Environmental, social, economic and cultural factors all interact to affect communities living and farming in dryland areas. Incorporating 41% of the world’s land area, and 16% of the world’s poor, dryland areas are in urgent need of a new kind of approach that ‘joins up these dots’ in tackling problems of chronic poverty, food insecurity, population growth, water scarcity, land degradation and climate change.

This ‘systems approach’ is not easy, but the gains can be enormous. In a pioneering effort, the ICARDA-led CGIAR Research Program on Dryland Systems, is using systems research to sustainably increase productivity and build the resilience of dryland communities in Africa and Asia. The program is addressing agricultural livelihood systems as a whole – crop, water, soil, land, policy and institutions – to develop solutions by leveraging the expertise of its diverse agricultural research partners – eight CGIAR centers, regional organizations and national institutions.

At program level, in 2014, ICARDA worked with partner CGIAR centers to roll out a robust contextual framework of agricultural livelihoods systems and consolidated program implementation at 13 action sites. Primarily the program focuses on three agricultural livelihood systems: the (agro)-

Incorporating systems modeling through knowledge partnerships
In November 2014, ICARDA, in partnership with Montpellier-SupAgro, the Montpellier institute of the International Centre for Advanced Mediterranean Agronomic Studies, Wageningen University, and the Technical University of Madrid, held a course in Tunisia to develop insights and refine the framework for integrated research aiming to build sustainable intensification and resilience in dryland agriculture – the goal of Dryland Systems.

The course built the capacity of researchers on the use of agro-ecological modeling and bio-economic modeling, which when coupled together can provide a consistent framework for assessing agricultural policy and development efforts – a valuable tool in keeping the systems research on track for intended outputs and outcomes.
pastoral, the cereal-based rain-fed and the irrigated systems. The sites selected are representative of these systems across five flagship regions – West African Sahel and the Dry Savannas; East and Southern Africa; North Africa and West Asia; Central Asia; and South Asia. Key challenges in each of the livelihood systems and possible entry points for change interventions were identified through in-depth analyses, along with investigation of synergies amongst different actors (individuals, households and community) as they interact with the farms. A number of integrated systems modeling approaches – such as crop sub-systems modeling, bio-economic modeling, agent-based modeling and participatory modeling – are in progress to take systems research to the next level.

On the implementation front, the program is using an innovation platforms approach to engage a diverse group of stakeholders in target regions – extension, NGOs, development agencies, local decision-makers, scientists and private sector – for participatory planning of research and testing of technologies and research methods with the end-users. The resulting research strategies and interdisciplinary research activities led to significant progress toward program goals in 2014.

Research progress and successes in 2014

The following offers a sampling of research strategies being tested and results thus far at two of the five flagship regions targeted by Dryland Systems that are led by ICARDA – North Africa and West Asia; and Central Asia.

In North Africa and West Asia

Farmers across North Africa and West Asia are largely agro-pastoralists, eking out a livelihood from the scarce water and highly vulnerable marginal lands of the region. More favorable agro-ecosystems exist, but suffer from poor yields. Rain is variable and where irrigation is prevalent, salinity and falling water tables are major concerns. Rangelands too are degraded with lack of water and overgrazing preventing regeneration.

The Dryland Systems Program is addressing the suite of challenges by integrating various strategies such as water management, conservation agriculture, value chains, community seed production, participatory improvement of local crop landraces, and livestock productivity.

Sustainable intensification in high potential areas

In Morocco where its rain-fed production system offers high potential, the program’s strategy is to intensify and diversify crops for farmers.

A deficit supplemental irrigation package has been introduced into wheat production for farmers in the Tadla region. This boosted wheat grain yield by 20–25% and allowed a saving of 1000–1200 m³ of irrigation water per ha. Men and women farmers also participated in the evaluation of more than 70 advanced elite lines of cereals and food legumes introduced by ICARDA for greater productivity in cereal-legume systems.

In irrigated systems of the Nile Delta, the program is disseminating raised-bed technology. This has been showing encouraging results in increasing crop yields for wheat and faba bean by 15–28%, while saving on irrigation water by 20–25% (see page 15).

Rehabilitating degraded rangelands

For the marginal low-potential lands in Tunisia, scientists are working with pastoral communities in Tafilah and Salamya to rehabilitate rangelands by setting up water harvesting and utilizing the water to plant shrubs, thus producing animal feed.

