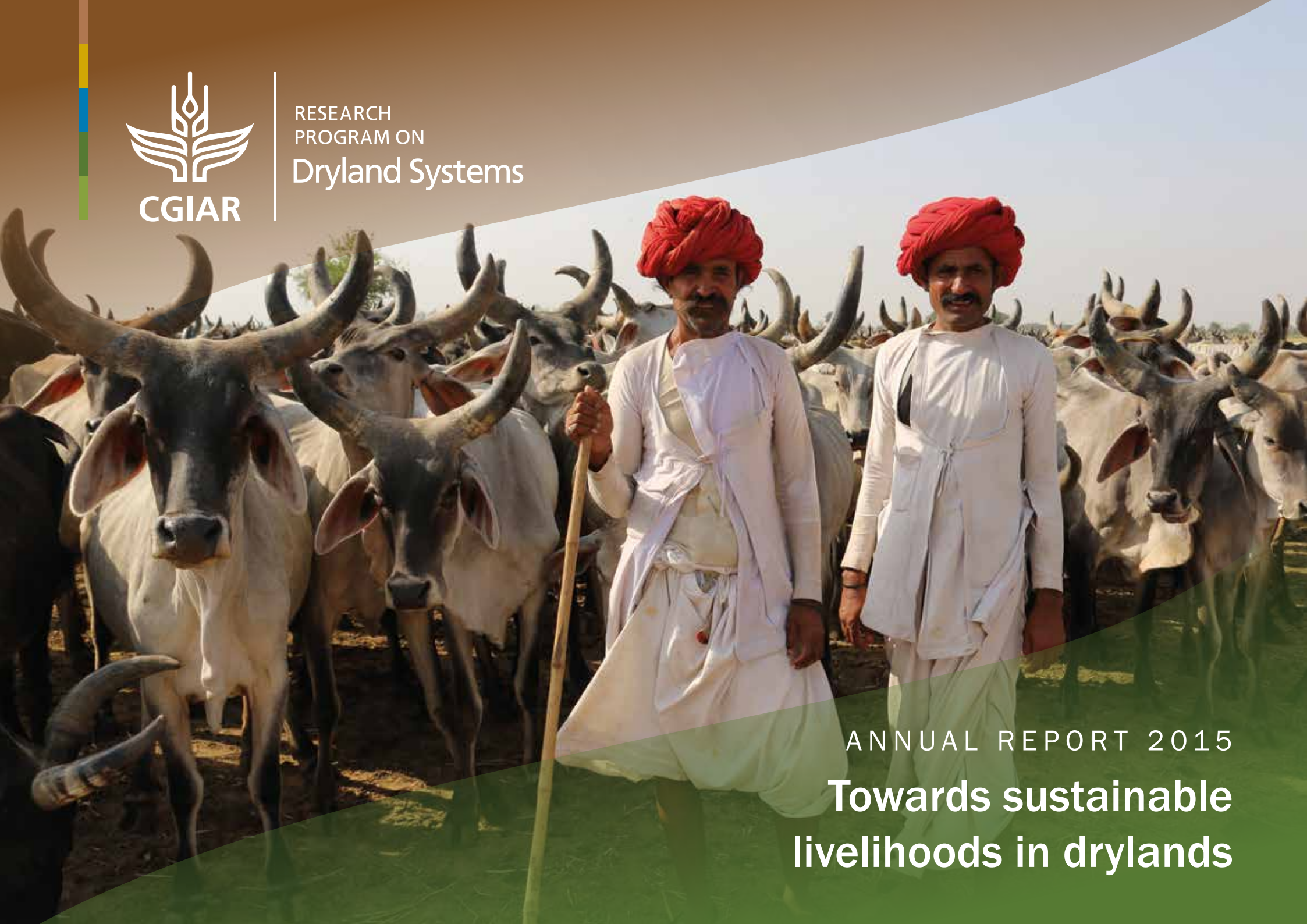
CGIAR

RESEARCH PROGRAM ON
Dryland Systems



ANNUAL REPORT 2015

Towards sustainable livelihoods in drylands

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Photo: ILRI/Stevie Mann

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Dryland Systems at a Glance

The CGIAR Research Program on Dryland Systems is a global agricultural research partnership to realize the potential of dryland communities. The program brings together eight CGIAR centers, and numerous international, regional, and national partners to engage in integrated agricultural systems research. Our partnerships contribute to improved food security, equitable and sustainable natural resources management, and better livelihoods in the world's dry areas.

Our Vision

We envision prosperous rural dryland communities with robust incomes, secure access to food, good nutrition and health, and the capacity to manage natural resources in equitable, sustainable, and innovative ways.

Our Mission

We seek to improve the lives of 1.6 billion rural people, and to mitigate land and resource degradation in 3 billion hectares covering the world's dry areas, by providing scientific evidence generated through our unique, integrated agricultural systems research.

Our Beneficiaries

Dryland Systems works to benefit the poorest, hungriest, least healthy, and most marginalized people living in rural drylands. In many areas, the degraded natural resources on which their livelihoods depend contribute directly to their low levels of wellbeing.

Our research primarily targets the needs of smallholder farmers, agro-pastoralists, pastoralists, and livestock producers. Others who add value along the chain from producer to consumer also stand to benefit from our work. In particular, we target women farmers and young people in search of dryland agricultural opportunities to improve their livelihoods, as well as other marginalized communities excluded from mainstream development. In our work to improve nutrition and food access, we particularly target women and children in the poorest households.

Most of our beneficiaries live in the world's regions where poverty and hunger are most prevalent: Sub-Saharan Africa and South Asia. We also focus on West Asia and North Africa where civil strife is driven by the lack of opportunities for rural communities. We believe that our efforts to address the needs of impoverished and marginalized dryland communities are critical contributions to achieving the United Nations Sustainable Development Goals by 2030.

Other rural communities not directly targeted by our program are also likely to benefit from our research. For example, systems research on climate change helps rural communities across the globe to cope with more frequent droughts and other severe weather events. Similarly, systems research on access to scarce natural resources in drylands can help reduce the potential for conflict and, thus, contribute to peace, prosperity, and thriving trade among countries and regions.

Photo: Prashant Panjiar

Message from the Chair of the Independent Steering Committee

Harry Palmier

Chair

Independent Steering Committee

In 2015, CGIAR announced a new strategy for designing and implementing a new brand of CGIAR Research Programs focusing on agri-food systems. The strategy stirs agricultural research towards practical solutions and innovations to reduce poverty, increase food and nutrition security, and improve natural resources and ecosystem services.

The CGIAR Research Program on Dryland Systems was launched in 2013 as the last in the first generation of 16 CGIAR research programs that were initiated between 2011–2012. Since then, Dryland Systems has forged the way in tackling the challenge of sustainable agriculture development through systems research of the harsh environmental and socio-economic conditions of rural drylands in the developing world, which are home to 1.6 billion people. The unique legacy of Dryland Systems – in terms of its key research knowledge, data, tools, and lessons learned – will be taken forward into the new, second phase of CGIAR global research programs. It will inform the way in which these programs will integrate the holistic systems perspective into agri-food systems research, to take into account both biophysical and socio-economic factors that shape agricultural livelihoods in both rural drylands and other ecosystems globally.

Over a relatively short period, Dryland Systems has delivered a body of robust scientific evidence. Its work and findings offer important lessons for sustained research in dryland agri-food systems in developing and developed countries. In 2015, such evidence convinced policy makers formulating the Sustainable Development Goals, the landmark Paris Climate Change Agreement, and Ankara Land Degradation Neutrality Agreement to take a holistic systems approach to global challenges.

Our hope is that the global commitment to reducing the negative effects of climate change and land degradation will be matched with increased investment in the years to come. Investment in systems approaches is critical to tackle climate change adaptation and mitigation, and to combat the land degradation that affects the lives of millions of smallholder producers and consumers in developing countries. As Dryland Systems consistently advocates, breakthroughs will not come from single discipline science alone. Appropriate, holistic, systemic responses to urgent issues of climate change, food security, and land degradation will only come through interdisciplinary collaboration between scientists and numerous other research and development partners.

With our scientists and many partners, I welcome the external evaluation commissioned by the Independent Evaluation Arrangement (IEA) this year. The evaluators concluded that the mission of the CGIAR Research Program on Dryland Systems is "highly relevant" and that "there is a clear need for investing in improving sustainable productivity of dryland agricultural systems which could benefit hundreds of millions of poor people."

In 2015, war and political instability ravaged many countries in the Middle East and North Africa. A growing body of scientific evidence suggests a strong correlation between climate change, land degradation, conflict, and migration. The case for continuing to support research in rural drylands of the developing world is stronger than ever.

"I firmly believe that the CGIAR Research Program on Dryland Systems is a good example of what the future of international research for development programs could look like. It engages in large-scale action research to identify 'best-bet' intervention packages and validates their effectiveness in specific agro-ecosystems, and promotes their scaling up to benefit the poor and highly vulnerable populations living in the rural dry areas of the developing world."

Harry Palmier, Chair, Independent Steering Committee

Message from the Program Director

Richard Thomas

Program Director

CGIAR Research Program on Dryland Systems

In a radical move away from commodity approaches, the new CGIAR strategy reorients research around agri-food systems. The strategy takes on board the systems thinking championed by the CGIAR Research Programs on Dryland Systems, the Humid Tropics, and Aquatic Agricultural Systems to address the complex development challenges through agri-food systems research. In 2015, on the recommendation of the Second Science and Implementation Meeting in April, and in response to a budget cut of around a third, the program streamlined and re-organized its work under three major agricultural livelihoods systems: (1) pastoral and agro-pastoral systems, (2) irrigated systems, and (3) rainfed systems including trees.

Our integrated systems approach to land degradation shaped the thinking and recommendations of the 3rd Scientific Conference of the United Nations Convention to Combat Desertification (UNCCD) and the 12th Conference of the Parties to UNCCD. The 195 Parties agreed to a global deal that set a new environmental target: achieving "land degradation neutrality" by 2030. The UNCCD Bureau of the Committee on Science and Technology has endorsed our systems approach to meet the target.

Four years of rigorous scientific work that we coordinated in the framework of the global Economics of Land Degradation (ELD) initiative culminated in publication of *The Value of Land*. An accompanying report, Reaping economic and environmental benefits from sustainable land management, summarized significant issues for policy and decision makers. The European Commission, as a net 'importer' of land embedded in imported products, recognized the relevance of the scientific evidence and recommendations for developing sustainable agriculture, ending poverty and hunger, curbing migration, and enabling global political and socio-economic stability.

The 70th Session of the UN General Assembly on adopting the Sustainable Development Goals (SDGs) approved Target 15.3 on Land Degradation Neutrality. Notably, the private sector is now using the business brief, Opportunity Lost: Mitigating risk and making the most of your land assets, to assess exposure to the risks of land degradation and to evaluate opportunities in sustainable land management.

Systems research addresses the complex dynamics of socio-ecological systems that operate at different scales of space, time, and human organization. Our work builds on previous research to address development challenges. Early successes are the re-greening of silvo-pastoral systems, integrating smallholders in agricultural value chains, gender empowerment through village-based seed enterprises in Afghanistan, the adoption in Nigeria of a policy promoting new, high yielding, heat-tolerant wheat varieties, and Index-Based Livestock Insurance in Kenya and Ethiopia.

Measuring the results and impact of systems research is not straightforward. To establish greater transparency and accountability for our results, we continued to develop and refine our user-friendly, interactive Monitoring, Evaluation, and Learning (MEL) system. In capturing and analyzing research outputs that deliver development outcomes, the MEL system sets the standard for effective results-based management to track progress across CGIAR. Three other CGIAR research programs and two CGIAR research centers have adopted the system, widening the scope for sharing knowledge and information and spurring greater innovation and interdisciplinary collaboration.

At this stage, we measure impact by foresight (*ex-ante*) assessments developed and implemented in 2015–2016, and incorporated into the new Dryland Cereals and Legumes Agri-Food Systems CGIAR Research Program. We anticipate critical mass improvements in drylands food security, livelihood equity, and resilience in five years.

Highlights 2015

During 2015, Dryland Systems research contributed to improving the lives of 1.6 billion people living in rural drylands of the developing world. We provided scientific evidence, tools, and practices generated through our integrated systems approach to agricultural research to shape global policies to mitigate land and resource degradation in 3 billion hectares of drylands.

We made significant advances in promoting the integrated systems approach to agricultural research in order to encourage new thinking, innovation, inclusive solutions, equitable policies, and to reverse the chronic lack of investment in drylands. In 2015, we exceeded 8 of our 34 targets by over 100%, and four of our targets by over 50%.

Rural drylands

1.6 billion people living in rural drylands of the developing world

3 million hectares where we mitigate land and resources degradation

Advancing Knowledge

Of the 567 publications authored by our scientists in 2015, one third of the peer reviewed journal articles (28 of 88) contributed multidisciplinary knowledge on systems research in drylands. We developed concepts for sustainable intensification in drylands, for example the concept that intensification in drylands will proceed very differently compared to other areas. For food systems, we developed the concept that resilience encompasses social, economic, and biophysical processes operating at many scales. Concepts we developed for critical research for sustainable dryland development encompassed anticipating dryland futures, co-producing knowledge for win-win options, and facilitating policies, institutions, and governance for scaling and enabling innovation.

Our analyses of integrated systems – about a quarter of our peer-reviewed publications – identified constraints, needs and preferences, priorities, intervention strategies, entry points, and actors in major agricultural production and livelihoods systems in drylands at scales ranging from farming system to regional, continental, and global.

Nearly two-thirds of our peer-reviewed papers reported the results of tests and validation of options to concurrently raise agricultural production, improve rural livelihoods, and conserve and enhance natural resources.

Around one-tenth of our peer-reviewed papers analyzed and integrated assessments of how agricultural livelihoods systems perform, and the implications for managing trade-offs, choosing options, and developing synergies.

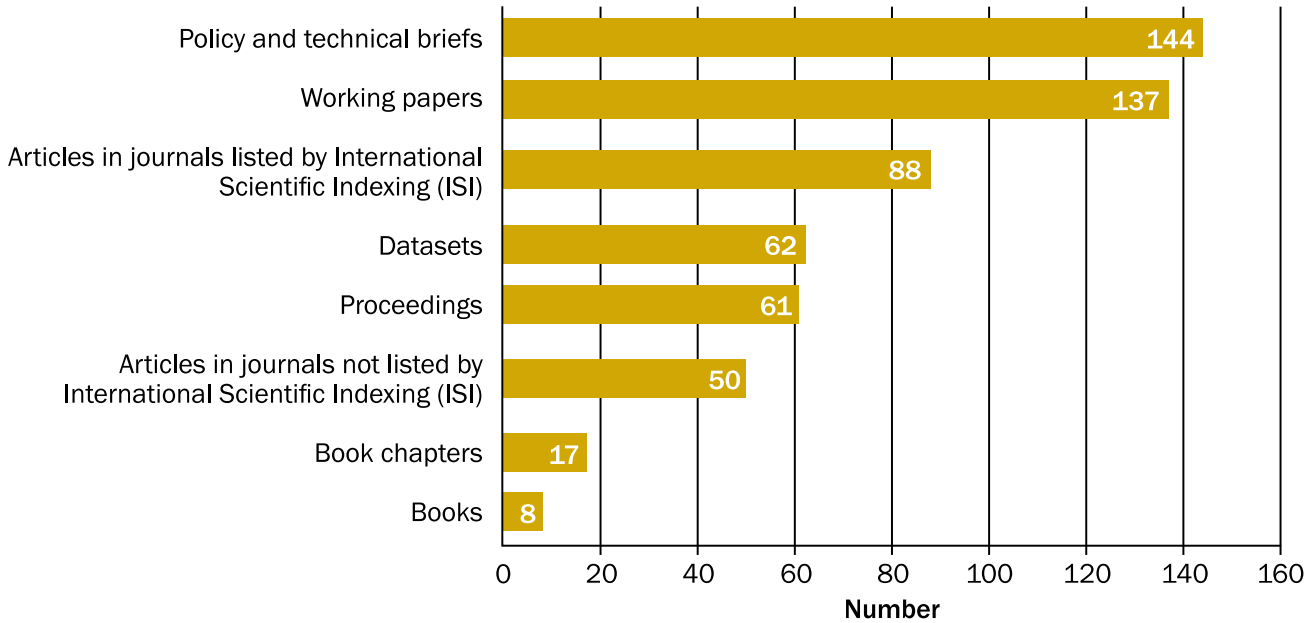
Considerable work has gone into synthesizing knowledge and information, for example, identifying global hotspots of land degradation, pinpointing socio-ecological situations to target, and reviewing integrated systems methods used worldwide. The results, and conclusions for scaling out and scaling up successful site-specific solutions from a global review of systems frameworks and programs, will be ready in 2016.

Sharing Information

In 2015, we provided open access to 55 geo-databases of information on drylands. The Dryland Systems component of the International Center for Agricultural Research in the Dry Areas (ICARDA) geo-informatics portal registered 1670 users in 119 countries. Using geographic information systems (GIS) we mapped hotspots of land degradation, the drivers of soil erosion in Sub-Saharan Africa, and productivity and trends in food production in Central Asia.

We worked on new databases to be shared in 2016, of livestock routes in Ethiopia and Kenya, geo-referenced sustainable land management (SLM) practices in drylands across the globe, socio-ecological contexts that shape the adoption and outcomes of SLM, and information on the livelihoods of 2,000 households in Central Asia, North Africa and West Asia, West Africa, East and Southern Africa, and South Asia.

Figure 1: 2015 Research Outputs



Exceeding our targets by >100%

Number of open access databases maintained

TARGET: **15**

ACTUAL

55

Number of publications in **ISI journals**

TARGET: 17

ACTUAL

88

Number of agro-ecosystems

analyzed or characterized

TARGET: 6

ACTUAL

17

in which innovations have been developed and are being field tested

TARGET: 3

ACTUAL

47

Number of policies, regulations, administrative procedures

drafted and presented for consultation

TARGET: 0 ACTUAL: **2**

prepared, passed or approved

TARGET: 0 ACTUAL: **1**

% of technologies under research that target women farmers

TARGET: 19% ACTUAL **44%**

% of 47 innovations that target decreasing inequality between men and women

TARGET: 4%

ACTUAL

24%

Exceeding our targets by >50%

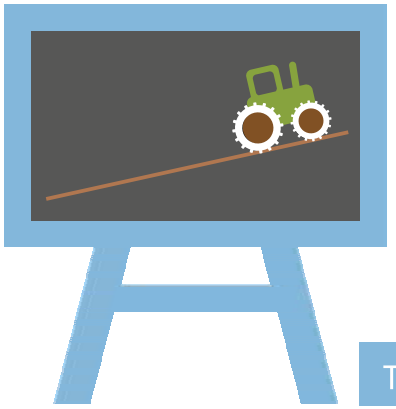
Number of users of our open access databases

ACTUAL

29,810

TARGET: **15,000**

Number of trainees in long-term programs



ACTUAL

61

TARGET: **32**

Number of policies, regulations, administrative procedures analyzed

ACTUAL

9

TARGET: **5**

Number of technologies/natural resource management practices released by partners globally

ACTUAL

8

TARGET: **5**

Measuring results and learning

Our online Monitoring, Evaluation and Learning (MEL) system captures and analyzes research outputs that deliver development outcomes. MEL provides information for managing our research efficiently. By enabling our management, scientists, partners, and donors to share information in real-time, MEL helps us see what we do well and can do more of, and where we can improve. In introducing greater transparency and accountability, our unique MEL system fills a gap in CGIAR and is a system that other CGIAR programs and centers are adopting.

