outcomes, and activities for each target region. The products of these efforts are presented in this report, and in the draft standardized logframes developed from the regional reports. These were used to articulate an impact pathway to guide the CRP's research efforts.

The CGIAR Consortium Board provided a critical short list of issues to be addressed, so-called "must haves", to guide the inception phase of the CRP (Box 1).

Box 1. CGIAR Research Program on Dryland Systems: Shortlist of critical "must haves"

1. Characterization of dryland systems
2. Clear hypotheses as an organizing principle to prioritize the research and results agenda
3. Provide criteria for choice of target areas and action sites in both the biophysical and social sciences
4. Prioritize activities to be carried out working from desired impacts to research activities
5. Provide detail on the underpinning science and agronomic, genetic, and farming system approaches to be evaluated once the first phase has progressed
6. Provide a comprehensive theory of how social change will result from the livelihood, gender, and innovations systems approaches in the current proposal
7. Discuss current research priorities and how they affect new initiatives
8. Identify clearly the research interventions proposed as a result of the diagnosis of the problems and constraints
9. Describe the framework for selecting external and center partners, their respective research activities, and how these activities collectively contribute to an integrated agroecosystem research agenda
10. Differentiate the roles of the crop/commodity CRPs and this systems CRP
11. Integrate available lessons learned from the Sub-Saharan Africa Challenge Program of the CGIAR
12. Develop a logical framework and articulate impact pathways to explicitly link a cluster of outputs to outcomes and impacts and to system-level outcomes of the CGIAR Strategy and Research Framework
13. Include a performance management framework
14. Build climate variability resilience and sustainable dryland systems through an integrated program combining indigenous knowledge with improved technologies, information dissemination, and engagement with stakeholders
15. Redefine management structure to ensure that the Steering Committee (strategic oversight) and the Research Management Committee (manage research) are not both chaired by the DG of the lead center, to avoid potential conflict of interest
16. Broaden the focus of the proposal to include Latin America and South Asia (cereal systems)

Executive summary

Key findings

This report provides an overview of the socioeconomic and biophysical state of five target regions with a view towards identifying and prioritizing research that aims at reducing vulnerability in more marginal agricultural systems of the dry areas and developing sustainable intensification in systems that have greater production potential.

A principal objective of this report is to provide well-rounded characterization of the areas that were chosen by broad consensus for research investment by the CGIAR Research Program (CRP) on Dryland Systems. The report outlines data and information on climate, soil, land use, land degradation, water resources, farming systems, poverty, market linkages, and institutional support and highlights major constraints, partners, and impact pathways in each of the five target regions.

The report also outlines how and why target regions were chosen and how they are categorized for the purposes of the CRP on Dryland Systems. From the consultations it became clear that the selected target regions are at different stages of development and are confronted by different challenges. Thus the entry points for the CRP in these target regions differ, as do the needs and opportunities in further development.

In the West African Sahel and Dry Savannas, key findings included serious challenges to reducing vulnerability and sustainable intensification resulting from drought, poverty, soil nutrient mining, and soil erosion. Poor infrastructure and a lack of institutional support for agriculture also greatly affect the area. Restricted livestock mobility and expansion of cropping onto marginal lands formerly used for grazing pose serious challenges to pastoral and agropastoral systems. Deforestation driven by demographic pressure is also a major regional concern. Major opportunities exist through increasing linkages of smallholder producers to regional livestock markets, increasing the capacity among farmers to raise production through improved access to inputs and technology, and providing sound options for better cropping and land-management systems. The CRP aims at improving the lives of 23 million people in the West African Sahel and Dry Savannas region and to mitigate land degradation on over 200 000 km^2.

In East and Southern Africa major swaths of agricultural land are categorized as arid or semi-arid, and frequent drought conditions affect livestock and crop production. Vulnerability to drought is exacerbated by poor infrastructure, low political will to serve these communities, and little market engagement. However, subsidies are currently available for much-needed soil inputs and some extension services and offer a means to cope with adverse environmental conditions; however, attention is needed to ensure that they do not discourage entrepreneurial undertakings. The CRP aims in six years to improve the lives of 20 million people in East and Southern Africa, and to mitigate land degradation on 600 000 km^2.

Currently, in North Africa and West Asia aquifer degradation is a pressing problem that will be exacerbated in the near future by climate change. Out-migration, farm fragmentation, and rejection of agropastoral lifestyles are also threatening the sustainability of farming in the region. This region is, however, easily connected to markets in Europe and has the potential to compete in those markets. The CRP aims in six years to improve the lives of 1.1 million people in the North Africa and West Asia, and to mitigate land degradation on 18 600 km^2.

In Central Asia and the Caucasus one of the major needs is for appropriate levels of mechanization for relatively large-scale farms. Farmers often lack experience and therefore need access to specialized irrigation training in order to better utilize the significant, but saline, water resources in their area. The CRP aims in six years to improve the lives of 500 000 people in Central Asia and the Caucasus, and to mitigate land degradation on 2 900 km^2.

In South Asia major swaths of land are classified as hyper-arid, usable only as rangeland for ruminants. In areas where irrigated agriculture is possible, soil and water salinity are major problems but, with a few exceptions, groundwater resources are not being over exploited. Greater levels of mechanization are also listed as a key priority for efforts to sustainably increase yields in areas of higher production potential. The CRP aims in six years to improve the lives of 65 million people in South Asia, and to mitigate land degradation on 465 000 km^2.

Agrobiodiversity in dryland systems

The five regions selected include major centers of diversity for crops, livestock species, vegetables, and trees of global importance. The genetic resources from these regions have evolved under harsh conditions, and are therefore crucial to overcoming the challenges of climate change and land degradation and for further diversification of farming systems to increase their resilience. This agrobiodiversity holds high potential for increasing diversification and sustainable intensification of the dryland farming systems, and can offer substantial opportunities for diversification and improvement of incomes in local communities to ensure sustainable livelihoods. Their potential for scaling out to other regions is also high.

Overall approach

Dryland systems in each target region have been placed into two general categories to better target research activities:

1) SRT2 (marginal, with high vulnerability), in which the goal is to increase productivity by 10–20%
2) SRT3 (higher production potential, with scope for sustainable intensification), in which the goal is to increase productivity by 20–30%

Consultations during the design and inception phases of the Dryland Systems CRP made clear that a great deal can be done in these systems. In the SRT2-type systems—dry, marginal, resource-poor areas with poor institutions and poor market connectedness—there are opportunities to avoid resource degradation and reduce vulnerability to system shocks and climate change. In SRT3-type systems—less marginal areas that tend to have better institutional support and access to markets—there are opportunities to sustainably intensify production. A significant number of partner organizations are already present in the areas in which the CRP proposes to conduct its research activities. Consequently, synergy with other organizations, as well as with other CRPs, will add to the effectiveness of the program. Factors constraining productivity of the agricultural systems in each of the target regions have been identified by consultation during the design phase and at regional inception workshops (RIWs), better enabling the CRP to contribute to solving “real world problems.” Specific hypotheses, outputs, and activities were also proposed at the RIWs to facilitate the attainment of agreed-upon outcomes by the CRP.

Section 1 – Introduction

1 Impetus for development of "integrated and sustainable agricultural production systems for improved food security and livelihoods in dry areas"

Dry areas of the developing world are characterized by persistent water scarcity and commonly suffer from land degradation. Most of the world's poor live in dry areas, including 400 million "poorest of poor" who survive on less than US$1 per day. Dry areas face several demographic challenges, including rapid population growth, high urbanization, age distribution that is heavily skewed towards youth, and the world's highest unemployment rate.

Among the 2.5 billion people living in dry areas, about one-third depend on dryland agricultural production systems for their food security and livelihoods. Dryland production systems cover about 3 billion hectares, or 41% of the Earth's land area, and employ a highly diverse mixture of crops used for food, feed and fiber; rangeland and pasture species; trees used for a multitude of purposes; and fish and livestock. The agroecosystems in which dryland production systems operate are challenging environments because of numerous biophysical and socioeconomic constraints. Biophysical constraints include drought, floods, temperature extremes, salinity, marginal soils, loss of biodiversity, and high vulnerability to land degradation. Socioeconomic constraints include poverty, social inequity, poor access to technology, underdeveloped markets, high population growth, and weak institutions. As a result of these many constraints, dryland systems in the developing world produce much less than is possible and, more importantly, much less than is needed by the growing populations who depend upon them for food security and livelihoods.

Because of the poor productivity of dryland systems, developing countries in the dry areas have had to rely increasingly on imported grain and other foodstuffs to meet their basic food requirements. Arab countries, for example, are the largest importers of cereals in the world. Countries in the dry areas have also witnessed proportionately greater rises in food prices than the rest of the world during recent commodity price shocks, and as a result their poor have suffered proportionately more. Increased dependence on imported food and higher food prices constitute threats to food security and livelihoods, and put the poor and vulnerable at particular risk.

To make matters worse, almost all global circulation models, and changes experienced over the last 20 years, predict that climate change will hit dry areas hardest, and particularly those in North Africa, sub-Saharan Africa (SSA), and West Asia. Specific projections of these models tend to suggest that climate change will further exacerbate the biophysical and socioeconomic stresses that societies in the dry areas must face, and with which their agricultural production systems must contend to ensure food security and livelihoods.

Benefits of sustainably increasing productivity of dryland systems include reduced poverty, improved food security, better health and nutrition, conservation of natural resources, and reduced social inequity. The first four of these benefits are restatements of the CGIAR System's "System Level Outcomes" (SLOs), while the fifth not only addresses the mainstreamed theme of gender but is also one of the criteria of sustainability.

The corollary must also be frankly stated and made clear to more affluent nations: The consequences of failing to address poor productivity of dryland systems include further land degradation and loss of biodiversity, more poverty, increased food insecurity, poorer nutrition, rising unemployment, rural exodus, and even greater social inequality. None of these bode well for political stability, as recent events in some of the dry areas illustrate.

2 Organization of the Dryland Systems CRP

The CRP on "Integrated and Sustainable Agricultural Production Systems for Improved Food Security and Livelihoods in Dry Areas," or more succinctly "Dryland Systems," targets the poor and highly vulnerable populations of dry areas in developing countries and the agricultural production systems upon which they depend. The Dryland Systems CRP, which was formerly known as "CRP1.1," was developed from Thematic Area 1 of the CGIAR's Strategy and Results Framework (SRF), "Integrated Agricultural Systems for the Poor and Vulnerable," which defines target areas as "systems characterized by major constraints, such as drought or other agroclimatic challenges, poor infrastructure and underdeveloped markets, or weak institutions and governance."

The Dryland Systems CRP begins with the premise that successful dryland agricultural production systems, such as those in parts of Australia and North America, have evolved through an integrated systems approach that includes the right mix of innovative partnerships, diverse technologies, and appropriate policies. Similarly, the Dryland Systems CRP uses a systems approach based on sound principles of the biophysical and socioeconomic sciences, development theory, and project management to develop the right mix of partnerships, technologies, and policies to improve targeted dryland systems in major dry areas of the developing world.

Conceptually, dryland production systems can be divided into two broad categories: Those with the deepest endemic poverty and most vulnerable people, which are often faced with severe natural-resource degradation, pronounced climate variability, and social inequity; and those in less marginal agroecosystems, which have the potential to positively impact food security and poverty in the short to medium term. These categories are somewhat arbitrary and admittedly simplify the inherent complexities within dryland systems, but they are consistent with the CGIAR SRF, and allow us to identify two basic but complimentary approaches to improving dryland systems:

- Reducing vulnerability and increasing resilience to biophysical and socioeconomic shocks despite marginal conditions; and
- Sustainable intensification of somewhat better-endowed production systems to reduce food insecurity and generate more income.

The overarching challenge for the Dryland Systems CRP is to deliver benefits to the poor and vulnerable in these two broad categories of dryland production systems. Consistent with the SRF's general principles, the Dryland Systems CRP is driven by a conceptual framework in which four strategic research themes (SRTs) are implemented as steps along an impact pathway, or logic model, that describes how the research will lead to outputs, which will in turn contribute to the four CGIAR SLOs:

- Reducing rural poverty
- Improving food security
- Improving nutrition and health
- Sustainable management of natural resources

and to four interrelated cross-cutting themes:

- Gender
- Youth
- Biodiversity
- Nutrition.

Each SRT within the conceptual framework has an associated set of targeted outputs (Table 1).

Table 1. Strategic research themes and associated outputs for the Dryland Systems CRP.

Strategic research theme	Output
1. Approaches and models for strengthening innovation systems, building stakeholder innovation capacity, and linking knowledge to policy action	1.1 Approaches and models for strengthening innovation systems, building stakeholder innovation capacity, and linking knowledge to policy action
	1.2 Enhanced capacity for innovation and effective participation in collaborative processes for international agricultural research for development
	1.3 Strategies for effectively linking research to policy action in a dryland context
2. Reducing vulnerability and managing risk through increased resilience	2.1 Combinations of institutional, biophysical, and management options for reducing vulnerability designed and developed
	2.2 Options for reducing vulnerability and mitigating risk scaled up and out within regions
	2.3 Trade-offs among options for reducing vulnerability and mitigating risk analyzed (within regions). Knowledge-based systems developed for customizing options to sites and circumstances
3. Sustainable intensification for more productive, profitable, and diversified dryland agriculture with well-established linkages to markets	3.1 Sustainable intensification options designed and developed
	3.2 Sustainable intensification options scaled out
	3.3 Trade-offs among sustainable intensification and diversification options analyzed (within regions). Knowledge-based systems developed for customizing options to sites and circumstances
4. Measuring impacts and cross-regional synthesis	4.1 Future scenarios and priority setting
	4.2 Livelihood and ecosystem characterization. Across-region synthesis of lessons learnt from SRTs 2 and 3
	4.3 Program impacts measured

Early program activities in the Dryland Systems CRP, and therefore intermediate development outputs (IDOs), will be concerned primarily with:

- forming partnerships as part of specific innovation platforms;
- further characterization of the various dryland systems in each target region;
- identification of technologies, institutions, and policies to manage risk or sustainably intensify systems; and
- development of tools for monitoring and synthesis.

Scaling up and **scaling out** are, in general, longer-term outputs.

The **specific goals** of the Dryland Systems CRP are to:

- prioritize key agricultural systems for impact;
- identify key researchable issues within target agroecosystems;
- increase the efficiency and sustainability of natural resource use (especially in-field);
- develop more resilient agricultural systems to manage risk and production variability;
- promote *in situ* and *ex situ* conservation and sustainable use of dryland agrobiodiversity to enhance food security and environmental sustainability;
- improve the productivity and profitability of agricultural systems through sustainable intensification, diversification, value-added products, and market linkages;
- identify niches of importance to the most vulnerable livelihoods;
- address constraints faced by the most marginal farmers; and
- develop new partnerships and models of working together.

3 Partnerships

A key component of SRT1, which centers on innovation, is partnerships. The Dryland Systems CRP will strive to include all major players: farming communities, national research and extension systems, policy-makers, international and regional organizations, advanced research institutes, civil society and non-governmental organizations (NGOs), the private sector, and development agencies.

The CRP will bring together people and institutions to provide the expertise needed at each stage of the research-for-development continuum. At the same time, the research aims to identify international public goods (IPGs) that can be scaled out rapidly to other areas with similar agroecologies and system properties, so that research findings can be rapidly disseminated and adopted. One of its major principles is the on-the-ground involvement of multiple stakeholders in each region and community. The Dryland Systems CRP starts with a needs assessment among stakeholders on a regional basis, with a view towards defining activities for the first three years. The program is expected to evolve, with a view towards streamlining its mandate and vision and expanding stakeholder commitment to (and investment in) this shared vision. Likewise, the stakeholder constituency, and therefore activities to be implemented, will evolve with the program. Nevertheless, we are already implementing the Dryland Systems CRP's concepts based on needs assessed prior to and during the inception phase.

Consistent with the guidelines of the CGIAR SRF, the Dryland Systems CRP has, with its many stakeholders, identified **five** target regions where both a broad range of dryland production systems are practiced and determinants of food security and livelihoods are highly variable. These are:

1) West African Sahel and Dry Savannas
2) East and Southern Africa
3) North Africa and West Asia
4) Central Asia and the Caucasus
5) South Asia.

Within these regions, the program adopted a hierarchical approach of characterization, prioritization, and selection of research sites, to include:

- **Target areas:** large areas representing a variety of dryland systems and their predominant livelihoods, which are not necessarily contiguous. These are:
    - **SRT2-type target areas** that are extremely agriculturally constrained, where risk and vulnerability to loss of production and income is the most immediate concern. These are drier, more-marginal areas that are not well connected to markets. Here, the priority is to minimize risks and reduce sources of vulnerability.
    - **SRT3-type target areas** where there is more production potential and opportunities exist for sustainable intensification. In these areas, the priority is to increase productivity and income while respecting the tenets of sustainability.
- **Action and satellite sites:** Sites that are representative of the two target area types, and where the implementation of the integrated systems research from the target areas will be implemented with program partners.

4 Status of the Dryland Systems CRP

CRP1.1 Dryland Systems was first submitted on 10 September 2010 to the CGIAR Consortium Board (CB) by the Lead Center, the International Center for Agricultural Research in the Dry Areas (ICARDA), as the proposal on "Integrated Agricultural Production Systems for the Poor and Vulnerable in Dry Areas". A revised proposal submitted on 28 February 2011 was approved by the CB on 4 March 2011, then approved, with 16 conditions, at the fourth Funding Council (FC) meeting, held on 5–6 April 2011 in Montpellier, France. Seven of these conditions, or “must haves,” were from the Independent Science and Partnership Council (ISPC), and nine were from the FC.

In response, ICARDA held two professionally facilitated workshops to address the “must- haves”. The first, held on 11–13 May 2011, consisted of a core writing team of ten partners who met in Dubai, United Arab Emirates (UAE), to identify inputs and stakeholders needed to ensure a participatory and transparent process for selecting research sites and identifying priority activities. The second workshop, entitled “Dryland Systems Regional Design Working Meeting,” was held in Nairobi, Kenya, on 27–30 June 2011, and was attended by about 80 stakeholders from the five target regions. This meeting was intended to broaden participation in the decision-making process for implementation sites and to ensure that proposed research built upon ongoing work and existing projects. The June 2011 meeting constituted the seventh meeting in 12 months for the Dryland Systems CRP planning.

A third version of the proposal, which included a description of how the “must haves” were addressed, was submitted to the CB on 17 July 2011 and forwarded to the FC on a “no objection” basis along with ISPC comments to the effect that it was too early to consider the proposal as having met its specific conditions. The ISPC suggested that it would be necessary to make further comments on a more detailed proposal after the inception meetings had concluded and their outcomes had been analyzed.

At the sixth meeting of the FC, held on 8 and 9 November 2011 in Rome, Italy, unconditional approval of an inception phase was given, allowing the use of US$10 million from the Windows 1 and 2 budget component of the proposal version submitted in July 2011. The period of the inception phase was left to the judgment of ICARDA. Conditional approval was given to the overall proposal, including program content, the remaining Windows 1 and 2 budgets of US$60.33 million, and Window 3, which represents the bilateral component.

The expectation of the FC was that the proposal was to be revised based on the activities during the inception phase. The resultant fourth version of the proposal will be reviewed by the ISPC, which will then submit a commentary on the revised proposal and advise the FC. The revised proposal will be circulated to the FC for virtual approval on a “no objection” basis. If there is any objection, the Chair of the FC and the Chair of the CB will discuss and agree on the next course of action.

5 Inception phase actions and activities

The FC’s unconditional approval of the inception phase and its conditional approval of the overall proposal on 9 November 2011 represent the beginning of the Dryland System CRP, albeit under the onus of the 16 “must haves” and other critiques of the ISPC. The Dryland System CRP has viewed the inception phase as an intimate and necessary part of its implementation phase and, since the FC’s approval, has undertaken the following actions:

1) Following interaction with the ISPC chair, four international expert consultants were appointed to facilitate the inception phase: Drs John Lynam, Paul Vlek, Brian Keating/Peter Carberry (jointly), and Rodomiro Ortiz. These consultants have strengthened the program’s level of expertise in agroecosystems, natural-resource management (NRM), and innovation systems.
2) A meeting was held in Dubai, UAE, on 28 and 29 January 2012 to prepare for the CRP1.1 Framework Development Workshop. It was attended by senior ICARDA staff and the four consultants.
3) The CRP1.1 Framework Development Workshop itself was held over three days (30 January–1 February 2012) in Dubai, UAE. It was attended by the DGs of ICARDA, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the World Agroforestry Centre (ICRAF), the International Livestock Research Institute (ILRI), the five target region “focal points,” the Director of the Sub-Saharan Africa Challenge Program (SSA CP), and various subject-matter experts.

4) An Interim Steering Committee was formed from the four Centers to organize regional inception workshops (RIWs). A full Steering Committee is to be formed later, as described in the CRP proposal.
5) The Director of CRP1.1 Dryland Systems was recruited from among four short-listed candidates chosen from a pool of 27 applicants. The selection committee included representatives of three CGIAR Centers, and ICARDA's Director General, Deputy Director General–Research, and Assistant Director General of International Cooperation and Communication, and the Director of ICARDA's Human Resources Department. The committee unanimously agreed to extend an offer to Dr. William Payne, Professor and Research Director of the Norman Borlaug Institute for International Agriculture at Texas A&M University. Dr. Payne began his duties on 16 June 2012.

In addition to these actions, the Dryland Systems CRP undertook the following research-planning activities:

Groundwork. In all five target regions, interim Interdisciplinary Research Teams (iIRTs) were formed from a variety of partners that included national, regional, and international agricultural research and development organizations. Their tasks were as follows:

1) Identify, prioritize, and select major target areas to be addressed within each target region. Action sites were to be selected within target areas using seven criteria:
    i) Accessibility, including proximity to research facilities (partners, CGIAR Centers, etc.)
    ii) Ability to test research hypotheses
    iii) Representativeness of the target region
    iv) Potential for scaling out (e.g., existing supportive institutional environment, presence of other actors, appropriate target population size, etc.)
    v) Ability to attract financial and other needed resources
    vi) Potential synergy with other CRPs
    vii) Availability of existing data on production systems and socioeconomic factors
2) Characterize target areas and action sites to fill in critical information gaps and identify major constraints to and opportunities for achieving outcomes associated with SRTs for the two broad categories of dryland systems.
3) Develop a research proposal to achieve the SRT outcomes for presentation and discussion with stakeholders at subsequent RIWs. For each target region, proposals were to characterize production systems, identify putative action sites, potential partners, major constraints, and potential research activities.

During the groundwork numerous meetings were held with all relevant stakeholders.

Regional inception workshops: Five RIWs were organized by the iIRTs with the following objectives:

- Inform the various partners of progress in the Dryland Systems CRP, including its overall scope, approach, and intended impacts both globally and within each target region
- Revisit and finalize target areas, and the associated action and satellite sites, where the majority of the research will be implemented
- Characterize sites for their agroecosystems and livelihoods
- Identify major constraints to production and livelihoods
- Analyze successes and failures in the target regions
- Form hypotheses and research questions for action sites

- Identify and prioritize research-for-development interventions to address these hypotheses and questions
- Develop detailed work plans, including specific research activities, approaches, and methods, partnerships, and stakeholders
- Discuss and agree on the elements for a complete logframe to be completed after the RIW
- Identify linkages with other CRPs and engagement strategies for joint research
- Discuss elements for the capacity development plan using innovation platforms, to be finalized after the RIW
- Discuss and agree on the elements for the monitoring and evaluation plan at the regional level, to be finalized after the RIW.

Brief excerpts from summaries of the five RIWs follow below. Full press releases are available upon request.

1) West African Sahel and the Dryland Savannas: A three-day workshop was held in Ouagadougou, Burkina Faso, on 28–30 May 2012. The meeting was presided over by the host country's Minister of Scientific Research and Innovation, Prof. Gnissa Isaïe Konate. The workshop was organized by ICRAF, and attended by some 60 delegates.

   The meeting was conducted in a highly participatory manner. The participants discussed the key constraints and challenges of achieving food security and improving rural livelihoods in the drylands of SSA. During the workshop, participants finalized the mapping out of the program's action sites, developed a consensus around the key constraints and research hypotheses at each action site, finalized site characterization, and clarified the roles of multiple partners.

   Action sites included the Kano–Katsina–Maradi (KKM) action transect and the Wa–Bobo–Sikasso (WBS) action transect.

   Satellite sites included Cinzana, Fakara, Ouahigouya, and Tolon-K.

