ICRISAT

Annual Report

2023

Celebrating INTERNATIONAL YEAR OF MILLETS 2023

Foreword

Message from the **Director General**

I am honored to present ICRISAT's annual report showcasing some notable developments made throughout 2023. This year holds profound significance for ICRISAT as it commemorates the International Year of Millets - a tribute to the grain that embodies our proud 50-year legacy of pioneering advancements in climate-resilient, nutritious and productive dryland agriculture.

I wish to extend my appreciation to the Government of India for its visionary advocacy in securing 2023 as the United Nations Year for raising awareness on millets. India's efforts to elevate the prominence of this humble grain on the global stage not only highlights the nation's leadership in agricultural innovation but also its role in driving transformative changes in dryland agrifood systems.

These endeavours, of course, are not undertaken in isolation. They reflect a collaborative spirit within the Global South, with agro-innovations from across Africa surpassing what could be achieved through efforts alone in Asia, highlighting the power of cooperation.

This deeply inspires us at ICRISAT, as our work in the development of dryland cereals and legumes and agri-innovations, more broadly, transcends mere scientific inquiry. We innovate to provide food and nutrition security to the billions of people living in drylands. Here, millets and legumes sustain lives and livelihoods, serving as a lifeline in the battle against hunger and malnutrition. Notably, these practical outcomes contribute to the Sustainable Development Goals on multiple levels.

The year has also allowed us to demonstrate the power of our own institutional partnerships in advocating for the global community to focus on the importance of millet. Aside from national governments, we have been honored to draw upon our enduring partnership with the Food and Agriculture Organization of the United Nations and other bodies tasked with promoting and mainstreaming millet to empower smallholder farmers, foster sustainable development, eradicate hunger, address climate change, support biodiversity, and revolutionize agrifood systems.

Finally, ICRISAT's Governing Board decision to join the One CGIAR Unified Governance positions the Institute to accelerate these goals. It is envisaged that this strategic alignment will result in significant mutual benefits across the entire research arena, and we look forward to extending our collaboration.

On behalf of ICRISAT, I thank all our stakeholders, partners, collaborators, and supporters for their steadfast commitment to our mission. Collectively, we will continue to sow the seeds of progress, ensuring a more just and sustainable future for this generation and those to come.

Dr Jacqueline Hughes
Director General, ICRISAT

Message from the **Governing Board Chair**

The year 2023 marked a significant milestone for ICRISAT on multiple fronts. The resolution passed by the Governing Board, signaling our intention to join the One CGIAR integrated partnership, followed by our subsequent participation, solidifies our formal reintegration into the CGIAR family.

We are encouraged that this partnership will empower ICRISAT to further enrich its impactful contributions while facilitating the exchange of expertise and resources with the foremost alliance of agricultural research organizations globally.

This step also underscores the importance of collaboration, recognizing that the pervasive and complex challenges of our time, notwithstanding climate change, new geo-political posturing and other impacts — particularly affecting dryland agriculture in the Global South — are best met through unified efforts.

It epitomizes the strength of partnerships, a core principle deeply ingrained within ICRISAT's ethos. For the past 50 years, our achievements have been propelled by our collaborative approach, working hand in hand with partners to harness scientific research in tackling the formidable challenges posed by dryland agriculture.

From the development of improved crop varieties in our advanced laboratories to innovative landscape management to the promotion of good public policy, our mission is defined by individuals who steadfastly believe in the transformative potential of equitable living standards, with nutrition and food security at the forefront.

With this in mind, I join my fellow Board Members in extending heartfelt congratulations to the Government of India for its steadfast advocacy, culminating in the designation of 2023 as the United Nations International Year of Millets. This recognition serves as a global validation of the significant nutritional and food security contributions of this grain.

Few organizations in the sphere of global agricultural innovation have wielded as profound an influence on millet development and advocacy as ICRISAT. As such I also extend my sincere gratitude to its leadership and staff for their pivotal role, alongside the FAO and other valued partners, in the successful execution of this Year. It serves as a timely reminder and celebration of our collective impact in the drylands of Africa, Asia, and beyond.

In conclusion, I am reminded that the select achievements presented in this report are made possible by the generous contributions of our stakeholders, partners, and collaborators. In the spirit of collaboration and shared purpose, I extend my deepest gratitude to you, for your invaluable support and unwavering commitment to our vision of a better future for the drylands and those who call it home.

Prof. Prabhu Pingali
Chair, ICRISAT Governing Board

ICRISAT thanks its donors, partners and supporters for enabling us to keep delivering the innovations that overcome hunger, malnutrition, poverty and environmental degradation for the 2.1 billion people who reside in the drylands of Asia, sub-Saharan Africa and beyond.

Contents

2023 Highlights

ICRISAT signs the CGIAR Integrated Framework Agreement, to join the One CGIAR Integrated Partnership.

ICRISAT joins the FAO and the Government of India to celebrate the International Year of Millets 2023 at the opening ceremony held in Rome. (see page 18)

ICRISAT joined the India Pavilion and AgriFood Pavilion for panel discussions and featured millets and millet products at the COP28 showcase corner.

The ICRISAT genebank deposits 96% of its collection at the Svalbard Global Seed Vault in Norway. (see page 28)

ICRISAT wins the prestigious UNDP Mahatma Award 2023 for its work in Bundelkhand, India.

The food processing unit in Koraput district, Odisha, designed and implemented by ICRISAT and the Government of Odisha recognized as the 'Best Millet Processing Unit' at the International Millet Convention held in Bhubaneswar. (see page 47)

ICRISAT joined the 3rd Agriculture Deputies Meeting & G-20 Agriculture Ministers Meeting held at Hyderabad.

ICRISAT and the Ethiopian Ministry of Agriculture's Landscape Segmented Fertilizer Advisory Tool, Supported by CGIAR's EiA Initiative, is helping Ethiopian farmers to significantly improve their yield in sorghum, teff, and wheat. (see page 32)

ICRISAT partners with FAO Saudi Arabia to boost the country's cereal production.

Pearl millet and sorghum seed kits were distributed in areas of Niger and Chad suffering seed loss caused by drought and exacerbated by the conflict in Ukraine. (see page 28)

2023 Highlights

176
active projects across

33
countries

Nigeria
3
3

India
7
1

Active project locations:

- Asia
- Africa
- Australia
- North America
- South America
- Europe

Varieties released using ICRISAT-supplied germplasm and breeeding material

- Sorghum
- Pearl millet
- Small millet

Corporate

ICRISAT Governing Board Members

Prabhu Pingali
Chair, ICRISAT Governing Board
USA

Himanshu Pathak
Vice Chair, Secretary, Department of Agricultural Research and Education & Director General, ICAR, India
(Ex officio member)

Manoj Ahuja
Secretary, Ministry of Agriculture & Farmers Welfare, India
(Ex officio member)

Jacqueline Hughes
Director General, ICRISAT
(Ex officio member)
UK

Somesh Kumar
Chief Secretary of the State of Telangana, India
(Ex officio member, until Jan 2023)

A Santhi Kumari
Chief Secretary of the State of Telangana, India
(Ex officio member, from Jan 2023)

Yilma Kebede
Chair, Program Committee
Ethiopia

Lindiwe Sibanda
Chair, CGIAR System Board
Zimbabwe

Patrick Caron
Vice Chair, CGIAR System Board
France

Alice Ruhweza
Member, CGIAR System Board
Uganda

Shenggen Fan
Member, CGIAR System Board
China

Folasade Ogunde
Chair, Audit and Risk Committee
Nigeria

Cathy Reade
Chair, Corporate Governance Committee
Australia

Bonnie McClafferty
Member, Audit and Risk Committee
USA

Regine Andersen
Member, Corporate Governance Committee
Norway

Yaye Kene Gassama
Member, Audit and Risk Committee
Senegal

Laurie Tollefson
Independent Member (until Apr 2023)
Canada

Jim Godfrey
Chair of Finance, Operations and Resource utilization Committee (until Oct 2023)
UK

Hilary Wild
CGIAR System Board
UK / Ireland

Neal Gutterson
CGIAR System Board
USA

Alyssa Jade McDonald-Baertl
CGIAR System Board
Australia

Corporate Service Directors

ICRISAT's Corporate Services Division ensures the seamless operation of ICRISAT's mission. The division supports all departments, allowing them to concentrate on their primary tasks while overseeing essential functions such as Human Resources, Communications, Finance and Business Development.

Sanjay Agarwal
Assistant Director General

Angshu Sengupta
Deputy Director General

Lydia Murimi
Business Development

Kunal Sarkar
Human Resources

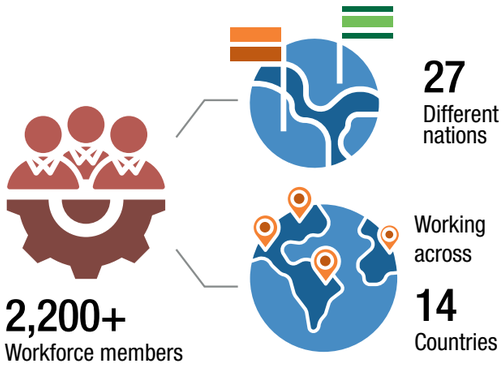
Ramon Peachey
Communications

Human Resources

In the past year, ICRISAT has continued to invest in its human capital, recognizing that our workforce is integral to achieving our organizational goals. With over 2,200 workforce members from 27 different nations, our diverse team hails from around the globe to deliver on our mission. Efforts to enhance staff retention have been evident through strategic interventions in organizational development and compensation and benefits. Notably, pay scales were revised globally following a comprehensive salary review.

Capacity development remains a priority for the Institute, with over 21% of staff members benefiting from internal career progression opportunities. In a pioneering move, ICRISAT successfully conducted its first-ever election for the Global Staff Council, ensuring representation from all job grades and locations. This platform empowers staff to voice their opinions and ideas, facilitating formal consultation on critical organizational matters.

A thriving organizational culture is essential for maintaining staff morale and engagement. ICRISAT remains committed to fostering a positive work environment through ongoing efforts in culture building, learning and development, and diversity and inclusion initiatives. Strategic recruitment efforts have strengthened senior management and leadership cadres, focusing on achieving gender balance.



Business Development

In 2023, we maintained strong partnerships with 70 collaborators and embarked on 58 new projects, bringing our total active projects to 176. These initiatives reflect our ongoing commitment to advancing sustainable agricultural solutions and driving positive change in dryland regions.

