Agriculture and climate experts have warned for some years now that rising temperatures and frequency of extreme climate events including heat waves experienced in many parts of the world will lead to a drop in major staple foods like maize and wheat.

One cereal stands out in this looming climate chaos: pearl millet. Now, the decoding and sequencing of the pearl millet genome by a global team of 65 scientists from 30 research institutions has revealed critical coping strategies.

The analysis of genetic variability among a thousand pearl millet lines has led to a better understanding of the ability of this dryland cereal to survive soaring temperatures (over 42 degrees Celsius) and its exceptional drought tolerance.

This discovery, published in *Nature Biotechnology* on Sept 18, 2017, may also help develop climate adaptation strategies in other important cereal crops.

Pearl millet, a staple in the Sahel and semi-arid India, has the extraordinary capacity to resist baking heat. While most cereals like rice or maize cannot support temperatures over 30 to a maximum of 35 degrees Celsius when they start forming their grain, pearl millet will fill its grain in temperatures of up to 42 degrees Celsius.

Dr Rajeev Varshney, Research Program Director – Genetic Gains, ICRISAT, who coordinated the Pearl Millet Genome Sequencing Consortium explains, “We have found that compared to other cereals like wheat, rice or maize, pearl...
millet has a more diverse repertoire of genes for natural wax proteins, which act as thermal protection for the plant.”

A global research team across ten countries (India, China, France, USA, Germany, Austria, Senegal, Niger, Italy and UK) used the latest innovations in DNA sequencing and analysis to identify new genetic tools like molecular markers related to drought and heat tolerance, as well as other important traits (better nutrition profile, pest resistance).

With recent advances in big data and statistical genetics, this research will catalyze breeding efforts to improve this crucial staple food for the food security and resilience of millions of people in arid and semi-arid Africa and Asia in particular.

Reliance on this climate resilient cereal by dryland populations goes back centuries. Archaeologists have even found that despite recurrent droughts, millet-eating farmers between the 11th and 15th centuries in Ghana did not starve as their popular staple was pearl millet.

**Pearl millet is a nutritious dryland cereal**, rich in protein, fibre and essential micronutrients like iron, zinc and folate. Nutrition studies have shown it **has the potential to fight iron deficiency**, the most widespread micronutrient deficiency and major cause of anemia, affecting the health and development of a third of the global population.

Pearl millet is grown on about 27 million hectares worldwide and is a daily food for more than 90 million people, among the most vulnerable in arid and semi-arid Africa and Asia. It is also an important source of fodder for millions of farms.

However, the plant’s yields have remained low over the last six decades, as this cereal is mainly grown in poor soil conditions without irrigation, minimal and no fertilizer and other agricultural inputs.

Investment in genetic research for this so-called “orphan” crop has been inadequate despite being the main food and feed for many farmers. As a result, breeders had limited genetic information to develop high-yielding superior varieties and hybrids that respond to farmers’ constraints.

This new pearl millet genome research enables a better understanding of its genetic variability, and researchers have already identified candidate genes of very important traits, such as resistance to downy mildew, a very damaging millet disease, and heat tolerance.

Such crop heat resistance will be crucial for farmers in many parts of the world as climate experts forecast further heat waves in years to come. With new biotechnology methods, we could foresee the transfer of these heat and drought tolerance traits to other important food cereals in the near future.

Professor M S Swaminathan, father of the Indian Green Revolution, has been a strong advocate of nutritious pearl millet, which is now included in the food basket of the Indian public distribution system in some Indian states, including Karnataka.

Unlocking the DNA data of this climate smart nutri-cereal will generate new pearl millet varieties to push the drive for more productive, nutrition-sensitive and resilient farming.

This article was published in Thomson Reuters News Foundation.
**ICRISAT in Global News**

**Breaking legume’s crop wild relative barrier**

Domesticating crops for traits like higher yields is not without risks. Over time, domesticated varieties can lose other important traits that make them resilient to biotic and abiotic stresses. In a new study, scientists from ICRISAT report progress in transferring disease and stress resistance traits from wild relatives of several legumes to their domesticated varieties.

**Biotechnology does not mean only GM crops**

Biotechnology covers a range of low to high-end technologies important for the prosperity and nutritional security of developing countries. However, public perception remains focused on genetically modified (GM) crops. Dr Rajeev K Varshney of ICRISAT highlights how scientists and policy makers need to focus on the benefits of these technologies for smallholder farmers and communicate better for effective adoption.

**ICRISAT introduces new groundnut varieties in northern Ghana**

ICRISAT introduced three high yielding groundnut varieties in Ghana with the aim to better farmers’ income, nutrition and health status. The project, funded by the United States Agency for International Development (USAID) through its Feed the Future program, will enhance farmers’ knowledge on improved groundnut production technologies and complementary crop management practices, and reach 170,000 direct beneficiaries and 250,000 indirect beneficiaries across the six districts covered.
Sprouting grains for stronger bones: The power of finger millet

Calcium is key for growth and we need plenty of it in our daily food from a very young age. Yet, about half the global population, mostly in Asia and Africa, lack calcium in their diet and are prone to many related ailments ranging from cardiovascular diseases and diabetes to bone loss, which leads to crippling osteoporosis at old age.

Scientists from Aberystwyth University, UK and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) recommend biofortifying finger millet, an already calcium-rich dryland cereal grown in India and Africa, to combat this significant micronutrient deficiency.

One woman out of three and one man out of five will be exposed to bone loss and related fractures during their lives and the societal cost is rising fast, both in developed and developing countries. Think of a bone lifesaving account. Children need to get as much calcium as possible during their childhood to prevent osteoporosis which is very difficult to detect at an early stage. In the US, osteoporosis is costing around US$17 billion annually.

Different strategies are in place to prevent calcium deficiency with contrasting results. Food fortification e.g. breakfast cereals or flours, may not reach the most
vulnerable, while supplementation tablets have well documented side-effects. Eating calcium rich food, like dairy products, seems to be the most efficient way to combat calcium deficiency. However, many cannot switch to dairy because of lactose intolerance, purchasing power or being vegan. Therefore, selecting (biofortifying) and promoting calcium-rich crops has a great potential to combat calcium deficiency. This is where finger millet stands out. 