2) East and Southern Africa: More than 45 researchers and development partners met in Nairobi, Kenya, at the regional workshop for East and Southern Africa, kindly hosted by ILRI. CRP1.1 Dryland Systems partners and stakeholders gathered to debate the details of research action sites and partnership roles for the program. ICARDA organized these events along with seven other CGIAR Centers (ICRAF, ICRISAT, ILRI, the International Water Management Institute [IMWI], the International Potato Center [CIP], the International Center for Tropical Agriculture [CIAT], and Bioversity International) and the SSA CP. Key challenges and constraints for livelihoods and food security were discussed, action sites were chosen, and research hypotheses for the region were finalized. Site characterization and the roles of the various partners and stakeholders were also decided upon.

   Action sites chosen for this region include Ghanzi and Kweneng in Botswana; Vryburg and Kuruman in South Africa; Karas in Namibia; the triangle from Garissa in Kenya to Borana in south-central Ethiopia to the Somali region in southeast Ethiopia; the Chinyanja Triangle covering Zambia, Malawi, and Mozambique; the Oromia zones of East Shoa, West Shoa, and Horagudru, and the Amhara zone of North Shoa; and Kajiado–Serengeti–Shinyanga in southern Kenya and northern Tanzania.

   Satellite sites for this region included Baringo (Kenya), and Geregera, Afar, and Koneba (Ethiopia).

3) North Africa and West Asia: Rabat, Morocco was the venue for a three-day RIW for the North Africa and West Asia region. The workshop, held on 2–4 July 2012, was co-organized by ICARDA and the National Agricultural Research Institute (INRA), Morocco. More than 80 international experts and researchers participated, including participants from 12 countries of West Asia and North Africa. Other stakeholders present included representatives of

international development agencies and donors (African Development Bank, Islamic Development Bank), international research centers (Bioversity International, ICRAF, the International Center for Biosaline Agriculture [ICBA], the World Vegetable Center [AVRDC]), regional research forums (Association of Agricultural Research Institutions in the Near East and North Africa [AARINENA], Forum for Agricultural Research in Africa [FARA], SSA CP), and European research institutions (Centre de coopération internationale en recherche agronomique pour le développement [CIRAD], France; Institut Agronomique Méditerranéen de Montpellier [IAMM],-France; University of Göttingen, Germany; National Institute for Agricultural Research [INRA], France; Agropolis International, France). Opening the workshop on behalf of the Moroccan Minister of Agriculture and Marine Fisheries, Prof. Badraoui (DG, INRA/Morocco) pointed out the relevance of the CRP1.1 program to Moroccan agriculture and ongoing strategies for agricultural development, especially Pillar II of the Green Morocco Plan. He also expressed the commitment of the Moroccan Government to support CRP1.1 and work with the other countries of the region to achieve the objectives of this program.

Action sites chosen for this region were Jordan–Syria, Meknes–Saiss (Morocco), and the Nile Delta (Egypt).

Satellite sites chosen for this region were Beni Khedache–Sidi Bouzid (Tunisia) and the Karkheh River Basin (Iran).

The proceedings of the workshop and the various reports and documents are published on the CRP1.1 wiki site (http://cgiar-drylands.wikispaces.com/).

4) Central Asia and the Caucasus: Participants at a three-day RIW held on 12–14 June 2012 in Tashkent, Uzbekistan, endorsed an ambitious research framework that will tackle the challenges of sustainable agricultural development under the harsh environmental conditions of drought, high soil salinity, and extreme climatic conditions.

The RIW was organized by ICARDA in partnership with other international agricultural research centers based in the Central Asia and the Caucasus (CAC) Region: AVRDC, Bioversity International, CIP, IWMI, and ICBA. The workshop was opened by Prof. Sherali Nurmatov, Deputy Minister of Agriculture and Water Resources of Uzbekistan. In his welcome speech, he stressed the importance of improving the well-being of rural population in harsh arid areas through the introduction of sustainable livelihood options in the agricultural sector using innovations and state-of-the-art technologies.

The event was attended by about 100 participants from the international centers, national research institutes and universities, farmers' and community-based organizations, private sector, and international development and donor agencies. The participatory working environment led to a strong exchange of ideas with the aim of reaching consensus to move this program from inception to implementation. CRP1.1 will build its research agenda on a unique combination of multidisciplinary agroecosystem approaches and site-specific action relying on gathering baseline information and measuring impact. The participants openly shared their views to help shape the program's agenda in the CAC region. With their contributions, the strategic framework for integrated research was set and endorsed.

Action sites chosen for this region were the Aral Sea, Rasht Valley, and Fergana Valley.

Satellite sites chosen for the region were the Kura-Arax plain in Azerbaijan and the Kashkadarya province in Uzbekistan.

5) South Asia: A three-day RIW for South Asia was held in Dubai, UAE, on 25–27 June 2012. The gathering was organized on behalf of CRP1.1 by ICRISAT and involved ICARDA, ILRI, IMWI, CIP, and Bioversity International. Some 50 participants from India, Pakistan, and Afghanistan attended and took part, including scientists from national programs and state agricultural universities, NGOs, and the private sector. The aim of the workshop was to confirm

the CRP1.1 action sites for South Asia, to collectively understand what a systems approach is and does, to identify system-level problems and hypotheses in and across action sites, and, crucially, to build partnerships. The meeting also had lively sessions on gender, livelihoods, and smallholder profitability to help stimulate thinking about the systems approach. By the close of the meeting action and satellite sites had been selected, a set of 10–12 system-level hypotheses had been generated along with definitions of outputs and agreements on partner activities and contributions to research in the action sites.

Action sites chosen for South Asia included Jodhpur, Barmer, and Jaiselmer in Rajasthan, India; Bijapur in Karnataka, India; and Anantapur and Kurnool in Andhra Pradesh, India.

Satellite sites chosen included Chakwal in Pakistan and Maharashtra/Madhya in Andhra Pradesh, India.

Plan for full implementation: Following the completion of groundwork and the RIWs, the outputs of the RIWs were consolidated and integrated for inclusion into the inception phase report and into the revised proposal by the Drylands Systems Director, in consultation with the many partners who make up the CRP.

Section 2 – Interim Inter-disciplinary Research Team Reports

As has already been mentioned, partnership is a key component of the Dryland Systems CRP, and especially within the context of SRT1, which frames partnership as part of the innovation research process. The iIRTs, which provided leadership in the research planning process of the inception phase of the Dryland Systems CRP, are examples of this. The iIRTs facilitated all groundwork, target area and site characterization, and they then produced written reports on each of these activities. Typically, groundwork and site characterization involved: (a) an initial global consultation in Nairobi, Kenya, in July 2011; (b) subregional workshop meetings with stakeholders in SRT2- and SRT3-type systems; and (c) follow-up meetings and electronic communication among consultants and key staff to facilitate synthesis and write-up. The subregional workshops and the stakeholder communication involved further underscore the partnership approach taken by the Dryland Systems CRP.

Each of the iIRTs was asked to provide the following deliverables for their respective target regions:

- Action site characterization for the two categories of dryland systems in the target area
- Description of constraints and problems
- Hypotheses and major research questions
- Outputs, outcomes, and activities
- Partners
- Impact pathway and logframe.

The full iIRT reports are much too detailed and voluminous (100–180 pages) to include in this inception report or the revised proposal, but they can be accessed through the Dryland Systems CRP website. They provide a wealth of biophysical and socioeconomic characterization data for the various SRT2- and SRT3-type dryland systems, and in effect constitute the first output of IPGs of the Dryland Systems CRP. On a very practical level, they provide key information with which to revise the Dryland Systems CRP proposal and address the “must haves” of the ISPC and FC.

They also provide the basis for a research and performance management framework based on a standard logframe that is being developed from the various impact pathways and logframes from the five iIRT reports. The logframes are meant to capture and assess both the impact pathway (as embodied in the conceptual framework) and the scientific method through which outcomes will be attained where the CRP works. The standardized logframe starts with a specific problem identified with stakeholders during the consultative process and the desired outcome (Table 2). Hypotheses were then identified with a view to producing research and other types of outputs that would lead to the desired outcome. Research activities related to achieving such outputs—literature review, experiments, training, communication, etc. —are now being refined, along with suggested objectively verifiable indicators of outputs. The standardized logframes are too long to be presented individually but they are available for the various target regions.

The standardized logframe frame will be incorporated into a research and performance management framework that will track progress towards CRP outcomes and the larger four SLOs. It will also be linked to data acquisition, flow, and utilization, especially within the context of SRT4 and the models employed; and it will be used as a tool for budget tracking (through activities) and performance assessment (through tracking and analyzing uploaded data). The framework is currently under development with the Statistical Services Centre at the University of Reading and will be implemented as one of the first activities during the implementation phase.

Table 2 is a sample of the standardized logframe developed for CRP1.1.

Table 2. Sample logframe.

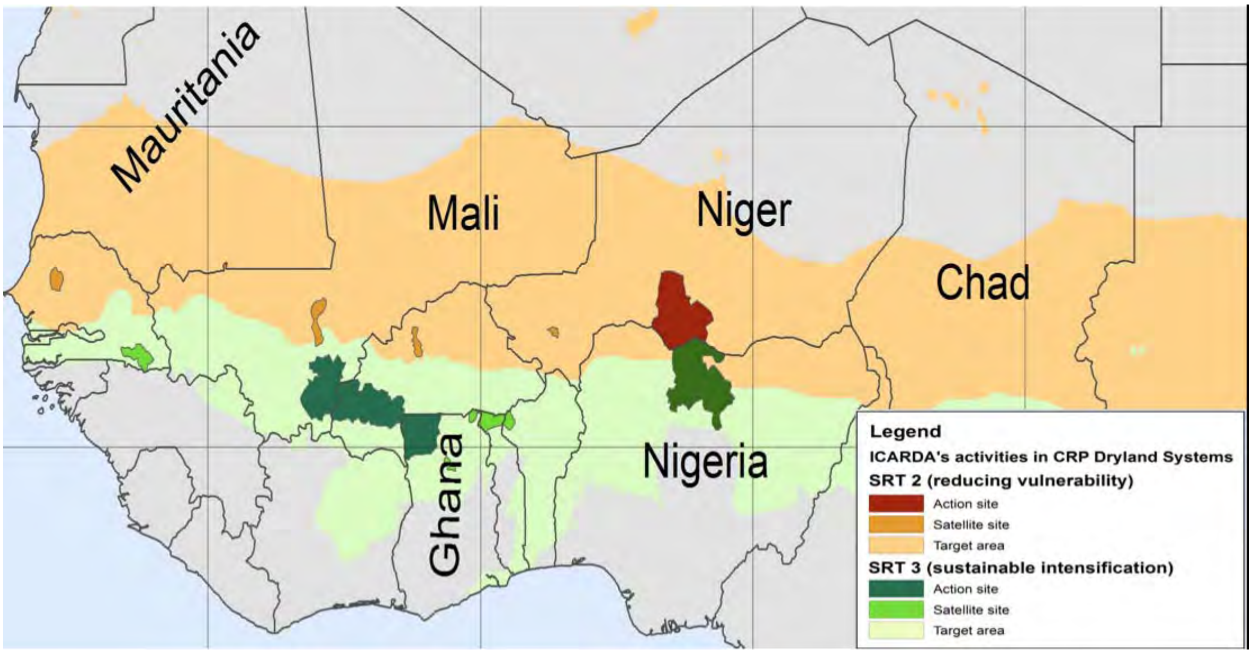
Sample Logframe					
	Central Asia & Caucasus				
	Problem: Sustainable Management of natural resources				
SRT	Desired Outcome	Hypothesis	Outputs	Activities	Objectively Verifiable Indicators
SRT2-3	Improvement of integrated land conservation. Watershed management is established and operational in Rasht and Kyzyl-Suu Valleys and Aral Sea region.	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 functioning and responses in addressing agricultural constraints (for rangelands and irrigated agriculture)	Output 2.1. Innovation knowledge platform for integrated land conservation, watersheds management is established and operational in Rasht and Kyzyl-Suu Valleys and Aral Sea region	Activity 2.1.1: Knowledge synthesis, generation, packaging and dissemination (knowledge platform) of Sustainable Land and Water Management practices in the Aral Sea Basin (Central Asia)	Number of improved technologies and management options adopted by participating farmers and end-users.
				Activity 2.1.2: Understanding land conservation and soil fertility in the degraded environment of Rasht and Kyzyl-Suu Valleys: establishing practices aiming at a sustainable land conservation and improvement of soil fertility.	Number of national policy-makers, scientists and other stakeholders who are using the knowledge platform.

The iIRT reports are not perfect. The site characterization process consisted of an intense three-month period in which as much relevant site data as possible was collected, especially from national programs. Not all data sets were immediately available, and inevitably there were glitches encountered while trying to obtain biophysical and socioeconomic data. Furthermore, not all iIRTs used exactly the same format or disciplinary emphasis in preparing reports, impact pathways, or logframes, resulting in some inconsistencies. But the iIRT reports are to an extent “living documents” that will have to be periodically updated and fine-tuned through an iterative process to improve their content, much as the Dryland Systems CRP proposal itself, as well as a number of consortium strategic documents on gender, biodiversity, etc.

In the synopsis that follows, we summarize biophysical and socioeconomic site characterization for the action sites (satellite site summaries are not given due to space constraints). We also describe constraints and the partnerships that have been formed or can potentially be formed to address these constraints. Finally, research questions and/or hypotheses identified during the RIWs are given, as they lend themselves to the standardized log frames.

6 West African Sahel and Dry Savannas

Figure 1. SRT2 and SRT3 areas in the West African Sahel and Dry Savannas region.



Based on the seven selection criteria, and in recognition of the spatial complexity of dryland systems, in the West African Sahel and Dry Savannas (WAS&DS) Dryland Systems CRP will work along two "action transects" that cover SRT2/SRT3 gradients rather than identify "homogeneous" SRT2 and SRT3 action sites. The action transects selected are:

1) The Kano–Katsina–Maradi (KKM) transect, which is mostly located within the SRT2 target area; and
2) The Wa–Bobo–Sikasso (WBS) transect, which is mostly located within the SRT3 target area.

Table 3. Research sites for the West African Sahel and Dry Savannas, identified within action transects.

Research site		Administrative levels					Approx. center coordinates	
	Code	1	2	3	Area (km^2)	Population	Lat.	Long.
Aguié	KKM1	Niger	Maradi	Aguié	35 100	3 117 810	13.05	7.78
Daura	KKM2	Nigeria	Katsina	Daura	24 192	6 483 429	13.03	8.3
Kofa	KKM3	Nigeria	Kano	Bebeji	20 131	9 383 682	11.55	8.27
Duori	WBS1	Ghana	Upper West	Jirapa-L.	18 476	576 583	10.6	-2.76
Orodara	WBS2	Burkina Faso	Kenedougou, Hauts-Bassins	Orodara	25 344	1 410 284	10.98	-4.92
Sougoumba	WBS3	Mali	Sikasso	Koutiala	70 280	2 625 919	12.17	-5.18

6.1 SRT2/SRT3 action sites

6.1.1 Biophysical characterization

Climate

The WBS action site has only one rainy season per year, with long-term mean annual total rainfall ranging from 667 mm in the northern part of the transect (Duori) to 1121 mm at the Orodara site and 1095 mm at the Tamale site. In the KKM action site, there is also only one rainy season with long-term average annual total rainfall ranging from 533 mm in the northern site (Aguié) to 891 mm in the southern site (Kofa). The aridity index on the KKM SRT2 transect is between 0.03 and 0.35 while the aridity index on the WBS SRT3 transect is between 0.35 and 0.65.

The rainy season usually starts in April or May in the southern part of the WBS transect and in June in the northern part, and ends in October along most of the transect, except in the extreme north where it ends in September. The rainy season usually starts in June in the southern part of the KKM transect and in July in the northern part, and ends in September. The severity of drought can be considered as moderate in the southern part of the WBS transect but high in the northern part, and the area is vulnerable to early, mid-, and late-season drought. The severity of drought is high throughout the KKM transect, and drought risk is high throughout the season.

Soil types and health

Using the soil classification system of the Food and Agriculture Organization of the United Nations (FAO), the most widespread soils in the WBS area are mixtures of Ferrasols/Oxisols, Luvisols/Alfisols, Ferralitic Arenosols, and Arenic Gleysols/Cambisols. Organic carbon (C) content is 0.34–1.44% and total nitrogen (N) content is 0.02–0.12%. Available phosphorus (P) (Bray I) is 2.0–7.4 mg/kg soil, except for bottom valley soils where these values tend to be higher. The main textural classes are loamy sand, sandy loam, loam, sandy clay loam, clay, and silty clay loam. These characteristics impose some limitations on crop production including restriction of plant rooting systems, high runoff, and low retention of water and nutrients.

In the KKM area, the most widespread soils are Luvic Arenosols, Eutric Regosols, Luvisol/Alfisol/Ferralic Arenosol, Gleyic Luvisols, Gleyic Cambisols, and Eutric Fluvisols, according to the FAO soil classification system. There is no constraint in rooting depth on sandy soils. However, most of the root mass of annual crops (millet, sorghum, cowpea) is in the top 30 cm of the soil. The soil texture being extremely sandy (85–95% sand), water-holding capacity ranges between 0.15 and 0.07 g/cm^3. Organic C content ranges between 0.15 and 0.30% in top soil and decreases to 0.08–0.10% at 50 cm depth, except on manured soils. The pH of the top 30 cm of soil ranges between 4.5 and 6.2 in the dominant sandy soils.

Land cover and use

The greater proportion of the WBS action site has been cropped or grazed since the 1990s. The farming systems have undergone a number of changes over time, due to population and livestock increases, changes in the economic situation, and the introduction of new farming technologies. Rainfed cropping systems are the most important across the KKM action site. With increasing population and livestock, all the landscapes in this area are reaching a point of full exploitation.

Land degradation

It has been reported that 46% of soil degradation in Africa results from water erosion, 36% from wind erosion, 9% from nutrient losses, 3% from salinization, and 4% from physical deterioration. In the WBS area, estimates in Burkina Faso indicate that in 1983, for a total of 6.7 million hectares of land cultivated, soil nutrient mining amounted to a total loss of 95 000 tons of N, 28 000 tons of P_2O_5, and 79 000 tons of K_2O, equivalent to US$159 million worth of N, P, and K fertilizers. In Mali, farmers extract, on average, 40% of their agricultural revenue from soil mining. The Soil Research Institute in Ghana reported that at least 23% of the country was subject to very severe sheet and gully erosion, 43.3% to moderate sheet and gully erosion, and 29.5% to slight to moderate sheet erosion. The KKM action site is particularly prone to wind erosion. The mean annual soil loss estimated for Katsina region of Nigeria is 17 tons/ha per year. Expansion of cropland, shortening of fallow duration and loss in soil fertility also tends to impoverish herbaceous flora, which are largely dominated by unpalatable weeds, causing a serious problem of fodder availability and quality in the rangelands.

Water resources

The majority of crops (about 80%) are rainfed in the WBS and KKM action sites. Almost all the WBS transect lies in the Volta river basin, where a number of water bodies flow through the region and make irrigated crop production possible. Irrigation is used mainly during the dry season. In the KKM, river and lake systems contain water only during the rainy season and have little or no water in the dry season. In both WBS and KKM areas, wells and boreholes are being dug to take advantage of the underground water bodies to irrigate vegetables. The Kano river authority is also implementing significant investment policies for floodplains in southern KKM.

Farming systems

Most cropping systems in both WBS and KKM transect areas are rainfed, but there is significant investment in irrigation systems by governments and farmers. In the WBS area, bush fallow and mixed systems dominate, with sorghum, maize, rice, cowpea, groundnut, yam, and cotton as main crops. Cereals and legumes are generally intercropped. In the KKM area, pearl millet, sorghum, cowpea, groundnut, rice, and, in the southern part, maize are grown as the main crops. Irrigated garden systems for vegetables and onions, often led by women, are widespread in the KKM area. The main irrigated crops are rice and maize. The government has made significant investment in vegetable systems, specifically onions, tomatoes, cabbage, potatoes, and peppers through farmer associations. Agropastoral and pastoral systems are the main livestock production systems in both the WBS and the KKM areas, with the pastoral system being limited by grazing land access. The main animal species are cattle, sheep, goats, and poultry; species vary among the action sites. The crossbred brahman/zebu cattle dominate in the WBS, while zebu breeds dominate in the KKM. Goat breeds also differ between action sites. Parkland systems with dominant local tree species such as *Vitellaria paradoxa* (shea tree), *Parkia biglobosa*, *Faidherbia albida*, and *Borassus akeassii* dominate in the WBS area; *Faidherbia albida* is widespread in the KKM area. Orchard systems with planted tree species such as *Mangifera indica* (mango)*, Anacardium occidentale* (cashew), and citrus species are the most common in the WBS. However, the *Moringa oleifera* garden system is growing in KKM areas where irrigation is possible.

6.1.2 Socioeconomic characterization

Poverty

In 2009, Niger was ranked the poorest country in the world, with the worst health and development problems of all 182 countries included in the United Nations (UN) Human Development Index. Some 60% of the population lives below the poverty line. Niger's gross per capita income is US$627 per year. The poverty profile is based on the Niger Living Standard Survey conducted by Niger Bureau of Statistics, which placed the proportion of poor people at 63.7% within the next few years.

Linkages to markets

There is a network of markets in the SRT2/WBS area and on average most adults attend at least one market per week. Most of the population travels to market on foot; some travel by bicycle and a few by public transportation. Markets range from small local markets to large markets attended by traders from large cities. The network of rural markets is dense and markets are held frequently. However, dirt roads are in poor condition which increases the cost of transportation to and from villages and camps, so that inputs (fertilizers, feed supplements, tools, etc.) are expensive or unavailable. Agriculture is largely subsistence oriented but crops such as cowpea, sorghum, and maize are also considered cash crops. The distance to the closest market ranges from 2 to 5 km, equivalent to less than a two-hour walk. Most farmers sell their produce just after harvest. There is always a glut at such periods, and farmers have very low profit margins.

The KKM SRT3 area also has a dense network of markets and on average most adults attend at least one market per week. Most of the population still reaches the market by foot; some travel by carts, and a few by public transport. Markets range from small, local ones to large ones in major cities and are attended by traders from near and far, including from neighboring countries (Benin and Burkina Faso). The network of rural markets is dense and markets are held frequently, but dirt roads are in poor condition, which increases the cost of transportation to and from villages and camps, which in turn increases the price of inputs (fertilizers, feed supplements, tools, etc.). The distance to the closest market ranges from 2 to 5 km, equivalent to less than two hours on foot. Most farmers sell their products just after harvest. There is always a glut at such periods, and farmers have very low profit margins.

Institutional support and policies

In both WBS & KKM action sites government provides institutional support through extension and research services, which are locally represented and act through specific projects and programs. Besides these permanent institutional supports, international and regional institutions, NGOs, and community-based organizations may also intervene directly. Still, the institutional support for the agricultural sector can be considered weak because of the small number of extension and research staff and low investment at all the sites. Most governments were subsidizing about 25% of the cost of fertilizer used for specific commodities. There are policies on land and water, but they are hardly enforced. There is no restriction on farmers' autonomy of decision-making for their cropping system. They decide what to grow depending based on their perception of the market and personal preferences.

6.1.3 Major constraints

The major constraints facing SRT2- and SRT3-type systems in WAS&DS are listed in Table 4.

Table 4. Major constraints farmers are facing in the West African Sahel and Dry Savannas.

Major constraints	Action sites	
	WBS (SRT2)	KKM (SRT3)
Biophysical		
Inadequate and erratic nature of rainfall	x*	xx*
Land cover degradation	x	xx
Low native soil fertility and general nutrient depletion in cultivated land	x	xx
Seasonal and prolonged flooding of more fertile floodplains and fadamas†	x	xx
Toxicity/acidification and poor structure in some soils of the floodplains and fadamas†	x	x
Wind and water erosion	x	xx
Diseases and insect pests (crops and livestock), *Striga* sp. infestation	x	x
Lack of labor-saving technologies for field operations and processing	x	xx
Overstocking of grazing area	x	xx
Low availability of nutritious species in grazing areas	x	xx
Inadequate improved cultivars/races for systems in the context of climate change and market demand	xx	xx

Major constraints	Action sites	
	WBS (SRT2)	KKM (SRT3)
Weak adoption of fodder crops in the farming system	xx	xx
Limited access to livestock production inputs	x	xx
Political and socioeconomic		
Low financial capacity of farmers to purchase necessary inputs and equipment	xx	xx
Lack of labor	x	xx
Lack or inadequate supply of essential farm inputs such as farm mechanization, fertilizers, agrochemicals, and advisory services	xx	xx
Overpopulation (land scarcity)	x	xx
Conflicts for the use of natural resource between farmers and pastoralists	x	x
Limited adoption of improved technologies	xx	xx
Seasonal migration of young people	x	xx
Inefficient market integration of agricultural products	xx	xx
Lack of affordable technologies for smallholder farmers	xx	xx
Ineffective extension services	xx	xx
Limited access to credit	xx	xx

* x = constraint present; xx = constraint strongly present.