Partnerships form the cornerstone of ICRISAT's approach to developing sustainable and impactful solutions. By fostering interdisciplinary collaboration, we leverage our globally recognized team of agriculture and food scientists alongside strategic partnerships with governments, research institutions, philanthropic organizations, NGOs, the private sector, and development practitioners. These alliances amplify the reach and impact of our work, enabling us to scale evidence-based interventions and drive lasting change in dryland agri-food systems.

Over the past five decades, our collaborative efforts have been instrumental in promoting resilience and prosperity in the communities we serve. We extend our sincere appreciation to our funders and partners for their invaluable support, which has empowered smallholder farmers in drylands to tackle poverty, hunger, malnutrition, and environmental degradation through efficient, sustainable, and profitable agriculture.

ICRISAT and the Indian Oilseeds & Produce Export Promotion Council collaborate to boost India's oilseed production.

ICRISAT and Zuari Farm Hub Limited unite to enhance digital innovations in India.

A delegation from the Embassy of the Kingdom of the Netherlands to Mali discuss avenues for deeper cooperation with ICRISAT's West and Central Africa Regional Office.

ICRISAT and Haryana Agricultural University collaborate to advance agricultural research and training in the state.

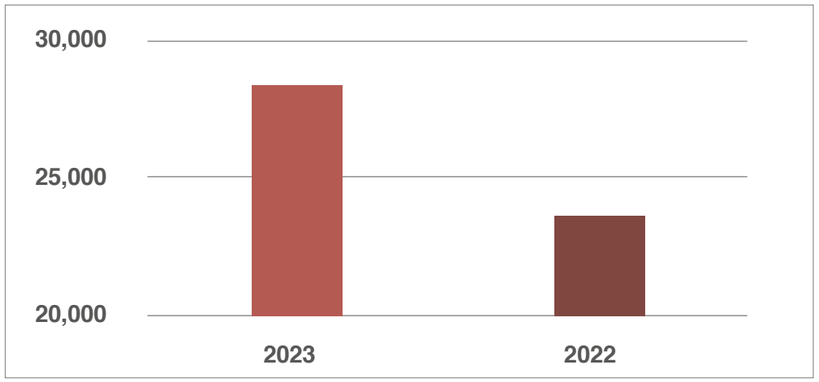
Finance

Financial Summary

US$ thousands

	2023	2022
Assets		
Investments, Cash and Cash equivalents	9,265	11,687
Current Assets	25,558	23,242
Property, Plant and Equipment	17,615	7,134
Other Non Current Assets	1,935	2,319
Total Assets	**54,373**	**44,382**
Liabilities		
Current Liability	15,184	12,558
Net Assets		
Unrestricted Net Asset	17,089	21,596
Restricted Assets	22,100	10,228
Total Net Assets	**39,189**	**31,824**
Total Laibilities & Net Assets	**54,373**	**44,382**

Grant Revenue 2023 vs 2022 in USD '000



With the entry of 58 new projects in 2023, the year also saw a 20% increase in grant revenue compared to 2022.

Communications

During 2023, the Communications Department embarked on a series of new initiatives aimed at bolstering our engagement with key stakeholders. Among these endeavors was the refinement of our communications strategy, honing in on fostering meaningful connections with National Agricultural Research Systems (NARS), government decision-makers, partners and funders, and influential members of the media sector.

We finalized the development of a new institutional website for launch in early 2024 featuring a contemporary design and enhanced user navigation, alongside planning for a new modernized logo and slogan more emblematic of our core competencies and expertise.

Our concerted efforts to expand media outreach yielded results throughout the year. We achieved extensive coverage, accumulating a total of 4,039 mentions, with significant visibility attained for the International Year of Millets 2023 through major channels such as France TV 24 and the Dutch Broadcasting Foundation (NOS), as well as through a diverse array of global and regional outlets spanning from MSN in the USA to Forbes, News Ghana, The Hindu Business Line and Infobae in Argentina and across over ten strategic markets.

Our social media presence witnessed substantial growth, with our combined platforms now exceeding 200,000 followers. Notably, our specialized International Year of Millets 2023 educational series garnered over 2 million impressions. It reached 160,000 individuals, earning on-promotion from entities including the CGIAR, International Treaty on Plant Genetic Resources for Food and Agriculture, FAO Saudi Arabia, Crop Trust, International Year of Millets 2023 Steering Committee, UN Biodiversity, The Forum for Agricultural Research in Africa (FARA), The Asia-Pacific Association of Agricultural Research Institutions (APAARI) and others.

In tandem with our media program, oversight of the Open Access Repository witnessed an uptick with 245 authored and co-authored publications, underscoring our commitment to knowledge dissemination. Weekly internal and monthly external newsletters ensured that both our internal staff and external subscribers remained abreast of developments. The communications team efficiently attended to communication requests from across the Institute and affiliated institutions, successfully completing 313 significant projects spanning media services, graphic design, videography, and printing.

As physical visits to ICRISAT HQ surged to 13,038 visitors, plans were initiated to develop a tailored online booking system poised to streamline visitor management processes and integrate seamlessly into our newly revamped website in 2024. This will now offer visitors convenient access to all ICRISAT locations with a simple click.

Media

4,039
Mentions

YouTube

38 videos and 3 livestreams

59,068
total views

671,417
impressions

585
new subscribers

Website interactions

284,504
visits

Visitors

13,038
Visitors to ICRISAT HQ

X (formerly Twitter)

51,622
Followers

47,374
engagements

861,537
impressions

Facebook

32,258
Followers

51,415
engagements

944,284
impressions

LinkedIn

111,461
Followers

107,397
engagements

1,548,555
impressions

Highlights

ICRISAT welcomed a delegation from Canada featuring the Honorable Minister of Agriculture and Agri-Food, Ms Marie-Claude Bibeau, alongside His Excellency, Mr Cameron MacKay, the High Commissioner for Canada in India on 15 June 2023.

The Director-General of the Food and Agriculture Organization of the United Nations, Dr. Qu Dongyu, paid a visit to ICRISAT headquarters on 14 June 2023.

His Excellency Mr Thierry Berthelot, Consul General of France in Bangalore, India, led a delegation to visit ICRISAT and its Center for Excellence in Genomics and Systems Biology (CEGSB) on 12 January 2023.

The International Year of Millets in 2023 marked a momentous year in recognizing the significance of these nutritious grains in global food systems. Millets, with their resilience to climate change and rich nutritional profile, play a crucial role in ensuring food security and promoting sustainable agriculture. This year's designation emphasized the need to raise awareness about the benefits of millets, fostering their cultivation, consumption, and value chains worldwide. ICRISAT, a recognised global leader in millet development, was proud to partner with the FAO in promoting the International Year of Millets 2023 across all regions where the Institute operates.

1. International Year of Millets 2023 opening ceremony in Rome.
2. As part of the World Food Day 2023 celebrations, ICRISAT conducted a Smart Food workshop in the Kayes region of Mali. The event attracted both women and men, providing them with training on how to prepare local food from crops such as sorghum, millet, groundnut, and cowpea.
3. ICRISAT partnered with the Indian High Commission in Malawi and organized a millets exhibition to celebrate the International Year of Millets at Lilongwe, Malawi.
4. The ICRISAT millet exhibit at the International Nutri Cereal Convention 5.0 organized by the Indian Institute of Millets Research.
5. Director General of ICRISAT, Dr Jacqueline Hughes and Dr Himanshu Pathak, Secretary, Department of Agricultural Research and Education, Government of India, co-chaired the opening session of the high-level forum 'Developing a Roadmap for Promoting Millets for Sustainable Agriculture.
6. ICRISAT co-organized a field day to mark IYM2023 at Matopos, Zimbabwe and showcased millet varieties to stakeholders across the value chain.
7. ICRISAT showcased products from the millet processing unit at Koraput at the International Convention on Millets (ICMOdisha2023) held in Bhubaneshwar, Odisha.
8. ICRISAT displayed various millet varieties and innovative millet products at G20.
9. ICRISAT partnered with the Indian High Commission in Malawi and organized a millets exhibition to celebrate the International Year of Millets at Lilongwe, Malawi.
10. His Excellency Mizengo Pinda, Former Prime Minister of Tanzania visits ICRISAT's Millet Exhibit at the 13th annual Africa Food Systems Forum held in Dar es Salaam, Tanzania.
11. Mr Mithika Linturi, Cabinet Secretary for Agriculture, Government of Kenya, Prof Ratemo W Michieka, Chairman of Kenya Sciences visits ICRISAT's millet booth at Africa Biennial Biosciences Communication symposium, Kenya.
12. ICRISAT joins regional side events, celebrating the International Year of Millets in Nigeria.
13. ICRISAT facilitated the discussion on promoting millet cultivation with the Assam Millets Mission.
14. ICRISAT showcased millet products at the 4th edition of Millets & Organics – International Trade Fair 2023, organized by the Department of Agriculture & KAPPEC, Government of Karnataka.

Research Outcomes

Message from the Deputy Director General-Research

The drylands, home to over 2 billion people worldwide, represent vast areas of Africa and Asia where communities rely heavily on agriculture for their livelihoods. These regions face unique challenges exacerbated by the ravaging effects of climate change, notably, unpredictable rainfall patterns, soil degradation, and desertification. Technological advancements are pivotal in overcoming these challenges and building resilience in such environments.

Consequently, I am pleased to share in the following pages some remarkable strides made by our researchers in 2023. From newly-developed, improved dryland crop varieties to advanced soil management techniques and to enabling public policy, our impacts are tangible and delivered through our comprehensive global research programs, which seamlessly collaborate across regions. The communities we serve merit nothing less.

Together, our focus on accelerating crop improvement through innovative technologies, enhancing the resilience of farm and food systems through pioneering landscape management approaches, and facilitating transformative changes in agricultural practices by collaborating with key decision-makers, are making great impact in communities, regions and countries.

As I reflect on the achievements of 2023, our collective endeavors have yielded significant progress. However, we recognize that much work remains to be done.

Our unwavering commitment to reducing poverty, hunger, malnutrition, and environmental degradation in the challenging landscapes of Africa, Asia and beyond remains steadfast. In short, we will continue seeing opportunities where others see challenges.