An Indian farmer’s organization in Kolli hills, in Tamil Nadu has been advocating for finger millet (called ragi in India) for years. They grow and market it, they eat it in various ways and value its resilience and health benefits. Here, children eat sprouted finger millet as part of their midday school meal. The group have been processing and packaging this super grain for urban markets, with the support of the MS Swaminathan Research Foundation (MSSRF), Bioversity International and IFAD. This is a survival dryland cereal which can grow with little rain, on poor soils, yet could reach yields of 10 tons per hectare when irrigated. It is the richest source of calcium among cereals, 3 times more than milk and 10 times higher than brown rice or maize. It is traditionally eaten as weaning porridge in some parts of India and Africa.

Under the CGIAR Research Program on Drylands Cereals, a nutrition profiling of hundreds (628) of finger millet varieties in Africa shows great variability in grain quality content. Breeding research has started working on calcium biofortification of finger millet, gaining a better understanding of what environmental factors and genes influence calcium grain richness without impeding its agronomic performance. Finger millet varieties in the pipeline with double the calcium of average varieties (up to 450 mg/100g edible portion) are now being tested by Kenyan and Tanzanian farmers. Dr Ojulong, ICRISAT research scientist working on finger millet highlights the vast potential of this work. “With the development of this biofortified finger millet that still performs well in the field, you need to eat a third less finger millet to meet your daily calcium requirements. Some Kenyan food processors are very keen on using it for the growing baby food market.”

However, eating finger millet is not enough to get its nutritional benefits, our body has to absorb it. This is what a nutritionist calls bioavailability, which is usually quite poor for grains, as it also contains compounds like phytates and tannins that prevent calcium absorption. However, such anti-nutrient compounds are important in plant growth and grain preservation. Tannins for instance prevent mould or insect damage. The way grain is processed and eaten highly influences calcium absorption.

A nutrition study assessing women self-help group diets in rural Karnataka State, India showed that a portion of finger millet consumed two times a day together with one portion of pulses and vegetables, met the recommended calcium daily requirements.

The most nutritionally sound way to prepare finger millet is grain decortication followed by malting (germination and heat treatment). But processed grains have a limited shelf life compared to decorticated grains. In Kolli hills, it works well because people have easy access to small village mills and can prepare small quantities depending on their immediate needs. The rest of the harvest can be safely stored for months.

Integrating the Kolli hills nutrition improvement practices could ensure calcium biofortified finger millet delivers its promises. Calcium deficient households could learn the best ways to cook finger millet to minimize the nutrient loss and recipes should suit their palate and preferences.

Increasing the market demand for this grain as a Smart Food would also incite farmers to grow it and local food processors would develop a range of value-added products reaching new consumers. MSSRF has been supporting farmer groups to raise the profile of this ‘climate-smart nutri-cereal’, which they say can help in the fight against hidden hunger. India has already incorporated millets in the Public Distribution System food basket, and it would make sense for African countries to add finger millet in the food aid basket too. Kenya, Uganda and Tanzania have promoted finger millet to a high value crop because of high potential in malnutrition alleviation and also as a high value cash earner.

To have a proof of concept for food security decision-makers, Dr Ojulong and his colleagues recommend support in scaling up the initial success of biofortified finger millet in Kenya and Tanzania, as well as implementing pilot nutrition studies for vulnerable groups (like children, nursing or post-menopausal women) in finger millet-eating communities to confirm the extent of finger millet calcium absorption and benefits.

Through this approach, which incorporates agriculture, nutrition and health, along with policy and market research, finger millet could combat calcium deficiency in coming years. Originally published on Farming First.org
Savvy sowing for Indian monsoon-dependent farmers

Rain fed farmers represent over 57 percent of India’s cultivated area and support 40 percent of the Indian population. These farmers often lack advice about what crop to plant, and when to sow seeds.

Digital tools developed by ICRISAT and partners are helping farmers access real-time data and simulation-based insights for decision-making to offset climate risks. Read more on the Thompson-Reuters News Foundation.

How safe treatment of wastewater can boost agriculture

Sixty five percent of irrigated croplands worldwide are dependent on wastewater, with 86% of these located in China, India, Pakistan, Mexico and Iran.

Untreated wastewater carries pathogens and bacteria, posing serious health risks to consumers. ICRISAT’s World Water Week story on the safe treatment of wastewater for agriculture was published on Huffington Post India’s blog.

BBC Focus on Africa

BBC Focus on Africa and the TV documentary ‘Africa’s Population Explosion’ on BBC World News covered ICRISAT’s smart food consumer education in rural communities in Kenya, research scientist Damaris Odeny highlighting how nutritious and drought tolerant traits were selected to improve production, and farmer Samuel Nduvi talking about his improved yields with better varieties and farming methods including on-farm crop diversification.
LAMP: A visual, fast and low-cost diagnostic device to fight a deadly, emerging disease

Chickpea is a lifeline food crop for India’s national food security. This protein-rich pulse is important for any Indian household’s diet, especially the poorest. With an annual production of over 7 million tons, India accounts for about three-quarters of world’s chickpea production. Over the past 5-10 years, with rising temperatures and a shift of chickpea cultivation from cool Northern India to semi-arid central and southern states like Andhra Pradesh, farmers have witnessed the rise of a deadly soil-borne disease, dry root rot (DRR), which can wipe out all their crop.

This soil-borne disease is caused by the fungus *Rhizoctonia bataticola* (*Synm Macrophomina phaseolina*), which thrives in crops exposed to soil moisture stress with temperatures over 30 °C during the flowering to pod-filling stages. The plant dries suddenly and its leaves become straw colored.

The problem is that several important diseases like Fusarium wilt have similar symptoms and DRR cannot be distinguished easily at the field level. At present, only laboratory methods are available to detect DRR with certainty: for instance, the commonly used polymerase chain reaction (PCR) techniques require specialized and expensive equipment. Farmers and agronomists feel helpless to assess the scope of this threat and design a proper pest management strategy.

Plant health experts from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have developed a fast, visual and user-friendly plant disease diagnosis device that is ten times cheaper than existing PCR methods. This test can quickly identify an emerging root pathogen that affects chickpea and over 500 other crops globally, including nutritionally and commercially significant crops such as soybean, maize, sunflower, groundnut, pigeonpea, jute, and sorghum.