Outcomes

Dryland Systems tracks progress towards outcomes by collecting information on specific, observable, and measurable changes. The data on indicators in this report do not cover all our work, all the countries where we work, or all the issues we address, but provide a selection of documented changes that have materialized as a result of our work in 2015. The long-term nature of research means that more outcomes will become apparent in the years to come. The process of developing and fine-tuning appropriate indicators to track outcomes of action research in the short, medium and long term is continuous.

Developing Integrated Tools

We developed tools for analyzing productivity, the efficiency of nutrients and labor, soil protection, and risks and trade-offs in smallholder systems. Our scientists calibrated climate change and technological options models for the major crops and for assessing mixed crop-livestock rainfed systems in West Africa, East and Southern Africa, and South Asia.

We developed a socio-ecological decision-support tool that analyzes interactions among farm households and communities in mixed crop-livestock systems in West Africa to support planning sustainable land management (SLM) in catchments.

With partners in national agricultural research systems (NARS), we developed guidelines and a manual for participatory analysis of interactions in agricultural livelihoods systems. Our Gender Guidelines for Biophysical Researchers provide scientists with practical steps and recommendations for mainstreaming gender throughout the research project cycle.

Photo: CIFOR/Ollivier Girard

Promoting the Integrated Systems Approach, Shaping Global Policy

Dryland Systems collaborated with the CGIAR Research Programs on Integrated Systems for the Humid Tropics and Aquatic Agricultural Systems to hold the International Conference on Integrated Systems for Sustainable Intensification in Smallholder Agriculture, 3–6 March, Ibadan, Nigeria. The conference focused on the shift from agricultural research to research on agri-food systems. Participants from over 30 countries presented strategies and urged decision makers to take an integrated systems approach to agricultural research. The shift to research on food value chains reflects the increasing emphasis on health and nutrition, "healthy diets from sustainable agri-food systems for all".

Our integrated systems approach shaped the thinking and policy recommendations of the 3rd Scientific Conference of the United Nations Convention to Combat Desertification, Cancun, Mexico, 9–12 March. Taking up systems thinking, the UNCCD Bureau of the Committee on Science and Technology proposed *"to develop and use a systems approach to assess vulnerability and adaptation capacities..."* and *"...to develop a user guide outlining the requirements of a systems approach to transdisciplinary research on issues of land degradation, climate change and biodiversity, and between socio-economic and biophysical systems."*

Our scientific evidence and innovative approaches enriched science and policy dialogue during the

conference. Dr Richard Thomas, Director Dryland Systems, in a keynote address, insisted that breakthroughs on urgent issues of climate change, food security, and land degradation will not come from single discipline science alone, but through interdisciplinary collaboration between scientists and a host of other actors. The side event, How to Encourage Innovative Capacities to Achieve Land Degradation Neutrality, stimulated thinking on integrated multidisciplinary approaches to building local innovation capacities. The capacity of people in drylands to innovate is key to improving rural livelihoods, reducing poverty, addressing climate change, curbing migration, and creating better opportunities for young people.

In September, the Economics of Land Degradation Initiative, involving scientists, academics, development practitioners, and policy makers in 30 organizations worldwide, with scientific coordination by Dryland Systems, culminated in the publication of *The Value of Land*. At the launch at the European Parliament, Dryland Systems together with our partners in the initiative, presented policy makers with robust scientific evidence of the value of land and its untapped potential for boosting national and global economic prosperity and sustainable development.

At a special session on the Economics of Land Degradation during the 70th United Nations General Assembly in New York, September 2015, Dr Richard Thomas, Director Dryland Systems and Scientific Coordinator of the Economics of Land Degradation Initiative, mediated a discussion on the key scientific findings and policy recommendations of *The Value of Land*. He stressed the need to focus on the most vulnerable communities affected by land degradation, which are those that depend on degrading land far from markets. Discussions informed global policy makers of the environmental and socio-economic costs of land as an undervalued asset in the global economy.

Dryland Systems research evidence helped shape the landmark global agreement on Land Degradation Neutrality reached at the 12th Conference of the Parties to the United Nations Convention to Combat Desertification (UNCCD COP12), in October. This agreement is expected to trigger the 196 UNCCD signatories to translate the global target into voluntary national targets for sustainable land management and restoration, and to develop national plans, strategies, policies, and regulations to support the implementation of targets. A Dryland Systems side event encouraged discussion on the challenges and constraints in adopting long-term, sustainable land management practices for effectively implementing the Convention on the ground.

> *"The moral imperative and the business case for acting on land degradation issues under the Sustainable Development Agenda has never been so clear as it is now with the overwhelming evidence from The Value of Land."*
> ***Monique Barbut, UNCCD Executive Secretary, UNCCD COP12***

In December, at the United Nations Conference on Climate Change COP21 in Paris, Dryland Systems campaigned for developing sustainable agriculture to save the Fertile Crescent under the newly agreed climate change agenda.

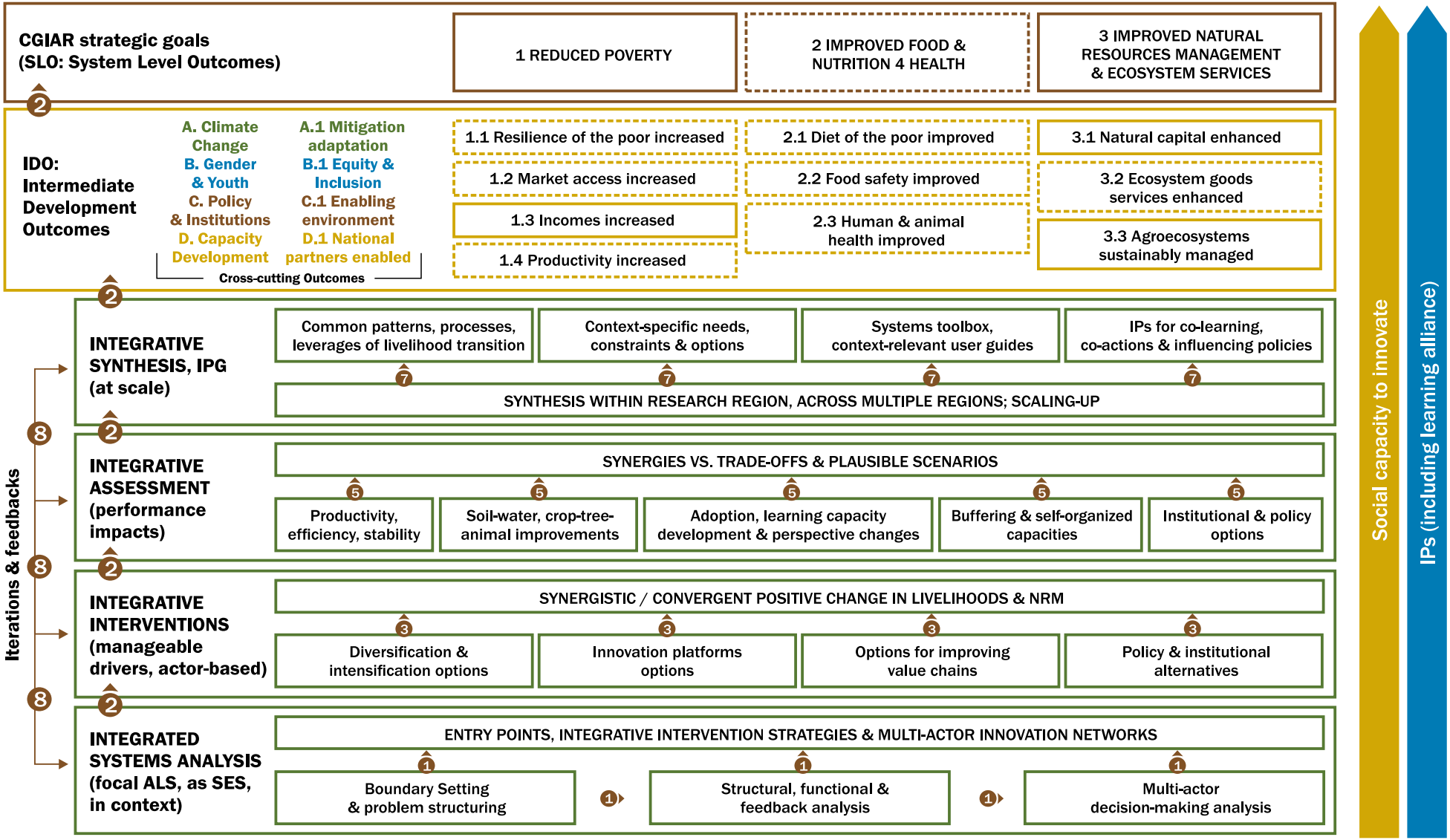
Our Systems Approach

Dryland Systems is part of the global effort to stem poverty, hunger, and environmental degradation. Our approach aims to achieve concrete outcomes. Collective integrated systems research involving more than 481 partners and many stakeholders targets the CGIAR strategic goals. Our Program Impact Pathway is fully aligned with the CGIAR Strategy and Results Framework 2016–2025; it directly addresses seven of the post 2015 United Nations Sustainable Development Goals, and contributes to five other goals.

"The systems approach and focus on knowledge sharing, institutions and governance, enables the CRP [Dryland Systems] to support other CRPs to deliver impacts and better target their interventions, so enhancing the value of research across the CGIAR."

Task Force Report to the CGIAR Fund Council on Drylands and Mission Critical Research Areas for the CGIAR

Figure 2: Dryland Systems Impact Pathway



Key: ALS Agricultural livelihoods systems; **IP** Innovation platform; **IPG** International public goods; **NRM** Natural resources management; **SES** Socio-ecological systems. **Boxes in green**: activities and outputs of interrelated phases of integrated systems research. **Boxes in yellow**: intermediary development outcomes driven research outcomes. **Boxes in brown**: development system level outcomes. **Dotted line boxes**: program focus and contribution to these outcomes is less than outcomes in **full line boxes** due to resource and capacity limitations of program researchers and partners. **Circled numbers**: risks and assumptions at each level of the Impact Pathway, described in Theory of Change, Table 1.

Box 1: Dryland Systems Approach Contributes to Sustainable Development Goals

Dryland Systems research directly addresses seven United Nations Sustainable Development Goals:

Dryland Systems research contributes to aspects of five other Goals:

Note: These icons are used elsewhere in the report to indicate how key research outcomes and activities are contributing to specific Goals.

Systems Approach Contributes to Sustainable Development Goals

The Dryland Systems integrated approach supersedes the piecemeal approach that has dominated drylands research, embracing both horizontal and vertical systems across sectors and scales. Our approach explicitly takes into account the economic, social, and environmental co-benefits needed to achieve viable livelihoods, and to ensure social and environmental well-being. The integrated systems approach closes the gap between science and policy that has prevented governments and international bodies from improving rural livelihoods.

The integrated approach identifies opportunities for the agricultural sector, in concert with the water and renewable energy sectors, to reverse the chronic lack of investment in dryland areas in the context of the new generation of national development plans inspired by the Sustainable Development Goals, the landmark Paris Climate Change Agreement, and the Ankara Land Degradation Neutrality Agreement.

The systems approach also deepens understanding of how drylands are likely to change in the future and so identifies opportunities to adapt effectively. Little is known about the interactions between the drivers of change that affect development outcomes in drylands. Mapping and predicting the vulnerability, resilience, and improvements in dryland systems in response to drivers of change, such as climate change and land degradation over the short to medium term, identifies how drivers interact in systems. Interactions between drivers affect food and nutrition security, incomes and employment, agricultural productivity, natural capital, and ecosystem services. The systems approach leads to a better understanding of the context by analyzing historical and current data and collecting new data to address gaps. Visioning and foresight studies explore potential futures.

Definition of integrated systems research

A holistic and interdisciplinary research approach that integrates components of human and agro-ecological systems across all dimensions to improve agricultural livelihoods in drylands.

The Task Force Report to CGIAR Fund Council on *Drylands and Mission Critical Research Areas for the CGIAR* and presented to the 13th meeting of the CGIAR Fund Council in Bogor, Indonesia in April 2015, reaffirmed the critical importance of systems research in drylands. The Task Force presented the value proposition for Drylands Research and three mission critical areas for future CGIAR research in drylands: (1) Anticipating drylands futures; (2) Co-producing knowledge for win-win options and (3) Facilitating policies, institutions, and governance for scaling and enabling innovation.

> *"Dryland systems research can in the medium-long term improve agricultural livelihoods, nutrition, and the environment of over 100 million dryland inhabitants and enable the wise use of ecosystem services valued at several hundred USD/ha on up to 300 million ha (10% of drylands) or 190 million ha of degraded drylands. This value proposition is based on integrated systems research, which develops and tests, with farming households and development partners, feasible combinations of technical, market, governance, and policy options. Together these options improve agricultural livelihood systems."*
>
> ***Task Force Report to CGIAR Fund Council on Drylands and Mission Critical Research Areas for the CGIAR***

Table 1: Link Between CGIAR Systems Level Outcomes and Mission Critical Research Areas in Drylands

	Mission critical research areas		
	1. Anticipating futures	2. Co-producing options	3. Facilitating policies, institutions, governance
SLO1: Reduced poverty	●●	●●●	●●●
IDO 1.1: Increased resilience to climate change and other shocks	●●	●●	●●
IDO 1.2: Enhanced smallholder market access	●●	●	●●●
IDO 1.3: Increased incomes and employment	●●	●●●	●●●
IDO 1.4: Increased productivity	●●	●●●	●●
SLO2: Improved food and nutrition security for health	●●	●●●	●●●
IDO 2.1: Increased productivity	●●	●●●	●●●
IDO 2.2: Improved diets for the poor/vulnerable	●	●●	●●
IDO 2.3: Improved food safety	●	●	●
IDO 2.4: Improved human and animal health through better agricultural practices	●	●●	●●
SLO3: Improved natural resource systems and ecosystem services	●●	●●●	●●●
IDO 3.1: Natural capital enhanced and protected	●	●●●	●●●
IDO 3.2: Enhanced benefits from ecosystem goods and services	●	●●●	●●●
IDO 3.4: More sustainably managed agro-ecosystems	●	●●	●●●
Cross-cutting outcomes			
A. Climate change	●●	●●●	●●
B. Gender and youth	●●	●●	●●
C. Policies and institutions	●	●●	●●●
D. Capacity development	●●	●●	●●

Relevance: ● minor; ●● significant; ●●● high

Key: SLO System level outcomes; **IDO** Intermediate development outcome.

To achieve the desired impact, our systems research is embedded and integrated in on-going development where it:

- Fosters partnerships that target social, institutional, and technical options
- Creates hybrid knowledge that builds science onto local knowledge to reduce yield gaps and enhance value chains
- Improves capacities of households and institutions to innovate
- Improves the effectiveness of development spending
- Realizes social, economic, and environmental co-benefits
- Creates platforms where the outputs of other CGIAR research programs can be delivered at scale
- Identifies diversification opportunities in agriculture for investments.

Achieving impact in drylands through research-in-development requires a departure from the conventional approach. Our novel, inclusive systems approach to co-produce new knowledge addresses the specific challenges of dryland areas.

Table 2: The Systems Approach Compared to the Conventional Approach

Conventional approach	Systems research approach for drylands
Focus on single commodities and single livelihood components	Focus on farming *systems* and livelihood *portfolios*
Aimed at improving productivity and closing yields gaps, regardless of risk	Explicit consideration of trade-offs among multiple aims – improving productivity, reducing risk, and social, economic, and environmental sustainability. Targets multiple wins where possible; balances trade-offs where not
Focus on discrete value chains, overlooking externalities	Attention to interactions between value chains, explicitly considering externalities
Focus on innovations and investments responding to specific drivers of change within sectors at discrete scales	Focus on interactions between multiple drivers of change and innovation and investment options across sectors and scales
Linear, research *for* development approaches	Iterative research *in* development approach
Mono- or multi-disciplinary	Inter- or trans-disciplinary
Scientific knowledge transferred to stakeholders	Local and scientific knowledge combined, co-generated and embedded in the broad community
Gender equality and social justice as isolated outcomes of the research process	Disadvantaged groups involved and empowered throughout

Systems research on the ground – transforming the livelihoods of Ethiopian agro-pastoralists

Abu Tona is a 39-year-old farmer in Haleku Gulenta Kebele, Adami Tulu, East Shewa, Ethiopia, where low and declining productivity is a major concern. Systems research involved examining soil, climate and crop data, sustainable intensification, pigeonpea as an intercrop for maize and wheat, and social and economic factors, such as access to microfinance. Researchers calibrated a crop simulation for local crops to assess the productivity, profitability, and sustainability of various options.

As one of the 50 farmers taking part in our program, Abu Tona tested out a couple of the 'best-bet' solutions offered by researchers. He planted pigeonpea as an intercrop to get more from his land. He also dug a farm pond to collect rainwater, which he used to irrigate onions and tomatoes.

Overall, the farmers who took part in the program increased cropping intensity by up to 60%, total production by 35%, and fodder availability by 20%. The income of farmers who built farm ponds rose by about USD 100. The area under pigeonpea expanded by 20%, boosting household nutrition and soil health.

Farmers collectively borrowed and fully repaid about ETB 5.1 million (around USD 235,000) a year from a microfinance company to invest in irrigation systems and farm inputs. Communal effort also rehabilitated about 100 hectares of degraded, shared land. Villagers planted 6000 multipurpose trees to prevent soil erosion and provide more fodder.

During 2015, a drought year in Ethiopia, farmers who took part in the program produced more food than farmers who did not. Our systems research, by addressing low and declining productivity holistically, effectively addressed the multiple challenges of food insecurity, access to finance, land degradation, scarce water, scarce livestock feed, and low incomes. The International Center for Agricultural Research in the Dry Areas (ICARDA) and World Agroforestry Centre (ICRAF) scientists who participated in the program observed that "bringing different stakeholders together and working collectively towards a common goal is the most effective way to develop locally relevant interventions with a high chance of adoption by smallholder farmers."

Photo: ICARDA

Photo: CIAT/Georgina Smith

Photo: CIAT/Georgina Smith

Agricultural Livelihoods Systems

Drylands are diverse both within and between dry regions – varying climatically, topographically, environmentally, economically, socially, and culturally. To deal with both differences and similarities, program work is in the main agricultural livelihoods systems encountered across 3 billion hectares in five regions. The regions where we work span different types of dryland environments or agricultural livelihoods systems (ALS). Our research is organized around three ALS flagships as follows:

1. Pastoral and agro-pastoral systems
2. Rainfed systems (including tree-based systems)
3. Irrigated crop systems (including tree-based systems).