Looking ahead, we remain resolute to advancing research and innovation, forging strategic partnerships, and driving meaningful and impactful change that will empower communities, enhance livelihoods, and create a sustainable future for future generations to come.

Dr Victor Afari-Sefa
Deputy Director General – Research (Acting)

Global Research and Regional Program Directors

ICRISAT's Research Directors form an outstanding team of leading global scientists pivotal in shaping the Institute's scientific pursuits and spearheading innovation in dryland agriculture. With robust scientific and academic backgrounds, they bring diverse expertise in agronomy, genetics, plant breeding, economics, and social sciences and more. This diversity enriches our research landscape and fosters interdisciplinary collaboration to address the multifaceted challenges in the drylands of Africa, Asia and beyond.

Dr Victor Afari-Sefa
Global Research Program - Enabling Systems Transformation

Dr Mangi Lal Jat
Global Research Program - Resilient Farm and Food Systems

Dr Sean Mayes
Global Research Program - Accelerated Crop Improvement

Dr Rebbie Harawa
Regional Program - Africa

Dr A Ashok Kumar
Regional Program - Asia (Interim)

Dr Arvind Kumar
Deputy Director General – Research (Until Dec 2023)

Country Representatives

ICRISAT's Country Representatives are instrumental in advancing the Institute's mission by devising local solutions for unique dryland challenges. Serving as the face of ICRISAT, they leverage their deep understanding of local contexts to collaborate with farmers, communities, and governments. Through partnerships and advocacy, they promote innovative technologies, sustainable practices, and resilient crop varieties tailored to specific agro-ecological conditions. Their efforts help bolster agricultural systems, enhance livelihoods and ensure improved food security in dryland regions.

Dr Rebbie Harawa
Kenya

Dr Martin Philani Moyo
Zimbabwe

Dr Andre F van Rooyen
Ethiopia

Dr Samuel M C Njoroge
Malawi

Dr James Mwololo
Mozambique

Dr Falalou Hamidou
Niger

Dr Ignatius Angarawai
Nigeria

Dr Jumbo Bright
Mali

1 Catalyzing Crop Innovations: Accelerated Crop Improvement

The Accelerated Crop Improvement program leads the development of improved crop varieties for Africa, Asia, and beyond. The Program employs advanced technologies and innovative approaches to develop improved crop varieties with desirable traits such as increased yield, better nutritional quality, and enhanced resilience to biotic and abiotic stresses. These involve using various tools such as marker-assisted selection, gene editing, phenomics, and speed breeding to accelerate the breeding process and reduce the time required to develop new crop varieties. Once varieties are developed, our seed systems research works to make them available to farmers.

1.1 Adapting to Climate Change: Restructuring for New Crop Varieties

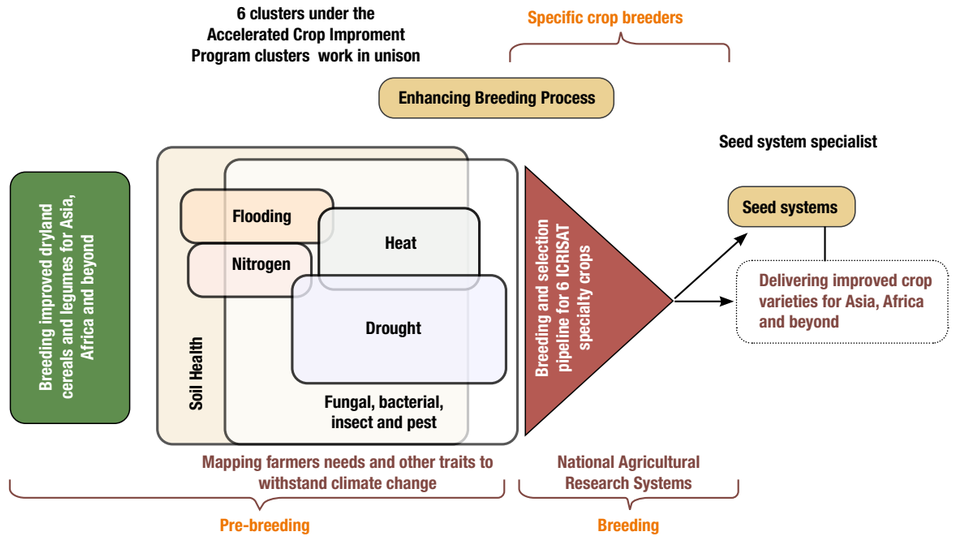
The Accelerated Crop Improvement (ACI) Program underwent restructuring in 2023 to further enhance the effectiveness of its response to the defining challenge of our time – climate change. With only six growing seasons remaining before the 2030 Sustainable Development Goals assessment, and as the world is witnessing climate change's increasingly apparent and harmful impacts, the Program's focus has shifted towards crop traits for breeding (pre-breeding) and enhancing the breeding process (six breeding pipelines).

This restructuring involves a renewed focus on developing new crop varieties with traits that meet farmers' demands for the drylands of Asia and Africa, while simultaneously addressing climate change's causes and effects. These traits will be identified through germplasm screening, wide crossing, mutation populations, and gene editing. The goal is to make trait-containing lines, along with DNA markers flanking the trait, accessible to interested parties, including breeders and partners nationally and internationally.

Our collaborative breeding efforts with partners and National Agricultural Research and Extension Systems (NARES) for six critical dryland crops – sorghum, pearl millet, finger millet, groundnut, pigeonpea, and chickpea – will continue to introduce new varieties in both Asia and Africa. Additionally, ICRISAT's work on landscapes will increasingly focus on selecting additional crops for diversified and resilient agricultural systems. This includes small millets (kodo, little, foxtail, proso and barnyard), as well as increasingly focus on oil seed crops (sesame, soybean, sunflower, mustard, and rapeseed). The Program is also positioned to collaborate more closely with partners on other relevant crops like lentils, lablab, and Bambara groundnut.

These efforts aim to provide smallholder dryland farmers with more options for growing environmentally friendly and economically viable complexes of crops. This aligns with the broader plan to assist farmers in making better choices regarding crop selection to increase their income and for sustainable resource use.

Our work directly connects with the two other global research programs at ICRISAT – the Resilient Farm and Foods Systems and the Enabling Systems Transformation programs. This connection involves sustainable optimization of resources within landscapes to determine the best combined crop choices, while establishing efficient value chains for the agricultural products farmers need to increase their income.



From trait discovery to seed systems: Navigating the reorganized journey of innovation through phases of pre-breeding, crop breeding pipelines and seed systems.

1.2. Technological Advancements

During the year, significant strides were made in pre-breeding and technology advancements to address critical dryland crop production, safety, and resilience challenges. The following examples highlight several groundbreaking developments led by the Accelerated Crop Improvement Program in gene editing, aflatoxin detection, crop screening, and speed breeding, each poised to support dryland agricultural practices and outcomes effectively.

Gene Editing Advancements

Gene editing was successfully confirmed in pigeonpea and groundnut, expanding upon previous sorghum success, with pearl millet also confirmed. Newly developed transformation vectors containing genes responsible for controlling the switch between leaf and flower production continue to undergo testing, with initial promising advancements in gene editing efficiency. Given the success of tailored gene editing and the responsiveness observed in multiple genotypes, from individual species and across various dryland crops, the potential of gene editing to contribute to increased agricultural productivity and food security in Asia and Africa is significant.

Next Generation Crop Screening

The LeasyScan* facility at ICRISAT has been significantly upgraded thanks to collaborative efforts with Phenospex. The upgrades now allow tracking individual plants during their early life when exposed to stresses and allow researchers to record 3D structures and capture 4D data during early crop development. With the capacity to screen 5,000 samples for a wide range of abiotic and biotic stresses in both soil and above-ground environments, this advancement promises to revolutionize crop screening methodologies further. By enhancing our understanding of crop responses to environmental factors, LeasyScan is augmenting the efforts for improved crop resilience, food security, and sustainable agricultural practices.

**The LeasyScan is a technology designed to assess the morphological and growth traits of plants, particularly during their early developmental stages.*

Speed Breeding Protocols

The successful implementation of speed breeding protocols for pigeonpea and finger millet in 2023 has accelerated breeding cycles in both crops by a minimum of 30 days. These protocols, which build upon existing methods for crops like chickpea and groundnut, offer a streamlined approach to crop improvement, significantly expediting breeding cycles and facilitating the faster development of resilient crop varieties, thereby enhancing food security and increasing farmer resilience.

1.3. Pre-breeding and Breeding

Breeding for Improved Pigeonpea

Pigeonpea holds significant importance in both India and Africa, where it is utilized as *dal* (split-pulses) in India, and as a staple green vegetable in Africa. Recognizing its value, India has prioritized pigeonpea as a key crop, aiming for self-sufficiency in pulses by 2027. A large-scale nationwide project commenced in 2023 to evaluate hybrids across India. This collaborative effort involved the Indian Institute of Pulses Research, the All India Coordinated Research Project, ICRISAT, and numerous other partners. Notably, pigeonpea is the first arable legume for which a functional hybrid system has been developed and adopted (expected to increase yields by approximately 30%). Plans to transfer this technology to Africa are underway.

Identification of photoperiod insensitive pigeonpea lines presents opportunities to extend current cultivation beyond the rainy season, potentially allowing for year-round cropping in India.

Furthermore, interspecific introgression lines showing heightened tolerance to the pod borer complex are being incorporated into elite Indian and African germplasm. This complements ongoing efforts involving a genetically modified approach utilizing a double Bt toxin-expressing line, slated for testing with lab-reared pod borer, *Helicoverpa armigera* in early 2024.

A comprehensive screening of 7,000 lines from the ICRISAT genebank has revealed extensive trait variation, including for plant size, architecture, determinancy, annuality, pod length, pod clustering, cold tolerance, and other critical traits. These findings promise an exciting future for pigeonpea breeding endeavors.

These advancements in pigeonpea breeding are anticipated to offer diverse African cultivation options. The market for green pigeonpea is also being explored in India, where chickpea is similarly commonly utilized.

Finger millet genomics and genetics

During the year, significant progress has been made in understanding the genetic makeup of finger millet, a staple crop in many regions. The DNA sequence of a specific line of finger millet from Kenya has been mapped and an improved genome sequence developed by experts from the University of Georgia, with collaborators from ICRISAT and breeders in Africa. Comparisons between the genetic information from 376 different finger millet varieties from India and Africa have yielded important insights into traits such as yield and nutritional value.