Published in *Scientific Reports, (Nature Journal)*, ICRISAT’s research demonstrated 100% accurate identification of DRR in chickpea using Loop-Mediated Isothermal Amplification Method (LAMP). Used in biomedical research to detect the presence of parasite flatworms in human blood, this LAMP method has now been successfully adapted to correctly detect and indicate the presence of *Rhizoctonia bataticola* which causes DRR.

This pathogen is soil borne and can remain in soil even after several crop cycles. It is emerging as a major threat in central and southern India (major chickpea-growing regions), with disease incidence ranging from 5% up to half the area in badly affected regions. DRR can destroy all of a farmer’s crop in favorable conditions, but fungicide treatments are underdeveloped and expensive, making...
‘on-farm management’ using timely irrigation techniques, early sowing times, and early maturing crops the only major remedies available to farmers.

With the LAMP technique, infection can be detected with the naked eye. Once DNA is extracted from a suspected plant or soil sample, it is put into a small tube containing a specific enzyme mix and indicator reagent SYBR green or HNB. After being exposed to a temperature of 63°C for 60-75 minutes, the color of the mixture in the tube changes from yellow to orange or dark blue to sky blue only if the pathogen \textit{R. bataticola} is present.

The LAMP method is ten times cheaper than the lab test (70 cents per sample as opposed to a PCR reaction costing US$ 5-7). It does not require advanced skills unlike in existing methods, apart from DNA extraction. Highly sensitive, the test only needs a minimum DNA concentration of 10 fg, thus requiring little more than basic knowhow of DNA extraction. In addition, the reagents used are eco-friendly and non-mutagenic, making their use safe for both humans and livestock. Therefore, the LAMP technique can be used in remote places. ICRISAT scientists suggest developing portable LAMP toolkits for district-level farm extension centers, or Krishi Vigyan Kendras (KVKs), so that farmers can quickly access advice on proper pest management to combat DRR. And while the study was conducted mainly on DRR in chickpea, LAMP can be applied broadly for a large number of other important crops affected by this fungal pathogen.

Adoption of this affordable user-friendly test by farmers and local extension workers may prove crucial to combat this rampant plant killer. Efforts to scale up the use of this test and develop easy-to-use toolkits, along with basic training for extension workers can help prevent crop losses and ensure food security for millions worldwide.

The research was conducted under the CRP-Grain Legumes program at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) by Mamta Sharma, Raju Ghosh and Avijit Tarafdar and funded by the Department of Science and Technology (DST)-Climate Change Division, Government of India, and the Science and Engineering Board (SERB), Government of India.

For more information visit: https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-015-0997-z; http://epubs.icar.org.in/ejournal/index.php/IPPJ/article/view/71229/30115; or contact Dr Mamta Sharma at mamta.sharma@cgiar.org.

This work contributes to UN Sustainable Development Goals
Data-driven solutions to support smallholder farmers make climate-smart decisions

In order to keep up with the challenges of ensuring nutrition for growing populations, the need for specific and reliable data to mitigate risks to agriculture from climate change, and to include smallholder farmers as stakeholders in the data revolution, the Department of Biotechnology (DBT), India recently launched ‘FarmerZone’.

Envisaged as an intuitive and collective open-source cloud-based data platform for providing climate smart high-tech solutions to smallholder farmers, FarmerZone is targeted at improving the lives of farmers by catering to a variety of farming needs – from coping with climate change, weather predictions and soil, water and seed requirements, to market linkages to sell produce directly from the farm.

The DBT organized a Smart Agriculture Conclave between 29 August – 1 September 2017 in New Delhi to launch the platform and invite collaborations from leading international experts.

At the conclave, experts from private, public and non-profit sectors along with farmers, brainstormed implementable solutions and discussed their potential role in designing and developing FarmerZone. The main aim of this platform is to design a model that can be scaled up and applied across a number of different agro-climatic zones.

Dr Suhas Wani from ICRISAT highlighted the needs and challenges of smallholder farmers and explained how these can be overcome through specific and quality data. For example, soil analysis data is crucial for decision support tools and timely advice to farmers. Many smallholder farmers depend on rain for agriculture and they suffer when monsoon becomes erratic. ICRISAT scientists have successfully implemented a sowing app which informs the best time to sow, in partnership with Microsoft. This cloud-based real-time sowing app has already supported 150 farmers in making climate smart decisions.

While many such initiatives exist discretely, or even as joint public-private initiatives like Krishidoot which leverages the power of ICT for enhancing agricultural productivity, the challenge of providing smart agriculture solutions to 46 million farming families need a more consolidated effort by various actors. The DBT also aims to establish sentinel sites and delivery systems using artificial intelligence and machine learning to facilitate the accuracy of solutions to address the needs of farmers in real time.

The conclave was held in collaboration with the Research Council UK (RCUK) and the Biotechnology and Biological Sciences Research Council (BBSRC).

You can read the summary of the conclave here.

DBT’s FarmerZone will be an intuitive cloud-based platform that will collect, collate and curate field and remotely sensed data along with market intelligence to create smart agriculture solutions to smallholder farmers. A MarketZone will connect farm produce to viable markets.

International partners to this initiative are – The US Department of Agriculture; FAO; IDRC; ICRISAT; GODAN; Penn State University; John Innes Center UK; Innovate UK; University of Reading; The Roslin Institute; Department of Business, Energy and Industrial Strategy (BEIS); and Aberystwyth University.

These partners will collectively contribute knowledge and resources to the FarmerZone.

This work contributes to UN Sustainable Development Goals
Innovative ways of improving the livelihoods of dryland farm families in Africa and Asia through strategic investments in research was the theme of the Governing Board Meeting held on 25-27 September at ICRISAT-Patancheru. Issues discussed in depth included monitoring and evaluation, impact assessments and scaling up digital agriculture.