At one end of the ALS spectrum – pastoral and agro-pastoral systems in marginal dryland areas where resources are scarce – our research focuses on increasing resilience and providing pastoralists and subsistence farmers with innovative practices, skills, and technologies to mitigate risks and vulnerability in the face of climate change and extreme events, such as droughts, flooding, and outbreaks of pests and diseases. In such systems, intensification is possible for subsistence farmers, but involves significant trade-offs that must be considered to limit exploitation of limited resources.

At the other end of the ALS spectrum – rainfed and irrigated crop systems (including tree-based systems) where resources are richer and more diverse – our

Box 2: Agricultural Livelihoods Systems

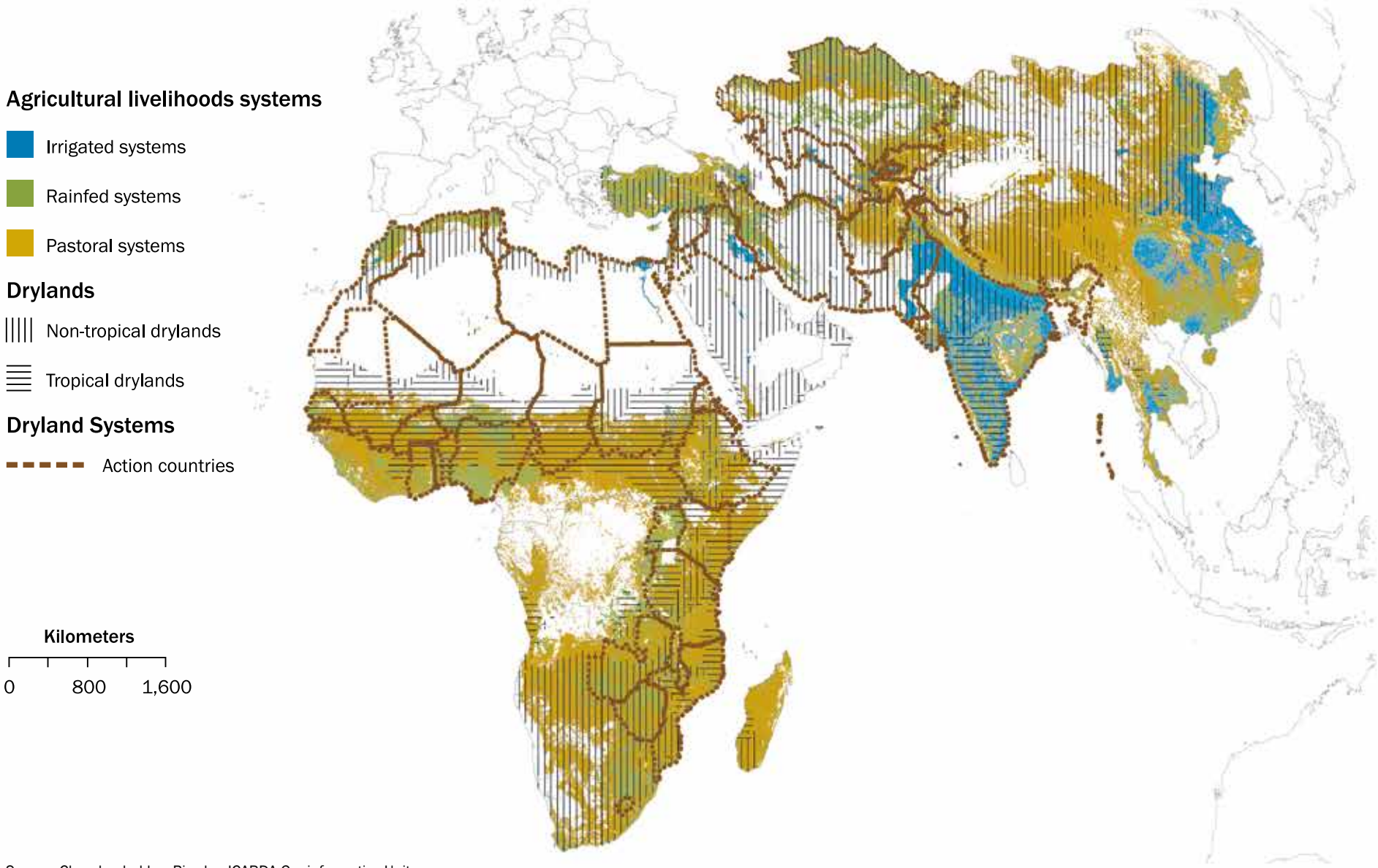
Agricultural livelihoods systems are defined as the sets of farming and other human activity systems that determine the livelihood opportunities for agricultural households, communities, and enterprises.

research focuses on providing farmers with innovative practices, skills, and technologies to intensify sustainable production and, therefore, to increase yields, maximize incomes, add value to products, break into commercial agriculture, and diversify livelihood opportunities.

Note: These ALS icons are used elsewhere in the report to indicate our research activities and interventions in various dryland systems environments.

Photo: IWMI/David Brazier

Figure 3: Where We Work



Source: Chandrashekhar Biradar, ICARDA Geoinformatics Unit

Analyzing Rural Livelihoods in Drylands

In 2015, we continued to systematically consolidate analyses and priorities across agricultural livelihoods systems in drylands at farm-household, national, regional, and global scales. Best practice case studies fleshed out the benefits of household livelihoods and context-specific analyses in promoting sustainable land management in rainfed drylands in Mali, Burkina Faso, Malawi, and India, in irrigated drylands in Morocco, Kyrgyzstan and Tajikistan, and in agro-pastoral drylands in Uzbekistan. The analyses show where action to improve the overall performance of agricultural livelihoods systems will be most effective.

We analyzed regional and global agricultural livelihoods systems in drylands to extrapolate where site-specific solutions could be most effectively scaled out and up. In Central Asia, we used agro-geoinformatics of cropping patterns and productivity in rainfed, agro-pastoral, and irrigated agro-ecosystems to determine hotspots of land degradation where limited resources for sustainable land management can best be directed. A map of global hotspots of human-induced decline in biomass productivity shows policy makers where measures are required to stem acute land degradation. A map of drivers of soil erosion in Sub-Saharan Africa shows where preventative measures would be most cost-effective.

Our participatory assessments of seed systems in Central Asia showed that village-based seed systems raise incomes and empower women. In Afghanistan, village-based seed systems improve the lot of women and involve them in decision-making processes from which they were previously excluded.

Validating Integrated Improvements to Agricultural Production and Soil-Water Resources in Drylands

We tested and validated solutions – conserving soil and water, reusing and recycling plant residues, and diversifying crops – for sustainable land and farm management to improve productivity, household incomes, soil and water resources, and gender equity in irrigated, rainfed, and agro-pastoral drylands in Central Asia, the Nile Delta, and India.

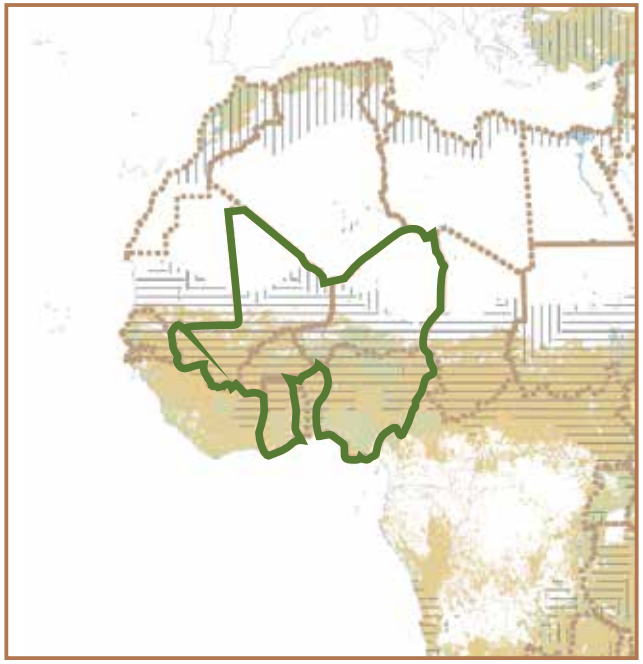
Enabling Institutions, Policies, and Governance for Scaling Out and Up

Our community-based innovation platforms in silvo-pastoral systems in western Rajasthan, India – areas challenged by scarce water and fodder, and land degradation – are scaling out re-greening. The webpages of online discussions towards more sustainable Food Security and Nutrition, hosted by the Dryland Systems Innovation Platform on Agricultural Innovation Systems in Central Asia and Caucasus countries and China, attracted 10,000 visitors in 73 countries, of whom over a third were women and around a tenth were young professionals.

Photo: Tulkun Yuldashev

2015 Research Highlights by Region

West African Sahel and Dry Savannas



- We calibrated Nutrient Monitoring (farm-NUTMON) with Data-Envelopment-Analysis Programming (DEAP) and Integrated Analysis Tool (IAT) models with household-farm data in West Africa. We calibrated crop simulation packages – Agricultural Production Systems Simulator (APSIM) and Decision-Support System for Agrotechnology Transfer (DSSAT) – for main crops in West Africa (Nigeria, Niger, and Burkina Faso) to capture technological options for scenarios of climate change. The databases and calibrated models interface with the Integrated Analysis Tool (IAT) model for assessing the behavior of *rainfed mixed crop-livestock systems.*
- We customized the Land Use Dynamics Simulator (LUDAS), a spatially explicit agent-based system, for *rainfed mixed crop-livestock systems* in West Africa. The model is being calibrated as a decision-support tool for Burkina Faso. We calibrated the Landscape-level Sustainable Land Management Planning Tool (LAMPT) for catchments in Burkina Faso, Ghana, and Togo to support sustainable land management planning.
- We classified smallholder livelihoods according to social and ecological conditions, and assets in *rainfed systems* in Mali and Burkina Faso.
- We mapped the drivers of soil erosion across Sub-Saharan Africa to determine where measures to prevent erosion would be most cost-effective.
- We established that fertilizing with crop and animal residues proved economically and ecologically efficient across Sub-Saharan Africa.
- Our work with farmers, millers, and bakers led the Nigerian government to pledge to triple the area of new high yielding, heat-tolerant wheat varieties introduced by ICARDA to 300,000 hectares in 2017.

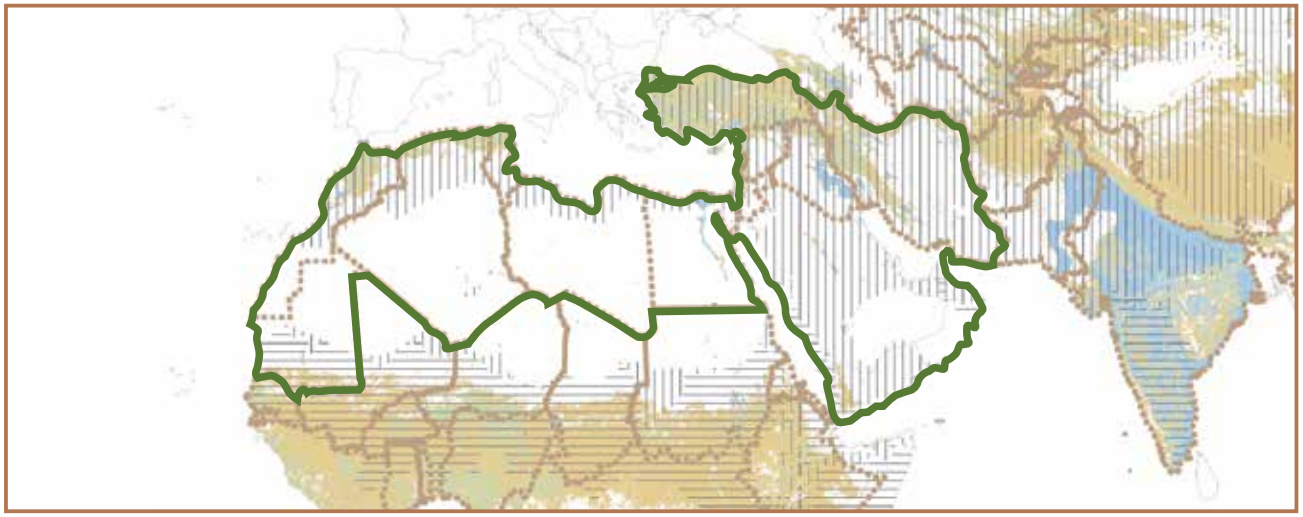
East and Southern Africa

- We calibrated crop simulation packages – Agricultural Production Systems Simulator (APSIM) and/or Decision-Support System for Agrotechnology Transfer (DSSAT) – for main crops in Ethiopia and Zimbabwe to identify technological options for scenarios of climate change. The databases and calibrated models are linked to the Integrated Analysis Tool (IAT) model for assessing the behavior of *rainfed mixed crop-livestock systems*.

- We produced a manual on the influence diagrams method for participatory analysis from a systems perspective. The manual is illustrated with case studies of natural resources management in Ethiopia and Malawi.
- We classified smallholder livelihoods according to social and ecological conditions, and assets in *rainfed systems* in Malawi.
- In Zimbabwe, multipurpose crops, buffering shrubs and trees, and micro fertilization, which we introduced, raised crop yields and protected soils.
- Index-Based Livestock Insurance (IBLI) schemes scaled up in Kenya and Ethiopia insured pastoralists against the scarcity of forage during droughts. The Government of Kenya launched the Kenya Livestock Insurance Programme, which offers limited livestock insurance to pastoralists in Northern Kenya.
- Our collaborative research on producing maps of routes pastoralists use to move livestock built local management capacities in Ethiopia and Tanzania.

Photo: ICARDA

North Africa and West Asia



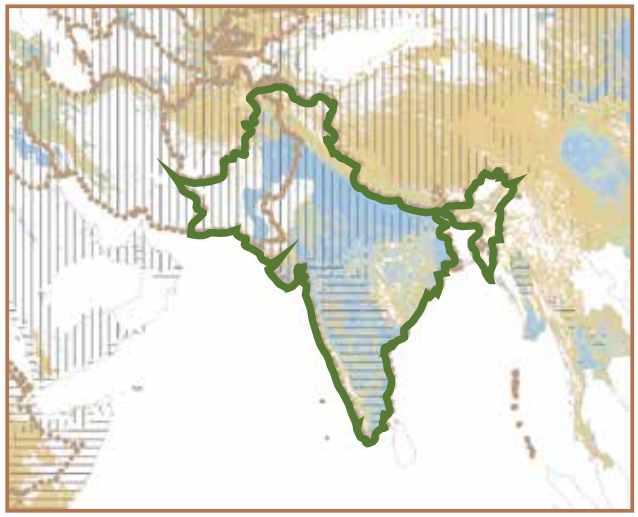
- Our holistic systems approach, taking account of both biophysical and socio-economic factors, provided a comprehensive inventory of research to assess soil and water conservation in Tunisia.
- We classified smallholder livelihoods according to social and ecological conditions, and assets in *irrigated systems* in Morocco.
- We prototyped a Dynamic Agricultural Household Bio-economic Simulation Model (DAHBSIM) that is being calibrated and validated in the Meknes region, Morocco.
- Raised-bed and cutback-furrow irrigation technologies boosted water productivity and energy efficiency in *irrigated systems* in the Nile Delta.
- In *rainfed and agro-pastoral systems*, zero-till, hill slope soil and water conservation, and supplemental and deficit irrigation boosted agricultural production and incomes.
- We found that cactus production can be complementary to the intensification of traditional or staple crops.

Photo: ICRAF/Sherry Odeyo

Central Asia

- Furthering understanding of what works where, we documented over 100 sustainable land management practices in the four main *agro-ecosystems* in Central Asia, rainfed and irrigated agriculture, mountains, and rangelands.
- Addressing marginal land and water, land degradation, and poverty, we introduced 16 alternative forage crops; environmentally resilient, nutritious quinoa; drought and salt-resistant licorice; and mung bean for double cropping.
- We provided robust scientific evidence that investing USD 11 billion in land rehabilitation over the next 30 years will prevent losses of almost USD 50 billion.
- We provided information on technologies that added value to the regional Climate Change Adaptation and Mitigation Program for the Aral Sea Basin (CAMP4ASB) launched by the World Bank.
- We set up an automatic weather station in Khorezm, Uzbekistan, that provided data for estimating evapotranspiration for scheduling irrigation, raising yields by 17% and water productivity by 37%.
- We classified smallholder livelihoods according to social and ecological conditions, and assets in *irrigated systems* in Kyrgyzstan and Tajikistan and *agro-pastoral systems* in Uzbekistan.
- Our agro-geoinformatic assessments of cropping patterns and productivity of *rainfed, agro-pastoral, and irrigated agro-ecosystems* identified hotspots of land degradation in Central Asia where investment of limited resources for sustainable land management would deliver most benefits.
- Our assessment of seed systems in Central Asia and Afghanistan showed that village-based seed enterprises raise incomes and empower women.
- Raised-bed and cutback-furrow irrigation raised water productivity and energy efficiency in *irrigated systems* in Central Asia.
- A Rural Women's Learning Alliance in Uzbekistan is leading local community efforts to cope with the negative effects of climate change and land degradation.
- Our innovation platform involving advanced agricultural institutions, national agricultural research systems (NARS), policy makers, the private sector, and banking services discussed improving access to credit, markets, and productive inputs, and facilitating dissemination of technical knowledge and advice for reducing post-harvest loss.

South Asia



- On-farm demonstrations and farmer field days in Chakwal, Punjab Province, Pakistan, showcased the value of cacti as a livelihoods game-changer resilient to climate change and depleted natural resources. Cacti provide nutritious green forage, fruit for sale, cactus seed oil for cosmetic companies, and boost food security.
- We calibrated crop simulation packages – Agricultural Production Systems Simulator (APSIM) and Decision-Support System for Agrotechnology Transfer (DSSAT) – for main crops in India to determine technological options for scenarios of climate change. The databases and calibrated models link to the Integrated Analysis Tool (IAT) model for assessing the behavior of *mixed crop-livestock rainfed systems.*
- We classified smallholder livelihoods according to social and ecological conditions, and assets in *rainfed systems* in India.

- Traditional micro-ponds proved useful in improving water-use efficiency and stabilizing water sources in arid *rainfed systems* in India.
- Fertilizing with crop and animal residues proved economically and ecologically efficient across South Asia.
- High value, low biomass crops, such as medicinal plants, drought-resilient trees, and cactus, which are complementary to traditional or staple crops, raise productivity.
- Community-based innovation platforms are re-greening silvo-pastoral systems in western Rajasthan, and native, high value medicinal plants, such as *Convolvulus pluricaulis* (used in the Ayurvedic preparation shankhpushpi), are strengthening value chains.

Number of farmers adopting medicinal plant (shankhpushpi) cultivation and value chain in India

100

Photo: ICARDA

Photo: CIAT/Georgina Smith

Outcomes 2015

Less Poverty

Our research for reducing poverty seeks to generate higher and more sustainable incomes and a better standard of living for households in the drylands of the developing world.

Understanding the drivers of poverty in rangelands

Central Asia

Ahmad, a wealthy agro-pastoralist Karakalpakstan in Uzbekistan, repaired 20 wells in rangelands reserved for *Shirkat*, pastoral Karakul sheep cooperatives, so that he could graze his sheep, goats, and horses. Shortly after, the *Shirkat* cancelled his permission to graze. He lost a significant amount as repairs to each well cost UZS 30 million (USD 11,500).