† Fadama is a Hausa name for irrigable land.

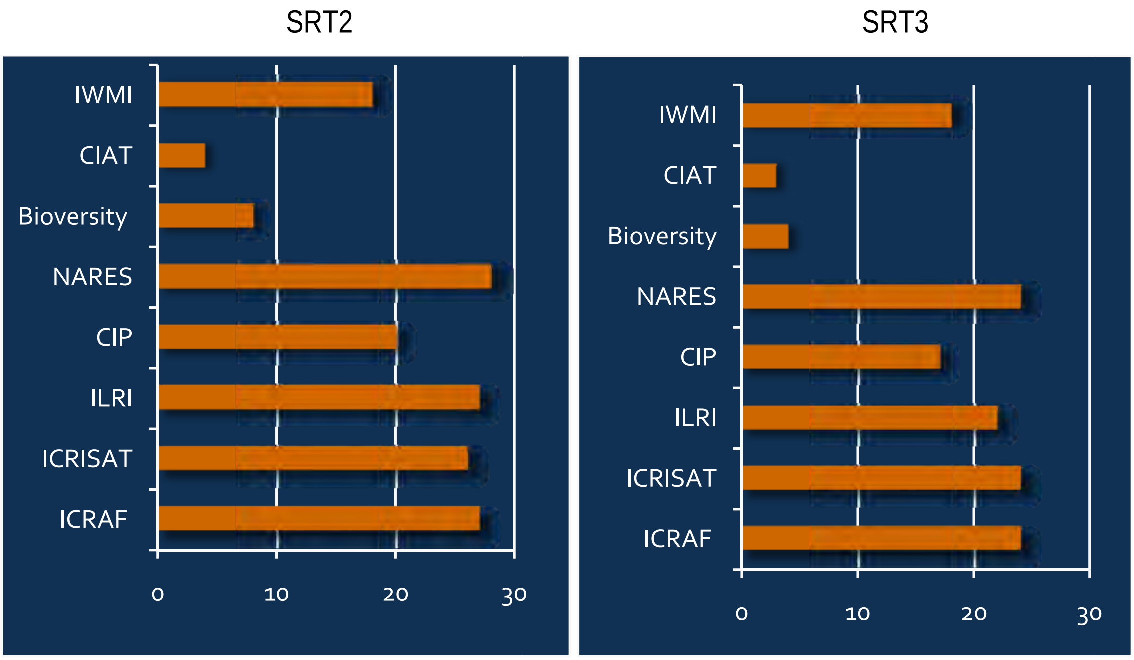
6.2 Partnerships

African countries have understood the need to promote policies that enhance regional integration to ensure sustainable agricultural productivity. The FARA at the continental scale and the Economic Community of West Africa States (ECOWAS) at the regional level are acting through the West and Central African Council for Agricultural Research for Development (WECARD) to implement the fourth pillar (agricultural research) of the Comprehensive African Agricultural Development Program (CAADP) of the New Partnership for Africa's Development (NEPAD). The West African Agricultural Productivity Program (WAAPP) is an ongoing program in all WAS&DS countries covered by the Dryland System CRP (Burkina Faso, Ghana, Mali, Niger, Nigeria, and Senegal). In addition, the Alliance for a Green Revolution in Africa (AGRA) is also acting at this moment in the WAS&DS countries.

6.3 Implementation plan

Plans for implementation of the Dryland Systems CRP in WAS&DS have been made using lessons from previous field work and from working groups at the RIW. Research questions were identified, organized into ten themes, and used to define 27 activities that will yield 20 outputs and outcomes. Figure 2 shows the number of activities that CGIAR Centers and national program partners will be involved in in WAS&DS under the CRP. Theory-of-change and uptake strategies have been used to develop the impact pathway of the CRP in WAS& DS.

Figure 2. Partners and the number of proposed shared activities for the West African Sahel & Dry Savannas.



6.4 Hypotheses for the West African Sahel and Dry Savannas region

The research questions identified for the region were used to formulate ten hypotheses relating to agricultural priorities (key issues) in the WAS&DS:

1) More efficient livestock-mediated nutrient transfer through dual-purpose crop varieties and fodder trees reduces feed gaps and increases overall system productivity.
2) Increased biomass production from better integration of trees, crops, and livestock increases soil organic matter content, water-holding capacity, nutrient availability, and system resilience.
3) Improved access and equitable participation in markets by smallholders adds value, enhances profitability and productivity and reduces vulnerability.
4) Security of land tenure enhances system intensification and reduces vulnerability of rural households.
5) Improved access to financial services (credits, savings, subsidies, insurance) enhances technology adoption, productivity, and community resilience.
6) Enriching agrobiodiversity improves system resilience and profitability for smallholders.
7) Empowering disadvantaged groups (women, youth, migrants) in decision-making and access to resources and technology increases productivity and reduces vulnerability of rural households.
8) Effective water harvesting and management increase both plant and livestock productivity and reduce exposure to climatic and other risks.
9) Strengthening local and national institutions (laws, bylaws, and conventions) reduces natural-resource degradation and conflicts.
10) Strong incorporation of indigenous knowledge in the innovation-systems approach accelerates adoption and scaling up of promising practices and services.

Twenty essential outputs from these were identified, and 27 qualified activities were identified that would lead to these outputs; these were included in the logframe. Additionally, logframes identified milestones, objectively verifiable indicators, research site locations, project partners, and deliverables.

Research questions and hypotheses as well as outputs, outcomes, and activities are available in the file “West Africa and Dry Savannas Standardized Logframe.”

6.5 Conclusions

6.5.1 Challenges to overcome

Both SRT2 and SRT3 regions are exposed to drought as a result of low rainfall and a single wet season per year. Low phosphorus levels contribute to poor soil health in the SRT2 area. As a result of increases in human and livestock populations the majority of landscapes in the SRT2 area are reaching full exploitation. In the SRT3 areas, soil nutrients are being mined on a very significant scale and are not being replaced via soil inputs. Gully, sheet, and wind erosion are causing large-scale soil losses, while expansion of cropland and shortening of fallow seasons are reducing soil fertility and impoverishing herbaceous flora. This is causing a serious problem in fodder availability and quality on rangelands.

Poverty is a serious challenge throughout this region, which is classified among the poorest in the world; Niger has the worst health and development problems of all 182 countries included in the UN Human Development Index, and this situation is deteriorating. In the SRT2 area the network of local markets is dense, but the dirt roads that connect villages to urban centers are in poor condition, which increases the cost of transportation and limits access to inputs. Constraints in the transportation system limit the ability of farmers to market their products elsewhere, causing local gluts of produce immediately after harvest, which significantly reduces the prices paid for crops. In general, institutional support for agriculture can be considered weak because of the limited numbers of extension and research staff and low overall investment at the farm level. Growth in the agricultural sector in this region has historically come from expansion of the area cropped or grazed. Today, demographic pressures have largely exhausted available land and in many areas farm sizes are shrinking. Land degradation and decreasing soil fertility also tend to result from increasing land scarcity and deforestation.

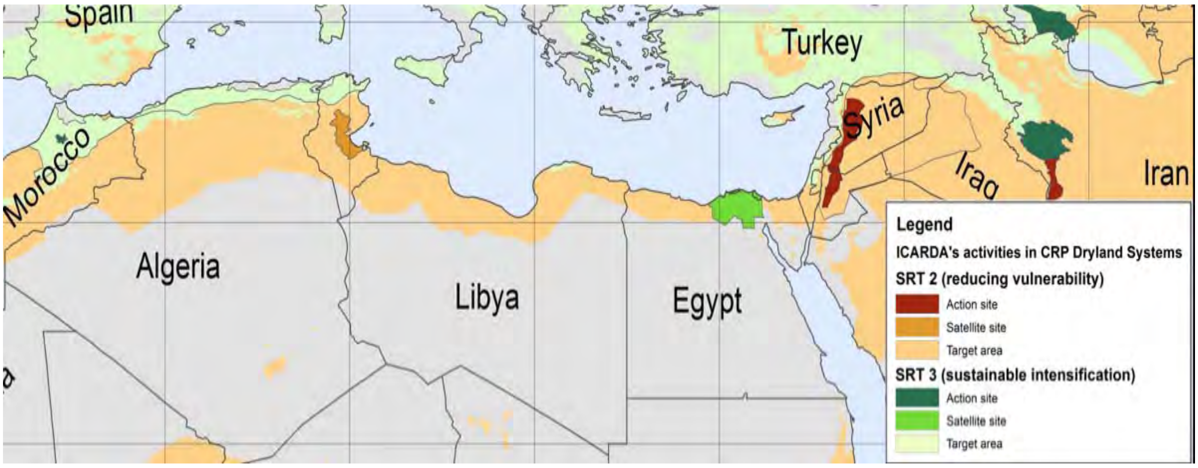
6.5.2 Opportunities

Due to varied sources of water, both rainfall and irrigation, cropping systems are highly diversified in both SRT2 and SRT3 regions. There is significant government investment in irrigation, and farmers are investing in vegetable production (onions, tomatoes, cabbage, potatoes, peppers) and fruit-tree-based systems. Most governments in the WAS&DS subsidize about 25% of the cost of fertilizer used for specific commodities. There are no restrictions on farmers’ autonomy of decision-making for their cropping system. Consequently, farmers are not likely to face institutional impediments to improved farm practices. Demographic pressure and increasing market demands in Nigeria offer an opportunity to intensify crop and livestock systems in the region. Opportunity also exists for increased private-sector participation in agricultural production and marketing, particularly in the Kano and Katsina areas.

These challenges necessitate an integrated soil fertility management system that includes locally available soil inputs and the knowledge needed to conduct local experimentation and testing with adapted grain and legume varieties. Strong potential exists for the development of an integrated water management approach to encourage water and soil conservation in order to boost yields and minimize soil and water degradation. Improved infrastructure will be a key development area in the evolution of rural farming in the WAS&DS, as the region has the potential to open up new markets and more evenly distribute food across geopolitical and geographic distances in a timely and cost-effective way.

7 North Africa and West Asia

Figure 3. SRT2 and SRT3 areas in the North Africa and West Asia region.



The SRT2 target area in the North Africa and West Asia (NAWA) region includes Jordan, Syria, south-central Turkey, and west and north Iraq, while the SRT target area includes the high rainfall areas (>500 mm) of the northern parts of Morocco, Algeria, and Tunisia, and much of Turkey. The action sites within these target areas include Syria and Jordan for SRT2, and Meknes-Saiss in Morocco for SRT3. There is a satellite site for SRT2 in Tunisia, and satellite sites for SRT3 in Egypt and Iran. Here, only the Action Sites are described.

7.1 SRT2 Action Site

7.1.1 Biophysical characterization

The **Syria-Jordan SRT2 action site** covers an area of about 36 600 km^2 in western Syria and Jordan, and represents a mosaic of marginal agricultural production systems typical of large parts of North Africa and West Asia. System productivity is determined by several physiographic features including elevation, topography, soil aspect, soil parent material, temperature, precipitation, potential evapotranspiration, hydrology, and human settlement. This action site contains a range of arid to semi-arid moisture regimes, as determined by the balance between precipitation and potential evapotranspiration. There are several irrigated areas, but the long-term sustainability of many of them is threatened by aquifer limitations.

Climate

The precipitation pattern follows a west–east gradient, with the highest precipitation in the west (300–400 mm) and the lowest (100–200 mm) in the east. The temporal variability of annual precipitation is high (23–60%), resulting in precipitation totals that can be higher, but are more often lower, than the means, thus presenting major challenges to the sustainability of rainfed cropping. Precipitation occurs almost entirely during the winter, with 90% falling between September/October and April/May, when temperatures are too low for crop growth. Therefore, for the most part precipitation must be captured and stored in one form or another for use by crops during spring and summer. Climate change is expected to reduce precipitation by 10–30% by the end of the twenty-first century according to circulation models described in the most recent report by the UN Intergovernmental Panel on Climate Change.

Annual growing periods are in the range of 4000–7000 degree days. Temperatures are largely determined by elevation. Risk of frost is high in February–March in central Syria and low to moderate in Jordan, particularly in February. Potential evapotranspiration (PET) rates follow the same pattern as temperature, with most of the site within the range of 1400–1700 mm annually. The vast majority of the site is defined as "arid," with small islands and narrow north–south strips of semi-arid land on the western boundary of the area.

Soils

The soils in the SRT2 action site are very diverse and have varying degrees of potential for agricultural use. Soil maps are available (posted on the website) that divide the region into soil taxonomic units based on their principal management properties. Although there are many productive soils in the region, soil constraints that must be managed include shallow depth, salinity, poor profile development, high gypsum or calcium content, and indurated horizons (hardpans).

Land cover and use

According to a regional assessment of land use/land cover that employed remote sensing (Celis et al., 2009), 4% of the action site is irrigated, 30% is under rainfed cropping, 19% is rangelands, and 45% is barren or sparsely vegetated. Geomorphologically, the action site can be divided into arid plains or *Badia* steppe with < 200 mm precipitation, the densely populated Hauran plains in southwest Syria, the Palmyrean hill-plain system—a complex of parallel hills and valleys stretching from Damascus to near the Euphrates (200–600 mm annual precipitation in the west to 100–200 mm in the east)—, and the semi-arid plains in western and northern Syria (350–200 mm annual precipitation).

Biodiversity, land, and water resources all suffer from several forms of degradation, including overgrazing of the rangelands, salinization of irrigated lands, soil erosion on steep hillsides, and aquifer depletion and contamination. In the rangelands, perennial vegetation has disappeared almost entirely, except in established range reserves. Wind erosion is common in the more arid parts.

Farming systems

It follows from the physiographic description that individual farming systems within the action site are also diverse. In irrigated portions of the plains, the most important crops are wheat, olive, pistachio, almonds, and cumin. Of particular concern is the high volume of water extracted from deep aquifers, which contributes to declining water tables. In the Hauran plains, intensive and specialized commercial agriculture has evolved into highly diversified, mechanized systems that offer employment to outside migrants. In rainfed portions, farmers grow more barley than wheat, but also grow rainfed wheat, cumin, and olives. Because of water scarcity, yields and incomes are low. In the mountains, major crops include fruit trees, grapes, and other perennials. The production environment is marginal because of the rocky soils and cold winters. Most of the perennial crop cultivation is concentrated on the western slopes, where average annual rainfall is higher than on the eastern slopes. Towards the drier eastern and southern part of this zone, marginal cereal cultivation predominates. In all systems, income is heavily influenced by farm size. Poor households generally have less than one hectare of cultivated land; for them off-farm income, including working as migrant farm labor, is proportionally more important to food security and livelihoods than it is to better-off households.

Agropastoral systems predominate in the semi-arid and arid east. This includes integrated but marginal cultivation of cereals in the 200–250 mm rainfall zone. Typically, cereals are grazed by sheep as a multipurpose forage crop. The traditional pastoral farming system in the Badia steppe is characterized by migratory herds of sheep, goats, and camels, which graze various areas as negotiated with other tribes. The annual movement cycle includes grazing in the Badia in spring and early summer, migration to cultivated areas to feed on crop residues in the summer and fall, and returning to the Badia in the winter, where animals are fed on concentrate feed, part of which is provided at subsidized rates through the cooperative system. Poor households make up about 60% of livestock holders, who have small ruminant herds typically consisting of fewer than 100 head. The loss of livestock in drought years affects them very seriously, as they have no access to credit to re-stock.

7.1.2 Socioeconomic characterization

Poverty

Poverty estimates vary. The United Nations Development Programme (UNDP) estimated that 11% of the population of Syria in 2004 was living below the national poverty line. In the Khanassir area, which is part of the action site, another study estimated that 30% of the population lived below the poverty line. Poverty is lower in the Jordanian part of the action site than in the Syrian part, with an estimated 5% of the population living below the poverty line.

Linkages to markets

There is a strong network of traders who trade dairy products, sheep, and feed. Producers depend heavily on these traders for capital and market access. Everyone living in the action site has access to local village markets; most are within two hours of major markets, but producers face the risk of loss of quality of perishable products because of poor feeder roads. The problem of access to credit leads to a complex relationship between middlemen and small-scale producers (cross cutting with SRT3). Dairy products in Syria have a market access problem. In Jordan, the demand for dairy products is very high and traders go to the countryside to buy dairy products to ensure the availability of their products in the local markets in towns.

7.1.3 Major constraints in SRT2 farming systems

Major constraints for SRT2-type farming systems are listed below.

Rangelands

- Encroachment of barley and olive crops on rangelands
- Degradation and overgrazing, especially around watering points
- Problems of livestock watering, and water point management
- Uprooting of vegetation for domestic use (fuelwood, construction of enclosures, etc.)
- Conflicts on grazing lands
- Animal health problems
- Rejection of pastoral way of life by younger generation
- Climate variability (drought, climate change)
- Lack of investment and diversification
- Difficult access to credit markets

Small-scale irrigated agriculture

- Low and irregular rainfall and scarce water resources
- Remoteness and difficulty of access
- Limited available land for cropping expansion
- Degradation of grazing lands
- Land-tenure problems (communal land under Forest Department control)
- Marginal and variable farm incomes
- Low level of exploitation of natural and cultural knowledge
- Lack of maintenance
- Pressure on natural resources
- Migration of youth to urban areas
- Lack of investment and diversification
- Difficult access to credit
- Overexploited groundwater resources
- Salinity

- Wind erosion
- Lack of skills in irrigation (maintenance of equipment) and production techniques
- Lack of organized market for agricultural products
- Lack of productivity and efficiency

7.2 SRT3 action site

7.2.1 Biophysical characterization

Meknes-Saiss SRT3 action site covers an area of about 1694 km^2 in the north of Morocco. Most of the site is a strongly dissected plain rising towards the south from 200 m to about 600 m above sea level. It also includes a flat lowland plain in the north at an elevation of 40–200 m above sea level and two hill ranges, a low one rising up to about 700 m in the west, and a larger one in the east rising up to about 1100 m.

Climate

The total mean annual precipitation is relatively high, ranging from 500 mm to 800 mm across the site. The precipitation is higher on hills, averaging 600–700 mm over the western hill range and 600–800 mm in the eastern hill range. The interannual variability of precipitation is moderate, with a coefficient of variation of 24%. Nevertheless, risk of drought remains high, particularly in the early part and the middle of the growing season. The precipitation pattern is typically winter rainfall, distributed over one long season; on average 90% of all precipitation occurs between November and April. Climate change is expected to reduce annual precipitation in this site.

Temperatures vary with elevation across the site. The range in the mean temperature of the warmest month is about 4 °C and for the coldest month about 6 °C. The latter implies a substantial risk of frost at higher elevation, but also suitable conditions for crops with chilling requirements. Potential evapotranspiration rates are moderate and within a narrow range of 1250–1400 mm annually. Annual growing periods are in the range of 6000–7000 degree days in most of the site, and 5000–6000 degree days at the highest elevations. The aridity index for the vast majority of the site is between 0.35 and 0.5, with a small portion (no more than 15% of the total area of the action site) on the eastern side of the site at an aridity index of between 0.5 and 0.65.

The moisture-limited growing period is long, 200–225 days across most of the area and somewhat longer at the highest elevations. In combination with the favorable temperature regime across most of the site, this suggests excellent conditions for growing a diverse range of climatically adapted crops.

Soils

Apart from shallow, undeveloped soils, the soils of the action site do not appear to be “problem soils” and the soil map does not evidence of major problems such as salinity. Thus it appears that most soils of the site are good agricultural soils, as would be expected given the widespread use of the land for agriculture.

Land cover and use

Most of the site is used for agriculture. Very little is still under natural forest or is bare rock. The dominant land use is rainfed cropping. Based on the local topography, two classes are distinguished: rainfed crops on land with slopes not exceeding 8%, and rainfed crops on slopes exceeding 8%. Much of the rainfed cropland occurs on slopes exceeding 8%, thus being exposed to considerable risk of erosion. Orchards are a very important component of the land-use pattern and are mainly concentrated along the eastern hills, where they may also occur in mixtures with remnants of the natural forest. In the northwestern plain, the dominant land-use pattern is a mixture of rainfed and irrigated crops, fed by groundwater. The urban center of Meknes occupies a large part of the SRT3 action site.

Farming systems

Based on the dominant land-use patterns, three main agricultural regions can be differentiated:

- The northwestern plain, with a mixture of rainfed and groundwater-irrigated crops
- The orchard-dominated hills in the east
- Undulating to rolling plains and low hills with rainfed crops in most of the area.

The rainfed mixed system is the dominant system of the action site, although in some areas supplemental irrigation for wheat and full irrigation for summer cash crops is developing rapidly. There are also tree crops (olives and fruit trees) and grapes. Common crops are wheat, chickpea, lentil, faba bean, and fodder crops. Many farms are intensively capitalized with a high level of inputs, and farmers are very sensitive to market opportunities. There are a number of specialized dairy and poultry systems within this ecological zone. These may also include summer crops grown following winter fallow or with some supplementary irrigation. Major production constraints are poor access to quality land by increasing numbers of small farmers, soil erosion on slopes during rainstorms, and erosion by wind on light, overcultivated, exposed soils.

7.2.2 Socioeconomic characterization

Poverty

Poverty amongst the rural population is estimated at 25% in the SRT3 area.

Linkages to markets

The distance to the closest local market is, on average, greater than two hours in the SRT2 area and less than two hours in the SRT3 area. An integrated characterization of SRT2 and SRT3 sites linkages to markets was given in the SRT2 section. For brevity it has only been included once.

Institutional support

The Regional Directorate of Meknes-Tafilalet and the Provincial Directorate of Meknes provide extension services at the provincial and communal levels. Moderate to high access to improved varieties is reported and the national Green Moroccan Plan provides subsidies for inputs. Farmers enjoy a high degree of autonomy to choose crops and crop areas.

7.2.3 Major constraints in SRT3 farming systems

Wheat-based system

Biophysical/technical

- Low soil fertility
- Lack of diversification
- Low input use (seeds, fertilizers, pesticides)
- Postharvest loss
- Low rate of adoption of agronomic packages
- Poor access to markets, lack of value-adding activities, lack of insurance

Socioeconomic

- Lack of economic scale
- Land fragmentation
- High illiteracy rates
- Differential incomes
- Land-tenure systems

Fruit-tree system

- Low input/technical use
- Lack of technical package
- Poor access to markets, lack of value-adding activities (value chain)
- Product quality
- Lack of labor
- Water quality

Vegetable-based system

- Low sustainability (water)
- Postharvest (storage)
- Price volatility
- Market stability
- Poor seed availability (potato)

7.3 Partnerships

Figure 4 lists partners involved in CRP activities in the SRT2 target area, and the number of activities they will engage in. Figure 5 lists partners and numbers of activities for the SRT3 target area.

Figure 4. Partners in the SRT2 target area and the number of activities they will engage in.