Additionally, a DNA chip containing 3,000 genetic markers has been developed, facilitating a more effective study of genetic variation in finger millet. These findings provide valuable insights for breeding improved varieties that better meet the needs of farmers and consumers.

Chickpea analysis for heat tolerance

During the year, the team undertook a thorough analysis of chickpea utilizing various 'Omic' technologies* to delve into the intricacies of heat tolerance, a crucial trait with increasing relevance for many crops in the face of climate change.

This multifaceted approach allows the Program to investigate chickpea responses to heat stress at the genetic, molecular, and biochemical levels. By deciphering the intricate interplay between genes, proteins, and metabolites we seek to identify key genetic elements and molecular pathways linked to heat tolerance in chickpeas. This not only benefits chickpea breeding programs but also holds broader significance for improving heat resilience in other crops facing similar challenges. Ultimately, this will contribute to global food security and sustainable agriculture in the face of climate uncertainties.

**'Omic' technologies encompass a range of advanced analytical tools, such as genomics, transcriptomics, proteomics, and metabolomics, which collectively provide comprehensive insights into the molecular mechanisms underlying important traits.*

Characterizing the pathogen *Fusarium udum*

Crop protection and seed health experts have sequenced the genome of the causative organism responsible for fusarium wilt in pigeonpea. They then re-sequenced 44 isolates from various regions in India to enhance our understanding of the disease's structure and dynamics and to inform breeding efforts. This research complements a nationwide survey in India that identified 9 major pathotypes using a pigeonpea panel known as a 'differential set', where individual plant lines can be infected by different strains (and combinations of strains) of Fusarium. This allows researchers to know which strains of Fusarium are present in a farmer's field and breed or recommend resistant cultivars.

Disease and grain quality predictions

The Climate Change facility has identified growing climate threats from pigeonpea Phytophthora blight and chickpea dry root rot. Greater emphasis will be needed on breeding cultivars resistance to these challenges, as the climate changes.

In addition, decreasing mineral and protein content under raising temperatures are major concerns for all crops, as revealed by climate change experiments, emphasizing the importance of routine screening for lines which can maintain their nutritional levels, particularly protein content, under changing climatic conditions.

New sources of disease and pest resistance

Ongoing screening of available germplasm over the past few years has revealed promising sources of resistance to Fusarium wilt and Pigeonpea sterility mosaic virus (combined), as well as Phytophthora blight in pigeonpea. Moreover, lines displaying resistance to Fusarium wilt and potential candidates for dry root rot resistance in chickpea have now been identified.

Lines tolerant to fall armyworm, sugarcane aphid, grain mold and shoot fly have been identified in sorghum. Evaluation is also now underway of promising lines for blast resistance in both pearl and finger millets. Introgression lines in chickpea and pigeonpea show promise for reducing the effects of pod borer *Helicoverpa armigera*.

ICRISAT Genebank's Global Reach and Impact

We achieved the 90% safety duplication target at the first level. To preserve our valuable genetic resources, by 2023, we deposited over 46,000 accessions at the International Center for Agricultural Research in the Dry Areas (ICARDA), U.S. Department of Agriculture -Agricultural Research Service (USDA-ARS), and the World Vegetable Center genebanks. Additionally, by 2023, 96% of the collection had been safety duplicated at the Svalbard Global Seed Vault in Norway, with a further 5,300 accessions deposited in 2023.

The impact of our genebanks extends far beyond ICRISAT, as we

added
976 accessions
totaling 130,000 accessions of eight dryland millets and three legumes from **144 countries.**

distributed
45,500 seed samples
to researchers worldwide in 2023.

Funded by The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH through Crop Trust, Regional Genebank in Niger has played a vital role in distributing seed kits of pearl millet and sorghum under the 'Seed Kits Project'. In total, 2,028 seed kits were distributed in Niger and Chad, with each selected household receiving 5 kg of pearl millet or sorghum seed. This was as part of a recovery plan for regions hit by drought and seed loss in recent years, along with the impacts of the war in Ukraine. Specifically, 1,220 seed kits of 17 varieties were distributed in Niger, while 808 seed kits of eight varieties were distributed in Chad.

These efforts have proven instrumental in providing seeds for planting on 2,028 hectares of farmland, ensuring the availability of high-quality seeds for local farmers. This initiative has enhanced food security and resilience against volatile food prices in the region.

Aflatoxin Detection Breakthrough

In a significant breakthrough, a quick diagnostic test (lateral flow immuno assay based on a monoclonal antibody) has been developed with a detection limit of 5ppb aflatoxin B1 contamination. Chronic exposure to aflatoxin B1 through contaminated food or feed can lead to liver damage, liver cancer, suppressed immune function, and growth impairment in children. It is particularly concerning in regions with hot and humid climates where conditions favor the growth of aflatoxin-producing moulds.

This test, which clearly identifies contamination levels as low as 5ppb (parts per billion), and is indicative down to 2ppb, holds immense promise for enhancing food safety. Initial testing on feedlots has demonstrated its efficacy, with potential applications also extending to a better understanding of resistance mechanisms in groundnut.

It also complements work on the expression of a Medicago defensin gene* in groundnut, which significantly reduces infection and toxin levels. In addition, recent screening of crop wild relative introgression germplasm has identified lines with reduced aflatoxin levels, suggesting that these combined approaches will likely yield significant progress against this severe health risk in the next year or two.

**The Medicago defensin gene refers to a specific gene found in the Medicago genus of plants, which includes species such as alfalfa and certain types of clover. Defensins are a class of small proteins found in various organisms, including plants, animals, and fungi. In plants, defensins play a role in defence mechanisms against pathogens such as bacteria, fungi, and viruses.*

Aflatoxin Mitigation in Malawi

In our pursuit of enhancing food safety and security, ICRISAT in Malawi embarked on a multifaceted campaign across four districts in 2023, employing radio programs and engaging stakeholders to raise awareness on Aflatoxin.

Despite progress, aflatoxin contamination remains a pressing concern. While most stakeholders have heard of aflatoxin, a knowledge gap persists regarding its origins and the contamination pathways for food. Farmers continue to grapple with the dilemma of prioritizing the cash sale of quality groundnuts, over preserving them as seeds and grain for local consumption, consequently perpetuating the planting and consumption of inferior-quality nuts with the associated risk of aflatoxin contamination.

To address these challenges head-on, ICRISAT initiated mitigation technology demonstrations across four significant districts, hosting field days that drew participation from 641 individuals (287 females, 354 males). However, it is crucial to acknowledge that there is no one-size-fits-all solution for aflatoxin mitigation. Instead, a comprehensive approach from field production to postharvest handling is essential. This holistic strategy and ongoing awareness-raising efforts represent part of our commitment to effectively manage the aflatoxin problem.

2 Safeguarding Sustainable Drylands: Resilient Farm and Food Systems

The Resilient Farm and Food Systems (RFFS) program aims to improve how smallholder farmers in dryland landscapes manage agricultural land, water and production inputs while creating new ways to enhance their livelihoods. The Program focuses on making farming more sustainable and productive while working closely with different groups to develop new ideas that help farmers grow more food, protect the environment, and benefit society.

In 2023, we made further progress by promoting our technologies and methods for sustainably managing natural resources across Mali, Zimbabwe, Ethiopia, Tanzania, and India. We also used technology to give farmers personalized advice and brought soil testing equipment to their farms. These efforts helped farmers deal with the challenges brought on by the vagaries of climate change. In addition, we developed effective strategies that can be used worldwide to fight drought and desertification.

2.1: Building Soil Resilience through Precision Agronomy and Agroecology

Enhancing soil resilience is paramount for improving dryland agriculture. Resilient soils are essential for sustaining crop productivity and ensuring food security in regions characterized by water scarcity and unpredictable rainfall. Investments in soil health and resilience can enhance water retention, nutrient availability, and overall soil structure, bolstering the capacity of dryland soils to support crop growth even in challenging conditions. Resilient soils are also better equipped to withstand the adverse effects of climate change, including prolonged droughts and extreme weather events. Through ICRISAT's efforts to promote soil resilience, we aim to empower smallholder farmers in dryland areas to establish more sustainable and resilient agricultural systems, fostering increased food production, enhanced livelihoods, and improved environmental sustainability.

An Agroecological Approach for Enhancing Soil Fertility and Crop Productivity in Southern Mali

In Southern Mali, farmers face challenges such as depleted soil nutrients and low crop yields due to population pressure and the high cost of fertilizers. To tackle this, we studied how corralling (penning animals, typically livestock, in an enclosed area) can improve soil fertility and crop productivity. Ten Tropical Livestock Units (TLUs) were corralled for varying durations (3, 7, 10, and 15 nights) on 150 m^2 plots between March and April 2023. Sorghum was then planted on these plots, and the carryover effect was evaluated the following year.

The study found that the 10 TLUs deposited significant amounts of dung and urine, ranging from 2.82 to 14.12 tons per hectare, depending on the duration of corralling. Soil organic matter increased by up to 4.32% after 7 to 15 nights of corralling, leading to taller plants and higher grain yields. Treatments with 7 to 15 nights of corralling contributed to 90% of sorghum production, profitability, and food security.

The approach improved soil organic matter and significantly influenced sorghum growth and yield. For farmers with 10 TLUs, corralling for 7 nights proved most beneficial. This duration resulted in significant organic manure deposition and allowed time for other fertilization needs.

Promoting the cattle stocking model is crucial for sustainable agricultural intensification, especially for crops like cotton and maize. Collaboration within farming or pastoral organizations can enhance awareness and technical training on natural resource management and corralling contracts. Additionally, increasing the duration of corralling improves soil nitrogen balance, highlighting the system's sustainability.

Transforming Smallholder Agriculture in Ethiopia with Innovative Agronomy: The Landscape Segmented Fertilizer Advisory

In 2023, the strategic partnership between ICRISAT and the Ministry of Agriculture of Ethiopia, under the auspices of the CGIAR Initiative - Excellence in Agronomy (EiA), culminated in the inception and execution of an innovative agronomic solution tailored for dryland regions: the Landscape Segmented Fertilizer Advisory (LSFA). This pioneering approach represents a significant milestone in advancing agricultural practices, underscoring our commitment to excellence and sustainability in the field of agronomy.