> *"It would be better if the* Shirkat *would distribute the land among the farmers, so that all family members can be involved as laborers on their own land..."*
> ***Matazim, a young smallholder agro-pastoralist***

Our research showed that because of uncertainty about land tenure, pastures surrounding rural communities are overused and degraded while remote rangelands where wells are in disrepair are underused. Experiences such as those of Ahmad discourage pastoralists from investing in improvements. This means that land degradation is lowering incomes and exacerbating poverty. Whereas traditional research would probably have focused on reversing rangeland degradation and improving rangeland productivity, our research focused on understanding the barriers the current tenure arrangements pose to lifting communities out of poverty. Research evidence indicates that a systems approach to rangeland tenure and inclusive rangeland management plans adapted to local conditions are required.

Matching crops, conditions and markets

Rajasthan

In rainfed agricultural livelihoods systems, droughts can mean that farmers earn nothing. Our introduction of medicinal plants in six villages in Barmer, western Rajasthan, a strategy to diversify and spread risk, and the links we helped set up between producers and markets, have helped 250 farmers through droughts. Farmers involved in our program now earn around INR 15,000–45,000 (USD 220–670) more a year than they earned previously. Their success is triggering interest among other farmers, non-governmental organizations (NGOs), government departments, and the media.

Shankhpushpi, a herb widely used in Ayurvedic medicine, has been used for centuries as a brain tonic and memory enhancer. Researchers showed farmers that shankhpushpi can be grown successfully with traditional grains like *bajra* and *gaur*. Once shankhpushpi germinates, it requires no more water than any other dryland crop.

> *"Shankhpushpi acted as a lifeline for my family as I earned INR 80,000 in the drought-like situation last year when other farmers ended up earning nothing."*
> ***Gaina Ram, farmer, Dhirasar Village, Barmer, Rajasthan***

Our systems research indicates that, by introducing high value commodity crops, such as shankhpushpi, which scientists have established are suited to the prevailing climate and soils, farmers can raise their earnings significantly.

Sharing fruitfully

Central Asia

For centuries generations of farmers in Central Asia have dealt with harsh environments, poor soils, spring frosts, soil salinity, and water scarcity by selecting strains of the native apple, apricot, pomegranate, and grape that produce the best fruit in their particular conditions. This means that the region is home to a huge range of varieties, each adapted to a particular mountain, foothill, or lowland environment.

The fruit play an important role in livelihoods, providing food and income year round. Apple and pomegranate

Photo: IWMI/Neil Palmer

are eaten fresh or can be stored for months. Apricots and raisins are eaten fresh and when dried can be stored for even longer than apple and pomegranate.

Researchers made an inventory of 109 varieties of six native fruits: apple, pear, apricot, grape, peach, and pomegranate. When they had tested how these varieties reacted to salinity, drought, and frost they looked at how saplings of fruit trees are produced and marketed – the 'seed system' – because farmers can only buy what nurseries offer for sale. Scientists worked with local nurseries to produce planting material of the varieties best adapted to local conditions. Nurseries raised and supplied 729,000 saplings to local growers. In 2015, 290 farmers obtained saplings of the fruit trees most suitable for local conditions.

Word of mouth is spreading knowledge of the best varieties for particular areas. Owners and managers of nurseries exchange contact details and track the varieties they produce. Farmers and fruit growers can now order the particular varieties best suited to their farms or orchards. Quality planting material benefits both farmers and nursery owners. Farmers have the assurance that the saplings they buy have desirable traits and nursery owners maintain a reputation for quality.

Research for improving food and nutrition security seeks to ensure that vulnerable households in marginalized rural drylands, where natural resources are scarce, have adequate, diverse, and nutritious foods throughout the year.

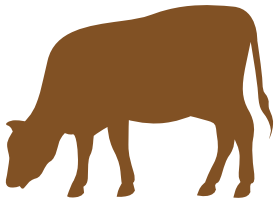
Less poverty: selected indicators of progress towards outcomes 2015

Resilience of the poor increased

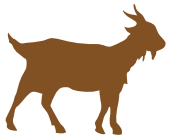
Number of next users adopting wheat technologies promoted by direct beneficiaries across **Ethiopia, Mali, Mauritania, Niger, Nigeria, Sudan**

70,000

Better market access



Number of livestock owners benefiting from better market infrastructure, fodder groups and women's milk cooperatives in **Kenya**



20,000

Higher incomes

Number of farming households adopting options and increasing income across **Algeria, Egypt, Eritrea, Ethiopia, Kenya, Morocco, Sudan, Tunisia, Yemen**

800

Increase in income of farmers adopting conservation agriculture practices across **Algeria, Morocco, Tunisia**

15%

Decrease in farmers' inputs for the same production across **Algeria, Morocco, Tunisia**

40%

Higher productivity

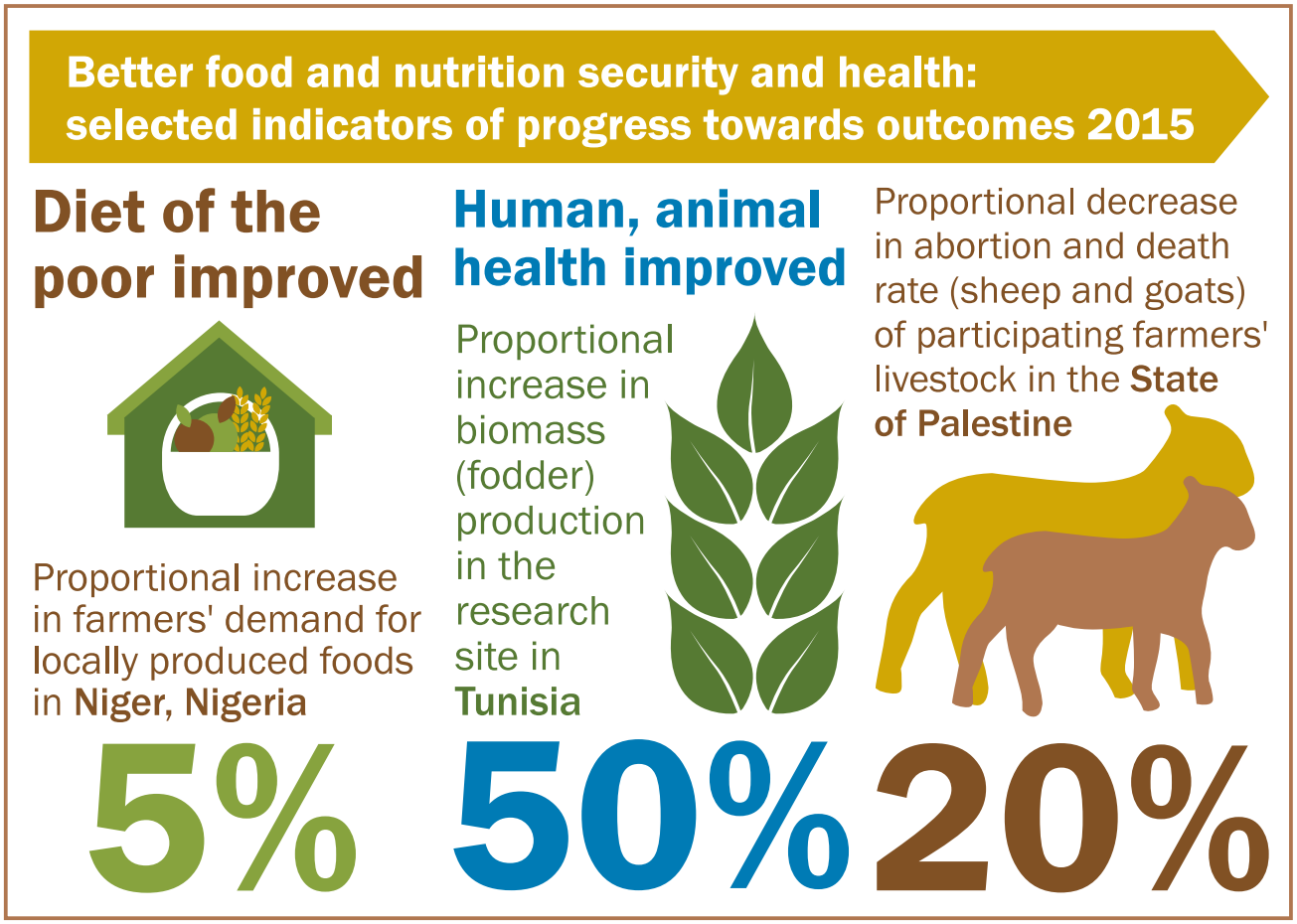
Increase in yield of faba bean in **Egypt**

30%

Better Food and Nutrition Security and Health

Investment in the new Sustainable Development Agenda 2030, adopted at the UN General Assembly in September, is urgently needed to address the root causes of terrorism and mass migration. Sustainable agricultural livelihoods systems are crucial in providing a healthy and productive future for young people around the world, particularly in Africa. For some 60% of young Africans, meaningful employment in agri-food system value chains is one of the only realistic options for a positive future.

> *"...it is clear that this [CGIAR] agenda cannot be achieved without healthy diets from sustainable food systems. Ending poverty and hunger is not possible without placing agri-food systems near the top of the priority list: agricultural research is truly the backbone to sustainable development."*
>
> ***Frank Rijsberman, CEO, CGIAR Consortium***



Changing mindsets, a shot in the arm for food production

Heat-tolerant wheat varieties are convincing Sudan's decision makers that domestic wheat production is a solution to growing dependence on wheat imports. Sudan currently produces only 30% of the wheat it consumes and imports some 1.5 million tonnes of wheat each year. Producing more wheat in-country, therefore, means better food security and that prices of basic foods are more stable.

Once considered not suitable for the hot, dry conditions prevalent across Sudan, heat-tolerant wheat has changed policy makers' perspectives, convincing many that wheat can be grown productively in the country. But these changes in perspective are not down to the introduction of improved varieties alone. While heat-tolerant varieties are a crucial factor, they are not enough.

Together with seed of the heat-tolerant varieties, researchers introduced practices to optimize wheat production under local conditions – new ways to prepare land, optimal dates to sow seed, methods for integrated pest management, and more efficient irrigation.

Drawing out women strengthens wheat value chains

Part of the wider effort targeting food and nutritional security was a workshop March 3–4, in Khartoum, that examined gender issues in wheat production. Participants from 12 countries – wheat breeders, socio-economists, agronomists, and monitoring and evaluation specialists in addition to gender experts – shared their understanding of the roles played by men and women. Ways to avoid gender assumptions and guide gender integration included empowering women to participate in conservation agriculture, seed production, improving irrigation, and encouraging them to choose wheat varieties according to taste and cooking quality. In Sudan, women have successfully taken to baking and making pastries that add value to wheat. Similarly, in Nigeria, women have set up small enterprises to make bread and other baked goods.

The integrated 'systems' approach can be replicated to tackle food security in agricultural livelihoods systems across Sub-Saharan Africa where similar conditions and import dependence prevail. The Sudanese government is now applying the approach to production systems for all major agricultural commodities, including food legumes.

Growing superfoods, a dry-season lifeline

In the dry season in the rainfed agro-pastoral agricultural livelihoods system in Mali, fresh fruit and vegetables are scarce. Lacking the micronutrients these foods provide, 'hidden hunger' is widespread.

Systems research in Malian drylands has encouraged ten villages across Sikasso to set up tree-based fruit and vegetable gardens, also known as foodbanks. The idea behind these living foodbanks is that they provide households with a ready supply of nutrient-rich, fresh food when it would otherwise be scarce. Villagers planted the foodbank gardens with baobab and moringa – trees whose fruit and leaves are described as 'superfoods'. The varieties that villagers planted had been selected and domesticated by scientists at the World Agroforestry Centre, based in Samanko, because, unlike traditional varieties, they produce fresh leaves throughout the year.

> *"In nature the fresh baobab leaf is available for only a very short time. But now with the science of species selection and domestication, we have varieties that make fresh leaves available all year round."*
> ***Brehima Kone, World Agroforestry Centre***

By 2015, seventeen farmers had set up foodbank gardens, partly to provide their families with fresh fruit and vegetables during the dry season, but also as a way to raise their incomes by selling the surplus in local markets. Ten women's associations, 500 women in all, have also taken up the idea.

Foodbanks, such as those flourishing in Sikasso, can be a lifeline for rural families in drylands in the West African Sahel.

Photo: ICRAF/Susan Onyango

More Sustainable Natural Resources and Ecosystems

Research on natural resources and ecosystem services seeks to develop equitable and sustainable management of land, water resources, energy, and biodiversity in drylands agricultural livelihoods systems of the developing world for generations to come.

Low cost, high return ponds kick-start rainfed agricultural growth

India

Photo: Prashant Panjiar

Scarce water is a major factor in low agricultural productivity in rainfed Andhra Pradesh. This means that a way to boost productivity is to make the most of every drop of rain. Micro-catchments that harvest rainwater are not expensive and are easy to construct. Even in Andhra Pradesh, where dams have to be lined with concrete to prevent water percolating away rapidly through the red soils, they are relatively cheap to create. A small farm pond, 10 meters by 10 meters and 2.5 meters deep, lined with 1 centimeter of concrete costs about USD 300.

During 2014 and 2015, 40 smallholders stepped up to work with scientists to build cement-lined ponds for conserving rainwater on their farms. Researchers involved families in siting and building the ponds to make sure micro-catchments worked as they were supposed to work and did not hamper other farming activities. Drawing on local knowledge was critical to locating the dams where they would catch most rainwater and would be most useful for crops.

During the long dry spells in 2015, the ponds helped farmers avert losses of up to 20% to 30% in their crops of groundnut, foxtail millet, and pigeonpea. On land next to the ponds they grew fruit, such as mangoes, which gave them an extra source of food and income. Some families even took the risk of growing a small plot of vegetables next to the dams, a fairly significant move in a conservative community, but one that enhanced household nutrition and earnings. Women took the opportunity to grow fodder for livestock, further boosting food supplies and income.

Our research shows that understanding the farming system is a critical first step in developing solutions that work on the ground and deliver a range of benefits. In the drylands of Andhra Pradesh, modest investments in ponds are kick-starting the stagnant growth engine of agriculture, paving the way to transforming livelihoods.

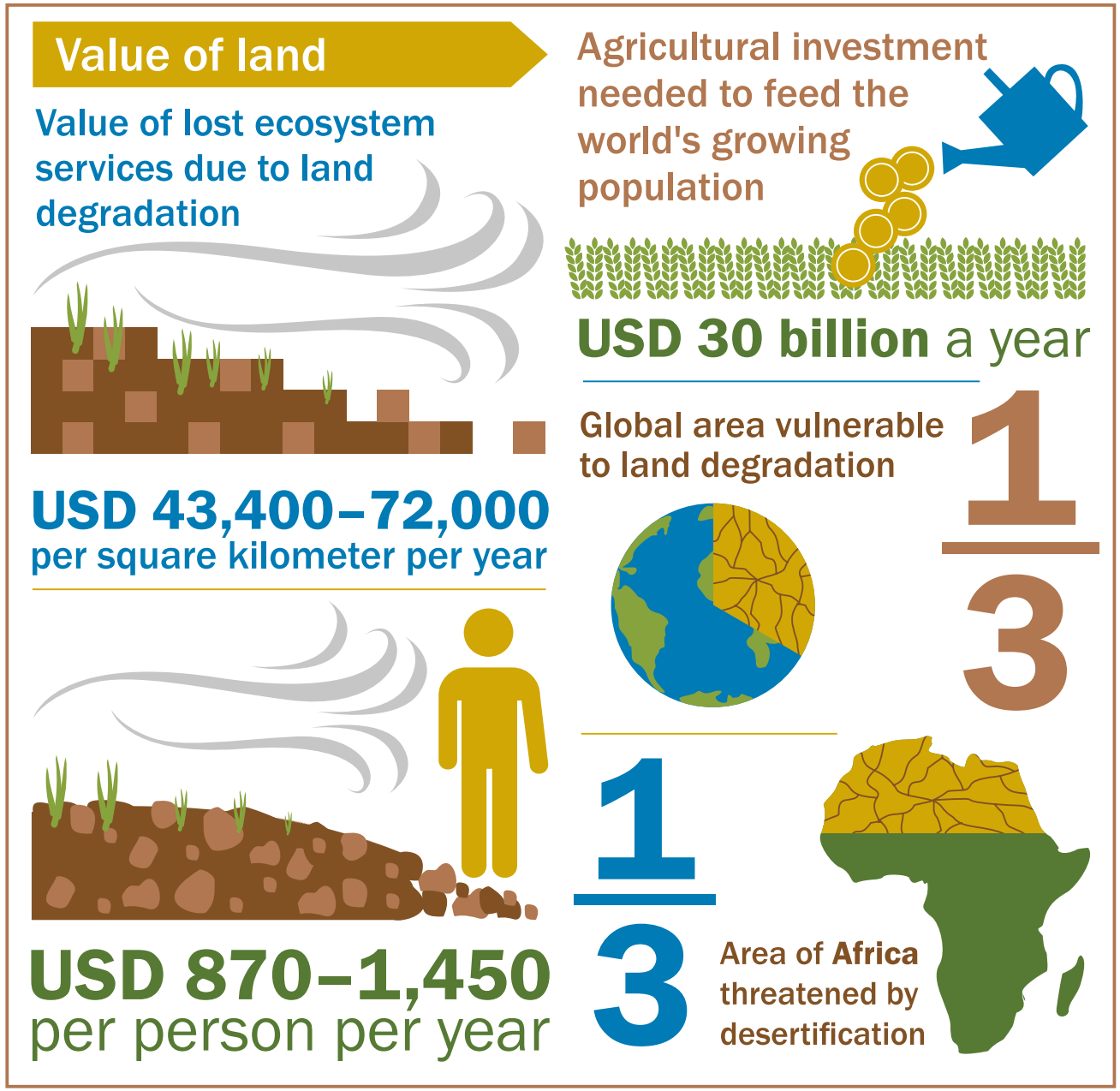
The Value of Land

Some 52% of agricultural land across the globe is moderately or severely degraded. But, few policy makers recognize that effectively addressing land degradation could help avert the migration of an estimated 50 million people forced to seek new homes and livelihoods in the next 10 years. Tackling land degradation could add USD 75.6 trillion to annual world income.

A ground-breaking report, *The Value of Land*, presents solid scientific evidence of the huge cost of not managing land well. The report was the culmination of the Economics of Land Degradation Initiative, a four-year collaboration involving 30 international research and policy institutes and funded by the German Federal Ministry for Economic Cooperation and Development, the European Commission, and the Korean Forest Service.

> *"We must focus our attention on identifying context-specific solutions at local and national levels... By making these scientific findings relevant to policy and decision makers, the world will gain a united view of how to address land degradation and improve human well-being."*
> ***Ibrahim Thiaw, UN Assistant Secretary General***

The authors of *The Value of Land* call on countries to recognize the enormous value of improving land management. They stress the need to enhance institutional capacity and knowledge for improving land management, and to develop national policy, economic, legislative, and regulatory frameworks.