Speaking on the occasion, Dr S Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) and Member of ICRISAT’s Governing Board remarked, “India witnessed an all-time production high in pulses in 2017.” While the production increase was partly due to the expansion of land under pulses, it was boosted by the adoption of high-yielding varieties and cultivars. “ICRISAT’s efforts are much appreciated in the realms of crop research and collaboration with government bodies. Integrating breeding strategies and new areas of genomics is an important issue worldwide and for India, and we must move faster in this direction,” he emphasized. While underlining the importance of South-South collaboration between national programs and ICRISAT engaging in Africa, he said there was greater scope to work together with ICAR to fill technology gaps.

Dr Nigel Kirby, Chair of the Board, highlighted the importance of plant breeding. “It is important to relate genotypes that are in germplasm collections to phenotypes and mitigate risks to make plant breeding efficient and cost-effective, which at the end of the day should give enduring hope to smallholder farmers,” he said.

Engaging in groundbreaking crop research to increase production and productivity is an extraordinary feat but it should be done with the consumer in focus. Research should be demand driven, and in this context, Dr Mohapatra suggested ICRISAT adopt a ‘value chain’ approach. He recommended that ICRISAT take a long-term view on resource mobilization and look for support beyond 5-10 years. Dr Kirby welcomed the idea to initiate deeper deliberations on higher level resource mobilization.

A call for strategic investments to stay ahead in the game

The Governing Board was pleased to hear the CGIAR Research Program on Grain Legumes and Dryland Cereals Agri-Food Systems is now ‘fundable’. While final approval is pending, the program is aimed at transforming underperforming agri-food systems in the drylands into well-functioning systems. Dr Peter Carberry, Deputy Director General-General-Research made a presentation on the proposal.

Dr Carberry also presented options to develop and fund strategic initiatives, including the issue of patenting for royalties from important ICRISAT innovations like the cytoplasmic male sterile gene in pigeonpea that could be used by the private seed sector. The Board appreciated this discussion, as scientists were asked for new ideas for Blue Sky Research or other initiatives with a focus on development.

Research Program Directors Dr Ramadjita Tabo (West and Central Africa) and Dr Moses Siambi (Eastern and Southern Africa) explained how ICRISAT’s investment of $5 million from reserves as part of the Africa Strategic Fund was used to modernize its research facilities in sub-Saharan Africa. The Board appreciated the cost-effective improvements to provide modern facilities for ICRISAT staff and partners as well as supporting strategic staff positions to position ICRISAT for success. However, skill gaps still remain based on regional needs in the drylands that will be addressed through structuring regional programs, partnerships and building national capacity. Future research needs like tackling emerging pests, digital agriculture, nutrition and latest genomics approaches should be promoted so that either through in-house or through new partnerships, ‘ICRISAT research programs stay at the forefront of science for development for the drylands’.
Young researchers showcase innovative ideas for the drylands

Three young ICRISAT scientists had the opportunity to showcase their groundbreaking ideas and research in climate change adaptation and modernization of crop breeding programs.

**Dr Dakshina Murthy Kadiyala**, a systems modeling expert from the Innovation Systems for the Drylands research program explained how using location-specific rainfall data, his team created an Intelligent Sowing Advisory Tool (ISAT) piloted in the semi-arid Anantapur district, Andhra Pradesh in collaboration with Microsoft India.

ISAT is a messaging tool for smallholder farmers to minimize climate risks and maximize yields and incomes. Farmers receive real-time, location, crop and soil-specific advisories using seasonal, medium range and two-week forecasts in their local language.

ISAT is ready for scaling up with support from the Indian Ministry of Environment, with plans to transfer this technology to Africa as well. ISAT’s work would help shape climate-smart agriculture policies as mapping of climate risk exposure will provide strategic insights into, for example, where and when a shift from cotton and maize to millets and pulses would be much more beneficial.

Full presentation on ISAT

**Dr Lekha Pazhamala**, DST research grantee, has found a way to lower the cost of pigeonpea hybrid production by reducing the need from three to two hybrid lines. This was possible by finding which environmental factor controls the production of male sterile pigeonpea hybrid lines.

Using the Leasyscan’s phenotyping analysis, Dr Pazhamala identified 24°C day temperature as the threshold between fertility and sterility of pollen.

Cytological studies expose the crucial stage of dissociation of tetrads which does not happen in sterile pollen. Transcriptome analysis showed that auxin, a phyto hormone known for its role in plant growth plays a key role as auxin production at a temperature above 24°C cuts off sugar transport to the pollen, thereby starving it. Below 24°C, auxin production would result in proper nutrient transport and dissociation of tetrads.

The Board applauded this promising research as a perfect example of a fruitful ICRISAT investment in Blue Sky Research that will yield much more.

Full presentation on genomics for converting 3- lines to 2- lines

**Dr Srinivasan Samineni**, chickpea breeder in the Asia program, explained a breeding strategy to develop early-maturing chickpea that can escape terminal drought. This is important because the pulse is often grown on residual soil moisture, for instance in rice fallows, way after rice harvest. Flowering time was reduced from 60 to 20-28 days as genomic regions controlling early flowering were mapped. Multi-parent advanced generation inter-cross (MAGIC) populations were screened for different traits including height, yield, and harvest index or seed size from 1,200 lines to 4 promising lines, which will be shared with ICRISAT’s national research partners.

This result can be strategically exploited given the high demand for chickpea. Dr Samineni talked about the **machine harvestable chickpea variety** released in 2016 which has high demand by farmers due to increased profitability.

Full presentation on accelerated chickpea breeding
Impact assessment

Given that the process link between evidence and decision making is crucial for research organizations, findings from three ex-post impact assessment studies conducted in 2017 were presented by Kizito Mazvimavi, Country Representative - Zimbabwe.

The UK Aid-funded impact study on the role of conservation agriculture in building drought resilience in Southern Africa and impacts from the Hybrid Parents Research Consortium on pearl millet in India were also mentioned.

From November, under the Tropical Legumes III project, ICRISAT will use DNA tracers to assess the adoption rate of improved chickpea varieties in Ethiopia.

Kizito Mazvimavi stressed that ICRISAT needs official peer-reviewed publications to maintain credibility. To ensure unbiased impact assessments, studies must be done by external consultants, usually 4-5 years after a project is completed. ICRISAT is committed to ensuring such studies are funded and done thoroughly. Dr Wendy Umberger, Director - Global Food Studies said, “ICRISAT has to allocate a side-budget for these impact studies. The Board needs to see what is the ICRISAT process; we cannot step away from it and it should be considered a strategic investment.”