The Landscape Segmented Fertilizer Advisory (LSFA) represents a sophisticated precision farming methodology meticulously tailored to meet the unique requirements of individual segments of the landscapes or geographic zones. This modern approach considers crucial variables such as soil type, rainfall patterns, topographical features, and crop diversity to deliver bespoke fertilizer recommendations. Leveraging advanced digital tools for data collection and farmer advisories significantly enhances the precision and reliability of these recommendations.

Farmers in Ethiopia are increasingly embracing the LSFA to drive yield optimization and foster sustainable livelihoods. This approach seamlessly integrates the invaluable insights of farmers, the specialized knowledge of extension agents, and the latest agricultural research findings. By promoting landscape-centric farming practices precisely attuned to the distinct needs of each geographic zone, LSFA effectively addresses challenges while capitalizing on emerging opportunities.

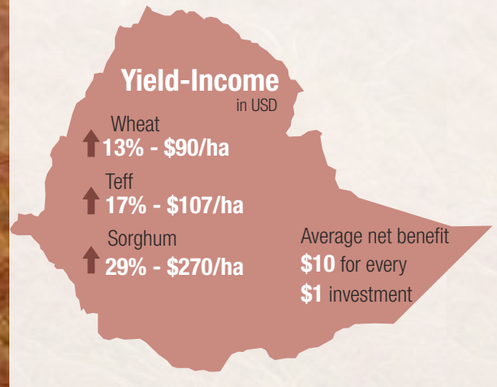
This strategy acknowledges the intricate interplay of diverse topography, soil compositions, and land use systems, ensuring the deployment of localized solutions within the intricate fabric of contemporary agriculture. The LSFA's emphasis on practical agronomic interventions, informed by grassroots feedback, underscores its commitment to fostering sustainable agricultural practices driven by internal expertise rather than external dictates.

The partnership has been further strengthened by the establishment of a vibrant community of practice, facilitated by social media platforms. Lead farmers, extension agents, agricultural experts, and researchers collaborate virtually via social media platforms like Telegram and WhatsApp, engaging in activities ranging from planning and implementation to monitoring and feedback.

Highlights:

- Strengthened local capacity for tailored agronomic solutions, fostering evidence-based innovations.
- Economically optimized fertilizer application empowers farmers to address escalating fertilizer expenses.
- LSFA's narrative epitomizes collaboration, innovation, and sustainability, showcasing the collective efforts of farmers, extension agents, researchers, and scientists.

Impacts



Beneficiaries

7,215
Farmer advisory users

2,916
Field day participants

2,376
Farmers trained

555
Extension agents, experts, researchers, and scaling partners trained

506
Social media community of practice users

Tailored Innovations in the Dryland Systems of Ethiopia

Communities residing in Ethiopian dryland areas perpetually grapple with erratic rainfall patterns. Frequently, rainfall arrives late and ceases prematurely, exacerbating farmers' difficulties. Local crop varieties traditionally relied upon are profoundly impacted by this water scarcity, leading to a mismatch between their maturity dates and the short rainy season, prompting farmers to abandon some varieties.

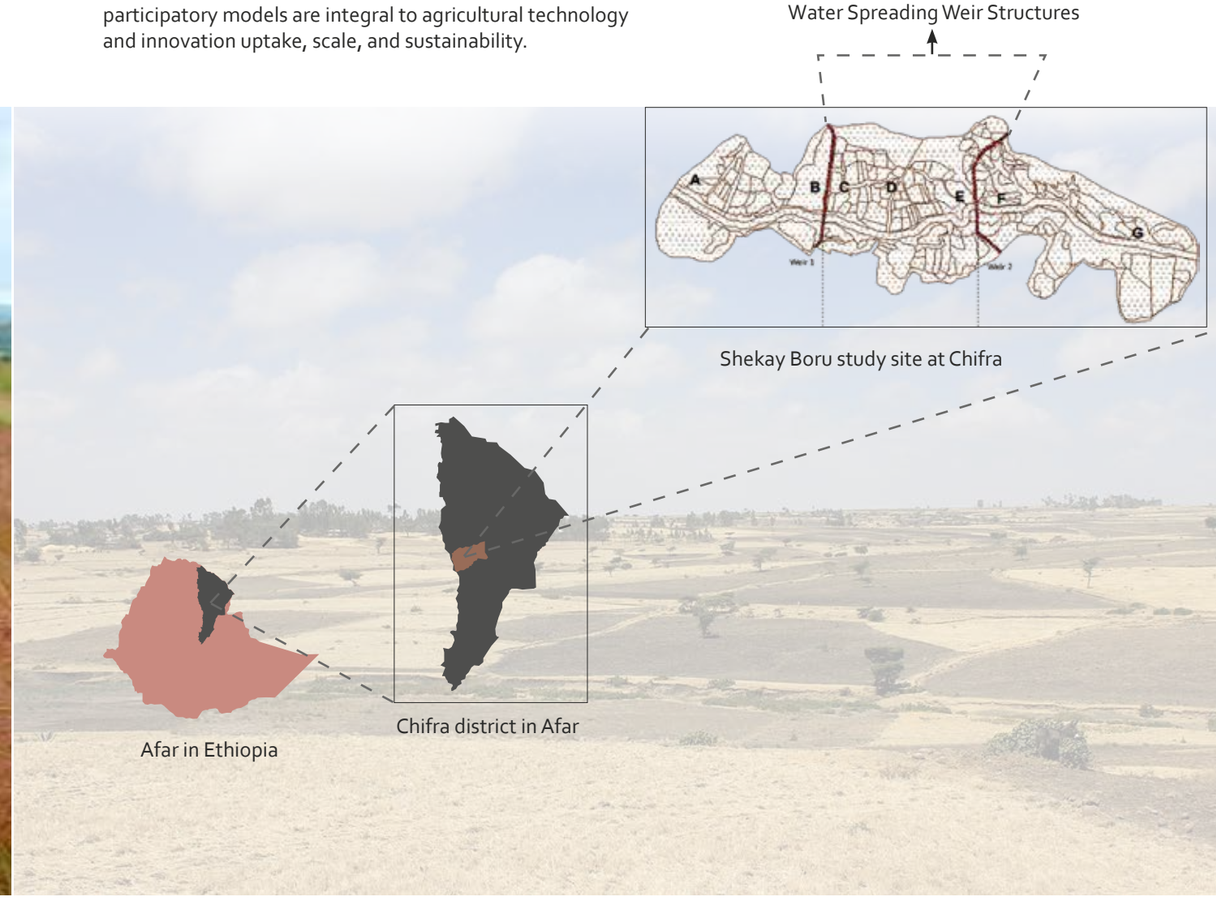
In response to these formidable constraints, 2023 saw the Resilience Project in Ethiopia, supported by the EU's RESET Plus Innovation Fund and ICRISAT, successfully champion innovative solutions tailored for dryland environments. Flood water spreading weirs and nutrient-dense, drought-tolerant crops have emerged as critical interventions.

Flood water spreading weirs - particularly crucial where rainfall is unpredictable - have proven to be a cost-effective mechanism for flood risk management, enabling flood-based farming practices. The project has also introduced nutrient-rich, high-yielding dryland crops, notably pearl millet and sorghum that addressed malnutrition while helping to withstand drought conditions.

Under this initiative, farmers are not merely recipients of innovation but actively participate as co-designers, leaders, and drivers of these transformative solutions. Such participatory models are integral to agricultural technology and innovation uptake, scale, and sustainability.

Significant benefits:

- Directly and indirectly impacted >1,600 farmers who gained access to new drought-tolerant and nutrient-rich sorghum and pearl millet seed varieties, technology demonstration, new knowledge and training.
- Generated an additional 3,000 kg of seed, via the seed revolving fund model, benefiting 5,000-6,000 farmers.
- Delivered 183 pearl millet germplasms and 30 pigeonpea germplasms to the Ethiopian national research system (ARARI) to develop new varieties with drought-tolerant and nutrient-rich attributes.
- Constructed 23 flood weirs, facilitating irrigation across 69 hectares and benefiting 280 individuals through flood farming.
- Provided employment opportunities to 547 skilled and non-skilled laborers (including 170 females) through weir construction activities.



An Agroecological Approach for Enhancing Soil Fertility and Crop Productivity in Semi-Arid Zimbabwe

In 2023, mobile *kraals* (livestock overnight holding pens) emerged as a significant innovation in semi-arid Zimbabwe's agricultural sector, tackling declining production levels due to soil and water management challenges, climate change, and limited access to inputs.

Traditionally, soil fertility management has relied on a labor-intensive method of taking animal manure from static kraals and spreading it in fields, resulting in nutrient losses during removal, storage, and dispersal.

In partnership with the USAID Bureau for Humanitarian Assistance (BHA) funded Resilience Food Security Activities (RFSAs), ICRISAT assessed the effectiveness of mobile kraals (agroecological approach) in soil fertility management and crop productivity in Zimbabwe.

The team utilized the Africa Centre for Holistic Management model, which suggests confining cattle in a designated area with a floor space of 3.5m² per animal for seven days to maximize fertilization.

The evaluation revealed significant differences in maize and sorghum grain yields between mobile kraaling and conventional manure application methods.

The mobile *kraal* has emerged as a promising solution to bolster crop productivity and soil fertility management strategies. Its cost-effectiveness and climate-resilience attributes position it as a viable option for upscaling, particularly in dryland regions where soil fertility is a perennial challenge.

While the evaluation suggests the enduring benefits of cattle manure, further validation through repeated studies is essential to confirm its efficacy.

Impacts

Increase in
Soil Nitrogen
Approximately, 25mg/kg after 4 weeks and 35 mg/kg by the end of the season

Increase in
Soil pH
Correcting soil acidity

Increase in
Yield
Average yield surpasses national grain yield average

- **Maize** **1,111 kg/Ha**
  average grain yield
  Sufficient to feed a family of 6 for 9 months*
- **Sorghum** **902 kg/Ha**
  average grain yield
  Sufficient to feed a family of 6 for 12 months*

*assuming each family member consumes 120 kg - 150 kg of grain per year

Increasing Community Resilience and Prosperity through Agroecology in Tanzania's Semi-Arid Region

An agroecology project implemented in Tanzania's semi-arid region has demonstrated the transformative potential of participatory agroecological practices in fostering resilience, improving nutrition, and enhancing income within local communities. By adopting landscape-scale natural resource management and integrated farm management approaches, the project has made significant strides in addressing the challenges of the semi-arid crop-livestock system. This success has been driven by participatory planning, comprehensive diagnosis, and robust community engagement strategies, all aimed at promoting integrated and agroecology-based farming practices and landscape management initiatives.