More sustainable natural resources and ecosystems: selected indicators of progress towards outcomes 2015

Natural capital enhanced

Number of hectares where farmers adopted improved wheat based technologies across **Ethiopia, Mali, Mauritania, Niger, Nigeria, Sudan**

134,000

Proportion of irrigation water saved by participating water user associations through water use efficiency in **Uzbekistan**

10%

Ecosystem goods services enhanced

Number of indigenous crop/tree varieties collected, preserved in genebanks, and available to local farmers in **Niger**

29

Number of hectares under conservation agriculture options across **Algeria, Egypt, Morocco, Tunisia**

16,021

Agroecosystems sustainably managed

Proportional decrease in mono-cropping by participating farmers in **Ethiopia**

15%

Number of farm households adopting improved, integrated tree-crop-animal and/or conservation agriculture across **Ethiopia, India, Morocco, Niger, Nigeria, Tunisia**

3,198

Photo: CIAT/Neil Palmer

Photo: ICARDA

Cross-cutting Outcomes 2015

Better Prepared for Climate Change

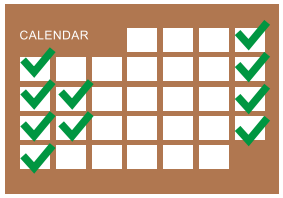
The breakthrough agreement reached at the Paris climate talks in late 2015 was momentous. Many countries included agriculture in their climate commitments, indicating that agriculture is now central to the climate agenda. The Paris Climate Agreement lays the foundations for major work to adapt developing country agri-food systems to become climate compatible or climate smart, and low carbon or carbon neutral.

The UNCCD Conference report, *Climate change and land degradation: Bridging knowledge and stakeholders* endorses the systems approach to deal with interactions between demographic pressures, unsustainable land management practices, and climate change that are exacerbating land degradation and desertification, and contributing to increasing poverty, malnutrition, migration, political insecurity, and conflict.

Better prepared for climate change: selected indicators of progress towards outcomes 2015

Adopting climate information in decision making in Mali

Number of female farmers
265,795



Number of male farmers
188,636

Implementing risk-reduction practices to improve resilience to climate change in Mali

Number of female farmers
11,680

Number of male farmers
11,410

Learning to live with climate variability

Ethiopia, Kenya

Many households in agro-pastoral agricultural livelihoods systems in southern Ethiopia and northern Kenya are learning to live sustainably with climate variability. Over 13,000 pastoralists in the region take out Index-Based Livestock Insurance. Livestock – the principal store of wealth and the foundation of livelihoods of pastoralists in the arid and semi-arid lands of the Horn of Africa – are at tremendous risk from frequent droughts. Pervasive poverty means that livestock losses can be catastrophic. Losing livestock in droughts can throw households into destitution.

Our research on the effects of Index-Based Livestock Insurance shows that it has a strong positive influence on well-being, and that the effects on well-being are particularly pronounced during droughts. Of households sampled by researchers, more than 40% had bought Index-Based Livestock Insurance at least once.

Index insurance is not a one-shot solution to pastoralists' vulnerability to climatic variability. But our research shows that the marginal benefit to cost

ratio of Index-Based Livestock Insurance substantially exceeds that of unconditional cash transfers, despite the imperfect coverage of risk. The Government of Kenya plans to launch an insurance scheme to help very poor pastoralists in the north of the country. The government will pay insurance premiums, but the pastoralists will receive any pay-outs directly.

Insurance schemes are one of various solutions that can be important to help strengthen resilience in agri-food systems where households need to shield themselves against risk. Insurance companies and NGOs are realizing that these previously ignored pastoralists are an important market for insurance, and are expanding into these areas.

Better resilience to climate change extremes and disasters

Number of organizations providing risk reduction services for farmers (Index-Based Livestock Insurance: sales, regulatory, information, etc.) in **Kenya**

Sweet potatoes for strengthening resilience to climate change

Malawi

Research to develop resilience to variable climatic conditions in rainfed agricultural livelihoods systems in Eastern and Southern Africa involved tried and tested action-oriented problem solving – understanding the system, introducing solutions, partnering with NGOs, demonstrating on-farm, and training.

In Malawi, we demonstrated six varieties of drought-resistant sweet potato in plots in six villages to show how the different varieties scientists had selected as best bets for local conditions performed. We trained 90 farmers to run trials, to look after mother plots to produce planting material, to harvest rainwater, and to conserve soil moisture.

Malawi experienced one of the worst El Niño droughts during the 2014–2015 growing season. Recognizing the value of timely, context-specific action, we gave about 1200 farming families cuttings of sweet potato, about 100 for each family, to buffer the effect of the drought. Despite the long dry spell, farmers harvested up to 9 tonnes per hectare against the national average of 4 tonnes per hectare.

Communities where we had introduced the new varieties of sweet potato quickly latched on to the value of drought resistance. Farmers saw for themselves how technologies that help boost productivity, nutrition, and incomes can help buffer their livelihoods in difficult and changing circumstances. They saved cuttings of sweet potato in nursery plots for growing on the next season. Our partner non-governmental organization, Total LandCare (TLC) and Lilongwe University of Agriculture and Natural Resources (LUANAR), plan to build on this momentum, scaling out the drought-resilient varieties of sweet potato and moisture saving agronomic practices we introduced.

Changing mindsets through “magic” beans

Pokoma Lebita, a farmer hosting a trial at Ungwe village in Linthipe, Dedza district, Malawi, wished she had had an opportunity to plant the ‘magic bean’ in a bigger area. The ‘magic bean’ is an improved variety of the common bean introduced by the International Center for Tropical Agriculture (CIAT) to rainfed agricultural livelihoods systems in Eastern and Southern Africa.

CIAT introduced the drought-resilient improved common bean, *Phaseolus vulgaris* L, genotypes SER43 and SER83 to the maize agri-food system in Malawi. Despite the 2014–2015 drought, yields of maize improved by almost 163% or 1050 kilograms per hectare. Farmers shown how to plant maize with appropriate ridging and spacing to conserve residual moisture, how to manage soil fertility in an integrated way, and how to intercrop beans, harvested good yields. Seeing is believing changed the mind-set of 209 farmers as far as beans grown with maize is concerned and attracted the interest of other farmers who attended field days.

Research such as this develops resilience to climate change, in this case from synergies among drought-resilient varieties, and integrated soil fertility and water management.

More Empowered Women and Youth

Research to empower women and young people seeks to improve their access to productive assets, inputs, information, and market opportunities, and to help them gain an equal share of incomes, food supplies, and other benefits. Providing healthy food and decent employment for everyone requires closing the gender gap, ensuring equal pay for both genders, creating attractive job opportunities for hundreds of millions of young people, and pushing for women's rights. Employment in the agri-food system, on farms, or in the food value chain, is still the most realistic option for the 60% of the next generation of African youth that will not migrate to the cities.

Learning together beats learning alone

Central Asia

In one of the many examples of women grasping opportunities to learn, share knowledge, and improve the lot of their families, 45 women in Karakalpakstan, Khorezm region in Uzbekistan, Dashauz province in northern Turkmenistan, and Kyzylorda region in Kazakhstan have set up a Rural Women Learning Alliance. The group of women learners spans agro-pastoral systems in the Amu Darya River watershed, the transition zone between irrigated agriculture and the Kyzylkum sandy desert.

It all started with a series of seminars led by scientists on non-traditional forage crops for feeding livestock in winter. Scientists showed that, even in the very saline, water-logged soils widespread throughout the region, there are many salt-loving species – halophytes – and salt-tolerant non-traditional crops that produce good quality forage and food grains.

The seminars were an inspiration. Women learned that agroforestry and mixed farming-livestock systems could help them earn more. They learned about the different trees – poplar, apple, apricot, mulberry, Russian olive – and berries they could intercrop with salt-tolerant species, their nutritional value and how to use them for forage, food, and for producing oil. The scientists demonstrated how to grow the different varieties, manage root zone salinity, irrigate, and control pests.

The women were particularly enthused by the class on cooking non-traditional nutritious grains, such as topinambur, proso, quinoa, pearl millet, and sorghum.

Motivated by their experiences, the women joined forces with scientists in the learning alliance. They aim to keep on learning and to encourage other women to do so too.

> *"[I] strongly believe that the created women-led learning alliance will play a good role in farming community partnerships and development."*
> ***Ms. Almash Adambetova, Koybak***

Gender and youth: selected indicators of progress towards outcomes 2015

Equity and inclusion

Gender inclusiveness in decision making:
Proportion of women able to and involved in canal water and groundwater management at policy level in **Uzbekistan**

10%

Gender inclusiveness in access to inputs:
Proportion of female livestock owners with access to inputs (water) in the **State of Palestine**

75%

Dryland Systems Youth Strategy 2015–2017

The strategy is designed to initiate a youth-led agricultural transformation, which enhances young people's access to, and control over, agricultural assets, technologies, services, products, income, and decision-making processes. The first of its kind in CGIAR, the strategy, developed through a comprehensive participatory process involving many stakeholders, will:

- Promote a transformative environment through innovations and by strengthening capacity
- Provide a framework for engaging policy makers by helping formulate policies, institutional reforms, and investment models
- Develop and implement interdisciplinary methods for integrating youth issues in systems research, further identifying challenges and strategies to meet the needs of young people.

Gender Guidelines for Biophysical Researchers

We produced a training video on Gender in Research Management, complementing the Guidelines: Integrating Gender into Biophysical Researchers, to mainstream gender in developing and implementing projects.

Photo: IWMI/Fasseh Shams

Gender and youth research highlights 2015

- Collaboration with United States Agency for International Development (USAID) on the Groupe Speciale Mobile Association (GSMA) agricultural information by mobile program started up-scaling in five West African countries, promising to enable more than 75,000 women to participate in tree value chains between 2015 and 2019.
- Systems research on mung bean, moth bean, groundnut, pigeon pea, and foxtail millet enabled women and youth in Central Asia and India to produce more food, food that is nutritious, and to produce seed for sale.
- Gender research in the Nile Delta showed how women contribute to adapting to climate change through innovations in crop and agricultural practices, while improving women's income-earning possibilities.
- A systems-perspective study in Morocco and Egypt on the gender gap in agricultural labor, and commercial and subsistence production provided insights that informed a Food and Agricultural Organization (FAO) tool to assess decent work for women in rural areas and promote evidence-based policy dialogue.

Gender and youth research studies 2015

- Our study in West Africa and India indicated that women undertake 57% of farm work, meaning that access to information and knowledge is critical for increasing their decision-making power in smallholder households. Six studies on gender-responsive extension services in India and in West and Eastern Africa produced similar findings. The studies recommend employing

female extension officers, and training both male and female extension officers to serve the different needs of men and women farmers. Because men and women derive different benefits from biodiversity, gender affects how women and men perceive and manage biodiversity, and how they make decisions about which species to grow.

- A pilot study, in collaboration with the Young Professionals for Agricultural Development (YPARD), the Global Forum on Agricultural Research (GFAR), and the Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), in the drylands of Morocco shed light on the complex web of socio-economic factors that affects the options and future choices of young people.
- A participatory systems analysis identified factors that prevent women from investing in agro-business in agro-pastoral and smallholder vegetable production in Eastern Africa. To overcome challenges to women in accumulating savings and securing loans, we helped women in East Shewa, Ethiopia, to set up savings and credit groups. The four groups, each with 20 members, have become role models for other women in the region. They use their savings and access cheap loans to intensify existing cropping systems with legumes. Women and children benefit from more income, access to new food sources, and better nutrition.

Photo: Alessandra Galie

Better Policies and Institutions

Dryland Systems engages with policy makers at the global level on issues of land degradation and desertification. Our innovative approaches and solid scientific evidence enrich science-policy collaboration under the United Nations Convention to Combat Desertification, improving decision making on critical land degradation issues.

Moving towards multifunctional rangelands

Tunisia

The cost of land degradation in Tunisia is estimated at about TND 80 million (USD 40 million). The competition for land between the many *de facto* users and users with traditional entitlements contributes to severe degradation. Tunisian policymakers work with our researchers to assess and analyze legislation on land management. A working group that includes representatives of the ministries involved is looking at the social and institutional bottlenecks in solving management conflicts to develop a new pastoral code for common rangelands.

> *"We need to move away from the narrow vision of considering rangelands as a source of feeding for livestock and wildlife. We must broaden our perspective and treat rangelands as a multifunctional environment, considering also aspects of eco-tourism and carbon sequestration."*
> ***Participant, multi-stakeholder workshop on a new pastoral code, June 16, 2015***

Tunisian policy makers are not only listening to what scientists and local stakeholders have to say; they are embracing whole new ways of doing things collectively. The working group is spearheading the process of defining a shared vision and plan of action for managing common rangelands.

Teaming up for sustainable silvo-pasture systems in South Asia

India

In Jaisalmer, Jodhpur and Barmer – three districts in the western part of Rajasthan – scientists invited community stakeholders to discuss the results of research on sustainable management of community silvo-pasture systems. The knowledge provided by the community helped fill gaps and align research with local priorities and needs.

In parallel, consultations between researchers and communities considered how to improve and advance equitable by-laws and institutional arrangements for sustainably developing and managing silvo-pastures. Scientists teamed up with Gramin Vikas Vigyan Samiti (GRAVIS), a grassroots organization, to organize village development committees to test management strategies for common silvo-pastures.

The integrated systems research, involving close collaboration with rural dryland communities, has significantly increased biomass productivity and reduced land degradation. Communities, especially those of smallholder farmers, are benefiting from

Better policies and institutions: selected indicators of progress towards outcomes 2015

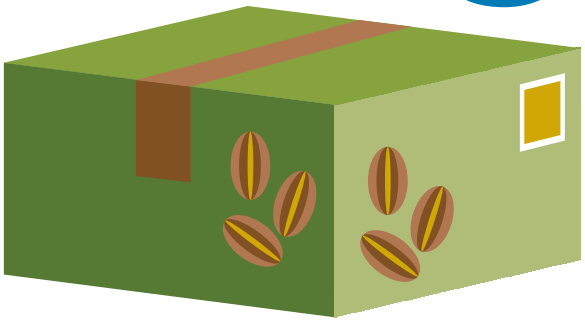
Enabling environment

Number of livestock farmers in **Ethiopia**, **Kenya** benefiting from more investment by government, NGOs, and donors to enhance resilience

500,000

Number of seed system frameworks adopted by national governments (**Ethiopia, Mali, Mauritania, Niger, Nigeria,** and **Sudan**)

6



more water, food, and income. Community-led solutions developed as a result of integrated systems research are the new model for ensuring sustainable natural resource management in millions of hectares across this vast dry region, where some of the world's poorest live.

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

GRAVIS has started to scale out this model to 20 other places in western Rajasthan that face similar challenges of scarce water and fodder, and degraded land. Collectively devised institutions are as important as biophysical measures for improving productivity and managing common property resources in a sustainable way.

Shaping policies for managing the Mount Marsabit ecosystem

Kenya

Mount Marsabit, a green oasis surrounded by desert, is an ecosystem of vital importance for thousands of people, including pastoralists and agro-pastoralists. Our study of institutions and governance in the Mount Marsabit ecosystem recommends a nested institutional structure for managing natural resources.

Photo: ILRI/George Wamwere-Njoroge

The nested institutions would interface with existing structures and tap into traditional governance systems. The study, by furthering understanding of critical governance issues, is helping to change local mindsets and practices. More inclusive decision-making processes are taking the needs of the poorest and most vulnerable members of communities into account.

Local stakeholders interacting with the Dryland Systems research team subsequently decided to set up a forum – encompassing all stakeholders – to consider how to manage natural resources in the Mount Marsabit ecosystem. The forum will consider both biophysical and socio-economic issues.

Strengthened Capacity

Our capacity development targets individuals and organizations that can contribute to developing dryland agricultural livelihoods. We focus on three aspects of capacity development: first, building knowledge, skills, and capacities; second, partnering with those who can maximize the effect of our capacity development effort; and third, ensuring that the capacity development we do is sustainable.

Developing capacity to innovate

One of the ways we develop capacity is by explaining what we do. An exhibition booth and presentations by Dryland Systems described our work in innovation platforms at a side event, *Capacity to Innovate*, at the UN Convention to Combat Desertification (UNCCD) 3rd Scientific Conference, 9–12 March 2015, Mexico, *Combating desertification, land degradation, and drought for poverty reduction and sustainable development – the contribution of science, technology, traditional knowledge and practices*.

Strengthening knowledge, skills, and capacities in agricultural livelihoods systems research

ICARDA and Dryland Systems presented a training course, *Integrated, Gendered Systems Modelling Research Approach to Dryland Systems: From Concepts to Practices and Implementation*, in Cairo, Egypt, 23 August–3 September. The course widened participants' interdisciplinary perspectives, and built their capacity for analyzing feedback loops in agricultural livelihoods systems, taking into account gender and other social roles and dimensions. The hands-on course provided trainees with the knowledge and skills to implement what they learned and to train

Figure 4: Skills Development

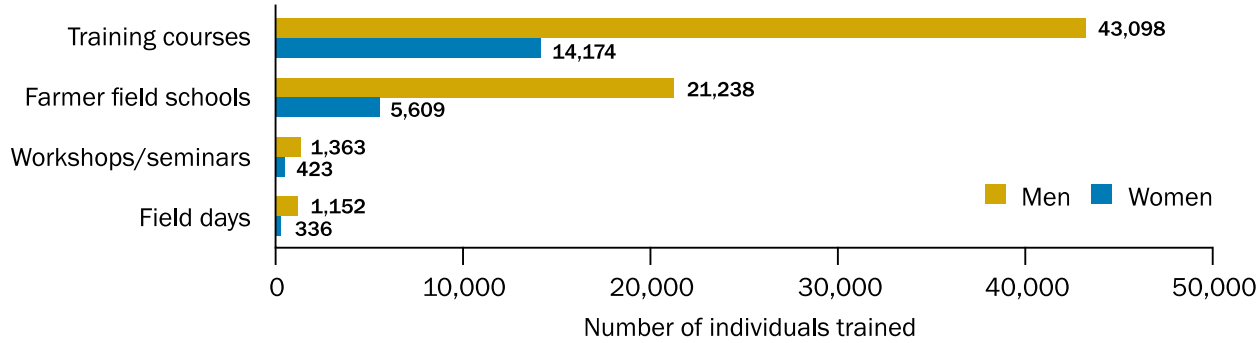


Figure 5: Building Knowledge

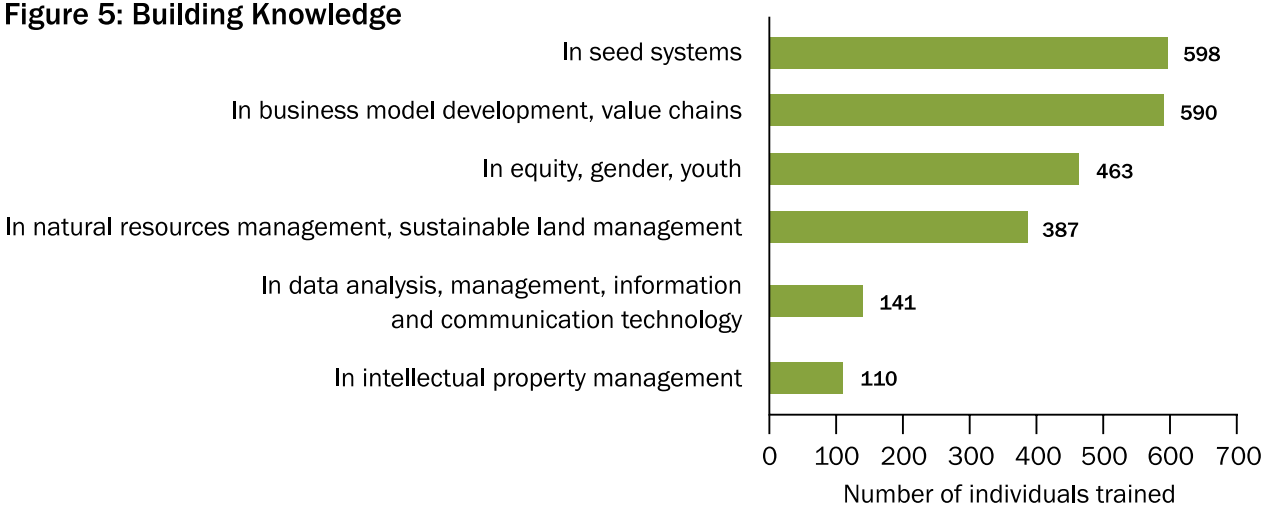
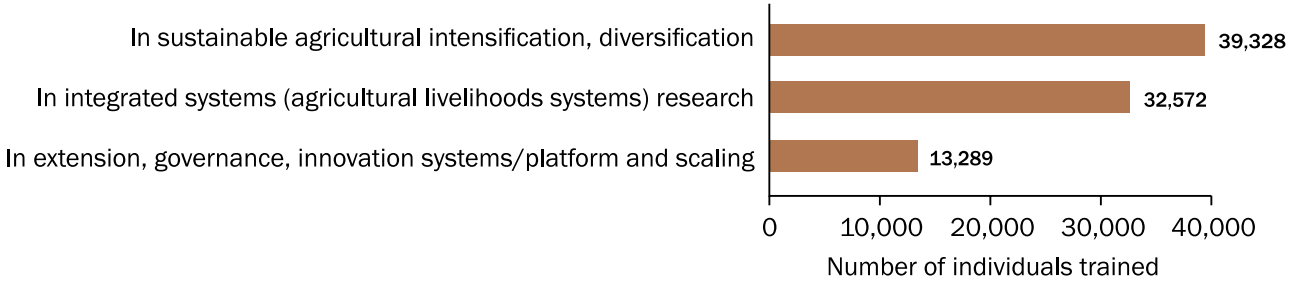


Figure 6: Building Knowledge in Systems Research



others. Participants received learning materials that they can re-use for training in their institutes or for further self-learning and development.