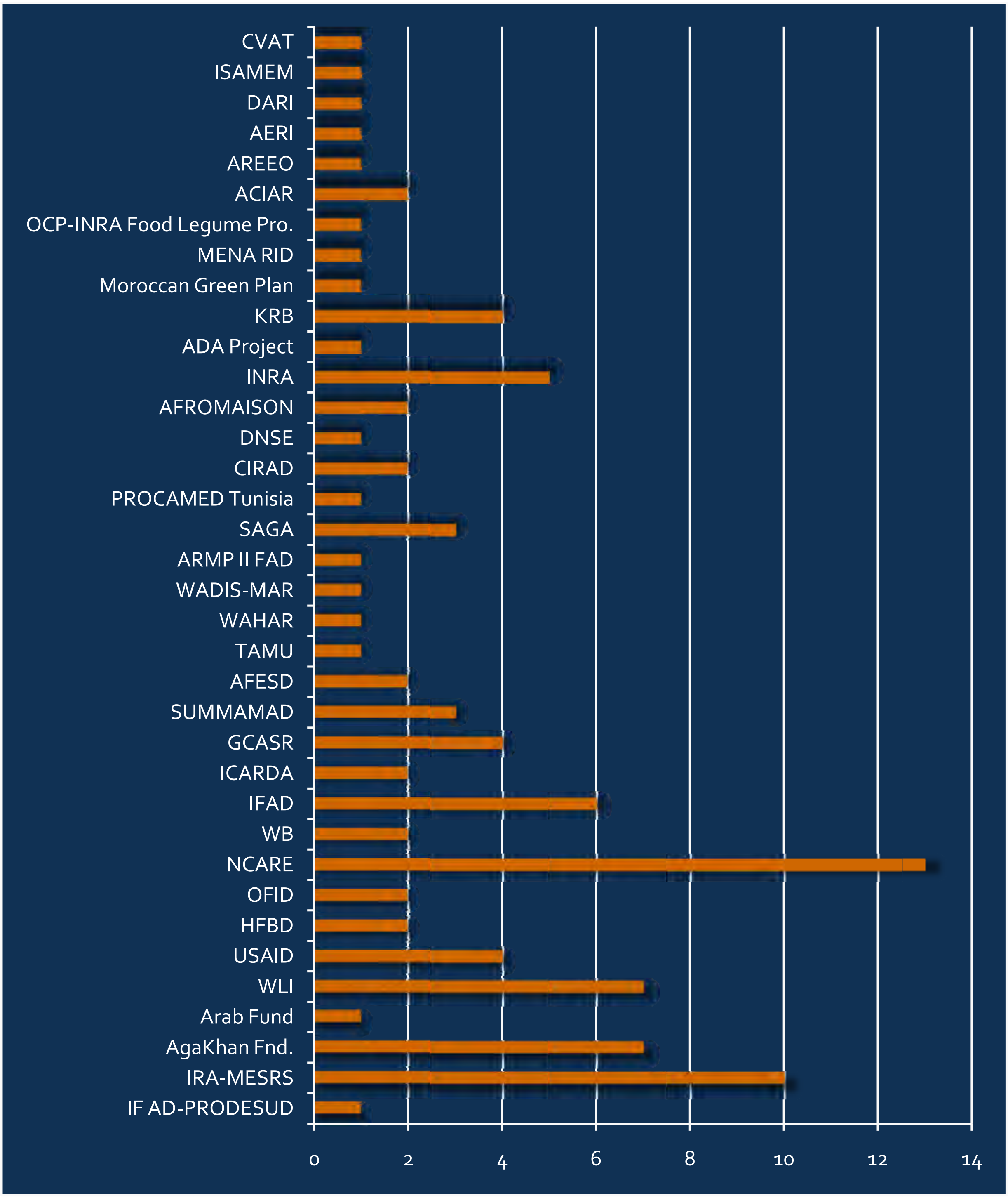
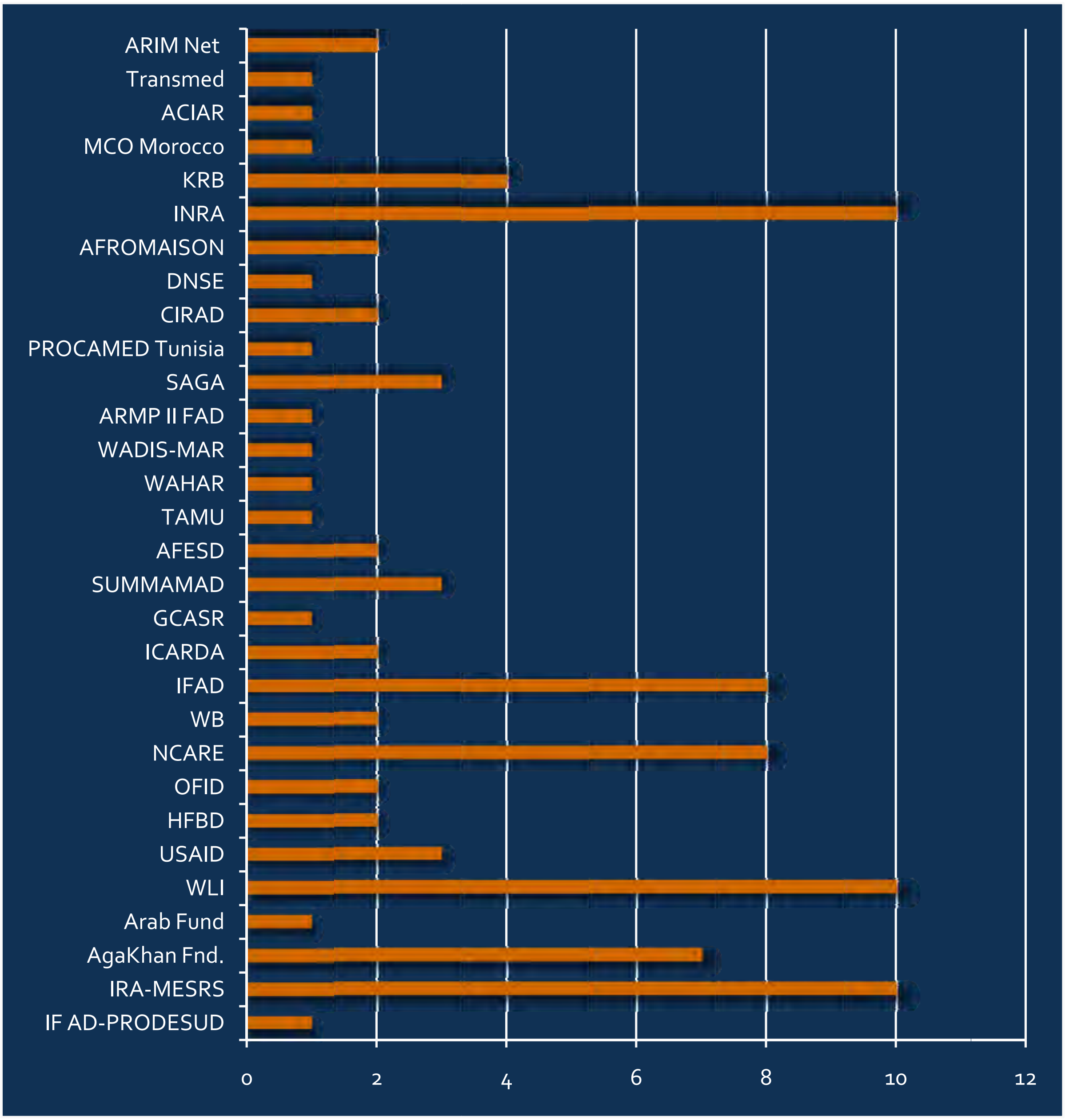


Figure 5. Partners in the SRT3 target area and the number of areas activities they will engage in.



7.4 *Hypotheses for the North Africa and West Asia region*

The following hypotheses have been agreed upon through the RIW in NAWA and represent a key link in the impact pathway.

1) The use of an innovation platform in community-based organization of rangeland involving agropastoral stakeholders will help halt land degradation and restore ecosystems and improve livelihoods.
2) Rangeland production systems can be made less risky and more resilient by integrated technical, institutional, and policy innovations that aim at rangeland rehabilitation and sustainable management.
3) Irrigated production systems can be sustainably intensified through policies and institutions that ensure efficient use of land and water resources.

4) Use of the innovation-systems approach will enhance the adoption and utilization of improved technologies, markets, and policies.
5) System analysis of production and market system performance will allow optimal intensification of the production and market systems and the assessment of potential impact of innovations both in socioeconomic and ecological terms.
6) Some form of farm aggregation (associations/organized farmers' groups) will lead to the realization of economies of scale, thereby leading to increased access to innovations, investments in agriculture, improved market efficiencies, and increased competitiveness and value addition.
7) The rainfed wheat-based system can be sustainably intensified and diversified through integration of crops, trees, and livestock, agricultural innovations, and institutional arrangements providing pathways out of poverty.
8) Equitable distribution of responsibilities and benefits along the value chain among men, women, and youth will enhance development of the target areas.
9) Achieving gender equality in sustainable agricultural production and rural development efforts will greatly contribute to the elimination of hunger and poverty.

The logframes for the SRT2 and SRT3 target areas are available in the file "NAfr & WAsia Standardized Logframe".

7.5 Conclusions

7.5.1 Challenges to overcome

One of the major challenges facing the sustainability of irrigated agricultural systems in the SRT2 target area is degradation of aquifers, in terms of both the level of the aquifers and the quality of the water being produced.

High temporal variation in precipitation is an issue in SRT2, with annual coefficients of variation ranging between 23 and 60%. This variability, along with climate-change projections that predict a reduction in precipitation by 10–30% by the end of the century, poses severe challenges to rainfed cropping.

Poor households, often utilizing less than one hectare of land, comprise approximately 30% of the households in Syria and approximately 10% of the households in Jordan. Most households are not able to immediately rebuild their flocks and herds following droughts because they do not have access to credit. Farm fragmentation was also identified as a serious problem in Morocco and research on aggregation has been proposed.

In the SRT3 areas there is a distinct rejection of pastoral activity by the younger generation; this is leading to out-migration from rural communities. A lack of skilled agricultural and pastoral labor could become a serious problem in the agricultural sector.

7.5.2 Opportunities

Highly mechanized agricultural systems exist within the SRT2 area. In the SRT2 area there is also a strong preexisting network of traders for high-value items such as dairy products, sheep, wool and fruit. Because of the poor quality of roads, there is a high likelihood of spoilage en route to major markets, which has led to a complex relationship between middlemen and producers.

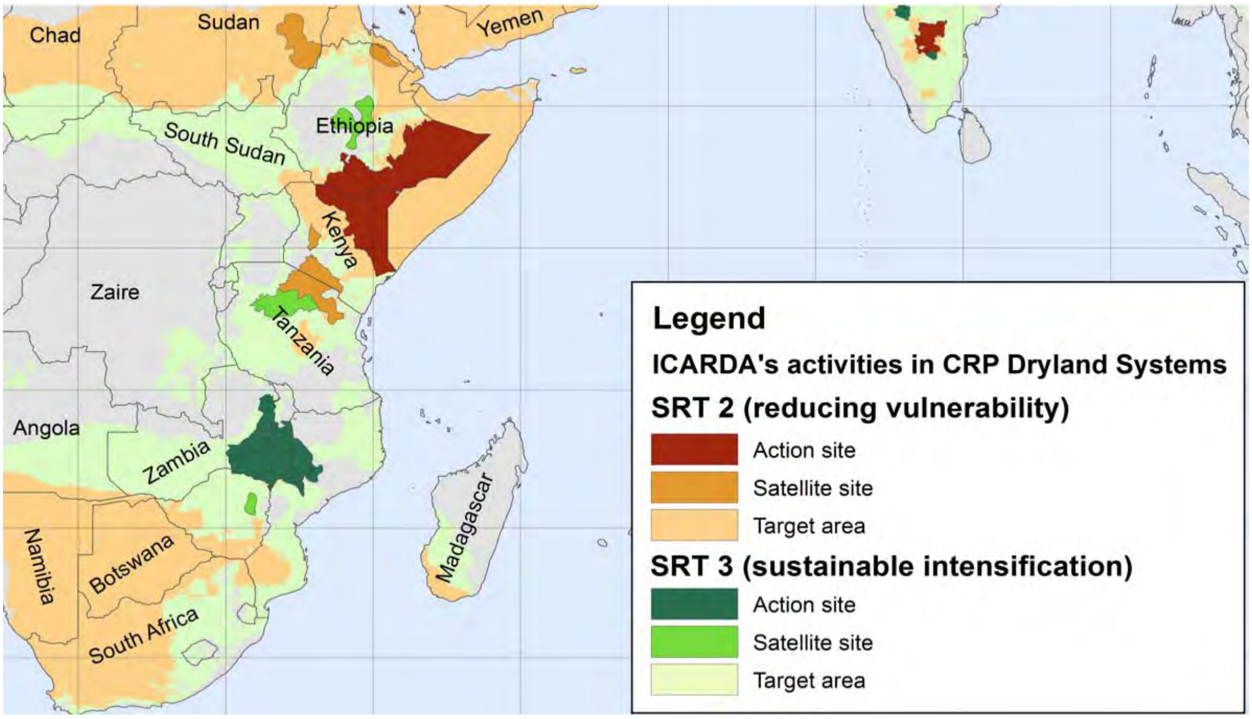
The growing period in the SRT3 areas of North Africa are quite long, ranging from 200 to 240 days. Given the favorable temperature regimes across most of the site, conditions are excellent for growing a diverse range of climatically adapted crops. There are few "problem soils" in the SRT3 target area and the soil map does not give evidence of any significant problems such as salinity. Thus, most of the soils in this region are good agricultural soils and are already under cultivation. This makes the potential for substantial short- to medium-term production gains more likely. Moderate to good access to improved varieties is reported and the national Green Moroccan Plan provides subsidies for soil inputs in SRT3 action site. In addition, farmers enjoy a high degree of autonomy to choose the crops and cropping areas that they utilize.

North African SRT3 areas are well-enough connected to the European Union market that its agricultural production systems are under pressure to be efficient in order to compete with global players. The Meknes area is a prime example of a region where wheat could generate good farm income if competitively produced. The production units vary considerably, with farms ranging from less than 10 ha to more than 100 ha. The small farms cannot benefit from economies of scale such as effective mechanization, and lack opportunities for capitalization and access to input markets. Under current systems, these small farms offer bleak prospects for future generations of farmers. Young people are increasingly looking for alternative opportunities in the cities where employment is scarce. The result is unbridled urbanization, with slums and social unrest.

A great number of potential R4D and development partners are already at work in this region, creating opportunities for synergy.

8 East and Southern Africa

Figure 6. SRT2 and SRT3 areas in the East and Southern Africa region.



The action site for SRT2-type systems (reducing vulnerability) in East and Southern Africa covers northeastern Kenya and southeastern Ethiopia. There will be satellite sites in eastern Sudan, northern Ethiopia, central Kenya, southern Kenya, and northern Tanzania.

The action site for SRT3-type systems (sustainable intensification) is the Chinyanja Triangle, which covers central and southern Malawi, the Eastern Province of Zambia, and the Tête Province of Mozambique. There will be satellite sites in the central Ethiopian highlands, north-central Tanzania, and the eastern highlands of Zimbabwe.

8.1 SRT2 action site

8.1.1 Biophysical characterization

The SRT2 action site domain, in which the Dryland Systems CRP hypothesizes that households are primarily concerned with reducing vulnerability and managing risk, extends from Northeastern Kenya up to Southeastern Ethiopia. It comprises the Borena Zone of Oromia State, much of the Somali State, and part of the Afar State in Ethiopia, and Marsabit, Garissa, Wajir, and Isiolo districts in Kenya.

Climate

Precipitation is bimodal—historically the long rains fell from April to June and the short rains in November and December. Long-term annual mean precipitation patterns show that 82% of the area receives less than 600 mm of rainfall, 12% receives 600–800 mm and 5% receives more than 800 mm. The coefficient of variation is greater than 21%. Temperature patterns vary across the sites and over the years. In the Borena region, the minimum temperature is 19 °C and the maximum is 26 °C. In Moyale, Ethiopia, diurnal temperature variations have decreased since 1980.

Seventy-one percent of the area is arid, including most of the Somali State (Hamero, Denan, Afker, Boh, Mustahli) and Borena Zone (Bannisa). On the Kenyan side, which includes the northeastern regions of Garissa, Modogashi, Dadaab, and Elwak and the North Horr in the Rift Valley, 27.25% of the area is semi-arid. Semi-arid areas include Ijara district in northeastern Kenya, much of Moyale and most of the southern region of Ethiopia, with small sections in the Hamero and Filtu parts. One percent of the action site is dry subhumid and just less than 1% is humid.

Potential evapotranspiration (PET) is 1900 mm to more than 2000 mm per year in southeastern Ethiopia and northeastern Kenya, 1600–1800 mm per year in southern Ethiopia, and 1900–2000 mm in the eastern-most part of Ethiopia.

The area is subject to frequent drought; major droughts occurred in the action site in 1999/2000, 2002/03, 2005/06, 2008/09 and 2010/11. The impact of droughts on assets, income, and food security is significant; livestock losses are heavy in droughts that last more than one season. Frequent droughts also mean that herds do not have time to recover between droughts. Food security is significantly affected and much of northern Kenya and parts of the Somali State in Ethiopia are in emergency status for several months following droughts.

Soils

In Northern Kenya and southern Ethiopia the soils are largely Yermosols, Xerols, Regosols, and Vertisols. Vertisols contain clay that expands when wet and forms wide cracks as it dries out; they retain huge amounts of water during wet seasons. The Yermisols are gypsic with highly decomposed organic matter and a buried genetic horizon (eastern part of Ethiopia/Somali border). Yermisols cover 30% of the study area. Yermisols in Kenya around Garissa and Modogashi have very high organic matter deposits while those around Moyale and in the southern and middle parts of Borena (Ethiopia) have minerals buried in the genetic horizon. The Regosols range from calcic with highly decomposed organic matter content (around Lake Turkana and North Horr) to lithocalcic (I-Re-3a). They occupy 24% of the study site. Xerosols occupy about 10% of the area.

Land cover and use

Sparse shrubs cover 38.29% of land in the action site. Grasslands occupy 31% of the land area, while trees growing in open to very open systems cover 23%. Only 3.36% of the land is bare. Water bodies occupy 3% of the action site. Shrubs and savanna, cropland, and urban-associated areas occupy 0.50%.

Some of the range in the action site is severely to very severely degraded. Increasing human populations, declining mobility, and sedentarization around water points has led to overutilization and localized land degradation. Overutilization and associated resource degradation varies across the action site. Local degradation can be intense, and is pervasive in Baringo. Similarly, *de facto* fragmentation continues as a result of conflict, administrative boundaries, sedentarization, and loss of key resources, although it is less pronounced and institutionalized than in the southern Kenya/northern Tanzania satellite site.

Water resources

Boreholes, seasonal pans, rivers, hand wells, dams, and lakes are all utilized.

Farming systems

The primary production system in northeastern Kenya and southern Ethiopia is extensive livestock production. Over 90% of the area is classified as “semi-arid and arid livestock only” by Robinson et al. (2011). The major land-cover classes are shrubs and grassland. The predominance of extensive livestock systems is one reason that the action site is large, 530 000 km^2. On the Ethiopian side there is scattered mixed rainfed cropping, with a significant concentration in the more humid zones of Borena. The area’s livestock systems include a mixture of sheep, goats, cows, and camels. In Kenya as a whole about 70% of all livestock are produced in the arid and semi-arid areas. In Ethiopia, the livestock sector, which largely originates from the arid and semi-arid lands, contributes 12–16% to Ethiopia’s gross domestic product (GDP) and 30–35% of agricultural GDP. Our calculations indicate a total of 2.4 million cattle, over 900 000 sheep and 1.3 million goats in the action site.

8.1.2 Socioeconomic characterization

Poverty

The percentage of people living below the poverty line ranges from 55–65% in northeastern Kenya to 71.9% in the Somali State. Poverty is a key indicator of vulnerability in the region.

Connection to markets

In the SRT2 target area 14% of households are within three hours of a market, 52% are within 3–8 hours, 25% are within 8–12 hours, and 8.5% take more than 12 hours to reach a market. People along the border of Kenya and Ethiopia generally live closer to markets, except for those around Illeret in North Horr.

Institutional support

Northern Kenya and southern Ethiopia are remote and isolated geographically, economically, and politically. Recently, the Government of Kenya initiated programs to focus on the region via the Ministry of State for Development of Northern Kenya. NGOs, including human rights activists, have tried to champion the rights of people in these marginalized regions. Low political will and disinterest in the drylands has led to high levels of neglect by the central government. Political and economic marginalization results in limited infrastructure such as roads, schools, and markets, which in turn limits opportunities for livelihood diversification. Increases in basic services and infrastructure would promote diversification and market engagement and reduce vulnerability in the region.

8.1.3 Major constraints in SRT2 farming systems

The stakeholders participating in the RIW identified five key factors constraining both current and possible future development pathways in the action site.

1) Pressure on land and diminishing access to resources, driven by both demographic factors (increasing human population and inward migration) and policy and institutional factors. The latter include poor land-use planning, which results in fragmentation of land holdings and

degradation, exacerbated by weak rules regarding land tenure. The loss of key resource areas used for grazing and drinking water in the dry season is especially critical to extensive livestock production.

2) Inadequate governance mechanisms and structures, exacerbated by the long-term political marginalization of these areas by national governments. This includes a breakdown of traditional management structures and systems. It also manifests itself in lack of infrastructure and basic services, as well as little political will to resolve the ongoing conflicts across the area.
3) Market involvement and access is the focus of many development interventions, as there is a growing demand for livestock meat and milk products. However, market participation is not equal; it is mainly wealthy male pastoralists with large herds who successfully market their animals. Women do market milk but often informally, with the exception of a growing camel milk trade.
4) Although livestock are highly valued assets, and milk and meat contribute significant nutritional value, livestock productivity across the production systems is often low. This is due a combination of factors including insufficient water and forage, especially during droughts, little access to veterinary care, and little attention by the research or extension community to better breed management.
5) Livelihood diversification is a strategy employed by many pastoralists, in some cases to accumulate wealth that is invested back into pastoral production. But among poorer households this diversification is often about survival, particularly given chronic food insecurity issues (McPeak et al. 2011; Homewood et al. 2010). There are too few sustainable alternatives to livestock production in action site for the growing numbers of people who depend upon non-livestock-related economic activities. This is in part a function of poor infrastructure, low education levels, and limited access to credit, but it is also due to poor governance and marginalization.

The overall problem statement currently is as follows: “Livestock production remains the highest-yielding and most climatically suitable agricultural activity in the East African drylands. The livestock industry is growing as domestic and export demand for livestock products increases. Paradoxically, in northern Kenya and parts of southern Ethiopia, a significant proportion of dryland communities are becoming poorer, chronically food insecure, and highly vulnerable to external shocks, particularly drought.”

In general, vulnerability in this region is a result of long-term lack of political will to develop these areas, which are highly impoverished in terms of basic infrastructure and services, including markets, schools, and security. At the same time, the populations of the drylands are expanding significantly. Communities are becoming increasingly dependent on nonpastoral economic activities. These rarely generate sufficient returns to reverse food insecurity or vulnerability and are often environmentally unsustainable and actually undermine pastoral production systems. The livestock industry is growing despite very low investment and weak understanding among technical advisors of how to manage, protect, or improve rangelands. Rangelands management is characterized by weakening governance arrangements and insecure land rights, particularly in the more populous and less arid drylands that provide vital seasonal refuges. Although meat from some dryland areas undoubtedly represents a significant part of the agrarian economy, data are not routinely captured and used to influence public or private investment. Commercialization of the livestock sector is biased towards larger producers and comparatively industrial livestock systems, often based outside of drylands.

Throughout the drylands, access to livestock markets is inconsistent and again favors larger producers. Access to veterinary services is generally poor and technical advice on ways to strengthen pastoralism, for example through enhancing local breeds, is limited or contradictory. The focus on the livestock industry results in breeds selected for meat rather than dairy production. Commercial markets for the primary pastoral product—milk—and for other pastoral outputs are virtually non- existent.

Clear divisions are emerging between livestock-rich and livestock-poor households, with those with small flocks and herds tending to gravitate towards urban centers, which can improve their access to markets and basic services but reduces access to quality rangelands. This can compromise the sustainability of the wider rangeland system and households' food security as access to milk (a core element of pastoral diets that is essential for child development) declines.

8.2 SRT3 action site

8.2.1 Biophysical characterization

The Chinyanja Triangle covers central and southern Malawi, the Eastern Province of Zambia, and the Tête Province of Mozambique (Kambewa 2010). Population density in the Chinyanja Triangle action site is high: 155 and 184 people per km^2 for the Southern and Central Regions of Malawi, 18.9 people per km^2 for the Eastern Province of Zambia, and 11 people per km^2 for the Tête Province of Mozambique (NSO, 2008; ZSO, 2000; MNIS, 2007). Agriculture is the predominant source of livelihood (Myburgh & Brown 2006), and most farmers cultivate less than one hectare of land (Ayaji et al. 2003).

Climate

Precipitation varies widely across the action site, from less than 600 mm annually in the Tête province in Mozambique to 1750 mm annually in central and southern Malawi. About 94% of the area receives 800 mm or more, and 6% receives less than 600 mm. In central and southern Malawi, temperatures range between 14 °C and 32 °C, while average temperatures in Zambia range between 16 °C and 24 °C.