In Jordan, the Al-Majidiyya and Muhareb community schemes to manage rangelands resulted in the revival of native species like Atriplex halimus, which is known to remediate degraded areas and fill the forage gap in late summer when herbage drops. Also in 2014, ICARDA scientists modeled and monitored the Al-Majidiyya watershed to determine the best ways to conserve water. The University of Jordan is now using the results to monitor erosion and assess the impacts of the soil conservation measures and intercropping techniques introduced by the
Adapting dryland communities to climate change through conservation agriculture

North Africa and West Asia is estimated to be one of the worst hit regions by climate change. To address the challenge, a major focus of Dryland Systems in the region has been promoting the adoption of conservation agriculture practices of minimum or zero till and leaving behind the crop residue in the field – a proven cost-effective way of stabilizing yields, conserving resources, and increasing efficiency in drylands.

In 2014, nearly 5080 farmers across Jordan, Syria, Tunisia, Morocco, and Iraq were engaged in applying the practice on over 39,000 ha. A key enabler in the success has been access for smallholders to locally fabricated low-cost zero till seeders. These machines have been innovated by a partnership of ICARDA with the Australian Center for International Agricultural Research, Iraqi researchers, and the private sector. On-farm demonstrations, training, and workshops enabled significant uptake of the zero-till technology.

The technology has increased cereal yields by 15–19% and net income of farmers by 29%. As a next step, scientists plan to factor in crop-livestock systems as part of conservation agriculture research to deliver integrated livelihood benefits.

Developing value chains

Research along value chains particularly aims to benefit women in marginal areas. For example, the program is leveraging olive production in Jordan which offers a sizeable market opportunity. In 2014, a value chain analysis of olive oil production in Karak, Jordan, revealed a diminishing water supply, manual harvesting and poor post-harvesting processes as major constraints to productivity and profitability. Efficient water harvesting techniques and harvesting machines are being tested in four orchards. Researchers are also factoring in emerging markets for organic products where higher returns can be used to set up micro-finance schemes for start-up enterprises by women. As a demonstrated success, the enhanced sheep milk processing developed by ICARDA’s team in Jordan for production of the traditional cheese ‘jameed’ is now being out-scaled to 15 villages, with support from IFAD-funded development project.

In Central Asia

Agriculture is a major source of livelihood for rural communities in the Aral Sea and Fergana Valley regions of Central Asia, but crop production remains poor given challenges such as salinity, frost, drought and diseases. The production system depends on irrigation, and given the scarce water resources, water use efficiency is a critical criterion for interventions.

Multiple-stress-tolerant crops

One of the underlying Dryland Systems strategies to increase productivity in the region is to develop multiple-stress-tolerant crop varieties that can meet the future needs of food crops for human and fodder for animals. In 2014, more than 300 improved germplasm and varieties of wheat, chickpea, mung bean, potato, alfalfa and other crops were evaluated with some important successes. A major outcome was a new wheat variety called ‘Davlatli’, developed jointly by ICARDA and the University of Bonn. The variety is high yielding and offers resistance to all the main abiotic stresses typical for winter wheat in many parts of Central Asia, making it a significant contribution to food security in the region.

Diversifying crop systems

To sustainably intensify and diversify productivity, the program introduced novel short-duration, erect and non-shattering mung bean varieties obtained from ICARDA’s partner AVRDC (the World Vegetable Center). The mung beans were grown in rotation with winter wheat and cotton, during the short fallow period. A popular part of the diet, mung bean is a low water consuming crop with the additional benefits of fixing nitrogen in the soil. The strategy helped farmers gain an additional 1.4–1.5 t/ha of crop that secures a price which is three to four times higher than that for wheat, while allowing greater overall water use efficiency. The program has established a seed system and is field testing wheat-mung bean crop rotations in four provinces to assess the effect on soil nutrients and the economic profitability of the integrated wheat-mung crop system.

Seed systems

Another strategy being developed is building the capacity of farmers in quality seed production for increased income generation, along with improved food productivity. Farmers
CACILM, a web-based ‘knowledge platform’ for Central Asia, launched in 2014, has synthesized and consolidated proven best practices on sustainable land management, providing stakeholders with easy access to farmer innovations, examples of sustainable management of water, land and forest resources, sustainable farming methods, pasture use, improved livestock and crop production, and promising scientific developments for climate change.