Building capacity through champions

People like Javana Ram Patel, a pastoralist who took the risk of adopting a new practice, are critical to the success of the Sustainable Intensification of Silvo-pasture Systems project, a collaborative effort between scientists at the Central Arid Zone Research Institute (CAZRI), the International Center for Agricultural Research in the Dry Areas (ICARDA), and the Indian Government.

The scientists showed that silvo-pasture, a mix of drought-resistant shrubs and trees, can produce more forage than traditional pasture across arid and semi-arid areas in India. Silvo-pasture creates beneficial microenvironments that hold moisture and keep producing forage for livestock when other pastures dry up.

Javana, a champion for silvo-pasture, works with scientists and offers his land for demonstrations. Early adopters like Javana lead by example, influencing others by showcasing the benefits of improved practices and showing that investing in new practices pays dividends.

Aside from producing more forage and saving livestock from starvation, the improved agronomic practices affect the entire agricultural livelihoods system, with significant impacts on people's livelihoods such as less poverty, better incomes, and increased resilience and adaptation to climate change.

Capacity development: selected indicators of progress 2015

Number of **male** trainees in short-term programs facilitated by Dryland Systems

66,851

Number of **female** trainees in short-term programs facilitated by Dryland Systems

20,566

Number of **male** trainees in long-term programs facilitated by Dryland Systems

PhD **28**, MSc/MA **31**, BSc/BA **2**

Number of **female** trainees in long-term programs facilitated by Dryland Systems

PhD **12**, MSc/MA **9**

Photo: ICARDA

Ensuring sustainability

Ethiopia, Tanzania

Learning by doing raises awareness and develops commitment. In Tanzania and Ethiopia, Dryland Systems scientists from the International Livestock Research Institute (ILRI) worked with government staff to produce national maps of the routes pastoralists take to move their animals from place to place. Through their involvement in producing the maps, government staff and other stakeholders in both countries learned a lot more about issues, such as the conflicts stock movements can cause between land owners and pastoralists, and the implications for trade across national borders.

In Tanzania, the map of livestock routes is already being used by national planners in land use and development planning departments. Government staff are working to produce more maps and to find ways to maintain livestock routes while balancing the needs of pastoralists and farmers whose land the routes pass through. The private sector is using the map to choose the best locations for abattoirs, veterinary clinics, and other services for pastoralists.

Ethiopia hosted an international meeting for countries to share information and experiences on livestock routes. Sharing information encouraged participants to plan further activities, such as developing national strategies to improve and protect livestock routes.

Helping people develop knowledge and enabling them to learn new skills ultimately leads to sustainable agricultural livelihoods. In this case, the knowledge and skills – of livestock routes and strategies to protect, service, and balance the needs of those affected by the routes – that have been gained will improve livestock production, increase incomes for pastoralists and agropastoralists, reduce conflicts over land use and animal movements, and stimulate the livestock trade both within and among countries.

Photo: CIAT/S. Malyon

Photo: Mahamane Larwanou

Communication and Knowledge Sharing

Communicating what we do and sharing the knowledge we develop are critical for making a difference to agricultural livelihoods in drylands. First, it is important to show those who support our work in different ways that the research we do provides value, it makes a difference to livelihoods in drylands. Second, by communicating the results of our research, we enable others to translate our results into their actions – ranging from action on farms to action in international conventions.

Photo: CIAT/S. Malyon

Sharing Research and Field Experiences

Our side event, on 19 October, during UNCCD COP12 sparked and fostered innovative ideas, fruitful collaboration, and constructive science-policy debate on critical land issues linked to sustainable development of vulnerable dryland communities.

By sharing Dryland Systems experiences in evaluating over 65 sustainable land management (SLM) practices and technologies on over 7.5 million hectares that involved 352,000 men and 117,348 women farmers, the side event encouraged wide reflection and discussion on the challenges in adopting long-term sustainable land management practices and the conditions for success.

Advocacy for Research and Development in Drylands

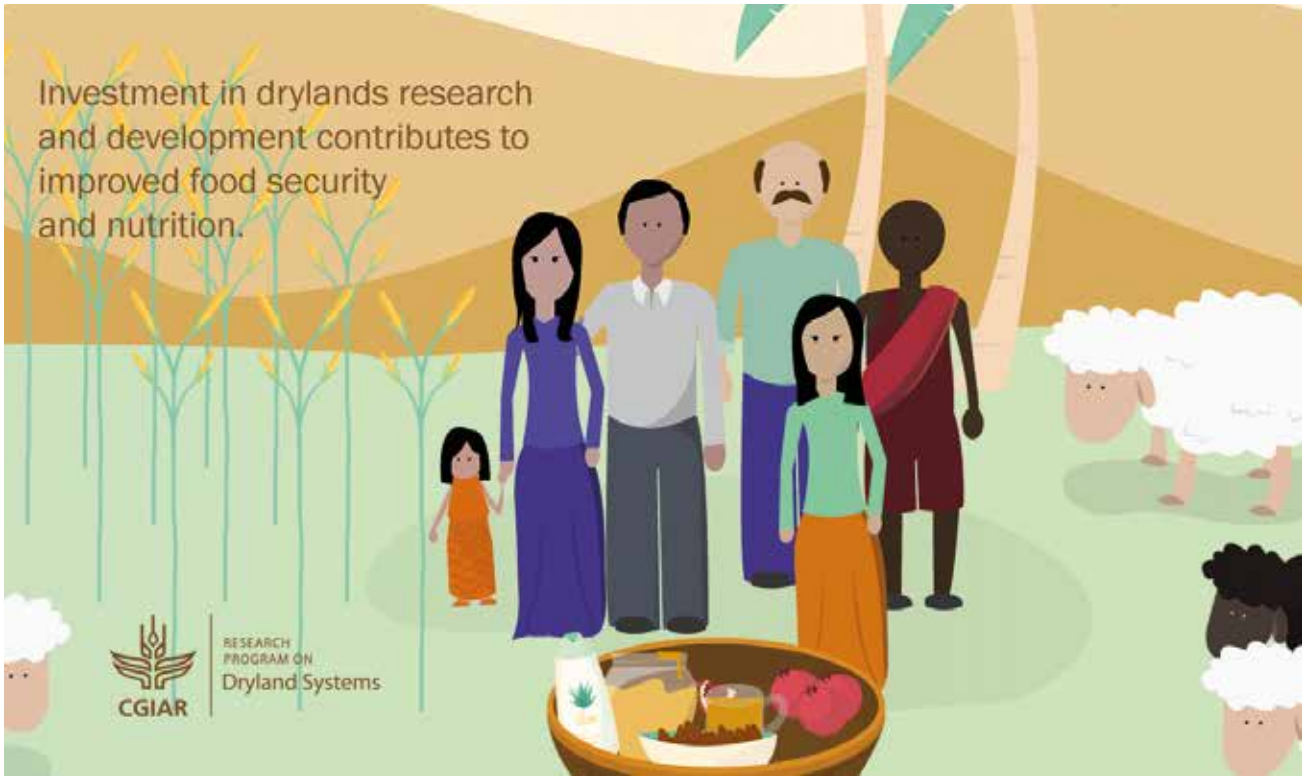
Sparking interest

In 2015, we produced a new animation video, The Opportunities You Never Imagined, which raises awareness of drylands and the value of investing in research on dryland issues.

Enabling communication for research delivery

Dryland Systems envisions communication as a way to build capacity for sharing knowledge and delivering research results to a variety of audiences, such as farmers, rural communities, policy makers, the scientific community, and extension agents. To help our scientists share knowledge and research findings, we developed tools and materials to support communication with different audiences at different levels, from local to global. By using the tools and materials, program scientists reinforce our brand and our reputation for quality systems research that helps address critical global challenges.

Snapshot from drylands animation video and campaign message



Widening digital reach

Our revamped website experienced a 735% increase in the number of users compared to 2014, a 319% increase in the number of pages viewed, and a 388% increase in the number of sessions. Our blog stories, coupled with our new approach to social media, are increasing the number of our followers and engagement. Facebook and Twitter drive 93.7% of our website traffic. This wider digital reach is leading to better understanding of our research and greater application of our research findings to identify practical and innovative solutions to development challenges in drylands and beyond.

Photo: Ibrahim Toure

Partnerships

Our partners play key roles in defining the drylands development agenda, in upstream and downstream research, in mainstreaming integrated agricultural systems research, and in ensuring that our research outputs and findings are effectively used by next and end users. Dryland Systems partnerships are the vital link between research and development. Partners are instrumental in scaling out and up best practices and technologies identified through systems research and, therefore, are paramount in making an impact. In 2015, many of our 481 partners reported evidence of the direct influence of program research outputs on improving dryland agricultural livelihoods and policies – in Egypt, Ethiopia, India, Jordan, Mali, Mozambique, Pakistan, the Sahel, Tunisia, and Zimbabwe.

> *"The successful implementation of sustainable land management across drylands depends on strong and collaborative partnerships that traverse the traditional boundaries within science disciplines themselves, as well as those between science, policy and development practice."*
> ***Dr Richard Thomas, Director, Dryland Systems***

Leveraging Partnerships and Resources for Greater Impact

A bilateral International Fund for Agricultural Development (IFAD) grant involves four centers. The USD 6–7 million grant links investments to the value of USD 110 million in Kenya through the Food and Agriculture Organization (FAO) and a Dutch government project in five countries in Africa. This

Vital links between research and development 2015

- In Uzbekistan, we partnered with a water consumer association in field experiments to assess water governance on-farm. With the World Vegetable Center (AVRDC) we developed improved varieties of mung bean for different methods of irrigation.
- In Uzbekistan and Tajikistan, we partnered with the Basin Irrigation System Authorities (BISA) to build capacity and transfer technology.
- In Central Asia, we aligned our research with the priorities of a special program of the Executive Secretariat of the International Fund for Saving the Aral Sea (EC-IFAS).
- In South Asia, our innovation platforms brought together five national agricultural research systems (NARS), five non-governmental organizations (NGOs), two private sector companies, and several state departments to align Dryland Systems research with state and regional priorities. We developed joint activities to enhance productivity – fertilizer management, recycling farm waste to improve soil fertility, mechanization, women-centered small-scale vegetable cultivation, conservation and management of green and blue water resources, fodder to strengthen livestock production, insurance, and capacity building.
- Our new partnership with the Rajasthan State Seeds Corporation (RSSC) and National Seed Corporation (NSC) led to the creation of a seed-grower farmers' group and village seed banks for drought-resistant moth bean.
- Our partnership with cattle breeding farms and Rajasthan Veterinary University will supply superior breeding males of high yielding cattle to farmers in four villages at subsidized rates.
- In East and Southern Africa, afforestation work in Adamitullu partners the Bureau of Agriculture, which supplies seedlings, the Adamitullu Research Station, which transports seedlings, and local farmers, who contribute labor to plant and manage trees. World Agroforestry Centre (ICRAF) researchers selected tree species for afforestation that would provide both economic and environmental benefits.
- In Kenya, the partnership between International Livestock Research Institute (ILRI) researchers, non-governmental organizations (NGOs), national governments, and the Kenya Livestock Marketing Council has attracted a new USD 8 million grant from the United States Agency for International Development (USAID) 2016–2018 for strengthening livestock markets.
- A new project on drylands restoration funded by the European Commission and the International Fund for Agricultural Development (IFAD) through the World Agroforestry Centre (ICRAF), partners with existing IFAD and several USAID and World Bank projects to build on successes and to ensure scaling up.

kind of project leverages partnerships and funds for greater impact. Another example is the global Land-Potential Knowledge System (LandPKS) project, which works to scale out technologies without diluting the research effort.

Dryland Systems CGIAR center core partners

- Bioversity International
- International Center for Agricultural Research in the Dry Areas (ICARDA)
- International Center for Tropical Agriculture (CIAT)
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- International Livestock Research Institute (ILRI)
- International Potato Center (CIP)
- International Water Management Institute (IWMI)
- World Agroforestry Centre (ICRAF)

Other CGIAR center partners

- International Food Policy Research Institute (IFPRI)
- International Institute of Tropical Agriculture (IITA)
- International Maize and Wheat Improvement Center (CIMMYT)

Partners in innovation platforms

The program implements its innovation platforms in partnership with a wide range of stakeholders to ensure the research-in-development continuum.

Figure 7: Dryland Systems Partners by Category

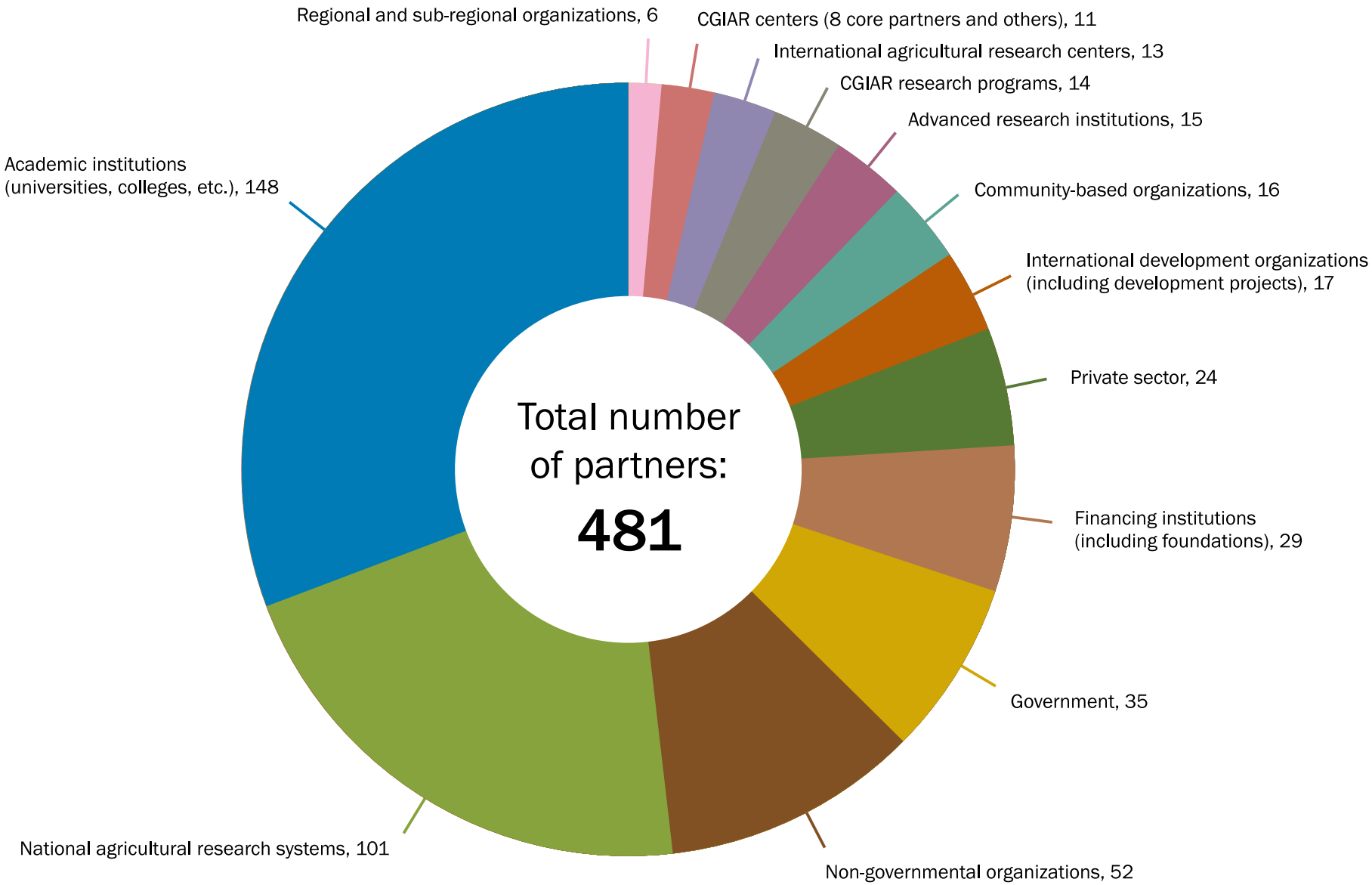


Table 3: Partnerships and Collaboration with CGIAR Research Programs (CRPs)

CRP	Cross-CRP collaboration activity	Role of Dryland Systems
Agriculture for Nutrition and Health (A4NH)	Joint gender-responsive research on nutrition	Mainstreaming women farmers is a big challenge due to lack of land rights. Our partners (ICRISAT and Bioversity International) mitigated these constraints using participatory research at Dryland Systems sites, showing that through promotion of kitchen-garden scale fruit-vegetable cultivation, women can be empowered to improve family nutrition as well to improve family incomes by selling surplus produce. Strong research collaboration with A4NH and World Vegetable Centre (AVRDC), and training activities helped include women in augmenting fodder production on common land and in marketing small ruminants.
Aquatic Agricultural Systems (AAS) and Humid Tropic Systems	Promotion of systems research approaches at CGIAR level and with partners	Co-organizer of the International Systems Conference.
Climate Change, Agriculture and Food Security (CCAFS)	Sharing systems research approaches, knowledge, and experience	Seminar on Cluster of Integrated Systems Analysis and Modeling in Hanoi, Vietnam, with the active participation of CCFAS South East Asia Office, CCAFS members from CIAT, and ILRI in Asia.
	Climate Smart Farmer Managed Natural Regeneration Method	Joint funding CCAFS/FTA/Dryland Systems for the implementing centers (ICRAF, ICRISAT) to generate evidence, in West Africa Dryland Systems field sites, on methodologies and to influence stakeholders for broader scaling up.
CCAFS/Forests, Trees and Agroforestry (FTA)	Joint gender-responsive research	Contributed to research on gender aspects of climate-smart crops and techniques in Egypt.
Dryland Cereals	Joint gender-responsive research	Contributed to research on gender norms in different dryland agricultural livelihoods.
FTA	Monitoring Evaluation and Learning	Joint design and piloting of online CapDev module to adopt CGIAR CapDev elements and indicators.