Digital agriculture

Three promising case studies on how digital agriculture is transforming the drylands were discussed. Ram Kiran Dhulipala, Head - Digital Agriculture and Youth, presented ihub incubatees – Kalgudi (from Vasudhaika), the “LinkedIn” for agricultural communities; Khethinext (from PALS Global) helping farmers better access finance, markets, inputs and knowledge through an e-commerce network; and Plantix, a plant pest identification mobile App that provides highly accurate solutions to plant diseases and pests and the nearest agro-shops selling appropriate inputs to treat pests and disease.

The importance of real-time monitoring and evaluation in assessing project results was highlighted in a presentation on ‘Modernizing M&E – Measuring for Big Impacts’, by Satish Nagaraji, Manager- Digital Agriculture (M&E and Tools).

The Digital Agriculture team of ICRISAT, in partnership with ihub incubates, has designed and developed modern ICT-based monitoring and evaluation tools to collect quality data with real-time tracking, actionable insights for course correction and implementation. These systems use Android-based smartphone applications to capture and transmit crucial data, photographs and geotags. A web-based multi-layered dashboard will share evidence-based impacts among various stakeholders, including donors.
Field visits

The Board took the opportunity to visit ICRISAT’s fields and see how the institute is modernizing its plant breeding programs. Some observations from our Board members:

“The quality of land, the way it’s being managed and the high quality of trials are commendable. Science is about quality and what we saw was quality, which helps harness our capability in plant breeding. Smallholder farmers hope for a better life and I believe that’s possible by introducing better varieties and science can play a major role in building that hope.”

*Dr Nigel Kirby*
Chair, ICRISAT Governing Board

“ICRISAT’s digitization and modernization of breeding programs is impressive and can have high impact in all regions. This is why it is crucial to have an assessment of the breeding programs as a way of continuously improving it.”

*Dr Rachel Chikwamba*
Member, ICRISAT Governing Board

Smart Food Endowment Fund

The Governing Board approved the establishment of a Smart Food Endowment Fund. This will escalate ICRISAT’s Smart Food initiative to a higher level after it gained significant global traction and support. This initiative has been selected by LAUNCH Food as one of the winning innovations for 2017.

Setting up the Endowment Fund is dependent on a business plan being developed and strategic partners will be sought to lead this initiative globally.

The Board celebrates the successful decoding of the pearl millet genome

The analysis of genetic variability among a thousand pearl millet lines has led to a better understanding of the ability of this dryland cereal to survive soaring temperatures (over 42°C) and its exceptional drought tolerance. This path breaking research was co-led by ICRISAT, BGI-Shenzhen, China and the French National Research Institute for Sustainable Development (IRD).
Modernizing ICRISAT’s crop improvement and breeding programs – Field visit photo essay

Hope for smallholder farmers – A word from ICRISAT’s Board Chair Nigel Kirby

Scaling up – How do we ensure innovations benefit farming communities – Rachel Chikwamba
Accelerating Africa’s Path to Prosperity: Notes from AGRF 2017

The 7th African Green Revolution Forum (AGRF) held in Abidjan, Côte d’Ivoire, between 4-8 September 2017, brought together public, private and non-government sectors to build collaborations towards the common objective of making smallholder farming in Africa profitable. This year’s meeting on inclusive economies and driving employment through agriculture saw a high-powered congregation of over 750 participants, among whom were several Heads of States, ministers of agriculture, representatives of development agencies, donor and private sector representatives, and farmer and civil society associations.

Several important reports were launched at the forum: the 2017 Africa Agriculture Status Report (ASSR) from the Alliance for a Green Revolution in Africa (AGRA) discussed the changing nature of agriculture, focusing on diversity amongst smallholder farmers. It underlined the importance of recognizing that different farmers require diverse types of assistance, and the need to intensify agriculture sustainably while placing smallholders at the center of value chains.

The Malabo-Montpellier report on nutrition (2017) highlighted the achievements of the last 15 years with respect to the fight against hunger. Between 1990 and 2015, hunger dropped from 27.6% to 20% in Africa, but better coordination between programs, and investments in nutrition-impact assessments are required to make further gains to ensure nutrition for all. The report also flagged the need to intensify efforts towards biofortification for improved nutritional outcomes, and asked partners to promote access to education on nutrition.

In tandem with the forum, the African Development Bank (AFDB) organized a consultation to discuss its flagship program, the Technologies for African Agricultural Transformation (TAAT) framework, at its headquarters on 8 September 2017. Contributing partners of the program, including the International Institute for Tropical Agriculture (IITA), ICRISAT, the World Bank, the International Fund for Agricultural Development (IFAD), and the Bill & Melinda Gates Foundation (BMGF) were invited, among others.

The TAAT framework stresses on the deployment of context-appropriate, proven agricultural technologies to reach actors along different commodity value chains in order to achieve rapid agricultural transformation across Africa. It seeks to raise agricultural productivity along eight Priority Intervention Areas (PIAs), with ICRISAT leading the development on the intervention on Food and Nutrition Security in the Sahel.

As the executing agency (with other CG centers), IITA and other key implementing agencies pushed for a revised Protocol of Agreement during the consultation. Further it was decided that the Feed Africa Flagship Program - TAAT will be launched during the Borlaug Dialogue International Symposium at the World Food Prize event in Iowa.

AGRF 2017 also highlighted the potential of using new technologies like digital tools and remote sensing for climate-crop advisories, and the use of cloud to improve knowledge-sharing and market linkages to transform African agriculture. Read reports from the conference here.
Knowledge sharing helps groundnut farmers in Uganda

Mrs. Leonora Okidi, a farmer of Pader district in Uganda, is delighted with her harvest. She is part of a group of farmers who participated in two field days held in Pader and Alero Nwoya districts conducted on 15 and 17 August as part of the Tropical Legumes III project. Leonora has been a beneficiary of using improved groundnut varieties Serenut 5R and 9. “I divided my five acres of land between the improved varieties over 2 acres and local variety Red beauty over 3 acres. After the rosette virus wrecked the local variety I had planted, I abandoned it. The improved varieties were able to withstand the virus. I was impressed. Now my groundnut crop is able to feed and school my 11 biological children and support 25 other dependents,” she declares.