Research highlight

GeSTA – the new frontier in agroecosystems research

The geospatial science, technology and application (GeSTA) research, led by ICARDA, is enabling scientists to effectively incorporate the constellation of biophysical, climatic, socioeconomic and institutional factors critical to supporting a ‘systems’ approach to drive sustainable agricultural development. GeSTA harnesses ‘big data’ from satellites down to drones observed at varied scales – farms, basins and landscapes – on a real-time basis to guide decisions. The information from GeSTA will be a key catalyst in integrating research across the various CGIAR research programs toward their unified goals of reduced poverty, food security, climate-smart agriculture, and sustainable natural resource management.

In 2014, 25 open access databases were established by the GeSTA team with CGIAR partners on its geo-informatics portal: geoagro.icarda.org. The Dryland Systems component of the portal is providing a comprehensive livelihoods database of more than 3000 household farms across program research sites for use by various stakeholders. As an example of its application, program scientists with their external partners used the database in conjunction with systems analyses of yield gaps to inform policy and management decisions for sustainable intensification in the Chinyanja Triangle in Africa.

healthy wheat harvest from raised-bed irrigation technology package, Egypt

Can fetch a US$0.15/kg higher price for quality wheat seed compared to wheat grain, and a US$0.50/kg higher price for mung bean seed over mung bean grain, by selling to seed processing plants. In 2014, 208 farmers received training from the program’s “Seed systems” initiative and produced 451 tonnes of improved wheat seed, earning US$67000 and 80 tonnes of mung bean seed, earning US$40,000. The income received from certified seed grade could be much higher if the farmers produced higher quality grades, such as super elite and elite seed.
Building food security through systems solutions: a case study

Several projects contributed to Dryland Systems research by testing and validating interventions that lie at the very heart of improving the integrity of agricultural production systems in drylands. The Arab Food Security Project was one such initiative that led to significant outcomes in 2014 that directly advance the goals of Dryland Systems.

Arab countries are the largest importers of wheat in the world and are also its largest consumers. But with water in short supply and climate change impacts, growing more and stabilizing wheat production is a challenge for farmers in Arab countries. To help address this problem, ICARDA scientists worked with the national agricultural research systems (NARS) of 10 Arab countries from 2011 to 2014 to develop and disseminate wheat ‘packages’ tailored to supplemental irrigation, full-irrigation, and rain-fed agricultural livelihoods systems.

The project partnered with national agricultural research systems to deploy responsive dissemination strategies, combining ‘live’ tests in farmers’ fields with capacity development at all levels – farmers, technicians and extension, scientists, policymakers and development workers. Furthermore, the project facilitated a vigorous exchange of experiences amongst the countries, synergizing large-scale impacts. More than 25,000 farmers were reached with improved technologies, reaping a 28% increase in wheat yield on average.

Some innovations tested and validated were mechanized raised-bed technology, bringing ‘more crop per drop’ for smallholders in the Nile Delta. On average, it increased wheat yield by 28%, while reducing irrigation water use by 20–25% (see page 15). Also the no-till farming systems increased wheat yields by 16% in Syria, 20% in Jordan, and 50% in Morocco.

A major component of the project, the Young agricultural scientists program, mentored and trained 34 young men and women as of 2014 – building national capacities for a food-secure future in the Arab region. These emerging scientists worked with ICARDA on various aspects of drylands agriculture such as plant breeding, plant protection, water and soil management, conservation agriculture, seed technology and socioeconomics.

The project is now progressing into a second phase for wider scaling, as agricultural ministers, heads of NARS and donors jointly endorsed the value of the research project for the region at a meeting held in Kuwait in November 2014.

“The technology packages demonstrated by this project are based on proven and confirmed research results, and thus we strongly and fully support this project.”

Adel El-Beltagy, Minister of Agriculture and Land Reclamation, Egypt

“The project results are important and calls us all to continue the project implementation into a second phase. The achieved yield increases in the country are supporting our strong political will and policy in providing food security in the Arab region through Sudan.”

Engineer Ibrahim Mahmoud Hamid, Minister of Agriculture, Sudan

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