Table 3: Partnerships and Collaboration with CGIAR Research Programs (CRPs) (*Continued*)

CRP	Cross-CRP collaboration activity	Role of Dryland Systems
Grain Legumes	Gender roles and constraints in Grain Legumes crops. Rehabilitation of food legumes	Joint funding with Grain Legumes for the implementing centers (ICRISAT, ICARDA) to field test (West and North Africa) and generate evidence on methodologies and influence stakeholders for broader scaling up.
Livestock and Fish (L&F)	Research and policy recommendations on Index-Based Livestock Products	Persuading pastoralists to take control over their own livelihoods by embracing Index-Based Livestock Products (IBLI) was a key activity pursued by program partner ILRI in coordination with L&F. The IBLI Unit within ILRI designed a set of classroom training materials, which are currently being used to train government extension workers and sales agents across northern Kenya and in the Borana region of Ethiopia. The development of eLearning modules covering the same content has also been commissioned.
Policies, Institutions and Markets (PIM)	Joint research on Economics of Land Degradation	Lead author in one chapter and co-author in two other chapters.
Maize	Assessment of dual purpose maize, maize silage technologies, and sustainable land management (SLM) practices to increase maize productivity	Joint funding of common partner (CIAT, ICRISAT) for field-testing and generating knowledge to influence stakeholders.
Roots, Tubers and Bananas (RTB)	Joint research on climate-smart agriculture	Our partners CIAT and CIP strengthened research collaboration with RTB and local university, LUANAR, to introduce orange-fleshed sweet potatoes as a mitigating strategy against drought and other external risks. Farmers benefitted from better yields and stored seeds for future use. This research area will be expanded further with collaboration with both RTB and CCAFS.
Water, Land and Ecosystems (WLE)	Joint gender-responsive research	Contributed to gender and agricultural extension services in Malawi as part of research on irrigation and gender-responsive extension services supported by WLE.
	Innovation platforms	Systems research aimed at all-round improvements in both productivity and sustainability requires active participation of several stakeholders. Dryland Systems faced constraints in delivery system outputs and focused 2015 research to foster Innovation Platforms (IPs) that were found to be the best means to facilitate the involvement of all stakeholders while improving extension services as demonstrated by the joint work with WLE.

Table 3: Partnerships and Collaboration with CGIAR Research Programs (CRPs) (*Continued*)

CRP	Cross-CRP collaboration activity	Role of Dryland Systems
WLE *Continued...*	Water management	Managing rainwater efficiently, and managing both green and blue water resources in an integrated manner to use it efficiently for high value crops is a challenge. Dryland Systems overcame this challenge by integrating, in partnership with WLE, water conservation at micro-watershed scale on individual farms and bigger catchment that bring water to smallholders as per their demands. Rainwater harvesting needs to be further promoted at farm-scale as a drought proofing strategy through low-cost farm-ponds which can kick-start the stagnant growth of agriculture and make it sustainable thereafter. This opens interesting collaboration opportunities with WLE and CCAFS through ICRISAT work.
Wheat	Shared experiences on innovation platforms, Integrated Systems Approach to Sustainable Intensification	Contributed to the WHEAT Innovation Systems Workshop, and WriteShop for the FP4 (Sustainable Intensification) of WHEAT Phase II.
Managing and Sustaining Crop Collections (Genebanks)	Ex-situ and in-situ agrobiodiversity conservation	Support community-level seed and genebank conservation with the participation of centers involved in CRP Genebanks (ICRISAT, ICARDA, CIAT).
Humid Tropics, WHEAT, and WLE	Monitoring, evaluation, and learning (MEL)	Promoted use of SDG indicators and improved CapDev indicators at CGIAR level.
RTB-Dryland Cereals (DC)-Grain Legumes (GL)	Monitoring, evaluation, and learning	Develop a common MEL platform harmonizing terminologies, indicators, planning, and reporting mechanisms for results-based management (RBM).
Consortium Office (CO)	Monitoring, evaluation, and learning	Supported the CGIAR community of practice (COP) for the conceptualization and operationalization of CGIAR RBM through participation in CGIAR community of practices for Evaluation (ECOP/IEA), Monitoring, Evaluation and Learning (MELCOP/CO), and co-chairing key working groups for improving the functioning of the Consortium (e.g. sub-intermediate development outcomes [IDOs] indicators development, MEL strategic initiative, online collaboration tools).

Financial Summary 2015

Dryland Systems expenditure in 2015 was USD 42 million. The expenditures were met from Windows 1 and 2 (16%), Window 3 and bilateral sources (80%), and from the center's and partners' own sources (4%). Windows 1 and 2 funds were reduced in the final Financing Plan to USD 6.9 million.

Figure 8: Dryland Systems Sources of Funds 2015

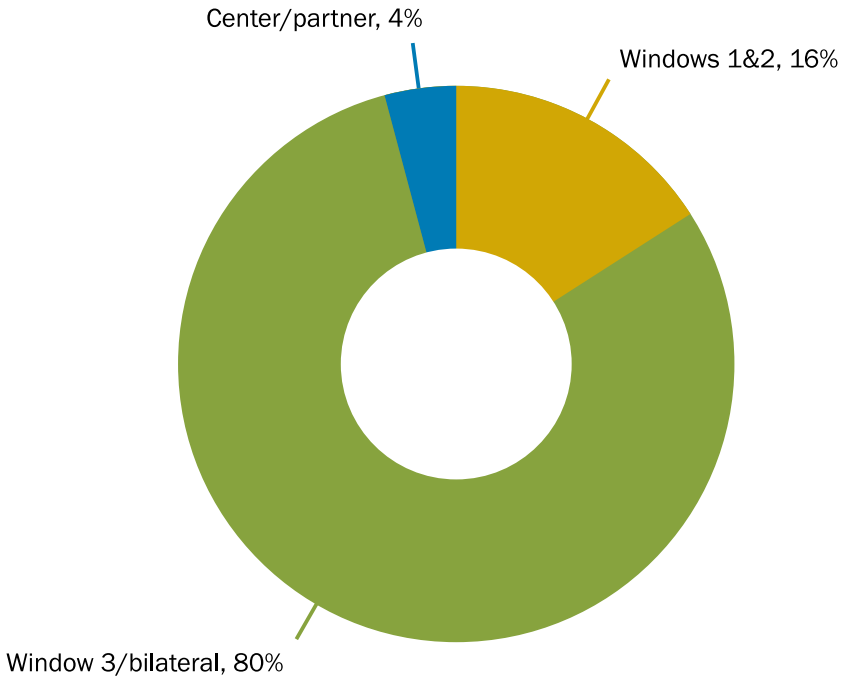


Figure 9: Dryland Systems Partner Shares in Expenditure 2015

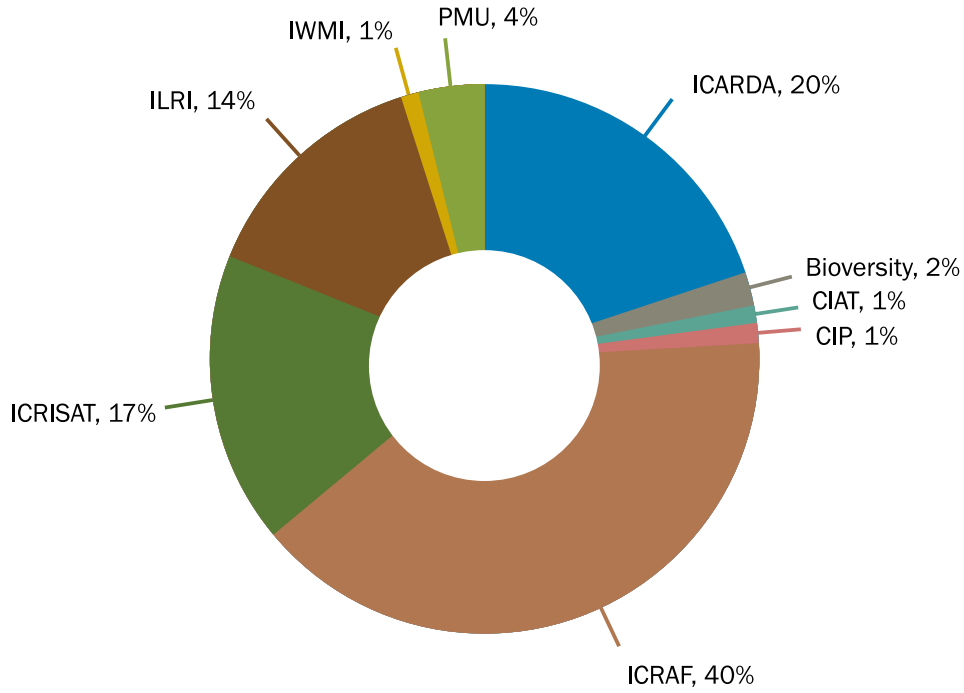


Table 4: Financial Summary 2015 (USD 000s)

	Planned expenditure	Actual expenditure	Executed (%)
Total expenditure	47,885	42,404	89%
Windows 1 and 2 funds	7,449	6,890	92%
Window 3 and bilateral funds	40,175	35,310	88%
Gender research	231	204	88%

Table 5: Expenditure by Region (USD 000s)

Region	Budget	Actual expenditure	Executed (%)
North Africa and West Asia	6,379	5,256	83%
Central Asia	2,311	1,765	76%
West African Sahel	20,500	16,388	80%
East and Southern Africa	11,273	12,633	112%
South Asia	3,133	2,685	86%
Management coordination	4,289	3,676	86%

Table 6: Expenditure by Partner Center (USD 000s)

	Budget			Actual expenditure			
Center	Total	Windows 1&2	Window 3/bilateral	Total	Windows 1&2	Window 3/bilateral	Executed (% total budget)
ICARDA	18,957	4,304	14,653	14,956	3,663	11,293	79%
Bioversity	811	198	613	773	198	575	95%
CIAT	528	114	414	452	114	338	86%
CIP	151	107	44	149	107	42	99%
ICRAF	14,532	682	13,850	12,752	731	12,021	88%
ICRISAT	8,263	962	7,301	7,027	961	6,066	85%
ILRI	4,361	807	3,554	5,979	807	5,172	137%
IWMI	282	275	7	316	309	7	112%

Table 7: Expenditure by Category (USD 000s)

Category	Planned expenditure	Actual expenditure	Executed (%)
Personnel	13,018	12,310	95%
Collaborator costs – CGIAR Centers	988	893	90%
Collaborator costs – Partners	13,048	12,226	94%
Supplies and services	10,592	8,978	85%
Operational travel	2,431	2,704	111%
Depreciation	1,754	1,166	66%
Sub-total direct costs	**41,831**	**38,277**	**92%**
Indirect costs	6,054	4,127	68%
Total all costs	**47,885**	**42,404**	**89%**

Photo: CIAT/Neil Palmer

Expenditure 2015

Personnel costs made up 29%, partnerships 31%, and travel 6% of the expenditures. Management and cross-cutting themes (Gender, Systems Analysis, Knowledge sharing, and Communications) made up 9% of the expenditures.

The West African Sahel region accounted for 39% of expenditure; the East and Southern Africa region accounted for 30%, and the North Africa and West Asia region for 12%.

Figure 10: Dryland Systems Expenditure by Category 2015

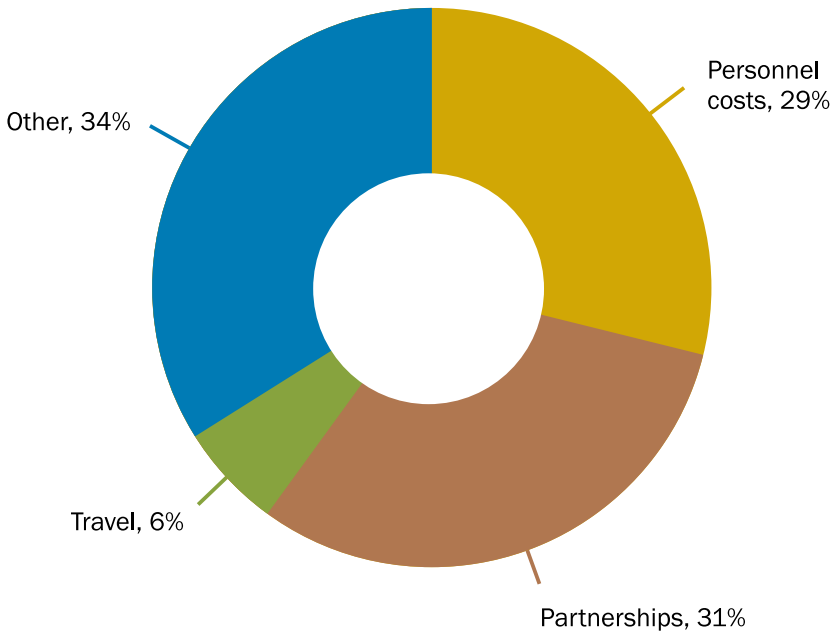
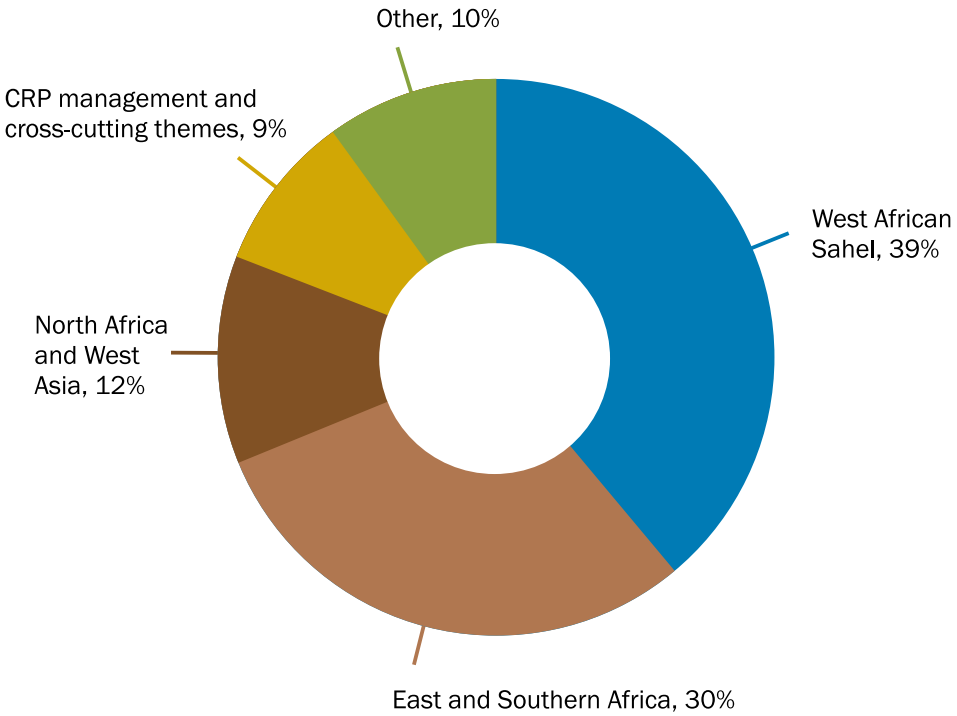


Figure 11: Dryland Systems Expenditure by Region 2015



Donors

Rural dryland communities in developing countries face challenges of poverty, food and nutrition insecurity, climate change, water scarcity, and land and resource degradation, as well as social and political unrest. Tackling these challenges requires significant resources and long-term financing.

Thanks to the support and contributions of our valued CGIAR Fund Donors and of bilateral donors who share our commitment to eradicating poverty, hunger, and malnutrition, Dryland Systems is advancing the livelihoods of smallholder farmers in dry areas. We are extremely grateful to all our donors for making our work possible as we strive to be more efficient, collaborative, and impact-oriented so that together we can truly transform the lives of impoverished rural dryland communities.

Photo: CIAT/Neil Palmer

CGIAR Fund Donors to Dryland Systems

- Australia
- Belgium
- Netherlands
- Sudan
- Switzerland

Bilateral Donors

- African Development Bank (AfDB)
- Agricultural Research Center of Egypt (ARC)
- Arab Fund for Economic and Social Development (AFESD)
- Asian Development Bank (ADB)
- Australian Agency for International Development (AusAID)
- Australian Centre for International Agricultural Research (ACIAR)
- Austrian Development Agency (ADA)
- Bill & Melinda Gates Foundation
- UK Department for International Development (DFID)
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Directorate-General for International Cooperation (DGIS), Government of The Netherlands
- DuPont Pioneer
- European Union (EU)
- Food and Agriculture Organization of the United Nations (FAO)
- Government of India
- Government of Iran
- Government of Russia
- French National Institute for Agricultural Research (INRA)
- International Fund for Agricultural Development (IFAD)
- Kuwait Fund for Arab Economic Development (KFAED)
- McKnight Foundation
- Offce Chérifen des Phosphates (OCP)
- OPEC Fund for International Development (OFID)
- United States Agency for International Development (USAID)
- United States Department of Agriculture (USDA)

Governance

Dryland Systems governance involves members of developing and developed country institutions, such as national agricultural research and extension services (NARES), the private sector, civil society, CGIAR, farmers' organizations, bilateral and multi-lateral donors, and international organizations. The program has a wide upstream and downstream reach that includes participants and institutions with a key role in defining the drylands development agenda.

Governance of the program is the responsibility of the Research Management Committee and the Independent Steering Committee under the fiduciary responsibility of the lead center. The Program Management Unit supports these two committees.

Independent Steering Committee

The Independent Steering Committee is responsible for the overall strategic direction of the program. The committee ensures appropriate allocation of resources, approves annual work plans, strategies, and governance documents, and monitors program implementation in terms of science quality and excellence.