Aridity index in the SRT3 action site ranges between 0.2 and 0.65. Along the northern portion of the transect, aridity index ranges between 0.5 and 0.65, while along the southern portion of the transect, aridity index is commonly between 0.2 and 0.5.

Soils

Soils include Cambisols, Luvisols, Cambisols, Arenosols, Fluvisols, and Ferralsols (FAO soil classification). There are small variations within the main classes based on the mineral and organic-matter content and texture. Orthic Ferralsols, with highly decomposed organic matter and buried genetic horizon (Fo76-2/3ab) are found in 18% of the study site, mainly around Lake Malawi and Lake Nyaza. Ferric Luvisols (LF24-1a) with highly decomposed organic matter occupy 18%. Chromic Luvisols occupy about 12%.

Land cover and use

Some 37.9% of the area is under shrub cover, classified as crossed-open deciduous. Tree cover occupies 31% of the action site. Cultivated and managed areas make up 24% of the area, and water bodies occupy 4%. Herbaceous species cover 2.04% of the site, and bare, artificial, and associated areas take up less than 1%.

Tête province is severely vulnerable to land degradation through droughts and floods. Soils in eastern Zambia have been degraded by past human land use. High human population density (126 persons per km^2), land fragmentation, and overcultivation (mostly of maize) are main causes of degradation.

Water resources

Boreholes, hand-operated wells, rivers, Lake Chirwa, Lake Malawi, and the Zambezi River are all within the SRT3 action site.

Farming systems

Roughly 47% of the production systems are "livestock only, arid–semi-arid." including much of the northern part of Tête province in Mozambique and most of Zambia except for the central district of Chipata. Less than 1% of production systems are described as "livestock only, humid–semi-humid". Another 40% are classified as "rainfed, mixed crop–livestock, arid–semi-arid" systems. In most of Malawi and Chipata district in Zambia, and in some parts of southern Tête, rainfed mixed crop–livestock systems in humid–subhumid conditions cover over 2% of the area. Other systems, including root-crop-based and root-based mixed-cropping systems make up 8% of the land area. Rainfed mixed crop–livestock systems and highland/temperate systems make up less than 1%. Built-up areas and irrigated mixed crop–livestock systems in the humid–subhumid category make up 1% of the production systems in the region.

Peanuts, rice, sugar beet, butter beans, cowpeas, cassava, maize, sorghum, and millet are grown in Tête province, Mozambique.

8.2.2 Socioeconomic characterization

Poverty

In Malawi, agriculture contributes about 37% of GDP, employs over 80% of the country's labor force, accounts for over 90% of foreign exchange earnings, and supplies more than 65% of the raw materials needed by the manufacturing sector (GOM 2001). In southern Malawi, poverty ranges between 70 and 90%. Poverty incidence ranges between 55% and 97% in Tête (Mozambique), and from 71% to 97% in Zambia.

Market access

Current estimates are similar to the SRT2 sites: 22% of households in the rural areas take less than three hours to travel to the nearest market, 38% spend between three and eight hours; 17% take between 8 and 12 hours; and 23% of the population takes more than 12 hours to get to the market.

Institutional support

There are restrictive administrative policies affecting resource access and use. Communities here are considered minorities and marginalized. Reform rules are not implemented on the ground.

The articulation of the Poverty Reduction Strategy (PARPA) and the Agricultural Sector Development Program (PROAGRI) established a landmark for economic development, with particular emphasis on the development of the agricultural sector and its contribution to rural livelihoods. Zimbabwe's Agricultural Policy Framework has remained unchanged, even with the implementation of the land reform program.

8.2.3 Major constraints in SRT3 farming systems

Despite the existence of relevant knowledge on agricultural adaptation and interventions at a farm level through the high social capital in the action site, this social capital is not being used to spread information. There is a need for a major intervention focused on technological, institutional, and policy options (TIPOs) that address the need for knowledge and innovation networks. There needs to be a sustainable strengthening of community knowledge and local opportunities that can be meshed with external support.

This knowledge is particularly important in addressing ways to intensify in the face of small farm sizes and limited scope for expansion/migration of farming communities. The current net returns per hectare from rainfed crop production and other land-based enterprises are low and "trap" these smallholder households in poverty. This is particularly true for the Malawi portion of the action site, where high population density, small plot size, and low soil fertility are critical issues. In Zambia and Mozambique, soil fertility and labor constraints are the key issues. Intensification efforts need to appreciate the constraints of low fertility and small plot sizes.

Farmer preference in the action site often favors a risk-amelioration approach in which multiple plots, each with different soil and water characteristics, are cropped if labor is available. Sustainable intensification approaches need to appreciate this heterogeneity of land pressure and preference across the action site.

Opportunities for intensification of agriculture must also consider the role of group action for inputs and outputs, mechanization, irrigation, and high-value crops, and policies to address land-tenure arrangements, taking into account differences among the three countries. High-value crops need to be considered within broader opportunities for diversification of production systems to encourage trends towards more diversified cropping and away from maize monocropping.

Extension services need to be strengthened despite pressure on limited government resources, and an enabling policy environment is needed that reduces obstacles for intensification. Therefore, value-chain innovation, integrated into a broader resilience and food-security enhancement, is needed. The experience of the SSA CP's Vegetable Task Force in areas near to and within the Chinyanja Triangle will be helpful in testing hypotheses on effective innovation-system approaches for intensification and diversification through markets in the SRT3 areas. This would also help address one of the "must haves."

8.3 Partnerships

Figure 7 lists partners involved in CRP activities in the SRT2 target area, and the number of activities they will engage in. Figure 8 lists partners and numbers of activities for the SRT3 target area.

Figure 7. Partners in the SRT2 target area and the number of proposed shared activities.

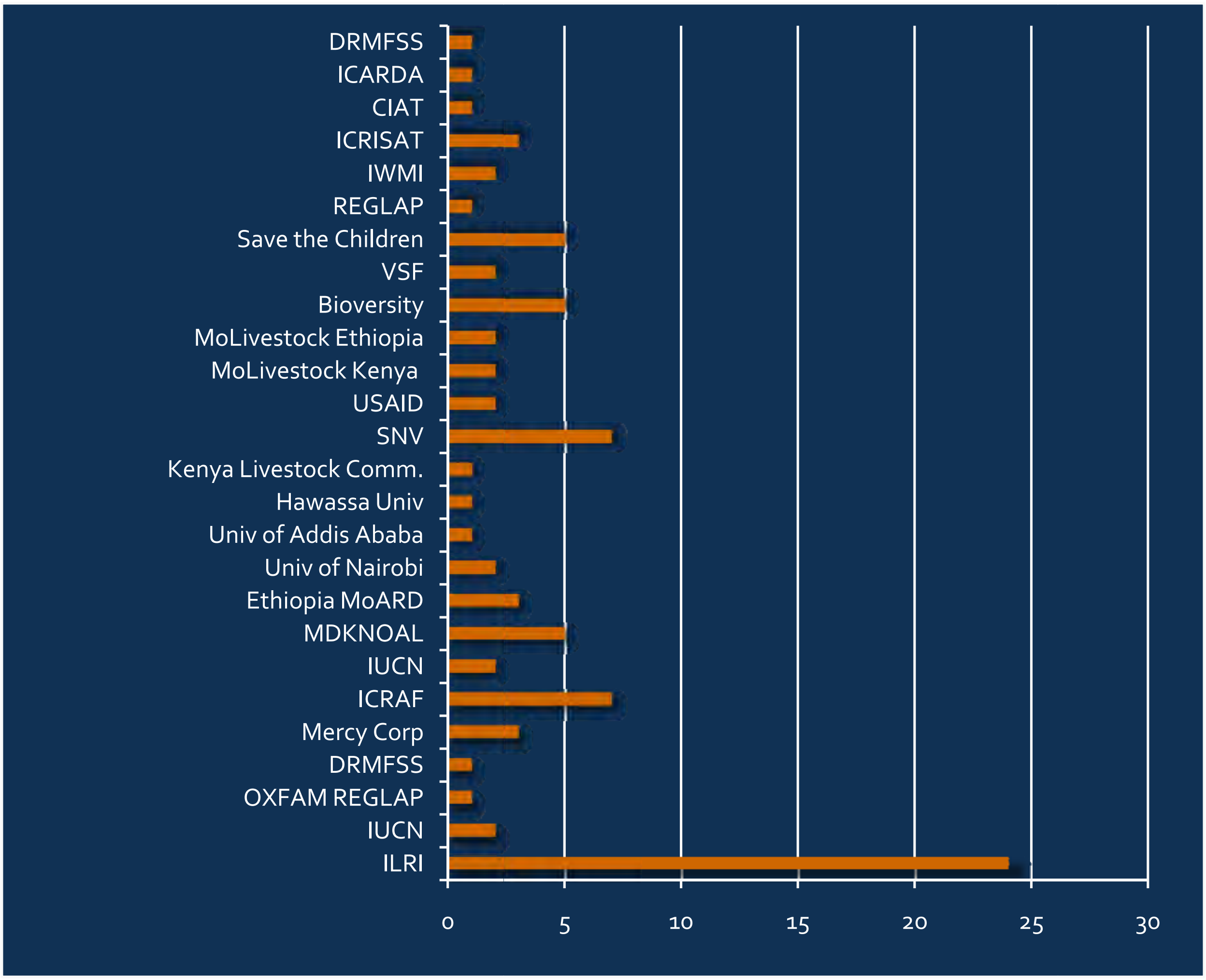
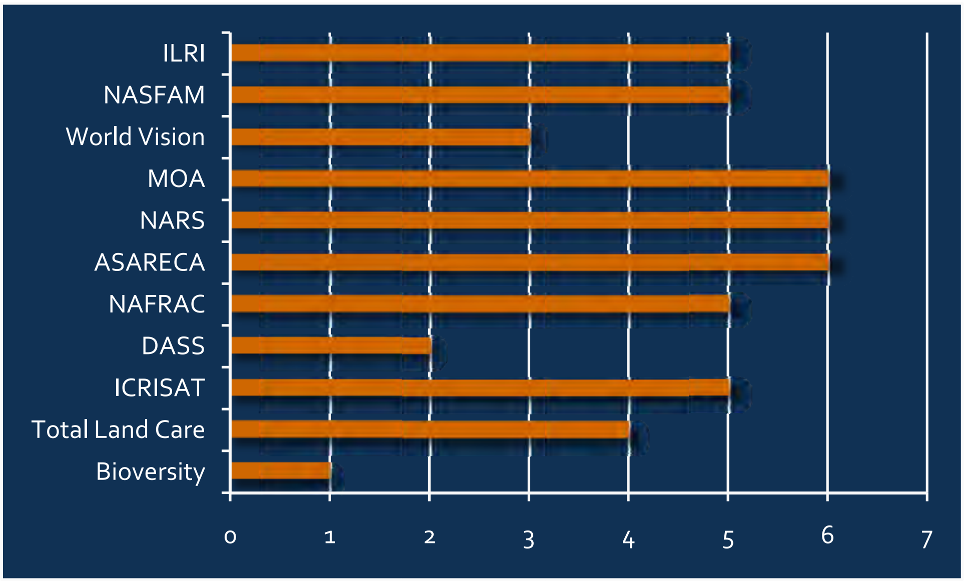


Figure 8. Partners in the SRT3 target area and the number of proposed shared activities.



8.4 Hypotheses for the East and Southern Africa region

Although the multiple drivers of vulnerability of dryland communities are well documented, attempts to reduce vulnerability are undermined by a limited understanding of how many people are vulnerable and to what extent in various dryland populations (urban:rural, NRM based:non-NRM based, aridity zones). Without a clearer analysis of this, efforts to reduce this vulnerability remain hampered because of an inadequate understanding of which interventions will really have impact.

The following hypotheses were developed to the guide CRP's research in the East and Southern Africa region:

1) Low political will to develop drylands and ineffective governance systems result in increased vulnerability to shocks such as drought, price increases, and conflict.
2) Despite strong growth in demand for livestock in both domestic and international markets, the productivity of many smaller-scale pastoralists in the drylands is declining, resulting in increasing poverty and vulnerability.
3) The productivity of smaller-scale pastoralists is further undermined by a lack of investment in the production of, or commercial markets for, other livestock-related products, particularly milk, fodder, and forage.
4) Growing and urbanizing populations in the drylands depend on nonpastoral economic activities that do not generate sufficient returns, are environmentally unsustainable, and can undermine pastoral production systems.
5) Agricultural intensification can only contribute substantially to reducing household poverty and food security where the combination of household assets (land, labor) and agroecological potential are favorable (and above a certain threshold).
6) Adoption of technologies by smallholder households is increased when all livelihood opportunities and constraints are taken into account.
7) Innovation-platform approaches that effectively link farmers to markets and all relevant actors along the value chain would enhance adoption of intensification measures and crop diversification.
8) It is possible to increase food production in a more sustainable way, improve food and nutritional security, and increase agroecosystem resilience, all at the same time.
9) System characteristics can be identified that quantify the potential of subsistence systems to intensify.
10) Intensification interventions can be combined with better NRM practices in order to enhance system sustainability without affecting productivity.
11) Improved links to markets through access to credit, development of cooperatives, and production of high-value products to meet urban demands will lead to sustainable intensification on farms with access to sufficient land and water resources.

Outputs, outcomes, activities, hypotheses, and indicators are all available in the file, "E&S Africa Standardized Logframe."

8.5 Conclusions

8.5.1 Challenges to overcome

Over 70% of the SRT2 area in East and Southern Africa is categorized as arid, and most of the rest as semi-arid. PET is three to four times the average annual rainfall. Not surprisingly, this area is subject to frequent drought, with significant effect on assets, income, and food security. Livestock losses are often heavy during drought and droughts are so common that herds do not have time to recover between them. Severe to very severe range degradation exists in the SRT2 area. Increasing human populations, declining mobility of livestock populations, and sedentarization around water points has led to overutilization of land and water and localized land degradation. Conflict is also occurring as a result of land fragmentation. The primary system in the SRT2 portion of the action site is livestock production. Poverty levels in the action site are high (55–70%), resulting in very high vulnerability.

Low political will and economic marginalization, resulting from the geographic isolation and poor infrastructure of much of the SRT2 portion of the action site, has led to high levels of neglect by the central governments. Increases in basic services and infrastructure would promote diversification and market engagement and reduce vulnerability in the region.

In the SRT3 areas, very high population density is contributing to land degradation and decreasing farm size through fragmentation. Market access is also a significant issue in SRT3 area as only 22% of households can reach the nearest market in less than three hours, and nearly one quarter require more than 12 hours to get to the market. Poverty in the SRT3 area ranges between 55 and 97%.

8.5.2 Opportunities

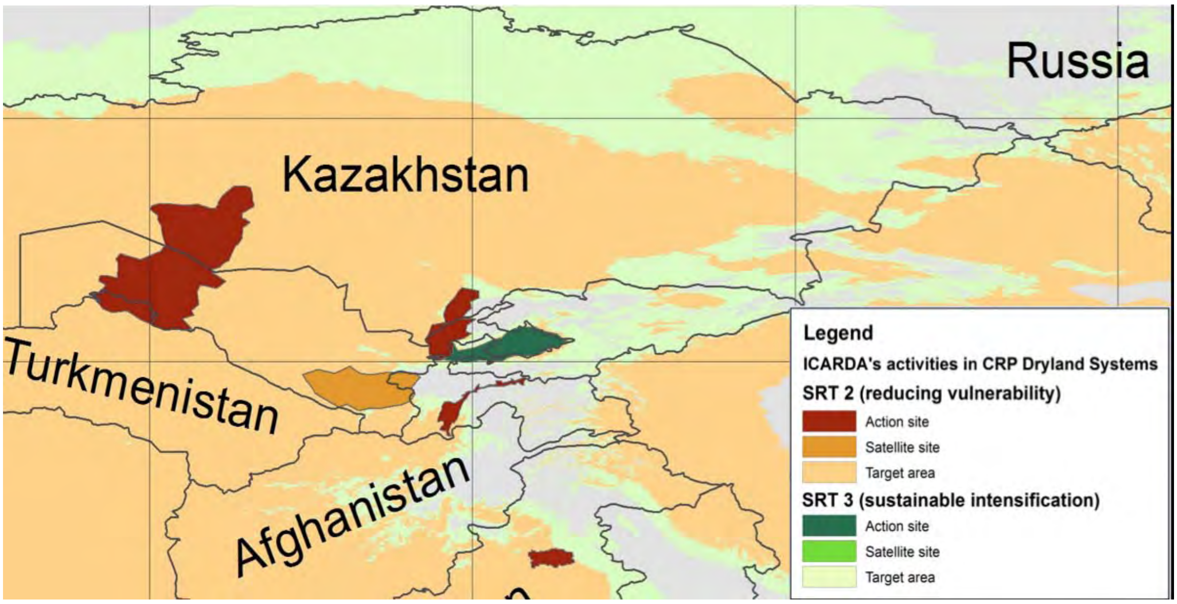
Water bodies cover almost 4% of the total land area in this region, providing significant opportunity for irrigated cropping as well as livestock watering.

Despite the existence of relevant knowledge on agricultural adaptation and interventions at a farm level through the high social capital evident in the action site, this social capital is not being capitalized upon to spread information. There is a need for a major intervention focused on TIPOs that addresses the need for knowledge and innovation networks.

The need for increased extension services and an enabling policy environment that reduces obstacles for intensification are important considerations in this action site. Therefore, value-chain innovation, integrated into a broader plan for resilience and food security enhancement, is needed.

9 Central Asia & Caucasus

Figure 9. SRT2 and SRT3 areas in the Central Asia and Caucasus region.



Conducting research and introducing innovative approaches and technologies will be implemented in two key areas:

1) Reducing vulnerability in agroecosystems affected by degradation of natural resources (SRT2)

Actions sites:

- Aral Sea region, including the Dashauz province (Turkmenistan), Khorezm province and the Republic of Karakalpakstan (Uzbekistan), and Kyzylorda province (Kazakhstan)
- Rasht Valley (Tajikistan and Kyrgyzstan).

2) Intensification of agricultural production in areas with potential for improving food security and improvement of living standards in the short to medium term (SRT3)

Action site:

- Fergana Valley, which includes Batken, Jalal-Abad and Osh provinces (Kyrgyzstan), Sogd province (Tajikistan), and Andijan, Namangan, and Fergana provinces (Uzbekistan).

Thirteen focal points from the action sites were involved in collecting primary data to characterize the sites. Local information was complemented by statistics available at national or provincial level. This section provides an excerpt from the description of each of the three action sites identified in the CAC region. Data processing and compilation of the raw data was carried out by the iIRT, coordinated by ICARDA's office in Tashkent (www.icarda.cgiar.org/cac).

9.1 SRT2 action sites

9.1.1 Aral Sea Basin: Biophysical characterization

The Aral Sea Basin (ASB) includes not only five Central Asian countries, but also parts of Afghanistan and a small part of Iran. The total area of the ASB is 180 million hectares, of which 7.9 million hectares are irrigated with more than 95 km^3 of water annually (Dukhovny and Sokolov 2003; Kijne 2005; Micklin 2008).

Climate

Annual precipitation within the Aral Sea site ranges from 90 to 150 mm. There are two main rainy seasons: spring and autumn. The coefficient of variation of annual precipitation in the region (n=70) is 35–37%. Temperatures exceed 40 ˚C on 12–17 days each year. Aridity index across the Aral Sea site is between 0.065 and 0.18. There is thus a risk of drought.

Table 5. Number of days with precipitation of 0.1 mm or more in the Aral Sea Basin action site.

Winter	13–23
Spring	13–16
Summer	3–14
Autumn	6–12

Temperature

Average annual temperatures range from 8.4 °C in the north to 14.5 °C in the south of the action site. Average maximum temperatures in July range from 32 °C in the north to 36 °C in the south, with an absolute maximum of 46.3 °C. The average minimum temperature in the coldest month range from −15 °C in the north to −3.5 °C in the south, with an absolute minimum of −39 °C.

Soils

Soils of the area are characterized as old-irrigated meadow-alluvial, sand-desert, sandy, grey-brown soils, and in some places are covered by saline soils. Some soils are of the *takyr* type and strongly saline, with a dark covering of alkaline soil.

Results of a survey of the chemical composition of soil from 2007–09 show that about 25% of the land area has low salinity soils (0–30 cm), about 35% has average salinity, and 20% of the area is highly saline. Highly saline areas cannot easily be reclaimed for agricultural purposes.

The territory downstream of Amudarya is characterized by high aridity and low snowfall in the winter. The soils that were formed here are shown in Table 6.

Table 6. Soil groups in the Aral Sea Basin (1984).

Soil type	Total area		Irrigated arable land	
	('000 ha)	%	('000 ha)	%
Grey-brown	6924.7	43	1.6	0.52
Takyr	980.0	6.1	24.9	8.10
Meadow-*takyr* and meadow-desert	285.0	1.8	56.1	18.3
Meadow-alluvial	1041.4	6.4	211.8	68.9
Swamp-meadow	13.6	0.08	12.9	4.2
Flood-plain-Meadow, alluvial	594.0	3.68		
Alkaline lands	658.0	4.08	-	
Desert, sandy	1960.5	12.1	-	
Water surface	3687.8	22.8	-	
Total	16144.9	100	307.3	100

Along the SRT2 transect there are concentrations of meadow-*takyr* and meadow-desert (18%) and meadow-alluvial (69%) soils on irrigated lands.

The reduction in water flow of the Amudarya river and the consequent fall in the level of the water table in the downstream area of the river Amudarya in recent years has resulted in a transition from meadow-type soil to desert-type soil. The drying of large territories of former deltoid lakes and the Aral sea-bottom has resulted in the formation of land that is unsuitable for agricultural use because of the predominance of saline sandy soils. Such soils are now a characteristic of the action site.

Soil problems posing serious management challenges include low content of humus and high topsoil salinity within the irrigated crop lands. Virtually all soils in the action site suffer from various degrees of salinity, with most of them (>50%) showing moderate or high salinity levels in the topsoil.

In the areas of meadow-swampland soils are difficult to cultivate and lack proper drainage systems. Land of this type comprises roughly 40–50% of the total arable land in the action site. As a whole, drainage systems are not in satisfactory condition, especially when not maintained.

Based on the information assembled by the Soil Institute (2003) R. Uzbekistan for the Khorezm region, the following conclusions can be drawn:

- Soils with satisfactory water infiltration (100–200 mm in 10 hours) make up 19% of the total territory
- Soils with unsatisfactory water infiltration (50–100 mm in 10 hours) make up 17% of the total territory
- Soils with very unsatisfactory water infiltration (up to 50 mm in 10 hours) make up 5% of the total territory

Land use and cover

There are no rainfed cultivated lands or crops at this site. The main crops cultivated in the Aral Sea Basin include: cotton, cereals, maize, alfalfa for forage, vegetables, and melon. The leading crop is cotton, which covers 30–50% of the total SRT2 area in the Aral Sea Basin. For the last few years, as a result of a reduction in water in the rivers, the area of rice has been significantly reduced. Nevertheless, rice varieties UzROS-59, Uzbek-5, Dubovski-120, and Nukus-2 are grown in this zone. Large-scale wheat cultivation started after independence, and for the last few years its area has varied between 190 400 and 332 200 ha.

Land degradation

Major factors causing the formation of salt-affected soils in the Aral Sea Basin include:

- evaporation of surface water and groundwater in low rainfall areas (secondary soil salinization);
- readily soluble salts flowing with surface and groundwater from surface drainage (primary soil salinization);
- capillary rise from shallow groundwater;
- hydraulic pressure of groundwater, which creates a continuous ascending current of groundwater from depressions to the surface;
- presence of mineralized groundwaters (strongly saline soils and alkaline land);
- vegetation (most often halophytes) raising concentration of soil-mineral content in the top soils while working as a mineral pump;
- security of district central drainage system or natural drainage; and
- content of salts in irrigation water (primary salinization).

Water erosion occurs on the foothill plains as a result of flood and furrow irrigation, and is a serious threat. Wind erosion is “average” in its severity. There are also large irrigated pasture lands that have not been widely examined and monitored for erosion.

The analysis of available data from pilot sites shows that soil organic matter content of irrigated cropland is decreasing year on year. The principal causes are:

- high turnover of organic matter due to regional agroclimatic conditions;
- constant and intensive soil tillage practices;
- insufficient or nonexistent application of fertilizers;
- reduction of the area in legume crops, practically the absence of a science-based crop rotation scheme, i.e., a monoculture;
- soil mulching with plant residues and other materials is not practiced.