Groundnut is an important legume in Uganda, and ranks second after beans as a source of dietary protein. The two field days brought together different stakeholders along the crop’s value chain, including officials from the local government, agricultural and commercial officers, NGOs (including ZOA, Lutheran World Federation, World Vision, GGAO and Food for the Hungry), traditional and religious leaders, researchers from NaSARRI and NARO, and local media (Luo FM), in addition to farmers.

At Pader, three separate sites were chosen: (i) demonstration plots sown with Serenut 1-14 series: these were farmer participatory variety trial plots for groundnut lines undergoing National Performance Trials (NPTs) for wide adaptability, (ii) multiplication fields of Serenut 5R, 8R and 9T varieties, and (iii) a local farmers’ field cropped with both the improved varieties of Serenut 5R and 11T alongside Red beauty, a popular local cultivar. Meanwhile, three blocks of seed multiplication sites sown with Serenut 9T (Aber), Serenut 14R and Serenut 5R served as learning materials at Alero Nwoya. All varieties involved lines developed by ICRISAT and on each field, the crops were nearing physiological maturity.

Challenges discussed by farmers

The field days allowed participants to exchange their experiences, discuss beneficial agronomic practices, and learn more about different seed varieties and sources. Farmers discussed the challenges posed by the groundnut rosette virus, which had caused severe damage amongst fields sown with landraces and seeds bought from local markets.

At Alero Nwoya, Mrs. Adong Christine from the Makmukemi group recounted how she had borrowed $7000 from the bank and planted 20 acres with local varieties of groundnut, but could only manage to harvest 2 bags (from potential 400 bags) due to crop damage.

Participating farmers and researchers shared many such experiences, learning from one another to exchange insights. They freely uprooted samples from the various improved varieties to see for themselves their yields, stay green traits, resistance to both late leaf spots and the rosette virus. Some of the immediate outcomes of the field days were:

- Visiting farmers bought small seed packs (0.5kg, 1kg, 2kg, 3kg) of improved varieties on spot, conveniently sized for immediate adoption.
- The crop’s near physiological maturity was timely as it helped farmers who had suffered damage on their crop of local varieties take hope; the event saw enhanced adoption of improved varieties to replace their damaged crop.
- Researchers from NaSAARI received requests from farmers to adopt their fields for research on improved varieties and as seed multipliers.
- Farmers sought the help of ZOA, the sponsoring NGO, for further training and frequent monitoring.
- Dissemination materials detailing good agronomic practices, pre-and-post harvest requirements, and the sources and benefits of improved seed varieties were explained and distributed among participating farmers.
A woman farmer carries small packs of the seed (1kg) as others continue buying in the background in Alero Nwoya District.

The Pader event, hosted by Green Globe Agriculturalists Organization (GGAO), was attended by 102 participants with 34 women farmers while the Alero Nwoya field day, organized by the Loyo Kwo Groundnut Seed Producers’ Group, attracted 61 participants drawn from 24 farmer groups, with nearly half the participants being women.

Project: Tropical Legumes III
Funder: Bill & Melinda Gates Foundation
Partners: Green Globe Agriculturalists Organization (GGAO), Loyo Kwo Groundnut Seed Producers’ Group, ICRISAT (Leader), CIAT, IITA and National Agricultural Research System (NARS) partners National Semi-Arid Resources Research Institute (NaSARRI) of the National Agricultural Research Organization (NARO), Uganda

This work contributes to UN Sustainable Development Goals
Nearly 55% of India’s population depends on agriculture for their livelihoods. However, the share of agriculture in the GDP has declined over the last five decades, with widening income disparity between the agricultural and non-agricultural sectors. To address this disparity, the Committee on Doubling the Farmers Income was set up by the Department of Agriculture, Cooperation & Farmers Welfare, Government of India, in April 2016.

Dr Ashok Dalwai, Chair of the Committee on Doubling the Farmers Income, and CEO of the National Rainfed Area Authority (NRAA), paid a visit to ICRISAT’s Patancheru campus on 7 September 2017. Addressing ICRISAT’s scientists, Dr Dalwai brought attention to the 14 volumes of “Strategy for Doubling Farmers’ Income by 2022” being published by the Department of Agriculture, Cooperation & Farmers Welfare. He invited feedback on the four volumes now published as drafts on the Department’s website, in addition to suggestions for the remaining volumes.

Scientists highlighted insights from ICRISAT’s projects and agro-ecological interventions, and the need to account for climate change impacts like increasing water scarcity and land degradation. They also stressed the development of agri-entrepreneurship and market linkages, and the value of investment in digital innovations for smallholders.

Dr SP Tucker, Ex. Chief Secretary, Government of Andhra Pradesh, and Advisor to the Chief Minister of Andhra Pradesh, also sent his comments on the strategy documents – which were presented by Dr Suhas P Wani, Regional Program Director – Asia Program, ICRISAT.

In closing, Dr Dalwai made note of ICRISAT’s commitment to achieving the Prime Minister’s vision, and invited the scientists to send any other feedback on the strategy documents through email. He conveyed his regard for Director General David Bergvinson, and thanked ICRISAT for organizing the session.
How to scale up the initial success of crop-livestock innovation platforms in Zimbabwe?

Goats and cattle are crucial for the livelihoods of dryland smallholder farmers of Zimbabwe, in particular during hard times. Yet, livestock is not well kept. Goats are left to browse deteriorated rangelands, while cattle are traditionally fed on nutritionally deficient cereal residues. Recurrent crop shortages affect feed quantity and quality, especially during the dry season. This is insufficient to maintain animal health or to sell the livestock at the market for a good price.

ICRISAT, ILRI, CIMMYT and Matopos Research Institute worked for 5 years with farming communities of Gwanda and Nkayi districts in Zimbabwe, under the ZimCLIFS project, funded by the Australian Center for International Agricultural Research, to introduce legume fodder crops like Mucuna as a solution for better livestock feed, and to improve market linkages for farmers to benefit from better livestock productivity. The approach used to identify pathways to improve smallholder food production and incomes, and facilitate farmers’ uptake of innovations was to set up agricultural innovation platforms (IPs).