Research Management Committee

The Research Management Committee is directly responsible for the overall coordination and management of the program's research implementation. The Committee is composed of representatives of the eight partner centers, the five regional coordinators, and is chaired by the program director. The committee reviews the annual work plans and budgets developed at regional and global levels to ensure consistency, integration, and appropriate budget allocation across the program. Once cleared by the Research Management Committee, work plans, budgets, strategies, and other governance documents are submitted to the Independent Steering Committee for approval.

Interdisciplinary Research Teams

The interdisciplinary research teams in each of the five regions identify needs and research priorities at local and regional levels, and draft, monitor, and implement annual plans of work and budgets. Chaired by regional coordinators appointed by the center coordinating work in the region, the teams are composed of representatives of each partner center (center focal points), local stakeholders (national agricultural research and extension services, NGOs, private sector), and action site coordinators.

Program Working Groups

To ensure coherence and organizational learning, the program has established several working groups on the cross-cutting issues of: data management and open access, gender and youth, communications and knowledge sharing, capacity development, and integrated systems analysis and modeling. The working groups are composed of staff in participating centers and their partners, and led by relevant Coordinators in the Overarching Flagship. Each group works to develop and implement shared work plans and strategies, as well as synthesize, share, and communicate research knowledge and outcomes at global level.

Photo: IWMI/Prashanth Vishwanathan

Dryland Systems People

Independent Steering Committee

Harry Palmier	Chair, Global Forum on Agricultural Research
Barron Orr	SC Member, University of Arizona
Jeffrey Herrick	SC Member, USDA-ARS Jornada Experimental Range
Aboubakar Njoya	SC Member, CORAF/WECARD
Bernard Hubert	SC Member, CIRAD
Ram Krishna Bhatt	SC Member, CAZRI
Mohammed Badraoui	SC Member, INRA-Morocco
Tony Simons	SC Member, ICRAF
David Bergvinson	SC Member, ICRISAT
Mahmoud Solh	SC Ex-Officio Member, ICARDA
Margret Thalwitz	SC Ex-Officio Member, BOT-ICARDA
Richard Thomas	SC Ex-Officio Member, CGIAR Research Program on Dryland Systems

Research Management Committee

Richard Thomas	Chair
Andrew Noble	Center Coordinator, ICARDA
Anthony M. Whitbread	Center Coordinator, ICRISAT
Mauricio Bellon	Center Coordinator, Bioversity
Lulseged Tamene Desta	Center Coordinator, CIAT
Philippe Monneveux	Center Coordinator, CIP
Jan de Leeuw	Center Coordinator, ICRAF
Polly Ericksen	Center Coordinator, ILRI

Photo: CIAT/Georgina Smith

Everisto Mapedza	Center Coordinator, IWMI
Antoine Kalinganire	Regional Research Coordinator, West African Sahel and Dry Savannas
Hichem Ben Salem	Regional Research Coordinator, North Africa and West Asia
Sikhalazo Dube	Regional Research Coordinator, East and Southern Africa
Bogachan Benli	Regional Research Coordinator, Central Asia
Shalander Kumar	Regional Research Coordinator, South Asia/Action Site Coordinator, Rajasthan

Program Management Unit

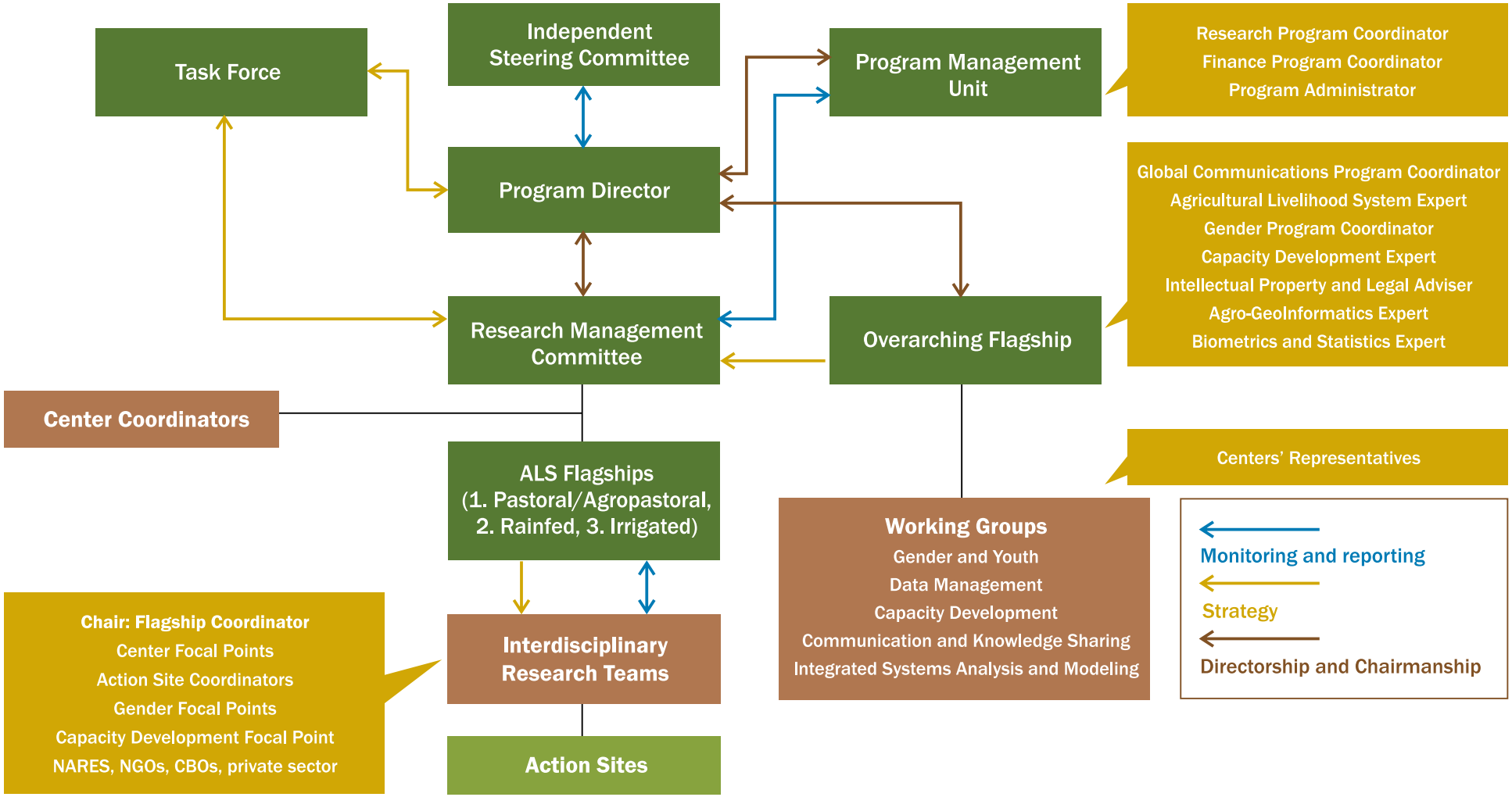
Richard Thomas	Program Director
Enrico Bonaiuti	Research Program Coordinator
Rima Dabbagh	Finance Program Coordinator
Linda Fattal	Program Administrator

Overarching Flagship

Tana Lala-Pritchard	Global Communications Program Coordinator
Enrico Bonaiuti	Capacity Development Coordinator (acting)
Anja Gassner	Chair of Data Management Working Group
Chandrashekhar Biradar	Geoinformatics Unit Head
Murari Singh	Biometrics and Statistics Section
Francesca Re Manning	IP and Legal Adviser
Quang Bao Le	Agricultural Livelihood Systems Expert
Karin Reinprecht	Gender Program Coordinator

Photo: IWMI/Ikuru Kawajima

Figure 12: Dryland Systems Governance and Management Structure



Key: ALS Agricultural Livelihoods Systems; **CBO** Community-based organization; **NARES** National agricultural research and extension services; **NGO** Non-governmental organization.

Photo: CIFOR/Ollivier Girard

Publications 2015

Publications extend the knowledge base, document the work done, and set new objectives. In 2015, the CGIAR Research Program on Dryland Systems produced 138 journal articles (88 in journals indexed by the Institute for Scientific Information), 8 books, 17 book chapters, 137 working papers, 62 datasets, 61 proceedings, and 144 policy and technical briefs – in total, 567 published knowledge and information products.

A clear move towards examining new system approaches emerges from this body of scientific knowledge with 66 journal articles (48% of the total published journal articles) presenting multidisciplinary and/or integrated systems research.

Figure 13: Themes of Dryland Systems Peer-Reviewed Publications 2015

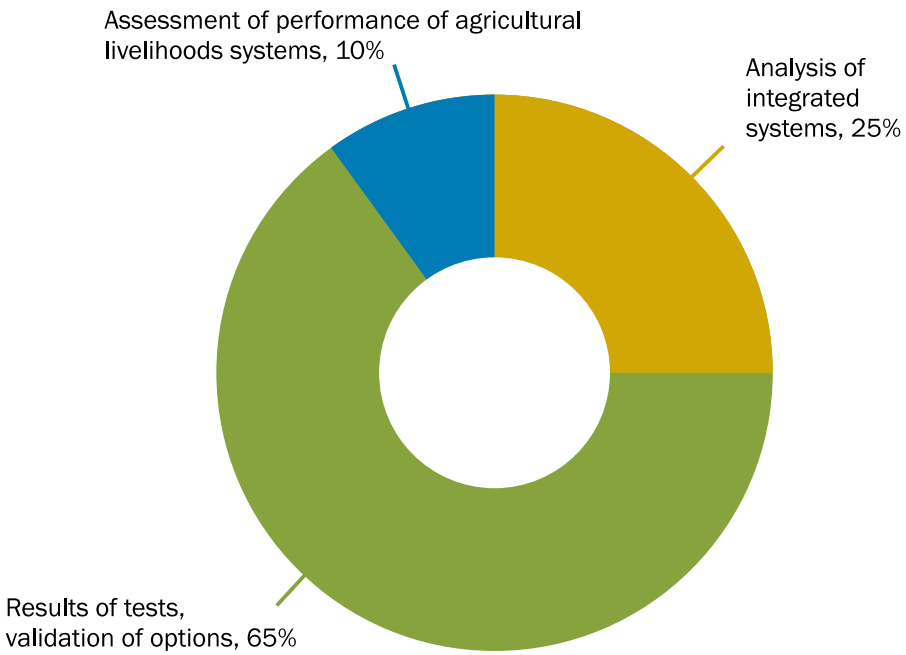


Figure 14: Articles in Journals Listed by International Scientific Indexing (ISI)

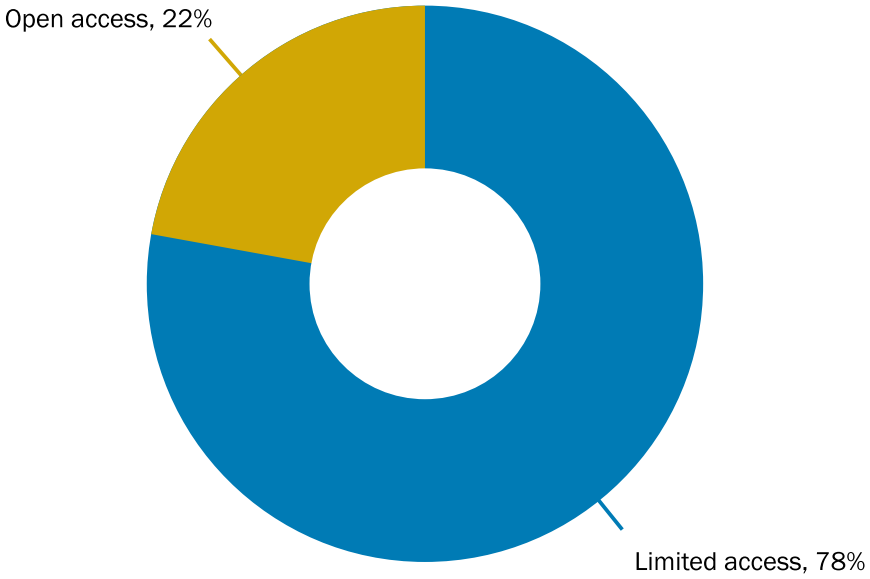


Table 8: 2015 Articles in Journals Listed by International Scientific Indexing (ISI)*

Center	ISI journal articles	ISI impact factor (range of ISI scores)	Open access	Mono-disciplinary (No. of ISI articles)	Multidisciplinary/ systems (No. of ISI articles)
Bioversity	4	0.631 – 2.000	1	4	0
International Center for Tropical Agriculture (CIAT)	1	1.897	0	0	1
International Potato Center (CIP)	1	1.215	0	1	0
World Agroforestry Centre (ICRAF)	9	0.553 – 3.402	6	3	6
International Water Management Institute (IWMI)	1	1.77	0	0	1
International Livestock Research Institute (ILRI)	4	1.146 – 2.902	2	1	3
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	33	0.00 – 7.885	4	29	4
International Center for Agricultural Research in the Dry Areas (ICARDA)	29	0.043 – 8.044	5	21	8
Project Management Unit	8	0.82 – 6.393	2	2	6
CRP Total**	**88**	**0.00 – 8.044**	**18**	**60**	**28**

* International Scientific Indexing (ISI) is a journal indexing and impact factor calculation service based on article citation.

** A publication jointly published by two or more centers is counted only once in the overall number of CRP publications.

Table 9: 2015 Articles in Publications Not Listed by ISI

Center	Non-ISI journal articles	Non-ISI journal articles on system approaches	Books	Book chapters	Technical reports and working papers	Proceedings	Datasets	Other
Bioversity	1	1	0	0	16	0	2	14
CIAT	0	0	0	0	7	2	0	12
CIP	4	1	0	0	6	0	2	8
ICRAF	5	3	0	0	27	0	5	16
IWMI	1	1	0	1	29	0	1	10
ILRI	3	3	0	0	19	7	0	22
ICRISAT	14	14	0	8	6	14	8	17
ICARDA	21	15	3	8	22	32	26	29
PMU	2	2	5	0	6	6	18	16
Total*	**50**	**39**	**8**	**17**	**137**	**61**	**62**	**144**

* A publication jointly published by two or more centers is counted only once in the overall number of CRP publications.

Selected Publications

The following is a selection of key Dryland Systems publications and research outputs produced in 2015:

Boogaard, B.K., E. Waithanji, E.J. Poole, and J.J. Cadilhon. 2015. Smallholder goat production and marketing: A gendered baseline study from Inhassoro District Mozambique. NJAS-Wageningen *Journal of Life Sciences* 74-75: 51-63.
DSpace: http://mel.cgiar.org/xmlui/handle/20.500.11766/4786
DOI: http://dx.doi.org/10.1016/j.njas.2015.09.002

Davies, J.M., L.W. Robinson, and P.J. Ericksen. 2015. Development Process Resilience and Sustainable Development: Insights from the Drylands of Eastern Africa. *Society and Natural Resources* 8: 328-343.

ELD Initiative. 2015. The value of land: Prosperous and positive rewards through sustainable land management. ELD initiative, Bonn.
ISBN: 978-92-808-6061-0.
DSpace: http://mel.cgiar.org/xmlui/handle/20.500.11766/3438

Homann-Kee Tui S., D. Valbuena, P. Masikati, K. Descheemaeker, J. Nyamangara, L. Claessens, O. Erenstein, A.F. Van Rooyen, and D. Nkomboni. 2015. Economic trade-offs of biomass use in crop-livestock systems: exploring more sustainable options in semi-arid Zimbabwe. *Agricultural Systems* 134: 48-60.
DOI: 10.1016/j.agsy.2014.06.009

Karlberg, L., K.K. Garg, J. Barron, and S.P. Wani. 2015. Impacts of agricultural water interventions on farm income: An example from the Kothapally watershed, India. *Agricultural Systems* 136: 30-38.
DOI: http://dx.doi.org/10.1016/j.agsy.2015.02.002

Robinson, L.W., P.J. Ericksen, S. Chesterman, and J.S. Worden. 2015. Sustainable intensification in drylands: What resilience and vulnerability can tell us. *Agricultural Systems* 135: 133-140.
DSpace: http://mel.cgiar.org/xmlui/handle/20.500.11766/4682
DOI: http://dx.doi.org/10.1016/j.agsy.2015.01.005

Tendall, D.M., J. Joerin, B. Kopainsky, P. Edwards, A. Shreck, Q.B. Le, P. Kruetli, M. Grant, and J. Six. 2015. Food system resilience: Defining the concept. *Global Food Security* 6: 17-23.
DSpace: http://mel.cgiar.org/xmlui/handle/20.500.11766/4297
DOI: 10.1016/j.gfs.2015.08.001

Valbuena D., S. Homann-Kee Tui, O. Erenstein, N. Teufel, A.J. Duncan, T. Abdoulaye, B. Swain, K. Mekonnen, I. Germaine, and B. Gérard. 2015. Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South Asia. *Agricultural Systems* 134: 107-118.
DOI: http://dx.doi.org/10.1016/j.agsy.2014.05.013

Ziadat F., and W. Bayu. (Eds.) 2015. Mitigating Land Degradation and Improving Livelihoods: An Integrated Watershed Approach. Routledge, New York, USA. 262 pp. ISBN (print): 9781138785182. ISBN (eBook): 9781315754444.
DSpace: http://mel.cgiar.org/xmlui/handle/20.500.11766/4735
DOI: http://dx.doi.org/10.4324/9781315754444

Abbreviations

AAS	Aquatic Agricultural Systems
ALS	Agricultural livelihood systems
APSIM	Agricultural Production Systems Simulator
AVRDC	World Vegetable Center
BISA	Basin Irrigation System Authorities
CAZRI	Central Arid Zone Research Institute
CCAFS	Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
COP	Community of practice
CRP	CGIAR Research Programs
DAHBSIM	Dynamic Agricultural Household Bio-economic Simulation Model
DEAP	Data-Envelopment-Analysis Programming
DGIS	Directorate General for International Cooperation
DS	Dryland Systems
ELD	Economics of Land Degradation
FAO	Food and Agricultural Organization
GFAR	Global Forum on Agricultural Research
GIS	Geographic information systems
GSMA	Groupe Speciale Mobile Association
HAFL	Scholl of Agricultural, Forest and Food Sciences (Bern University)
IAT	Integrated Analysis Tool
IBLI	Index-Based Livestock Insurance
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDO	Intermediate Development Outcome
IEA	Independent Evaluation Arrangement
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IP	Innovation Platforms
ISI	International Scientific Indexing
L&F	Livestock and Fish (CGIAR Research Program)
LAMPT	Land Management Planning Tool
LandPKS	Land-Potential Knowledge System
LUANAR	Lilongwe University of Agriculture and Natural Resources
MEL	Monitoring, Evaluation, and Learning
NARES	National agricultural research and extension services
NARS	National agricultural research systems
NGO	Non-governmental organization
NSC	National Seed Corporation
RBM	Results-based management
RSSC	Rajasthan State Seeds Corporation
RTB	Roots, Tubers and Bananas
SDG	Sustainable Development Goals
SLM	Sustainable land management
TLC	Total LandCare
UNCCD	United Nations Convention to Combat Desertification
USAID	United States Agency for International Development
WHEAT	CGIAR Research Program on Wheat
WLE	Water, Land and Ecosystems
YPARD	Young Professionals for Agricultural Development

Photo: ILRI/Stevie Mann

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