Key achievements

8
learning sites established

638
farmer households benefited directly

7,270
farmers benefited indirectly

310
hectares of land covered

Crop Productivity

Pigeonpea	Sorghum
▲ **83%** through improved varieties	▲ **116%** through improved varieties
▲ **31%** through tie-ridges	▲ **146%** through tie-ridges
▲ **86%** through *Fanya Juu/ Fanya Chini**	▲ **53%** through *Fanya Juu/Fanya Chini*

** "Fanya Juu" and "Fanya Chini" are Swahili terms used in agricultural practices, particularly in soil conservation and water management. "Fanya Juu" literally translates to "make high" and refers to techniques such as ridge tillage or constructing raised beds. "Fanya Chini" translates to "make low" and involves practices like trenching or digging furrows.*

Leveraging Mobile Soil Testing Technology to Reach More Farmers for Boosting Regenerative Agriculture

Soil health is paramount for dryland agriculture, where the limited availability of water and nutrients demands optimal soil conditions to sustain crop growth. Healthy soil fosters resilience against drought, erosion, and nutrient depletion, ensuring the viability and productivity of crops in arid and semi-arid regions.

As such, World Soil Day 2023 marked a significant milestone for ICRISAT with the introduction of the 'Technology on Wheels' initiative stationed in the Medchal-Malkajgiri districts of Telangana, India. This initiative, launched by ICRISAT in collaboration with Laurus Labs, underscores our firm commitment to promoting soil health and bringing technology to the farming community faster.

Under the 'Technology on Wheels' initiative, ICRISAT is providing cutting-edge soil testing services directly to farmers. This initiative aims to promote regenerative agricultural practices and enhance productivity while mitigating risks to human health and ecosystems.

Key features

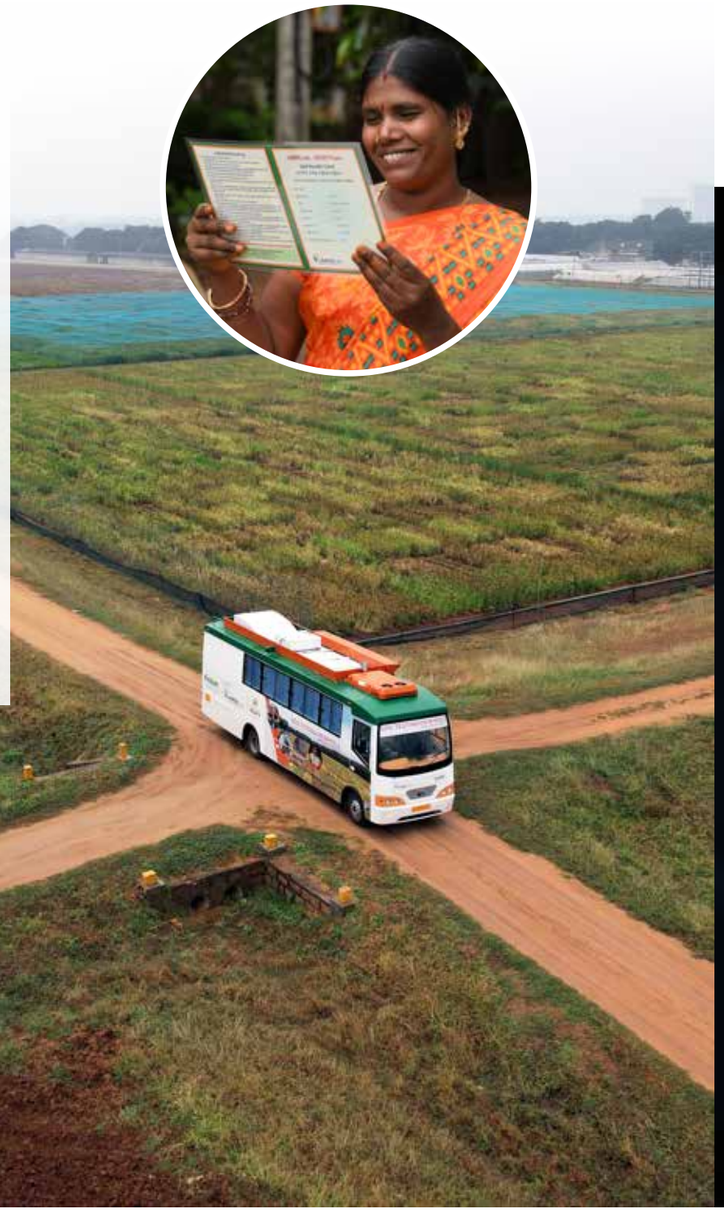
- Trained personnel proficient in handling analytical/digital tools at the farmer doorstep
- Modern equipment for accurate testing
- Quality assurance measures
- Environmentally responsible waste disposal practices

Services offered

- Comprehensive soil and water analytical services and recommendations for soil improvement at farm gate
- Capacity building programs for farmers
- Agricultural education outreach to youth in schools and communities
- Digital agro-advisories tailored to local needs

Impact

It is expected that the initiative will directly benefit over 8,000 farmers through soil testing services and advisories, with an additional 15,000 farmers benefiting from training programs and agro-advisories.



Advancing Climate Resilience and Food Security in West Africa: SERVIR-WA's Impact in 2023

In 2023, under ICRISAT's leadership, SERVIR-West Africa continued to make significant progress in agriculture, food, and water security, benefiting numerous small-holder farmers and stakeholders across the region.

SERVIR is a NASA and USAID partnership that supports locally-led efforts to strengthen climate resilience, food and water security, forest and carbon management, and air quality. It provides earth observation data from satellite imagery, GIS, and predictive models, aligning with its slogan 'connecting space to village'. The Program in West Africa is executed in partnership with a consortium of seven regional institutions across Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal, and with support from two US-based universities. The Program also receives direct science support from NASA and four NASA-sponsored grants to another set of US-based universities.

The initiative focuses on five themes: Agriculture & Food Security, Water Security, Ecosystem & Carbon Management, Weather & Climate Resilience, and Financial Instruments, with SERVIR-WA utilizing a dedicated stakeholder mapping process to elicit demand for services. This ensures that the science developed is led by relevant decisions for a diverse set of end-users, whether they are rural residents or national leaders.

Currently, SERVIR-WA is implementing 12 interdependent service areas to support agriculture and environmental decision-making across the region. These include season-to-season forecasting, predicting locust invasions, flash flood forecasting, environmental degradation monitoring, land cover monitoring, and crop monitoring, among others. ICRISAT also leads the 'financial instruments' theme, leveraging earth observation for disaster preparedness decision-making.

Services

Seasonal forecast services: Delivered comprehensive training in Python with support from the University of California, Santa Barbara, empowering climate service providers to analyze large datasets efficiently and in developing sub-seasonal forecast services for regional meteorological services.

West Africa Land Classification System: Initiated a process to standardize land classification systems in collaboration with regional institutions and the FAO, resulting in the development of a West Africa Land Classification System. This system enables scalable classification and integration across different systems on a trans-national scale.

Efforts were also directed towards monitoring unregulated artisanal mining activities in Ghana, employing advanced technologies to analyze and mitigate environmental impacts on forests and waterways.

Local Land Neutrality Planning Platform: In Burkina Faso, SERVIR-WA is establishing a Local Land Neutrality Planning Platform to help communities map and develop mitigation plans for achieving land degradation neutrality. Data and socio-economic information have been collected to create an internet platform for accessing relevant maps and data. District-level authorities are actively involved in plan development, with a focus on raising awareness of land neutrality principles among local communities, especially women.

Groundwater dynamics model: SERVIR-WA is addressing the challenges in rain-fed agriculture in Niger by developing a groundwater dynamics model, utilizing satellite imagery and hydrological modeling techniques. Collaboration with local technicians and a USAID-funded project facilitated the implementation of sustainable irrigation practices, particularly in vegetable gardening.

Financial Instruments: The Program focused on capacity building and youth engagement through the establishment of SERVIR Clubs, providing access to training sessions and materials. Additionally, young mathematicians contributed to the coding and development of services, further enhancing SERVIR's impact across the region.

2.3: Deploying Digital Innovation for Resilient Farm and Food Systems

Digital innovation is increasingly performing a pivotal role in bolstering the resilience of farm and food systems, particularly amid climate change and other adversities confronting smallholder farmers. By harnessing the power of digital technology, farmers gain access to real-time data, predictive analytics, and precision farming tools, empowering them to make informed decisions, adapt swiftly to changing conditions, and optimize resource utilization for sustainable agricultural practices.

Building Digital Soil Health Management Frameworks

- During 2023, ICRISAT focused on enhancing the monitoring and management of soil health frameworks in Asia and Africa. Leveraging ICRISAT's leadership in soil health, our strategy worked to integrate diverse stakeholders, aligning ongoing projects, government initiatives, and NARS programs to streamline soil management efforts and improve nutrient use efficiency. Through fostering partnerships and sharing best practices, our framework facilitated better harmonization, enabling nations to compare, learn, and collaborate effectively.
- This coordinated approach simplifies soil health reporting and enhances understanding of soil's contribution to One Health – an interdisciplinary approach recognizing the interconnectedness of soil, human, animal, and ecosystem health. By fostering collaboration across sectors such as human and veterinary medicine, environmental science, and public health, we address health challenges more effectively.
- To advance soil health frameworks, ICRISAT researchers are developing initiatives like soil spectral libraries using Near-Infrared Reflectance Spectroscopy technology. This enables rapid, cost-effective soil analysis, eliminating the need for extensive laboratory tests.