Water resources

The main sources of irrigation water in the Aral Sea Basin are:

- the river Amudarya
- the river Syrdarya
- groundwater
- drainage collector waters
- Lake Sarykamysh
- the small rivers created by spring-snow supply
- the river Turkmendarya
- the river Gurzhak-Vozeiv
- the river Gilichbay.

Groundwater level in the Aral Sea basin decreased from 1997 to 2011 by 240 cm, with a steep drop in 2001 due to drought.

Farming systems

Table 7. Area of crops grown by various types of farms across the Aral Sea Basin action site.

All types of households including	Irrigated land, plain							
	Total (ha)	Most cultivated crops (ha)						
		Cereals	Cotton	Potato	Veg.	Melon	Forage crops	Other crops
All types of farms, including	262 964	100 159	100 971	5 946	6 756	5 912	35 417	7 803
Farm businesses	227 084	85 786	100 266	3 141	2 822	2 836	28 915	3318
Dehkan (private) farms	31 187	15 408	0	2 720	3 795	3 000	5 291	973
Agricultural enterprises	4 693	1 965	705	85	139	76	1 211	512

The average farm holding size in Uzbekistan in 2011 was 107.7 ha, an increase from 16.4 ha in 1997. The common crop rotation practiced during the Soviet Union era was alfalfa for three years followed by six or more years of cotton; this has now been substituted with much shorter rotations. The most recent recommendations for Uzbekistan for cotton–wheat systems are annual or two-year rotations of cotton with winter wheat followed by summer crops (Khalikov and Tillaev, 2006). There is no widely agreed recommended annual crop rotation in the irrigated area, even though a small number of farmers apply the following crop rotation: cotton for one to three years, followed by one or two years of winter wheat or other crops, such as mung bean, soybean, maize, sunflowers, and vegetables.

In addition, site-specific recommendations are given in Uzbekistan according to agroecological zones. For soil types in the Khorezm region a rotation of alfalfa for three years followed by two years of cotton is recommended, or an annual rotation of winter wheat with mung bean as a summer crop followed by soybean and cotton (Khalikov, 2010). These recommendations, however, are not widely followed.

Livestock are an important part of Aral Sea Basin agriculture. Livestock are kept in intensive (industrial), extensive (grazing), and domestic types of system, depending on the natural and climatic conditions of the area. Dairy cattle and poultry farms tend to be concentrated in the peri-urban irrigated areas. Pasture-based livestock rearing is mainly practiced in the areas with low natural-resource potential, and domestic livestock are concentrated on lands near farm holdings with low natural-resource potential. Sheep, hybrid cattle, and camels are the most common types of ruminant livestock.

9.1.2 Aral Sea Basin: Socioeconomic characterization

Poverty rates in Turkmenistan and Kazakhstan are shown in Table 8. No data were available for Uzbekistan.

Table 8. Poverty rate at US$1.25 a day (PPP) (% of population).

	1990	1995	2000	2005	2010
Turkmenistan	14%	64%	25%		
Kazakhstan	0	5%	14%	0	0

Connection to markets

Agricultural products are sold on three types of markets in the Aral Sea Basin: *Dehqon* (independently operated) markets, universal markets, and mini markets. Their numbers vary with administrative regions; e.g., Khorezm province has seven main *Dehqon* markets, usually located one or two kilometers from the center of the capital city of each subdistrict. All locally produced agricultural products, except cotton, are sold at these markets, mostly by farmers. Often these markets also have a livestock section. Households are the main suppliers of animals; butchers, farmers, and traders are the primary purchasers of animals and animal products. Products such as oil cake, husks, and other nonagricultural products are traded by resellers. *Dehqon* markets are open one or two days a week. Usually three types of sellers can be found at the different market types: (i) people who are selling their own products (farmers), including household and *Shirkat* (cooperative) members; (ii) resellers or retailers who bought products from farmers or wholesalers; and (iii) wholesalers.

The markets are widely scattered all over the region. Distance from settlements to the nearest market ranges from 2 to 60 km. Only 15% of settlements are located more than 8 km from the nearest market. All settlements can reach the market within three hours of driving. For all crops, except cotton, difficult customs rules limit access to the international markets.

Institutional support

During the Soviet Union era, a centralized agricultural knowledge and information system theoretically linked research, extension, and production units. Since independence, the infrastructure and links have deteriorated. The transition from a centralized economy (collective farming) to more market-oriented frameworks (private farming) necessitates also institutional and organizational changes. Farmers have rapidly developed different needs and demands. In the Republic of Uzbekistan, training activities for irrigation and soil health at the national, regional, and local levels are made available to farmers by various institutions such as local offices of the Ministry of Agriculture and Water Resources, farmers' associations, and universities. Nevertheless, a major constraint remains the lack of experience and skill in managing complex irrigation systems and market-oriented farm enterprises. Despite the increasing demand by farmers for competent agricultural extension services, such services are only sporadically provided. In total, at least 14 types of agricultural organization have been involved in knowledge transfer to the agricultural population, but their influence has been patchy (Nazarov, 2008). Services provided attempt to address issues of production, trade, banking, and insurance, but in general providers are understaffed, insufficiently trained in broader issues associated with the current transition towards a market economy, and have limited resources. Even though the development of agricultural extension is becoming a matter of national importance, a national policy framework on extension-service development still needs to be developed.

9.1.3 Aral Sea Basin: Major constraints

Under the former Soviet system, agricultural production was organized in large, heavily mechanized state and cooperative farms complemented by private, small-scale, non-mechanized production for home consumption. The large farms were specialized according to a specific product or unit. Input supplies and marketing activities were organized from outside the farm. Important managerial decisions on farming strategies were made off-farm. After independence, Central Asia inherited a diversified agrarian sector and a large, educated work force. The diverse geographic and agroclimatic conditions offer favorable natural conditions for agriculture where irrigation is available.

Since independence, Uzbekistan has been rebuilding and restructuring its agricultural sector to strengthen self-sustained production. One avenue has been the privatization of former state and cooperative farms. After independence the pressure on water resources and the intensity of land use remained more or less unchanged because the new landowners followed the production patterns that they were accustomed to during the Soviet Era. However, the first post-Soviet years were impacted by the disruption of the former economic ties to land use, resulting in a distinct decline in agricultural production and unexpectedly low profitability. The costs of mechanized equipment became a large constraint. In addition, most farms faced a number of problems such as highly eroded and saline soils, reduced access to farm inputs (e.g., improved seeds, fertilizers, pesticides), insufficient supply of appropriate farm equipment, limited access to output markets, and a lack of purchasing power.

Furthermore, only a minority of the new landowners had substantial farming experience. The majority lacked agricultural knowledge and management skills since they were accustomed to working in other professions. Those with farming experience from state and cooperative farms have little experience with independent decision-making and farm planning.

Although the production decline was reversed in the early 2000s, this turnabout could not compensate for decades of land degradation resulting from erosion, waterlogging, compaction by large-scale mechanization, overgrazing, nutrient depletion, and, above all, soil salinization. The annual costs associated with land degradation in Central Asia are estimated at US$31 million (Sutton et al. 2008). In Uzbekistan where agriculture accounts for about 22% of GDP and employs 33% of the labor force (Statistical Committee 2010), the annual loss from highly saline croplands going out of production amounted to US$12 million (World Bank 2002). The loss in land value severely impacts Uzbekistan's economy.

Unsustainable agricultural practices have thus caused livelihood insecurity and environmental instability in the rural areas of the Aral Sea Basin. Irrigated agriculture is not only at the root of land degradation and water insecurity, but affects society beyond the agricultural sector. Consequently, increasing land and water productivity is a major pathway to sustainable development and poverty eradication. Present shortcomings in agricultural practices have many technical causes, and underscore the urgent need for agricultural training and extension. For example, water-saving approaches and modern irrigation technologies, such as the use of water metering on irrigation pipes and siphons, need to be introduced. Increasing land and water productivity can be a major pathway to sustainable development and poverty eradication.

Mounting concerns about environmental damage and food security have encouraged the search for better practices and land-use alternatives for the degraded croplands in dryland zones but, despite this, sustainable management practices and adoption of new technologies are rare in the Aral Sea Basin action site. Since the farming population has developed into heterogeneous groups, tailored training and advisory programs need to be developed for a variety of situations.

9.1.4 Rasht Valley: Biophysical characterization

Climate

Annual precipitation within the Rasht Valley action site varies from 416 to 915 mm. The coefficient of variation of annual precipitation in the region is 20–24%. Mean annual precipitation at Lyahsh, Tajikistan, ranges from 230 to 700 mm, while at Tavildara, Tajikistan, it ranges from 600 to 1500 mm. Seventy-five to 85% of annual precipitation occurs during the period from December to May. Summer and autumn rains are rare and short lived. Average annual temperatures across the site range from 5.7 °C to 11.7 °C, with the absolute maximum as high as 40.0 °C. The aridity index across the Rasht Valley site is between 0.35 and 0.65.

Table 9. Number of days with precipitation of 0.1 mm or more.

Winter	21–52
Spring	28–53
Summer	7–20
Autumn	9–19

All agricultural crops are irrigated and consequently the timing of the beginning or end of the rains has little influence on cropping. However, late thawing of snow can delay the beginning of fieldwork. Mass planting of potatoes and the cultivation of gardens begin on or around 15 May.

Soils

Soils in the Rasht Valley are shallow according to Kuteminsky & Leonteva's "Soils of Tajikistan" published in 1966. Water-holding capacity of soils is little studied and specific data are largely unavailable. Soil pH ranges from slightly acidic to slightly alkaline (pH 5.41–8.48).

Land cover and use

The Rasht Valley action site covers a total of 1 682 900 ha, of which 586 000 ha are agricultural land. Of this agricultural land, 3 500 ha are arable, 3 100 ha are under orchards, 516 000 ha are under pasture, and 2 200 ha are dedicated to hay production (Dushanbe, 2012). Potatoes and fruits are traditionally grown in the Rasht Valley. In the more humid areas of the mountain belt (Gissarsky, Karateginsky, and Darvazsky ridges) mesophilous, broadleaf forests and shrub vegetation are grown, including walnut, maple, and apple trees.

Water resources

The region is well provided with water. The river Surhob, which originates in Kyrgyzstan (where it is called the Kizilsu), joins the river Muxu. The river Suhab has many tributaries that originate from glaciers and are distinguished by their turbulent flows and an abundance of thresholds. Below the confluence of the rivers Obihingou and Surhob the river is known as the Vakhsh.

Farming systems

Historically there have been four types of farms in the Rasht Valley: state-run farms, collective farms, farmer-owned farms, and household plots. In 2011, eight state farms utilized 40 100 ha; 3 013 privately held farms utilized 275 000 ha; and an unknown number of household plots utilized 14 200 ha. Since 2004, there have been no collective farms in operation.

9.1.5 Rasht Valley: Socioeconomic characterization

Poverty

Poverty is prevalent in rural areas, where resource-poor people represent up to 80% of the population. In Tajikistan poverty is high but decreasing (89% in 1999, 64% in 2004, and 53% in 2007) as a result of economic growth and income from remittances (predominantly from the labor migration to Russia). Poverty is more widespread in rural areas and areas where cotton is the main crop.

Market access

The distance to the closest local market in the SRT2 regions is typically more than two hours.

Institutional support

There are pilot sites of the Tadjik Academy of Agricultural Sciences in the Rasht Valley which, together with experts from the Ministry of Agriculture, the Ministry of Water Resources, the Committee on Land Management, and various NGOs and international agricultural research centers, conduct various seminars and trainings for smallholder farmers.

9.1.6 Rasht Valley: Major constraints

The main problem in this region is a shortage of proper soil-cultivating equipment. Water-quality issues are also a serious constraint.

Other key constraints are land degradation, particularly soil erosion, and loss of agricultural biodiversity. Within low mountain zones, erosion commonly occurs near river outlets and on river terraces. In medium mountain zones, water erosion is much greater as a result of steep slopes and other factors such as rainfall intensity, poor soil cover, soil erodability, and overgrazing of cattle (Ahmadov, 2010). Erosion has accelerated in recent years, primarily in medium-mountain and high-mountain zones. The area of eroded land has increased by 8% in the last 15 years. In many areas, research suggests an annual increase in erosion of 2%.

Few data are available on agrobiodiversity losses. However, some observations in the action site indicate that there are efforts to restore biodiversity in pastures and through planting various types of trees.

9.2 SRT3 action site

9.2.1 Fergana Valley: Biophysical characterization

Climate

Precipitation varies between the flat alluvial plains of the Fergana Valley, which receives 150–250 mm of precipitation per year, and the mountains and foothills around the valley, which receive 300–600 mm of precipitation per year. Coefficient of variation of annual precipitation in the region (n = 50) is 24–35%. There are two rainy seasons, one in the spring and one in the autumn. The aridity index across the Fergana Valley action site is between 0.19 and 0.21.

Table 10. Number of days with precipitation of 0.1 mm or more in the Fergana Valley.

Winter	19–23
Spring	17–19
Summer	5–8
Autumn	10–12

Average annual temperatures range from 7 °C to 11 °C in the foothills of the eastern part of the valley to 14–15 °C in the plains. Average maximum temperatures in July are 34–35 °C in the plains and 25–30 °C in the foothills. The absolute maximum temperature is 43.9 °C. Average minimum temperatures in January are from −3 °C to +2 °C in the plains and −9 °C to −4 °C in the foothills. The absolute minimum temperature is −28.7 °C in the plains.

Soils

The plains of the Fergana Valley are a desert area with gray-brown, sandy desert, and *takyr* soils. There are gray soils in the foothills and low mountains, brown and brownish-black soils in the forests in the medium-mountain zone, and light-brown soils of grassland and steppe in the high mountains. The Fergana Valley falls under the Central Asian soil and climatic zone, which is characterized by continental climate (dry) and specific subtropical soils which differ from soils of the more northern regions of Eurasia. In the irrigated lands, soils are mainly medium loamy soils (44%), clay loamy soils (21%), loamy (25%), sandy loamy and sandy (10%), and stony or gravelly (0.1%).

Table 11. Soil salinity in the Fergana Valley, 2010 and 2011.

Year	Total irrigated area (000 ha)	Area under observation (000 ha)	Degree of soil salinity (0–100 cm layer)							
			Not saline		Low salinity		Average salinity		High salinity	
			(000 ha)	%	(000 ha)	%	(000 ha)	%	(000 ha)	%
2010	984	858	612	62.2	258	26.2	81	8.2	33	3.3
2011	984	856	617	62.7	255	25.9	80	8.1	32	3.3

Land cover and use

The total area of farmland in the Fergana province is 676 000 ha, of which 318 000 ha are farmland. This includes arable land, orchards, and pastures. The main rainfed crops in the region in 2011 were wheat, potatoes, horticultural crops, and melons. The main crops overall are cotton, wheat, vegetables, melons, orchards and vineyards, perennial plants, and other crops. The leading crop is cotton. Cotton covers 35–40% of the total area in the Andijan region.

Wheat production started in 1990, and in recent years the area under wheat has grown to 60 000–82 000 hectares. There were 16 301 ha of rangeland across the Fergana Valley in 2011.

Water resources

The main sources of water in the Fergana Valley are:

- River Karadarya—mixed filling
- Naryn river—mixed filling
- Maylisay and Tentaksay rivers—snow filling
- Syrdarya River.

The largest mountain rivers in the area are the Padshaata, Kasansay, Gavasay, Karaungir, Kurgart, Akburasay, Aravansay, Isfairamsai, Shahimardonsay, Sokh, Isfara, and Hodzhabakyrgan. There are many other smaller rivers. Flow in the Karadarya, Naryn, and Akburasay rivers is regulated by dams, including those at the Andijan reservoir, the Toktogul reservoir, and the Papan reservoir. The river flows of Aravansay, Maylisay, and Tentaksay are not regulated by dams.

Irrigation water is collected from springs, water-collecting headers, drainage water, and wells. According to the annual report of Narin–Kara–Dayra and Sokh–Syrdara River Basin Authority, in years of low water availability, 95% of water is used for irrigation. In the Fergana Valley, the quality of irrigation water meets water quality requirements for irrigation. Salinity of water in the rivers and small streams is low. During flood periods (April and May), the silt content in rivers and small streams increases to a noticeable level, especially in the foothills. Downstream, silt content increases as a result of wastewater and channel deformations. At the southern part of the Andijan region, collected drainage water is used again for irrigation as its salinity content is low and it meets the requirements for irrigation.

Farming systems

In the mountains of Fergana Valley, natural feeds, almonds, walnuts, and wild rose occur widely. In the foothills, wheat, barley, alfalfa, sainfoin, horticultural crops, fruits, and potato are grown. On the plains, wheat, cotton, tobacco, maize, potato, onion, carrot, beans, vegetables, melons, fruit crops, berry crops, alfalfa, and greenhouse crops are grown.

Livestock are an important part of the Fergana Valley's agriculture, contributing to the food and raw-materials industries. Sheep breeding is the most common type of livestock activity. The main breeds of sheep are "kyrgyzskaya," fine wool, merinos, "gissarskaya," and other local breeds. Meat and milk are consumed locally while wool is often exported. Goat is popular in the middle mountain regions. Local populations consume goat meat and milk, while goat hair is exported. Almost every rural family has at least one cow. From late May until the autumn cattle graze on remote pastures. Meat and milk are sold in the markets. Horses are housed during the wintertime, and are put out to pasture in spring. Yaks mostly graze on high mountain pastures and are used for meat and sometimes for milk.

9.2.2 Fergana Valley: Socioeconomic characterization

Poverty rates in the Tajikistan and Kyrgyzstan peaked in 2000 and have since declined (Table 12).

Table 12. Poverty rate at US$1.25 a day (PPP) (% of population).

	1990	1995	2000	2005	2010
Tajikistan			49	21	7
Kirgiz	0	19	34	23	6

The percentage of people in poverty in the countryside tends to be approximately 40%, which is higher than the national average.

Market access

Most people sell their agricultural products at the local market in their district. Individual farmers who have a vehicle or tractor transport their products to the regional centers of the Fergana Valley because prices there are on average 10–15% higher than in the district markets. The distance from most farms to small markets varies from 2 to 20 km, and the time that it takes to reach those local centers ranges from 35 minutes to 1 hour, depending on the type of transport. The distance from farmer households to the district center varies from 5 to 25 km and travel time may vary from 10 minutes to 1 hour, depending on the type of transportation. Those who have their own cars deliver their products to the regional centers, mostly within 10–60 km.

In Uzbekistan, the government sets targets for production of cotton and sells cotton on the world market; farmers do not have direct access to international markets. For other crops, such as wheat, rice, and vegetables, farmers have access to local and national markets.

In the other republics, such as Kyrgyzstan and Tajikistan, there are no longer any government targets for crop production; all crops can be sold on local, regional, or world markets. Cotton, fur, fiber, and partially dried apricots are all exported to world markets. Tobacco, meat, vegetables, rice, dried fruit, fruit, and honey are for sale at local markets. Tobacco, cotton, meat, milk, cream, butter, sour cream, yogurt, chalap, cheese, kurut, koumiss, wool, woolfell, eggs, etc. are for sale on both the national and local markets.

Institutional support

Various donor-funded projects disseminate knowledge and improved practices in the action site. For example, the project on “Improving water productivity at plot level,” financed by the Swiss Development Cooperation (SDC), established an information center with the involvement of the Scientific Production Association, SANIIRI. The center has organized training events, seminars, and site visits of scientists and experts. Experimental sites for the introduction and learning of effective methods of water conservation are being organized. Recommendations, booklets, and brochures to share experience in agricultural production are being published based on a systematic monitoring system established in the action site.

The Kyrgyz Research Institute of Agriculture, the Irrigation Research Institute, the Research Institute of Veterinary Medicine, the Research Institute of Pastures and Forages, and the Research Institutes of the National Academy of Sciences are working on the development of improved locally adapted crop varieties, animal breeds, and technologies.

The Central Administrative Board of Agriculture, which comprises 26 organizations connected with agriculture, is engaged in development of agrarian policy in the Sogd province in Tajikistan. Also, many international organizations are engaged in the distribution of technology. Private-sector advisory services, organized after the termination of international projects, operate successfully in the region. For the last five years, experts and scientists widely recognized in their fields of competency have been increasingly playing private consultancy roles.

9.2.3 Fergana Valley: Major constraints

The major constraints facing agriculture in the Fergana Valley are shown in Table 13.

Table 13. Factors adversely affecting the productivity of land in the Fergana Valley, their causes and consequences.

Problems	Causes	Consequences
Absence of science-based agricultural zoning	Focus on the production of raw cotton	Extensive development of agriculture, poor land management
Salinization	Poor irrigation management and poor drainage	The deterioration of soil fertility, increased consumption of irrigation water, tools, fertilizer, and labor
Rocky land	Reclamation of rocky land	Low fertility, increased consumption of irrigation water, and labor cost
Gypsum content	Reclamation of lands with gypsum content	Low soil fertility, waterlogging, salinity, karst topography
Untimely structure of sown areas	Monoculture	The lack of crop rotation, increased consumption of fertilizers and pesticides
Irrigation erosion	Poor irrigation techniques, land reclamation	Leaching and removal of topsoil
Wind erosion	Absence of an effective system of shelter belts	Blowing away of fertile topsoil
Water erosion	Plowing of steep slopes	Loss of topsoil
Inefficient irrigation	Lack of land grading, poor design, and weak irrigation scheduling	Erosion, low water productivity, loss of fertilizers, low crop yields

Water management

Analysis of the needs and requirements of farmers identified a number of constraints related to water management.

- Farmers do not have enough information about irrigation techniques and technology (e.g., the length of irrigation furrows are established without regard to slope of the fields or soil permeability). Many farmers do not have permanent and experienced irrigators who know the characteristics of their fields. Many farmers use furrow irrigation.
- Farmers are not aware of the principles of watering. It is difficult for them to determine the best timing and duration of irrigation. As a result, they use excessive amounts of irrigation accompanied by large losses of water.
- Supply of irrigation water is often delayed.
- Farmers do not have the means to carry out proper water budgeting and, in consequence, use water carelessly, where there is enough.
- Farm households have very little skill and experience in water management.

These deficiencies lead to land degradation, reduction of soil fertility, and decreased crop yields.

Land degradation

In the Fergana Valley, 11.4% of the irrigated land is affected by soil salinization. Mudslides are common. Protecting land from wind and water erosion is one of the most pressing issues for further development of agricultural production, protection, and improvement of land use. The "Uzdaverloyiha" Institute in Uzbekistan, together with various research and development projects, developed a set of erosion control measures, including defining the scale and sequence of measures to be taken. Measures include planting defensive forest strips, planting terraces on eroded hillsides, and consolidating forest sands along canals, rivers, reservoirs, and ravines. It is also necessary to enhance riverbanks, build tracts to combat mudslides, put in place protective levees and upland ditches, reconstruct irrigation networks, and organize irrigation planning maps.

In recent years, farmers have made much less effort to improve soil fertility in irrigated areas. Soil fertility is declining as a result of untimely tillage of the soil, compaction of the top layer of soil, breakdown of soil structure, and reduction in use of organic fertilizer.

9.3 Partnerships

Figure 10 lists partners involved in CRP activities in the SRT2 action sites, and the number of proposed activities they will engage in. Figure 11 lists partners and numbers of proposed activities for the SRT3 action site.

Figure 10. Partners in the SRT2 action sites and the number of proposed shared activities.

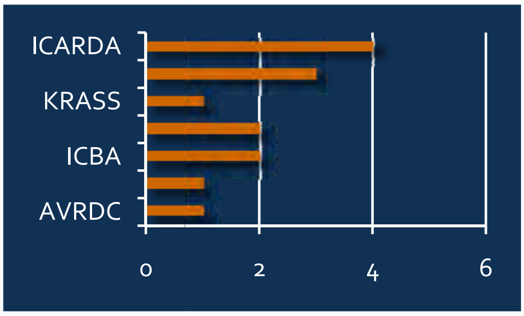
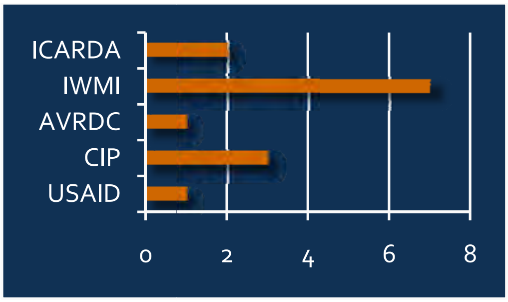


Figure 11. Partners in the SRT3 action site and the number of proposed shared activities.