During the ZIMCLIFS closing workshop that took place on 18 and 19 September in Harare, researchers, government representatives, farmers and other major project stakeholders looked back at the lessons learned on how farmers take ownership of the innovation processes within AIP, and how initial successes of pilot innovation platforms could be scaled up and out.

Sabine Homann-Kee Tui, senior scientist at ICRISAT Bulawayo, explained the rationale of using IPs to improve small farmers’ livelihoods. “The innovation platform provided a space for experimental co-learning which helped farmers to self-organize their farming system to increase their production and incomes. It initiated a dialogue between farmers and goat traders and farmers understood the link between good feeding and animal health and the impact on goat prices.”

Through IPs, lead farmers were identified and trained on-farm on integration of crops and livestock, marketing and self-organization. Mucuna, a legume fodder, was chosen across the sites because it fitted seamlessly in their farming systems. Farmers’ own field trials demonstrated that mucuna improves soil fertility when planted in rotation with cereals, and also reduces Striga infestation. As meat quality increased, goats fetched farmers better prices; goat value rose by about tenfold, from US$ 8 in 2006 to US$60-80 in 2015.

Investing in IPs and combining a participatory farming system analysis with better market linkages can lead to positive change in the drylands and aid in future climate adaptation, and is definitely worth scaling up and out.

Multiple benefits from Mucuna, even on poor soils, and under unfavourable climatic conditions.
FAO’s Regional Meeting on Agricultural Biotechnologies in Sustainable Food Systems and Nutrition in Asia-Pacific, held in Kuala Lumpur, Malaysia from 11-13 September 2017 stressed the significance of improving access to biotechnologies to improve food security and fight poverty. Even though smallholder farmers inhabit the world’s hungriest and most populous regions, they are often left out of the conversation on new technologies. The regional meeting noted that debate on the use of genetically modified organisms (GMOs) continues to monopolize popular discourse on biotechnology. However, a more holistic approach using wider range of low- to high-tech solutions in the biotechnology toolbox would prove a more useful approach for scientists and policy makers in the region.

Dr Rajeev Varshney from ICRISAT was one of the 15 members of the external Advisory Panel of internationally recognized experts to provide advice and guidance to the Task Force on these biotechnologies. He made two presentations; one, on the “Status and challenges regarding use of agricultural biotechnologies in the crop sector” and another on “Pulses for improved nutrition and the role of biotechnologies.”

He highlighted India’s need to adopt agricultural biotechnologies to feed a growing population of 1.3 billion. Significantly, he noted that “farmers make their own decision to choose biotechnologies of their own interest”.

The meeting was attended by over 200 delegates from 39 countries representing governments, policy makers, scientists, NGOs, FPOs, farmers etc. Read the report here.

This work contributes to UN Sustainable Development Goals.
Increasing participation of women and youth in chickpea value chain in Ethiopia

Aiming to change the historically low representation of women in the chickpea and lentil value chains in Ethiopia, the Ethiopian Institute of Agricultural Research, along with ICRISAT* and ICARDA#, has devised strategies to encourage women to participate in the Chickpea Improvement Program at the Debre Zeit Agricultural Research Center (DZARC).

The two-pronged strategy is as follows:
1. To organize women and youth into associations and provide them with skills and knowledge about chickpea seed and grain production
2. To establish seed production clusters with the women and youth and link them with seed laboratories for certification

In Ada’a Woreda (Ethiopia’s largest chickpea-producing region), three Peasant Associations (PAs) were formed with 128 women (22 youth (<25 years of age) formed another PA). DZARC organized a training workshop for 95 women on the benefits of improved seeds, modern production practices, local and export market potential, technical support and more. Each participant was then given 30-35 kg of chickpea seeds as a revolving loan: each farmer would grow crops using the seeds along with help from District Bureaus of Agriculture and DZARC. Once harvested, they would share 30-35 kg of the harvested seed with other members of the PAs.

Subsequently, five women members per PA would be selected to conduct farmers’ participatory variety selection (FPVS) trials on their farms, which would act as learning centers for other women evaluating and selecting varieties, based on their criteria and preferences for further testing on their own farms. The selected fields would be used to assess and monitor the women’s performance compared to plots owned by men in the same area as part of gender yield gap studies.

Finally, the PA groups would be connected to seed quality laboratories for inspection and certification, so that the seeds could be marketed as certified seed.

Future plans
The ultimate goal is to empower women and youth to specialize in seed production, value addition and marketing of chickpeas. Data obtained by monitoring the gender indicators – knowledge, land and labor access, decision making, access to markets and benefits sharing – could be used to design more effective interventions.

*ICRISAT, through the Tropical Legumes III project supports the chickpea breeding and seed dissemination activities

#The International Centre for Agricultural Research in the Dry Areas is supporting a community seed production initiative

This work contributes to UN Sustainable Development Goals

Partners: Ethiopian Institute of Agricultural Research (EIAR); The International Centre for Agricultural Research in the Dry Areas (ICARDA)
Brainstorming in Burkina Faso to meet farmers’ need for better seeds

Visit to TL III groundnut trials at Gampela, Burkina Faso. Among the visitors were Dr Ramadjita Tabo, Regional and Research Program Director, ICRISAT West and Central Africa; Dr Clarisse Barro, sorghum breeder; Dr Roger Zangre, Pearl millet breeder and HOPE II National Coordinator; Dr Korodjouma Ouattara; Dr Amos Miningou, groundnut breeder and TL III National Coordinator; Dr Chris Ojiewo, TL III Project Coordinator; Dr Hamado Tapsoba, Hope II Project Coordinator.

Improving genetic gain and strengthening the production and delivery of improved varieties of pearl millet, sorghum and groundnut were the focal points of discussion between partners of two projects – HOPE II (Harnessing Opportunities for Productivity Enhancement for sorghum and millets in sub-Saharan Africa, phase 2) and TL III (Tropical Legumes phase 3). The two project teams from ICRISAT visited the Institut de l’Environnement et des Recherches Agricoles (INERA-Burkina Faso) to discuss the achievements, challenges and adjustments required to meet farmers’ needs.