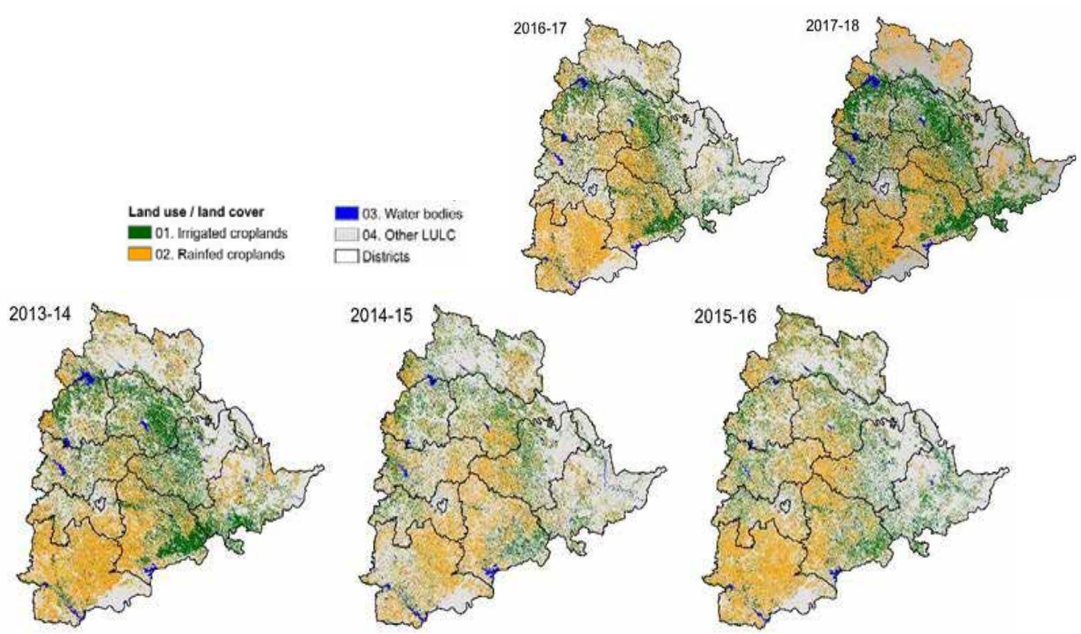
Application of Geospatial and Big Data Science for Assessing the Impact of Mission Kakatiya: A Geospatial Analysis of Cropland Changes in Telangana, India

ICRISAT conducted a comprehensive study to assess the impact of the Mission Kakatiya project on cropland changes in Telangana, India, providing valuable insights for decision-making and resource allocation in similar agricultural development initiatives.

With a significant investment from the State Government of Telangana, the project aims to repair and restore over 46,000 irrigation tanks over five years. Utilizing remote sensing imagery and land use/land cover mapping algorithms, the study analyzed temporal changes in cropland areas and water bodies between 2013 and 2018. Landsat 8's 16-day time series data were employed for spatial distribution analysis, with ground survey information validating the accuracy of the results.

The research revealed a substantial increase in cropped area under irrigation, with a 20% expansion in total tank area and notable increases in total cropland and irrigated areas (0.6 M ha and 0.2 M ha, respectively). Comparison with ground survey data demonstrated an overall accuracy of 87%, aligned with state agriculture statistics. The study concluded that periodic remote sensing monitoring is a rapid and cost-effective way of capturing land use/land cover changes resulting from such interventions, suggesting potential improvements with the use of higher-resolution satellite data.

Geospatial Analysis of Cropland Changes in Telangana (2013 - 2018)



Water Budget-based Cropping System Design: Future of Farming

The agricultural sector grapples with issues such as land degradation, water scarcity, and inefficient resource use, leading to increased water-energy-carbon footprints. Cropping systems across various agro-ecological regions often lack consideration of water budgets, resulting in the adoption of high-water requiring crops in low rainfall areas, exacerbating groundwater depletion. Conversely, regions with single cropping systems in high rainfall areas underutilize resources.

To tackle these challenges, ICRISAT conducted a pan-India water budget study to design sustainable cropping systems for smallholder farmers, categorizing all cultivable land into 21 major cropping systems. By dividing the country into 4,634 grids based on rainfall, temperature, soil moisture retention, and cropping management, water budgets were estimated from 2010 to 2020. Results show underutilization of rice-fallow areas despite ample runoff, while the rice-wheat system in northern India faces a negative water balance, exacerbating groundwater depletion. Additionally, sugarcane-based systems in low-medium rainfall zones exhibit unsustainable water deficits.

Addressing these issues requires rainwater harvesting interventions with landscape approaches and alternative cropping systems like oilseeds, pulses, millets, and vegetables, alongside landscape resource conservation measures and climate-resilient agricultural technologies to ensure food security in India without depleting groundwater resources.

3 Optimizing Value Chains: Enabling Systems Transformation

The Enabling Systems Transformation program works across all ICRISAT locations and with various dryland agricultural stakeholders to create a more supportive environment for the adoption of context-specific, sustainable, and resilient agricultural practices that can withstand future challenges. This is achieved through a combination of policy reforms, institutional changes, technological and nutritional innovations, social engagement and the capacity strengthening of key actors.

3.1 Building Effective Agri-food Systems in Africa and Asia

Africa and Asia are witnessing rapid population growth, making them the world's fastest-growing regions. Both continents possess significant potential to address the global challenges of poverty, hunger, malnutrition, and environmental degradation by developing robust and sustainable agri-food systems. With vast arable land, diverse climates, and rich biodiversity, they are uniquely positioned to feed their expanding populations while contributing to global food security. However, despite these advantages, parts still grapple with high levels of poverty, food insecurity, and environmental degradation, highlighting the need for transformative action.

Investing in resilient and inclusive agri-food systems can unlock their full potential to eradicate hunger and poverty and promote nutritional well-being and environmental sustainability. This requires improving agricultural productivity, enhancing market access, strengthening value chains, and prioritizing sustainable land and resource management practices. The following select case studies shed light on ICRISAT's impacts on delivering improved agri-food systems across both continents during 2023.

3.2 Africa

Youth-Led Transformation: Cultivating Sorghum and Advancing Smallholder Agricultural Practices in Kenya

In the arid landscapes of Western Kenya, where the struggle against drought is a constant, the cultivation of drought-tolerant crops emerges as a beacon of hope for vulnerable farmers. Sorghum, finger millet, and pearl millet stand out among these resilient options, offering a strategic lifeline to communities battling food insecurity and environmental challenges. Despite the evident advantages of sorghum, its cultivation during the short-rain season remains scarce, a paradox given the region's pressing need for water-efficient alternatives. Many farmers harbor myths about sorghum's suitability for this season, perpetuating the reliance on moisture-intensive crops like maize, despite their vulnerability to erratic weather patterns.

However, a transformative initiative led by ICRISAT, the "Scaling Commercialization of Drought Tolerant Crops Technologies," is rewriting this narrative. At its core lies a commitment to harnessing the potential of rural youth, empowering them to spearhead the adoption of innovative agricultural practices. Through a holistic approach that integrates improved varieties, market linkages, and targeted awareness campaigns, the program is revolutionizing smallholder farming dynamics.

Youth-led sorghum production has emerged as a shining example of this paradigm shift, breathing new life into the drylands of Western Kenya. By promoting bird-resistant sorghum varieties and fostering youth engagement across the value chain, the initiative is not only enhancing food security but also creating dignified and fulfilling employment opportunities for rural youth. The success of these endeavors underscores the pivotal role of youth in driving sustainable agricultural transformation, serving as catalysts for broader economic and social development within their communities.

As more farmers embrace sorghum cultivation in the short-rain season, the burden of ensuring food security becomes a shared responsibility, paving the way for collective resilience against climatic uncertainties. Moreover, the growing demand for sorghum seeds presents a lucrative business opportunity for young entrepreneurs, further amplifying the program's impact on youth empowerment and economic prosperity.

In essence, the journey towards transforming smallholder agricultural practices transcends the mere provision of modern technologies. It is a multifaceted endeavor that demands a concerted effort to challenge entrenched mindsets, foster inclusive market linkages, and cultivate a culture of sustainable intensification. With youth at the forefront of this movement, the vision of a more resilient, productive, and equitable agricultural landscape in Western Kenya is steadily becoming a reality.

Revealing the Effects of Better Groundnut Varieties on Household Markets, Costs, and Profits in Nigeria

For smallholder farmers in Nigeria, accessing markets is a vital avenue for enhancing agricultural productivity and household livelihoods. However, due to insufficient surplus production, many face challenges in fully engaging with lucrative market opportunities. The introduction of improved farm technologies presents a promising solution, potentially boosting smallholders' net marketable surplus through increased yields.

Drawing from data collected from over 1,300 households across Nigeria and employing advanced statistical analysis (innovative endogeneity-bias correcting endogenous switching regression), the study delved into the adoption and effects of improved groundnut varieties on household market participation, production costs, and net returns.

The findings reveal that approximately 30% of groundnut plots are now cultivated with improved varieties. The adoption of improved groundnut varieties translates to an 8% increase in household market participation and a remarkable 41% surge in the quantity of groundnut sold by respondents. Significantly, the adoption of improved groundnut varieties plays a more pivotal role in enhancing the intensity of market participation rather than merely influencing the decision to enter markets.

In addition, adopting improved groundnut varieties is linked with a 20% reduction in production costs and a staggering 59% increase in net returns. The study tentatively attributes these effects to the notable yield gains, reductions in per-unit production costs, and decreased downside risk associated with production.

The study's results underscore the pivotal role of improved groundnut varieties adoption in driving smallholder commercialization and stimulating agricultural investment by generating positive net returns.

New Insights Unearthed: Groundnut Value Chains in Tanzania and Senegal

In Tanzania, our study uncovered deep insights into groundnut production, revealing a significant opportunity to boost productivity by enhancing efficiency, particularly through the active involvement of women, access to education, and the adoption of new technologies. Meanwhile, in Senegal, we embarked on an innovative study to unravel the complexities of the groundnut value chain.

To unlock the full potential of this sector, policy interventions promoting climate-resilient practices, gender equality in seed systems, mechanization, financial inclusion, and value additions are required. On one front, empowering women with access to education and technology is key. Conversely, diversifying product offerings and improving access to seeds, machinery, and climate-smart solutions are vital steps.

The team is working to seize such opportunities to transform the groundnut value chain by working with influential actors at all stages. By supporting women and embracing innovation, we are paving the way for a future where resilience and prosperity go hand in hand.

Enhancing Mali's Food Systems: Investigating Gender in Artisanal Food Production with ICRISAT and the World Food Programme

Throughout 2023, ICRISAT continued its efforts to bolster Mali's agri-food systems, fostering resilience among populations affected by war, economic turmoil, and political unrest. With a steadfast focus on the women and youth of Mali's northern and central regions – communities grappling with insecurity and instability for over a decade – this year marked a concerted push to empower these demographics.