9.4 Hypotheses for Central Asia and the Caucasus

The following hypotheses were developed by consensus at the RIW for Central Asia and represent the collective experience and expertise of numerous stakeholders thought the system.

1) Development and adoption of an innovative knowledge platform for integrated land conservation and watershed management in the upper and lower reaches of the Amudarya and the lower reaches of the Syrdarya will lead to improved institutional functioning and responses in addressing agricultural constraints for rangelands and irrigated agriculture.
2) Improved options and practices for integrated water- and land-resources management, increased diversity in the portfolio (including neglected and underutilized species) adapted to

soil salinity in target cotton–wheat–rice–livestock production systems will increase soil and environmental health, facilitate sustainable agricultural productivity, improve diets and nutrition, and increase employment in the Aral Sea Basin.

3) Increased diversification of mixed production systems integrating horticulture, agroforestry, value-adding activities, and improved market access will enhance water productivity, human nutrition, and livelihoods of rural women and men, thus increasing employment in the Rasht Valley and in neighboring areas.
4) Systems analysis integrating bio-economic modeling for optimum scenarios will enable scaling out for agropastoral and mixed vulnerable production systems.
5) Through the Dryland Systems CRP, development and adaptation of an innovative knowledge platform for addressing constraints in agricultural production will increase institutional functioning and livelihoods in the Fergana Valley.
6) Diversification of the characteristic vegetable–horticultural–potato production system through integrated pest management, 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.
7) Innovative and combined policy, institutional, and technological approaches to optimize water productivity and equitable allocation will lead to sustainable intensification of the cotton–wheat–livestock production system in Fergana Valley.
8) Integrating environmental and socioeconomic analysis will help to develop optimal scenarios for trade-off resolution and up- and out-scaling interventions in similar production systems of the CAC region and globally.

Outcomes, outputs, activities, indicators, problems and hypothesis are all available in the file “Central Asia Caucasus Standardized Logframe.”

9.5 Conclusions

9.5.1 Challenges to overcome

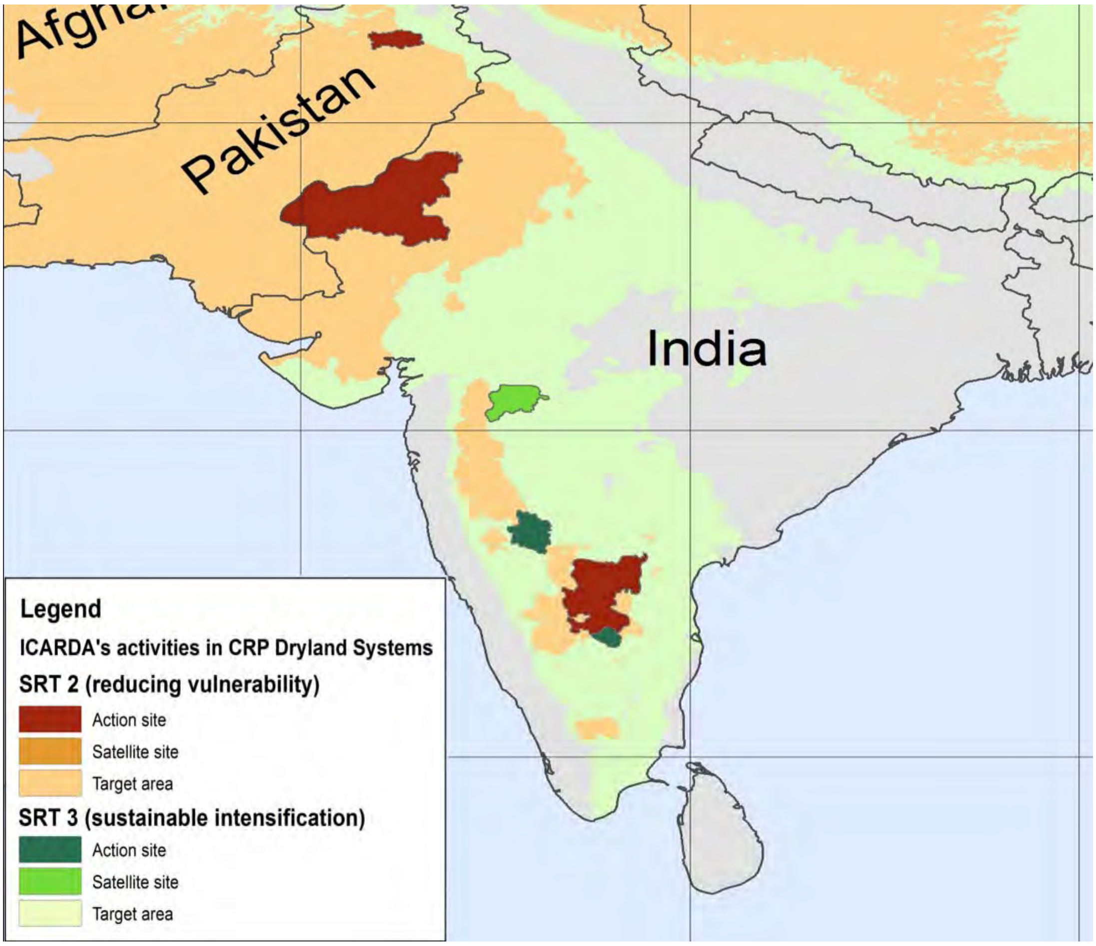
One of the main challenges to overcome in the CAC region is the lack of mechanization and farmer experience. Because of the poor availability of heavy tractors, indurated pans are forming in some areas, restricting rooting depth in crops. The formation of salt-affected soils, caused by evaporation of surface waters in low rainfall areas, soluble salts found in surface water and groundwater, and salts in surface drainage water, is also of concern. Farmers lack the water-management expertise needed to conserve the soil and maximize yield. In addition, farmers are often not allowed to manage their own water resources, as the decentralization process has not been completed in this region. Since the end of collective farming at the end of the 1990s, demographics have changed significantly in farming communities. Most farmers are young and do not possess the background knowledge needed to farm effectively. For all crops, except for cotton, difficult customs rules limit access to the international markets in the SRT2 area. Most countries are also landlocked, making access to international markets a significant issue.

9.5.2 Opportunities

The region has significant water resources that could be used for irrigated cropping. Farm holding size is shrinking but still relatively large compared with most of the developing world, with plot sizes averaging approximately 17 ha. Water supplies are shrinking, but reducing water wastage offers huge opportunities to expand irrigated cropping. Almost all settlements can reach their nearest market within three hours of driving.

10 South Asia

Figure 12. SRT2 and SRT3 areas in South Asia.



A long list of potential action sites in South Asia were discussed and proposed. Maharashtra, Karnataka, and Andhra Pradesh in India were all identified as having large SRT2 and SRT3 areas, while Rajasthan in India and Pakistan and Afghanistan were identified as mainly SRT2-type areas. Based on a higher poverty index, pockets of Rajasthan and Andhra Pradesh are deemed to be SRT2 areas, and much of Maharashtra and Karnataka is deemed to be SRT3 areas. Parts of Pakistan in the region of Chakwal have pockets of high poverty for both SRT2 and SRT3.

The action sites chosen and their characteristics are shown in Table 14.

Table 14. Action sites in South Asia.

Action site: District	Sub-district (Mandal, Tehsil, Taluk, Block)	SRT	System
Jodhpur, Barmer & Jaiselmer, Rajasthan	Osian, Chohtan, Jaiselmer	2	Rangeland, agropastoral
Bijapur, Karnataka		3	Mixed crop–livestock, black soils
Anantapur & Kurnool, Andhra Pradesh	Kalyandurg, Dhone	2/3	Mixed crop–livestock, red (and black) soils

During discussions at regional workshops held within India, smaller administrative units were identified where research will be implemented on the ground. The approach will be to identify clusters of villages within these Mandals/Tehsils/Taluks that allow hypotheses to be tested and outcomes understood.

10.1 SRT2 action site

10.1.1 Rajasthan: Biophysical characterization

Rajasthan, situated in northwestern India, contains one of the largest arid ecoregions in India. Three districts (Jodhpur, Jaiselmer, and Barmer), situated in southwestern Rajasthan (hot arid ecoregion), were selected as the SRT2 action site.

Climate

The climate of all three districts belongs to the Marusthali hot, hyperarid ecoregion, with shallow and deep sandy desert soils and a growing period of less than 60 days per year. The area is characterized by hot summers. The mean annual precipitation ranges from 277 mm at Jaiselmer to 500 mm at Jodhpur, with a west–east gradient for both rainfall amount and coefficient of variation. The mean monthly maximum temperature at Jodhpur varies between 26 °C and 43 °C, while the mean minimum temperature ranges between 9 °C and 30 °C. Rainfall meets less than 25% of annual potential evapotranspiration demand (1800–2000 mm). This results in huge deficit of water for crop and livestock production throughout the year. Poor rainfall distribution is also a major constraint. The aridity index for the SRT2 action site ranges between 0.03 and 0.35.

Soils

The major soil types in the three districts include Torripsamments, Calciorthids, and Camborthids. All of these soils are dominated by Aeolian parent material and coarse particle size. Generally, the soils in the action site have low water-holding capacity, organic-matter content, and cation exchange capacity (CEC). In Rajasthan, 83% of the area is affected by wind erosion (Kar et al., 2009). Wind erosion is the major cause of land degradation, with some 92 000 km^2 of rainfed and irrigated cropland being slightly to moderately affected.

Land cover and use

Agricultural, wasteland,[1] and grazing emerged as the most important land-use and land cover types in the three districts. Wasteland is the major land-cover type in Jaiselmer, with a decreasing trend along the west–east transect. Agricultural land is increasingly important in Barmer and Jodhpur Districts. Jaiselmer has experienced strong land-use change since 1966 as barren land has become agricultural land.

Water resources

Traditionally, this arid zone depends on uneven monsoon rainfall, which is scattered in distribution and very unpredictable. Groundwater forms a critical component of the overall water-resources scenario in the three districts. Its availability, quality, and management are major concerns in all the districts. Availability of groundwater tends to show an east–west gradient. In addition, salinity is a major problem, and limits efforts to develop water resources. Development of groundwater resources for supplementary or full irrigation has been under way for years in the three districts. There is general concern that groundwater is over exploited in Jodhpur.

Water in the Luni River Basin (858 million m^3) originates in the western slopes of the Aravali Range at an elevation of 550 m and plays an important role in irrigation, particularly in the eastern districts of Jodhpur. Additionally, the Indira Gandhi Canal, with a total water volume of 1700–3000 million m^3, is an important source of water for irrigation in the western parts of Rajasthan (e.g., Jaiselmer).

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[1] According to ICAR, wastelands are lands, which, due to neglect or degradation, are not being utilized to their full potential. These can result from inherent or imposed constraints, or both, such as location, environment, chemical and physical properties, and even management conditions. In essence, they are degraded lands.

Farming systems

The farming systems in Rajasthan fall under the pastoral and sparse arid farming systems classification of Dixon et al. (2001). This system goes across South Asia and covers some 112 million ha. In the west (Jaiselmer), pastoral and small ruminant systems dominate, with some transhumance to Gujarat and central India, depending on the season. These are rangeland systems with extensive and degraded natural pastures and some wadis or *khadins* (depressions) where trees and some crops can be grown. Moving east, as rainfall increases systems change from pastoral to agropastoral and then to mixed crop–livestock–tree systems. In Jodhpur district, these are essentially parkland systems with *Prosopis* species. In all districts, there are pockets of irrigation, mostly from wells but also from surface water. About 75% of land in Jodhpur and Barmer is under some form of agriculture, while in Jaiselmer only 30% is agricultural land and the rest is defined as wasteland. The major crops are rainfed *kharif* pearl millet and fallow followed by chickpea or mustard, and wheat under irrigation. Yields increase with rainfall but are still very low, with high year-to-year variability (e.g., average yield of pearl millet (1966–2009) is 0.24 t/ha; SD 0.239 t/ha). All farms keep ruminants; total livestock numbers per district in 2009 were 2.8 million in Jaiselmer, 3.3 m in Jodhpur, and 4.3 m in Barmer. Four major production systems were identified:

1) Small-ruminant-based production: This system is mainly in low rainfall (<250 mm) areas and is a traditional system in the western parts (e.g., Jaiselmer). A distinct feature of this system is that the management of the herd involves seasonal or permanent mobility within and between districts (*taluks*) in search of feed and markets. Recently this system has undergone a shift in herd composition from sheep to goats as a result of an increased demand for milk and meat. As more land has been converted from barren or rangeland to cropland and livestock numbers increase, there has been an increase in land degradation, increasing shortage of feed, degradation of biodiversity, lack of equitable access, and continued degradation of common pool resources (CPR).
2) Large-ruminant-based production*:* This system can be found in pockets across the action site where there is sufficient water to grow feed and provide drinking water. The system is evolving towards an intensive dairy system. Shortage of feed and the spread of diseases were two of the major constraints mentioned.
3) Rainfed crop production: This is found throughout the action site but its intensity, productivity, diversity, and system components are strongly shaped by the amount and frequency of rainfall (which ranges between 150 and 300 mm per annum). This system overlaps with irrigated systems in various parts of western Rajasthan. Rainfall variability, soil erosion, land degradation, nutrient depletion, poor access to improved inputs, shortage of labor, decreasing land-holding size, and increased costs of production are some of the constraints reported.
4) Rainfed and irrigated crop production*:* In many areas there is access to water and irrigated agriculture can be practiced. In terms of scale, these systems can be operated by communities or community clusters within the larger rainfed systems. In addition to the problems mentioned for the rainfed system, depletion of groundwater and increasing salinity are major constraints in this system.

10.1.2 Rajasthan: Socioeconomic characterization

Some 96/2% of the population the Rajasthan action site is rural. The three districts in Rajasthan rank lowest in all districts in India for both livelihoods and natural-resources indices (CRIDA/NRA 2012).

Market access

Barmer and Jodhpur districts are well supplied with feeder roads, but many people live more than five hours from the nearest market (Figure 13).

Figure 13. Travel time to the closest local market in Barmer and Jodhpur districts (SRT2 action area).

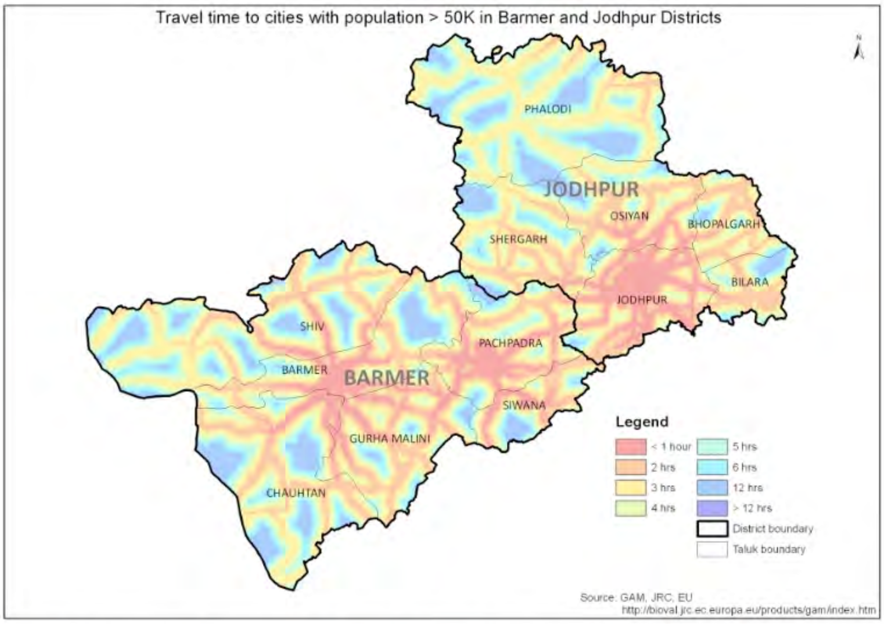

Fig . Distance from markets to rural agricultural producers

Institutional support

There has been, and continues to be, a considerable body of work around production systems in the action site (summarized by Kar et al. 2009), most notably by the Central Arid Zone Research Institute (CAZRI) but also by state agricultural universities and some NGOs. There are also many livelihood-based programs and government programs related to livelihood and agriculture. For example, MPOWER (mitigating poverty in Rajasthan, funded by IFAD and the state government) is working in 1000 villages in six districts linking research and developing platforms for reaching farmers. The Sir Dorabji Tata Trust (SDTT) supports productivity-enhancing projects in many districts of Rajasthan, including Barmer. Likewise, about 20% of all watersheds in Rajasthan have been "treated" under the Integrated Watershed Management Program (IWMP). There are also relevant programs with Tribals under the National Bank for Agriculture and Rural Development (NABARD). NGOs actively working in Rajasthan include BAIF Development Research Foundation, SURE, Gramin Vikas Vigyan Samiti (GRAVIS) and Seva Mandir, working on livelihoods, livestock, water, health, etc.

10.1.3 Rajasthan: Major constraints

A number of important drivers and trends were identified during the RIW. Although most of the drivers and constraints are cross-cutting issues for the three sites, the magnitude of their importance varies depending on the major production system. Those drivers and constrains can be summarized as follows.

1) Rainfall is low, from a long-term average of 350 mm in Jodhpur to 196 mm in Jaiselmer, with coefficients of variation of between 42% and 57%. Climate change is expected to exacerbate this variability. The Intergovernmental Panel on Climate Change's A2 scenarios suggests a 30% reduction in seasonal rainfall and a 4–5 °C increase in mean temperature in the action site.
2) Land degradation is a major driver of change in Rajasthan, with 83% of the total mapped area affected by wind erosion. Some 92 000 km^2 of rainfed and irrigated cropland are slightly to moderately degraded.

3) **Land-use change** is stated to be a common problem in all the three districts, but the biggest change has occurred in Jaiselmer, where barren wastelands have become cultivated wastelands. Rangelands are also being converted to rainfed or irrigated cropping lands—about 103 000 ha in Jodhpur District in the last 10 years, for example. In Jodhpur District about 136 000 ha have also been converted from rainfed to irrigated single or double cropping.
4) **Development of surface water for irrigation and depletion of groundwater** are major drivers of agricultural development but also constraints in the three districts. In some areas, there is over exploitation of groundwater. Access to drinking water for households and livestock is also a major issue, affecting women in particular.
5) There has been a **loss of agrobiodiversity**, driven by land degradation as a result of wind erosion, increasing grazing pressure, mechanization of agriculture, and land-use changes, especially in rangelands.
6) **Landholding sizes are declining** slightly throughout the action site. Tenure, encroachment on CPR, and other land issues are disincentives to invest in agriculture.
7) In the last couple of years all three districts experienced a **change in livestock population and herd structure**, reflecting increasing demand for dairy products.
8) **Labor shortage and the high cost of labor** are problems throughout the action site.
9) In all three districts there have been recent changes in **cropping pattern**. There is a trend towards growing higher-value cash crops in winter under irrigation, where this is available.

10.2 SRT2/3 action site characterization

10.2.1 Andhra Pradesh: Biophysical characterization

Anantapur and Kurnool districts are in the southern part of the state of Andhra Pradesh on the Deccan Plateau. The two districts cover an area of 17 600–19 200 km^2. They are well connected by rail and road to the major cities of Hyderabad in the north and Bangalore in the south. Topography is mainly flat, with small hills and uneven terrain. Anantapur and Kurnool districts both have about 3.6 million people (2001 Census), of which 75% live in rural areas. Population densities are around 200 people/km^2. About 80% of workers in rural areas are involved in agriculture, as are 11% of workers in urban areas.

Climate

Kurnool District falls within the hot and arid subregion of the Deccan Plateau (according to the classification of the Indian Council of Agricultural Research [ICAR]), with an annual average rainfall of approximately 670 mm. Anantapur is within the Karnataka Plateau Rayalaseema subregion, with an annual rainfall of 560 mm. The coefficient of variation for rainfall in Anantapur (1911–2004) is 28% and this district experiences drought on average once every five years. The length of the growing period is on average 119 days and the probability of a dry spell occurring is greater than 50% for 15 weeks of the season. Kurnool also has variable rainfall, but receives more rain during the monsoon period. The number of rainy days is between 45 and 53. Rainfall variability is high in both districts: Anantapur, for example, had an arid climate in 21 of 34 years between 1971 and 2003. The 1980s and 1990s have seen a lot of dry years. In terms of growing season onset and cessation, and hence length of the growing period, the onset of the monsoon has been as early as 1 June and as late as 18 August, and the cessation as early as 18 September and as late as 4 December.

Soils

The soils in Kurnool District are red soils or Alfisol (33%, or more than 300 000 ha) and black soils. In Anantapur red soils occupy 78% of the area (more than 900 000 ha) and are predominantly (59%) shallow (less than 0.3 m).

Land degradation

Approximately 45% of Andhra Pradesh's land area is susceptible to soil erosion and land degradation (Vepa et al., 2003) and about 45 600 km^2 or 17% of the total geographical area is degraded. In Anantapur District, 31% of the area is classified as suffering strong water erosion, 50% as suffering moderate water erosion, and 17% as suffering slight erosion. Strong winds also contribute to soil erosion. Soil loss in Anantapur is estimated at about 4.8 tons/ha per year. Soil analysis in the district in 2007–08 revealed that 80% of more than 19 000 samples were low in N, deficient in zinc and iron, and low in organic carbon. Potassium and P levels were good. The application of nutrients based on soil tests could significantly increase yields.

Water resources

The gross irrigated area in Kurnool is 212 000 ha or about 22% of the total cropped area, and in Anantapur is 137 000 ha or 17% of the cropped area. The major sources of irrigation are tube wells (bore wells) and canals. In Anantapur, 65% of the area is considered safe (greater than 70% utilization) in terms of groundwater availability; 23% is considered critical (90–100%) or semi-critical (70–90%); and only 12% is considered overexploited (greater than 100% utilization).

The irrigated area in Anantapur increased gradually from the 1960s onwards, reaching a peak of about 17% in the 1990s. In recent decades the area has declined to 10–12%. Tank irrigation accounted for 40% of the irrigated area in the 1960s, but has steadily declined in importance, as have open wells. There has been a large increase in tube or bore wells, leading to the overexploitation of groundwater. Tanks are being renovated in some areas.

In Kurnool, groundwater exploitation is largely within the safe zone (less than 70% of net available resources), with only 8 out of 52 *mandals* (subdistrict administration units) having extraction greater than 70%. In Anantapur, 49 of 63 *mandals* have extraction rates of greater than 70% and 28 of these are overexploited (greater than 100% utilization). Of the selected *mandals* in the two districts, Kalyandurg in Anantapur is overexploited.

Land use and cover

In both districts agriculture is the major land use. Kurnool has more forest and barren land than Anantapur and is more intensively farmed. In Anantapur, maximum net sown area has not increased in the last 40 years. The major changes that have occurred are that cultivatable wasteland has declined from about 150 000 ha to 51 000 ha. The noncropped area (current fallow) has varied substantially from year to year. In 2009, a low rainfall year, current fallows covered 433 000 ha, compared with only 32 000 ha in the high rainfall year of 2005. In Kurnool, the major land-use change has been a reduction in forest from a peak of nearly 800 000 ha in 1969 to 410 000 ha in 2009. Cropped area also varies from year to year.

The major land-use changes that have occurred in the last decade are the conversion of rangeland and uncultivated land to annual cropping and the loss of agricultural land. In the case of Kurnool, rainfed cropping land has been converted to irrigated single cropping, and irrigated single cropping to irrigated double cropping, a further sign of intensification.

Farming systems

Livestock are important in all systems in Kurnool and Anantapur. Breeds are almost exclusively local rather than improved. Total livestock numbers are between 3 and 4 million head in Kurnool and 5–6 million head in Anantapur; the difference is largely due to more sheep being kept in Anantapur. All farmers keep backyard poultry. There has been a big increase in sheep numbers in Anantapur in the last decade, from 900 000 to 3.2 million. In Kurnool the increase over the same period has been from 638 000 to 1.6 million. In both districts the number of buffaloes has increased relative to cattle, especially in Kurnool, and the ratio of goats to sheep declined. Higher buffalo numbers in Kurnool reflect more opportunities for intensification associated with better access to markets and greater water availability. Livestock numbers in the two *mandals* reflect these district-level trends.