- They witnessed on-station evaluation of 100 genotypes of sorghum (from ICRISAT Kenya) at the INERA research station at Saria (80 km from Ouagadougou, Burkina Faso) as part of the HOPE II project. These new varieties are more resistant to stresses such as Striga, drought and anthracnose.
- TL III activities contributed to improving the national breeding program in Burkina Faso for new groundnut varieties tolerant to foliar diseases, aflatoxin and drought. The project enabled Farmer Participatory Varietal Selection and community seed production by setting up three multi-stakeholder innovation platforms in major groundnut production areas.
- Training on Breeding Management System (BMS) strengthened trial design as well as data collection, management and analysis. New biotechnology tools in the sorghum and pearl millet breeding programs include the use of Marker-Assisted Selection (MAS) and germplasm genotyping for specific traits.
- Preliminary tests of yellow grain millet under Hope II aim to test performance of new high-yielding and nutritious yellow lines to meet farmer’ needs.

Positive impact on gender

In 2016, there were 42 women groundnut seed producers in Burkina Faso. In 2017, about 180 women are now producing community seed on at least 0.25 ha each. This number is expected to increase in the coming years. There are also more individual seed producers that are producing certified seeds.

Dr Jeff Ehlers, Program Manager, Bill & Melinda Gates Foundation, urged both projects to realize the importance of data, stressing, “There is need to gather high-quality data, including data that will enhance our understanding of the trends, particularly on the gender dynamics”.

Key takeaways

- Rotation plans between cereals and legumes as well as intercropping activities to be included. Crop rotation on both projects sites would help increase the quality of the soils.
- Higher investments needed for training young scientists and students as part of ensuring sustainability.
- Research should have measurable impact on smallholder livelihoods.
Harnessing Opportunities for Productivity Enhancement (HOPE II) for Sorghum and Millets in sub-Saharan Africa

**Funder:** Bill & Melinda Gates Foundation

**Partners:** Institut de l’Environnement et Recherches Agricoles (INERA), Burkina Faso; Institut d’Economie Rurale (IER), Mali; Institute for Agricultural Research (IAR) of Ahmadu Bello University (ABU) and Usman Danfodiyo University of Sokoto (UDUS), Nigeria; Ethiopian Institute of Agricultural Research (EIAR), Ethiopia; Department of Research and Development (DRD), Tanzania; National Semi-Arid Resources Research Institute (NaSARRI) of the National Agricultural Research Organization (NARO), Uganda.

**Tropical Legumes III (TL III)**

**Funder:** The Bill & Melinda Gates Foundation

**Partners:** International Institute of Tropical Agriculture (IITA); International Centre for Tropical Agriculture (CIAT); INERA, Burkina Faso; Institut d’Economie Rurale (IER), Mali; Institute for Agricultural Research (IAR) of Ahmadu Bello University (ABU), Nigeria; Savanna Agricultural Research Institute (SARI), Ethiopian Institute of Agricultural Research (EIAR), Ethiopia; Department of Research and Development (DRD), Tanzania; National Semi-Arid Resources Research Institute (NaSARRI) of the National Agricultural Research Organization (NARO), Uganda; Indian Institute of Pulses Research (IIPR)-India

This work contributes to UN Sustainable Development Goals.
Enabling Tanzanian common bean farmers with resources and market linkages

Over 300 farmers attended a farmer’s field day in Northern Tanzania to learn about quality seed of improved common bean varieties, best agronomic practices and latest technologies which would help boost production, productivity, as well as improve the quality of beans produced. This was part of the Tropical Legumes III project led by ICRISAT to improve inputs and market opportunities for common bean farmers.

Farmers gathered information, expanded their networks and learned about making agriculture sustainable and profitable. They were provided information on:

- How to control disease infestation and insect invasion to the crop
- How to utilize land efficiently by optimal spacing
- How much fertilizer/herbicide/insecticide to apply and how frequently
- Why improved variety seeds were cost-effective in the long run
- How beans could be used in various kinds of dishes (recipes)
- How to minimize post-harvest losses and maximize profits
- How small seed packs are better aligned to the needs of smallholder farmers.

The field day served to inform common bean farmers about increased opportunities and possibilities in farming, including benefits of improved seeds, market value of processed foods, and advantages of shared knowledge in a networked value chain.

The field day was organized at the Agriculture Seed Agency (ASA) seed farm at Ngaramtoni, Arusha, and was attended by 341 participants including seed companies, farmer groups (175 women, 129 men) extension agents and public organizations. Remarkably, there were more women than men present at the field day, presumably due to conscious efforts by the Tropical Legumes III project to include more women in their projects. Several new improved bean varieties such as Lyamungu 90, Lyamungu 85, Jesca, Njano Uyole and Uyole 96 were displayed to the farmers and other stakeholders.

Partners: The International Centre for Tropical Agriculture (CIAT), Selian Agriculture Research Institute, Uyole Agricultural Research Institute, Agricultural Seed Agency (ASA), Tanzania, Meru Agro, The Beula Seed Company Limited

Funder: Tropical Legumes III

Farmers listening to advice from ASA/SARI staff on growing beans with better yield. Photo: Shida Nestory

This work contributes to UN Sustainable Development Goals

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
8. Decent Work and Economic Growth
13. Climate Action
17. Partnerships for the Goals
ICRISAT’s Seed Systems: Models and lessons learned

ICRISAT’s Seed Systems: Models and Lessons Learned booklet explains the rationale of ICRISAT’s work on seed systems in the drylands, the different approaches and their impact on the ground. Improving farmers’ access to improved seeds in the drylands is seen as a cost-effective strategy to improve farm productivity and food security. Different models of seed systems are tested and developed by ICRISAT and its development partners in sub-Saharan Africa and Asia depending on the local context. It includes small seed packets, groundnut seed revolving fund in Malawi, support to community-based systems, farmer seed organizations or local seed ventures, and public-private seed partnerships like the Hybrid Parents Research Consortium for pearl millet and sorghum in India. ICRISAT’s vision on seed systems is demand-driven, holistic and working in partnership, along the crop value chain.

OAR link: oar.icrisat.org/10195