Cropping systems in the red soil areas of Kurnool and Anantapur are predominantly *kharif* (rainy-season dependant). In Anantapur, groundnut is the dominant crop, occupying more than 800 000 ha out of a total cropped area of about 1.1 million ha. Groundnut is usually intercropped with pigeon pea or sunflower with about 12 rows of groundnut to one row of other crops. There is some post-rainy season or *rabi* chickpea, but this is in the black soil area. Irrigated rice is also grown in some areas. Horticultural crops (trees and vegetables) occupy about 77 000 ha in Anantapur. The dominant groundnut variety in Anantapur is TMV2, a landrace over 50 years old. There are few new varieties available to farmers because of problems with the seed systems. Diversification of cropping systems is highly desirable but few alternative systems are profitable. Castor and guar are being promoted; foxtail millet also grows well, but there is little market for it. An analysis of remote-sensed land cover in 2010/11 (a high rainfall year) shows about 60% of the area under rainfed cropping, with pigeon pea/sunflower, groundnut/sorghum, and sunflower/maize being the predominant crop combinations. Rangelands occupy about 15% of the area, and forest/evergreen vegetation the rest.

Over the last 40 years the major change in Anantapur has been the increase in groundnut area, in part at the expense of sorghum and pearl millet, but largely due to area expansion. In recent years the area of groundnut has fluctuated considerably. In the last ten years chickpea area has increased and some of this expansion is due to contract farming. Maize has also started to be grown on small areas.

Kurnool, with slightly higher rainfall and more black soils, has more crop diversity than Anantapur, both in rainfed and irrigated areas, though again groundnut dominates in the *kharif* season and chickpea in the *rabi* season. The main rainfed cropping systems in Kurnool are pigeon pea/sunflower, groundnut/sorghum, and sorghum/millet. Maize is also being grown on 23 000 ha. Analysis of land use in 2010/11 shows a significant area of forest and shrubland/wasteland (about 30%) in Kurnool. Irrigated crops occupy about 25% of the area and rainfed 35%. Irrigation uses both surface water and groundwater. Cropping patterns in Kurnool have also changed since the 1960s. Sorghum, both *kharif* and *rabi*, and millet have both declined steadily, while groundnut reached a peak in the 1990s and has declined in importance since. The cotton area has also fluctuated and is low at present. In the last 20 years chickpea has increased substantially, though this is mainly on black soil areas. This increase is driven by a decline in chickpea in northern India and the availability of short-duration, heat-tolerant cultivars suitable for the south.

Rice is the most important crop in Kurnool in terms of total production, followed by groundnut, chickpea, sunflower, maize, and sorghum. Yields of rainfed crops are low, around 1 t/ha for groundnut in the *kharif* season. Yields in the *rabi* season are double those in the *kharif* season. Maize is increasing in importance in Kurnool and its yields are substantially higher than traditional rainfed staple crops and rice.

In terms of production, groundnut is the most important crop in Anantapur, followed by rice (under irrigation) and chickpea. Yields in Anantapur are about half those in Kurnool, only 525 kg/ha, reflecting the lower rainfall in this area.

10.2.2 Andhra Pradesh: Socioeconomic characterization

Poverty

Poverty and market access characterization data is missing from the iIRT report.

Market access

Institutional support

ICRISAT, ILRI, and IWMI are the main CGIAR Centers working in these districts. ICRISAT's work is focused on watershed programs (CRP5), diversification of livelihoods, and closing yield gaps (CRP1.1) though soil-test-based interventions. IWMI has worked extensively on the Krishna river basin that covers much of Andhra Pradesh. ILRI is involved with fodder quality (CRP3s) and dairy value chains. CRP3s on legumes (groundnut, pigeon pea, and chickpea) and dryland cereals (sorghum, millet, small millets) are also working in these areas. There is also some CRP7 activity by ICRISAT in both districts. ICRISAT has a long-term village-level study site in the neighboring district of Mahabubnagar.

Given the number and wide range of government and nongovernmental schemes that address agriculture and livelihoods, a key institutional priority is convergence—getting the many agencies operating in one location to work together.

10.2.3 Andhra Pradesh: Major constraints

A one-and-a-half day workshop was held with 25 participants from Kurnool and Anantapur to look at systems, constraints, and drivers in the two districts. The major points arising from this workshop are as follows:

1) Labor is in short supply. Migration, lack of interest in agriculture, and the rural employment guarantee scheme (MGNREGA) are reducing the labor supply, with significant implications for agriculture.
2) Greater mechanization is a priority and contract farming was noted as being a potentially important change agent.
3) Climate, especially temperature, is of concern. Both these districts experience highly variable climates and increasing temperatures in summer. The monsoon is perceived to be more unreliable now than in the past.
4) Groundwater levels are declining in some areas and traditional village tanks are no longer functional. Irrigation is nonetheless an important driver of intensification.
5) Markets and food habits are changing. Dairy and dryland horticulture are both driving change.
6) Government policies and schemes have a large influence on agriculture, some positive and some negative. Policy was perceived to still be important in future, whether through minimum support prices, MGNREGA, "missions," etc.
7) Landholding size is declining. Landholdings have become smaller, and are too small to sustain livelihoods. In both districts there has been a dramatic increase in the number of small holdings relative to large holdings, and the decrease in landholding size is seen as a major issue. In Anantapur, marginal and small holdings (less than 2 ha) account for 66% of the land holdings.
8) Changes in livestock holdings. There is a shift from cattle to buffaloes for dairy production, and a shift from goats to sheep. Improved breeds are rare.
9) Fodder availability has decreased, in part because of the dominance of groundnut for human consumption (although groundnut is also a major source of fodder) but also because of increasing numbers of livestock.
10) Soil fertility/quality/health has declined because of continuous cropping and lack of inputs (organic matter/manure, fertilizer).

11) **Access to credit and information** is a constraint and small farmers are exploited by middlemen/traders.

12) **Seed systems are a particular constraint in Anantapur**. Multiplication of groundnut seed is expensive and difficult relative to multiplication of smaller-seeded crops.

10.2.4 Andhra Pradesh: Partnerships

There has been, and continues to be, a considerable body of work around production systems in the action site by the Central Research Institute for Dryland Agriculture, Acharya N. G. Ranga Agricultural University, and some NGOs. Anantapur is also the focus of a recent high-level ICAR National Level Technical Expert Committee initiative and an MS Swaminathan Foundation report for the Office of the Principal Scientific Advisor to the Government of India. The All-India Coordinated Research Project for Dryland Agriculture has a centre in Kurnool and Anantapur, as does the Agricultural Research Service at Anantapur and Nandiyal in Kurnool District. There are also *Krishi Vigyan Kendras* (farm science centers; KVKs) in both districts for technology dissemination and capacity building. There is the existing Community Managed Sustainable Agriculture program in Andhra Pradesh and in Anantapur and Kurnool districts. There is a new soil health/production program just launched for Andhra Pradesh (with ICRISAT) that will promote soil-test-based macro- and micronutrient applications. Nearly one-third of Anantapur District has been covered by watershed programs under the District Watershed Management Agency. Within communities, self-help groups are also key partners for microcredit, information exchange and capacity building. The Government of India supports these groups extensively, and a large proportion are women’s groups.

10.3 SRT3 action site

10.3.1 Bijapur, Karnataka: Biophysical characterization

Bijapur has an area of 10 540 km^2 divided into five *taluks* and 199 *panchayats*. The total population is about 2 million. Population density is mostly around 150 to 160 people/km, except Bijapur where the largest city is.

Climate

Bijapur District falls in the Deccan Plateau, a hot, semi-arid ecological subregion (ICAR classification), with an annual average rainfall of approximately 600 mm. The coefficient of variation for rainfall is about 28%. Long-term (1941–90) rainfall totals in the *taluks* range from 655 mm in B. Bagewadi to 609 mm in Muddebihal. Most rain falls during the southwesterly monsoon season. The aridity index across the SRT3 site ranges from 0.35 to 0.65, and the mean aridity index is 0.38 for all locations in Bijapur with a standard deviation of 0.030.

Soils

Black soils constitute 90% of the area. There are 400 000 ha of medium-depth black soils, 262 000 ha of shallow black soils, and 234 000 ha deep black soils. There are widespread nutrient deficiencies in these soils, and the application of a soil-test-based balanced nutrient treatment can substantially increase yields.

Water resources

The gross irrigated area is 294 000 ha or about 27% total cropped area. The major sources of irrigation water are canals, bore wells, and open wells. In terms of groundwater availability and use, 23% of the area is considered safe, 36% critical or semi-critical, and 41% is considered overexploited. Bagewadi, Muddebhial, and Sindage are the most over-exploited *taluks*. Groundwater levels are increasing in some canal command areas.

Farming systems

Bijapur District has a total land area of 10 540 km^2. Half the land area is under annual cultivation, 20% is barren, and 20% is nonagricultural. Land use has not changed greatly in the last 40 years, the most notable feature being the year-to-year variability in current fallows. Overall, there has been an increasing trend in the area of fallows. An analysis of land-use change between 2000 and 2010 based on remote sensing shows that the major change has been the conversion of rangelands to rainfed cropping and the loss of land to “other” uses. The area of land under irrigation has not increased significantly.

Livestock are an integral part of all systems and total livestock numbers have increased in the last decade to more than 3 million head. This is associated with increases in all types of livestock. Buffaloes have increased relative to cattle and goats have declined substantially relative to sheep. Backyard poultry are kept by all farmers. There are very few improved livestock types. The greatest number of livestock, and the greatest number of buffaloes, is in Indi *taluk*, which has the largest area under irrigation.

Depending on soil depth, cropping in Bijapur can be either *kharif* (rainy season), *rabi* (post rainy season on residual moisture), or both (extended *kharif*). The net sown area in Bijapur is 872 000 ha and the area sown more than once 193 000 ha, giving a cropping intensity of 122%. The major field crops cultivated include pigeon pea (red gram), sunflower, and pearl millet in the *kharif* season and sorghum, sunflower, and chickpea in the *rabi* season. Yields of rainfed crops are low.

The area under irrigated maize is increasing and this is associated with very high yields relative to other staple cereals. In terms of area planted, maize and pearl millet are the dominant crops. Horticultural crops (trees and vegetables) occupy about 27 000 ha, mostly under irrigation. Data from remote sensing show about 75% of the area as rainfed and 10% as irrigated. The major rainfed system is sorghum or millet, followed by pigeon pea/sunflower and sunflower/maize. In terms of area trends, *rabi* sorghum has declined in the last 20 years while pigeon pea, chickpea, and maize are all increasing.

Crop production in Bijapur is dominated by *rabi* sorghum at 234 200 t, followed by chickpea with 79 600 t. In the *kharif* season, maize is now the dominant crop with far superior yields to other crops, especially sorghum.

10.3.2 Bijapur, Karnataka: Socioeconomic characterization

Poverty and market access

Poverty and market access data are not currently in the iIRT report.

Institutional support

Bijapur District is covered by many Federal and State Government schemes and is well served by NGOs, state agricultural universities, and research institutes. Bijapur has a regional agricultural research station under the University of Agricultural Sciences, Dharwad, an All-India Coordinated Project on Dryland Agriculture center, and KVKs.

Bijapur, Karnataka: Partnerships

Data for a partnership chart, which outlines the partners in each area and the extent of their participation with CRP1.1, as is provided for the other regions, is not currently in the report for South Asia.

NGOs such as BAIF, Myrada, Vishala, and MPOWR work in the districts and in some of the selected *hublis*. Federal government schemes operating include the Mahatma Gandhi National Rural Employment Guarantee Act, the Integrated Watershed Development Program, the National Horticulture Mission, and the Irrigation Mission. The state government has programs for seed subsidy, soil health (Bhoochetana), horticulture, livestock, crop insurance, integrated farming systems, and organic farming.

ICRISAT has two new village level study (VLS) sites in Bijapur plus two long-term VLS sites in the neighboring district of Solapur in Maharastra. ICRISAT also has extensive past and current research in Karnataka, including Bijapur, that includes watershed programs (*Sujala*, World Bank), soil health (Bhoochetana), horticulture (SBY). The Bhoochetana program works in every district in Karnataka and with more than 250 000 farmers in 2011 and has led the way in implementing successful "convergence". A consortium of CGIAR centers has also just started a new project in Karnataka on technology dissemination.

10.4 Hypotheses for the South Asia Region

The following hypotheses were developed by consensus at the RIW for South Asia and represent the collective experience and expertise of numerous stakeholders thought the system.

1) Identifying gaps and strengthening formal and informal institutions (e.g., bylaws) and increasing social capital, especially of women and communities, will enhance equitable and sustainable uses of natural resources/CPR.
2) Integration and convergence of activities of all actors (stakeholders) and research-for-development programs, and the development of institutional and policy frameworks, will improve delivery and sustainability of system-level performance.
3) *In situ* and *ex situ* water harvesting, and improved soil- and water-management practices, will increase system water productivity, reduce soil erosion, and improve system resilience.
4) Integration of trees, crops, and livestock for higher biomass production, combined with efficient biomass utilization, can increase biomass availability in systems.
5) Increased agrobiodiversity of agricultural systems and community-level landscapes, including CPR, will contribute to enhanced system resilience and livelihoods.
6) Livestock productivity and profitability can be improved and environmental impacts reduced by better feed and herd management, and marketing.
7) Agropastoral and pastoral-system-based livelihoods can be improved by reducing conflicts with sedentary farmers and by improving access to and management of CPR.
8) Validated adaptation measures can reduce climate-induced vulnerability and risk.
9) Sustainable intensification does not necessarily reduce risk.
10) Quantifying the effect of declining landholding size on productivity, sustainability, and livelihoods will influence land policy.
11) Strengthening value chains and establishing public–private partnerships will increase the profitability of smallholder farmers.
12) Gender-friendly labor-saving technologies will provide opportunities for livelihood diversification.
13) Characterization and geospatial analysis of natural resources and other livelihood capitals that determine system boundaries and synergies will increase the impact of the research program.
14) Understanding farmers' livelihood strategies (which depend on their assets), and targeting interventions accordingly, will enhance adoption (of improved production, marketing, and value-addition technologies).

Logframe data including problems, outcomes, outputs, hypothesis, activities and indicators available in the document "SAsia Standardized Logframes.

10.5 Conclusions

10.5.1 Challenges to overcome

In the SRT2 section of the action site the climate is classified as hot and hyperarid, with only 250–500 mm of precipitation per year and annual potential evapotranspiration of 1800–2000 mm per year. There is thus a huge deficit of water for crop and livestock production throughout the year. Poor rainfall distribution is also a major constraint. Traditionally this arid zone depends on uneven monsoon rainfall, which is scattered in distribution and very unpredictable. Groundwater forms a critical component of the overall water resources scenario in the SRT2 districts. Its availability, quality, and management are major concerns.

Salinity is major problem, and substantially limits efforts to develop water resources. Groundwater has been exploited for irrigation for many years in the three SRT2 districts. There is general concern that groundwater is overexploited in some areas. There is also a shortage of labor; consequently, labor is increasingly costly throughout the SRT2 action site. Greater mechanization must be a priority in both SRT2 and SRT3 areas, and contract farming is noted as being potentially important as a change agent. Landholding sizes are shrinking and are now generally too small to sustain livelihoods. In all districts the ratio of small holdings relative to large holdings is decreasing and this is widely recognized as a major issue.

10.5.2 Opportunities

Rivers and groundwater resources are present and already playing a major role in providing water for irrigation. Livestock production systems based on small and large ruminants exist in the SRT2 areas with low rainfall. Some of the large-ruminant-based systems are evolving towards intensive dairy production to meet an emerging demand from population centers. Livestock diseases and shortage of feed are major constraints to this system; fodder availability is declining as a result of the increasing importance of groundnut for human consumption and an increase in livestock numbers.

SRT3 areas are well connected by rail and road to major cities to both the north and the south. Water from tube wells is classified as “overexploited” for irrigation in only 12% of the areas in which it is utilized, meaning that its use is largely sustainable for the foreseeable future.

Section 3 –Addressing "Must Haves"

A detailed response to each of the 16 FC and ISPC "must haves" will accompany the revised proposal, but since the inception phase was intended to inform the revision process, a summary is given here.

To address the "must haves," clear characterizations have been offered for each of the five target regions. These have been used to identify action sites and to place them conceptually into two categories, SRT2 and SRT3, using a water-balance approach and other criteria. Hypotheses are outlined at the end of each regional characterization to help in prioritizing the research and results agenda, and a more general set of interregional hypotheses is offered in the conclusions section below to generalize the problems, outcomes, and working hypotheses that will shape the direction of the CRP as a whole.

Biophysical and socioeconomic criteria for the choice of sites have been standardized across regions and presented above with all the homogeneity that characterization activities during the inception phase and deliverables from the RIW reports would allow. While there are gaps and inconsistencies, a wealth of characterization data has been provided on each target region and clear prioritization has been made based on characterization data, specified criteria, and stakeholder input. A standardized logframe has been developed, which articulates impact pathways linking a cluster of outputs to the CGIAR system-level outcomes, working from impacts to activities.

A comprehensive theory of how social change will result from the livelihood, gender, and innovations systems proposed is described in the proposal and also incorporated into the logical framework, which includes essential components of the impact pathway: identified problems and desired outcomes, hypotheses to drive research, research outputs, research and development activities, and verifiable indicators. Many of these individual components need to be revisited for clarity within target regions and for consistency between regions, and this must be a top priority upon CRP approval.

But the framework nonetheless provides the basis for research and performance management. Partners' roles have been discussed at RIWs and the participation of partners in the CRP was assured through their contribution to defining outputs and activities at the workshops—these now form part of the logframes. Resilience and sustainability in the face of climate variability are core elements of the CRP for both SRT2 (reducing vulnerability, increasing resilience) and SRT3 (sustainable intensification) categories of dryland agricultural systems. By including many stakeholders during the inception phase, the research program has incorporated indigenous knowledge, improved technology, information dissemination, and community engagement.

The CRP will be implemented with considerable consistency across regions, while recognizing that agricultural systems in each region are unique. As indicated, this consistency needs to be improved in terms of the problem statements, desired outcomes, hypotheses to be tested, and activity description. Nonetheless, significant congruency already exists. Below is an encapsulation of commonalities from among the regional logframes that were identified during the RIWs. These bullet points represent the core common goals of the CRP within the global context of dryland agricultural systems, and suggest key areas in which major advances in scientific knowledge and understanding may be expected.

11 Common problems among the five target regions

- The unsustainable management of natural resources given high rainfall variability and moisture stress
- High levels of rural poverty
- Resource stress as a result of demographic change
- Limited understanding of the degree and scope of vulnerability among dryland populations

- Lack of communication between national research and development programs, NGOs and CGIAR Centers
- Inadequate policy to promote technology for agricultural and pastoral rehabilitation within government
- A policy environment that does not encourage adoption of new technology and limits market access
- The marginalization of women, youth, and other groups.
- Poor soil- and water-management practices that cause land and water degradation
- Development goals are not agreed upon in a participatory, multi-stakeholder environment
- Decreasing or insufficient biomass and system productivity
- Declining or insufficient agrobiodiversity
- Poor access to information regarding new technologies or techniques
- Decreasing landholding size
- Inaccessibility of markets and financial resources
- The increasing vulnerability of rural farming communities as a result of resource, knowledge, and institutional changes
- The inefficient utilization of water resources in dryland environments
- Degraded soils constrain productivity and sustainability
- Climate change is causing rapid degradation of natural resources
- Increasing competition for scarce biomass
- A lack of investment in the production of livestock-related products.

12 Widely shared outcomes between the five target regions

Regional commonalities in the logframes include the following:

- A widely agreed upon framework to define and measure vulnerability for the purpose of informing policy and programming
- Farmer attainment of higher plant and livestock productivity and profitability
- Increased food security, including better nutrition
- Improved rural employment
- Greater biomass availability for animal and cropping systems
- Improved access to and adoption of appropriate technology and technical advice by smallholder farmers
- Better access to markets and financial services by smallholder farmers
- High-value product markets made accessible to smallholder farmers
- More-effective buffering and system resilience to reduce vulnerability to system shocks and climate change
- Higher levels of empowerment for youth and women in community decision-making
- Stronger institutions to serve the rural poor and greater government awareness about system and livelihood interdependencies, leading to more-effective policy changes and institutional innovations
- Broad stakeholder participation in the research and development cycle through innovation platforms

- Higher levels of biodiversity and lower levels of land degradation facilitated through better management of soil, water, and genetic resources
- Farmers are equipped to manage their natural resources in a more sustainable way
- Improved options for mixed production systems are communicated to smallholder farmers.
- Trade-off analyses to establish the optimal mix of land use/land cover and cropping systems
- Dryland Systems CRP to inform other CRPs, and vice versa
- Better understanding of system characteristics, opportunities, and constraints
- Effective communication of CRP findings to all stakeholders
- Postharvest and processing technologies have been improved and communicated and value-adding options increased.

13 Widely shared hypotheses between the five target regions

Commonalities in the research hypotheses are particularly crucial to giving a sense of how the overall CRP comes together to solve a common set of research problems despite implementing that research in a number of locations. The hypotheses listed below fell into several thematic groups that reflected the core objectives and methodological distinctiveness of the CRP. Common foci included water management, soil improvement, value chains, biodiversity, technology transfer, ecosystem resilience, social networking, institutional reform, access to physical and financial markets, gender, and youth. All are part of the pathway to progress in the areas of rural poverty, poor nutrition, ecosystem degradation, social instability, poor productivity, and social inequality.

Interregional commonalities in the logframes include the following:

- Adopting appropriate technologies, institutions, and policies will reduce vulnerability and improve livelihoods in dryland production systems
- Farming systems are less productive than they could be because of the interrelated constraints of nutrient and moisture deficiencies
- Understanding farmers' livelihood strategies and targeting interventions accordingly at a system level will enhance development and adoption of improved products and technologies
- Conservation and efficient use of natural resources—land, water, and genetic—will halt land degradation and improve sustainable productivity
- The use of innovation platforms will help to improve targeting of research, enhance adoption and dissemination rates, and guide policy to improve food security and livelihoods in dry areas
- Integrated soil and water management enhances agricultural productivity
- Effective water and soil management can enhance intensification, reduce risk and increase land productivity
- Integrated analysis of socioeconomic and biophysical processes is important to design steps that can help reduce vulnerability and enhance sustainable intensification in dryland agroecosystems
- Increased agrobiodiversity can increase plant productivity to mitigate food shortages and increase overall system productivity, profitability, and resilience
- Improved access to and equitable participation in markets by smallholders adds value, enhances profitability and productivity, and reduces vulnerability
- Validated adaptation measures can reduce climate-induced vulnerability and risk

- Improved access to financial services (credit, savings, subsidies, insurance) enhances technology adoption, productivity, and community resilience to system shocks
- Empowering women, youth, and other disadvantaged groups in decision-making and access to resources and technology increases productivity and reduces inequity and therefore vulnerability of rural households and communities
- Strengthening institutions can serve to reduce natural-resource degradation and conflicts, and to increase equitable and sustainable uses of natural resources
- Integration and convergence of stakeholders using an innovation platform will improve delivery and sustainability of system-level performance
- Adopting appropriate technologies, institutions, policies, and options will reduce vulnerability and improve livelihoods in dryland production systems.

14 The overall theory of change

One general hypothesis for adoption is the "ladder," where farmers start with their own resources and knowledge, maximize these before moving to external inputs, then integration, and finally specialization. At all stages, assets will determine the ability to reach the next rung, while attitude to risk will determine a willingness to invest. We need to ask what type of technology is required by farmers, classified according to their assets, vulnerability, and attitude to risk; some will want low-risk/low-investment technologies, some low-labor technologies, while others with more assets may be willing to invest more in technologies. The theory of change starts by using this analysis to define research questions (household constraints × drivers) and develop hypotheses about the effect of interventions and/or about processes that have or have not led to outcomes (e.g., what is the impact of migration or MGNREGA on labor availability and outcomes for systems?). Sites have been selected where there are gradients (e.g., rainfall, access to irrigation, access to markets, livestock, degradation, etc.), and where production and livelihood systems are undergoing change. Learning why things did not work is as important as learning from successes.

The livelihoods framework and vulnerability analysis will be a key component of the theory of change as it provides a basis on which interventions can be targeted and assessed on households and communities in the context of overall livelihood strategies and the biophysical characteristics of the production system. This will help determine the type of stakeholder, partner, and entry point (e.g., NGOs for human and social capital; government policy for financial and physical capital). Other typologies may also be needed that are appropriate to hypotheses at different levels or scales.