In collaboration with the World Food Programme (WFP), a groundbreaking research-for-development initiative between ICRISAT and WFP took centre stage in Mali. The project centered on empowering women and young agro entrepreneurs through comprehensive training programs. These sessions covered innovative processing techniques for 'Smart Food', business management essentials, and agricultural product marketing strategies.

By actively involving women in artisanal food processing and fostering their skills through capacity-building initiatives, the project yielded remarkable outcomes. Across communities served by the program, the results were tangible: increased revenue streams, job opportunities, enhanced nutritional standards, and greater social recognition of women's pivotal roles in society. Through collaborative efforts and targeted interventions, the team is continuing to drive meaningful change, paving the way for a more resilient and inclusive agricultural landscape in Mali and West Africa more broadly.

Supporting Women Farmers: A Framework for Gender-Inclusive Adaptation in Senegal

ICRISAT embarked on an extensive study in dry areas of Senegal to explore gender-specific adaptation strategies amid climate risks, impacts, and socio-technical conditions. Unveiling a significant gender gap, the study illuminated the challenges women farmers face in accessing critical resources like climate information services and climate-smart agriculture technologies.

This discrepancy compels women to rely more heavily on traditional coping mechanisms, while their involvement in decision-making concerning major crops like millet and groundnuts remains notably limited. Identified barriers to adaptation include a dearth of climate-smart agriculture knowledge, resource constraints, and the absence of timely climate information.

Proposing an innovative framework, the study charts pathways toward gender-responsive, climate-resilient agriculture in Senegal's drylands. At its core lies the recognition of women's indispensable role in driving agricultural resilience. To unlock the full potential of both male and female farmers in building sustainable systems, it underscores the urgent need to enhance women's participation in farming decisions and facilitate their access to climate information services and climate-smart agriculture technologies. By targeting these barriers and empowering women through improved decision-making and access to climate services and smart practices, the region's farm and food systems stand poised to bolster their resilience significantly.

While the impacts of gender studies may not always be immediately evident, the ongoing commitment to research and advocacy for women is undeniably making strides compared to decades past. Through these continued efforts, subtle yet significant shifts in gender dynamics are unfolding, gradually fostering greater equity and empowerment for women in the drylands.

3.3 Asia

Unveiling the Potential of Machine Harvestable Chickpea: Transforming Agriculture and Labor Markets in Andhra Pradesh, India

A randomized control trial was conducted across the vibrant landscapes of Kurnool, Kadapa, and Prakasam districts in Andhra Pradesh, India, to delve into the intricacies of adopting machine harvestable chickpea, evaluating its cost-effectiveness, and exploring its impact on labor markets.

The study shed light on a series of findings:

- The utilization of harvesters among 'treatment farmers' surged by 10% compared to their counterparts, a statistically significant difference.
- On average, these chickpea varieties yielded 34 kilograms more than their non-machine harvestable chickpea counterparts. Notably, farmers planting chickpea variety NBeG-776 witnessed even more substantial yield disparities.
- Farmers employing machine harvestable chickpea and combined harvesters enjoyed a distinct cost advantage over those engaging in manual harvesting and threshing.
- Encouragingly, a willingness to cultivate machine harvestable chickpea varieties prevailed among farmers, transcending treatment status.
- An examination of their willingness to invest in machine harvestable chickpea seeds revealed a slight inclination among treatment farmers as prices escalated.

Critically, the study ventured into the impact of machine harvestable chickpea adoption on the female labor market. Despite witnessing a reduction in labor days for harvesting, female workers experienced increased wage rates. Similarly, labor days for threshing dwindled in treatment arms compared to control villages.

These discoveries provide valuable insights into how adopting agricultural technology impacts communities' socioeconomics. With practical strategies in hand, they open doors to promoting sustainable agricultural growth and managing labor markets effectively in similar contexts.

Exploring the Impact of Climate Change on Food and Nutrition Security in India

In a collaborative effort with the World Food Programme, ICRISAT embarked on a study to investigate the repercussions of climate change on food and nutrition security in India. The study involved a meticulous examination of 231 articles sourced from Web of Science, PubMed, and CABI, employing a diverse set of 100 keywords to paint a comprehensive picture of the current research landscape surrounding climate change effects.

The findings unveiled a sobering reality: climate change poses significant challenges across all dimensions of food security in India. Yet, amidst these revelations, the study identified glaring research gaps, particularly in understanding the impact of climate change on traditional crops and biodiversity. It also pointed to a pressing need to prioritize research on how climate change affects food utilization and stability.

At a deeper level, the study scrutinized climate change impacts on food stability at the district level for major food crops, unearthing a profound influence on crop production instability. Notably, crops like maize, pearl millet, and *kharif*-sorghum bore the brunt of these effects.

Through the development of a climate hazard index, ICRISAT examined the intricate interplay between crop production and climate change, revealing negative correlations between climate hazards and the production of staple crops such as rice, wheat, pulses, and oilseeds.

Looking to the future, our projections using the IMPACT model paints a nuanced picture: while food availability in India may not face severe impacts, the affordability and accessibility of food could be compromised due to projected increases in commodity prices.

Deciphering the Rural Food Landscape in India for Policy Action

Location is a critical determinant in India's intricate food systems, influencing the consumption of food types. To understand this dynamic better, ICRISAT created a scoring system to look at both external and personal factors. Our research found interesting trends: in rural areas, people tend to eat more foods rich in carbohydrates, often grown at home or bought with help government-subsidized products. However, they usually overlook foods high in protein and micronutrients, mainly because they're expensive or not preferred. This is influenced by factors like taste, culture, and limitations in the food available. These findings are essential for policymakers working on food security and nutrition in rural areas. Particularly in low-income countries experiencing rapid changes in food environments, this research can provide valuable insights for addressing emerging challenges related to food consumption patterns and their impact on local populations.

Nutrient-Packed Innovations: Transforming Indian Cuisine with Millet

In a quest to address the deficiency of essential nutrients in popular Indian vegetarian dishes, a groundbreaking study was undertaken by Nutriplus Knowledge, a nutrition arm of the Agribusiness and Innovation Platform at ICRISAT. Its aim was to harness the potential of underutilized millet varieties and create nutritionally superior products that would meet daily dietary requirements.

The initiative began with carefully selecting six sorghum, pearl millet, and finger millet varieties. Through meticulous nutritional profiling, three standout varieties emerged, each exhibiting high iron, protein, or calcium levels. Armed with this knowledge, the team blended these nutritional powerhouses into a formula yielding a superior end product.

Utilizing predictive modeling based on the nutritional and functional properties of individual flours, millet flour blends were expertly crafted to maximize their nutritional benefits. From these blends emerged an array of mouthwatering creations: Indian flatbreads and biscuits that met the criteria for protein, calcium, and iron and the rigorous standards set by the Food Safety and Standards Authority of India (FSSAI).

The result was products that surpassed market offerings in nutritional value and remained affordable for consumers. With the ability to address protein, iron, and calcium deficiencies, these products have the potential to further contribute significantly to the fight against malnutrition.

As these innovative creations enter the market, their success hinges on consumer acceptance. However, if consumers embrace them through effective marketing and educational campaigns, these products possess the potential to transform Indian diets, thus paving the way for a healthier, more nourished future for all.

ICRISAT and the Walmart Foundation Collaborate to Strengthen Farmers' Livelihoods and Market Opportunities for Millet- and Pulse-based Products in Andhra Pradesh

The collaborative venture between the Agribusiness and Innovation Platform at ICRISAT and the Walmart Foundation, titled "Strengthening Farmers' Livelihoods and Value Chains for Enhanced Incomes and Harnessing Market Opportunities for Sustainable Development," was implemented in the Ananthapuram district of Andhra Pradesh. The primary objective was to develop competitive, inclusive, and sustainable value chains to uplift livelihoods by establishing strong market connections.

The project encompassed various activities, including improving crop production practices, sustaining operations of primary processing centers, and developing secondary value-added products at the secondary processing unit. This innovative model also prioritized gender inclusivity, as a women-led Farmer Producer Company managed the secondary processing unit. These women were thoroughly trained in all relevant aspects of unit management, ensuring effective operations.

The project created employment opportunities, enabled farmers to command premium prices, and facilitated better market access. It also raised awareness about nutrition among rural households in the project area, focusing on enhancing nutrition knowledge and highlighting the importance of millets.

Fostering Local Entrepreneurship in Odisha, India through Millet Processing Units

The Agribusiness and Innovation Platform of ICRISAT, in collaboration with the Odisha Livelihood Mission and the ICRISAT Development Center, is driving economic growth, job creation, and skill development by establishing food processing units in the state of Odisha, India.

In partnership, the two bodies have designed and implemented micro, small & medium enterprise food processing units, adhering to the guidelines of the Food Safety and Standards Authority of India. The initiative promotes sustainable livelihoods among women, farmers, and youth by integrating agriculture, nutrition, and entrepreneurship. It has spurred job growth in Odisha's Koraput district, improving the local community's socioeconomic conditions.

Operated by the Rajput *Gram Panchayat** Level Federation, the millet food processing unit produces nutritious ready-to-cook and ready-to-eat products such as finger millet *khichdi*, finger millet sweet meal, and millet cookies. ICRISAT provides continuous capacity building and mentoring to ensure the unit's sustainability to enable independent management.

Following a local-to-local approach, the processing unit sources raw materials from farmers, local self-help groups, and *gram panchayat* level federations, and supplies finished products to 55 schools with 3,600 students under government nutritional schemes. This model has proven to be sustainable and prosperous and especially beneficial to women. In 2023, women from the Koraput district were honored with the 'Best Millet Processing Unit Award' at the International Millet Convention in Bhubaneswar.

Since its inception, the Millet Food Processing Unit has produced 3.5 tons of food products, generating sales totalling US$ 8,448 in its first year of operation.

**gram panchayats are a basic governing institutions in Indian villages*

Bridging the Nutrition Gap with Millet and Pulses: Promoting Dietary Diversity among Tribal Women in Telangana, India

In the Indian state of Telangana, its tribal communities grapple with profound economic deprivation and entrenched social exclusion. In response, ICRISAT has continued to work with these groups to make positive changes. The Giri (Tribal) Poshana (Nutrition) Program has emerged as a beacon of hope. Spearheaded by ICRISAT and the Tribal Welfare Department of the Telangana Government, this initiative seeks to revolutionize the dietary diversity and nutrition landscape among tribal populations. Since its inception in 2021, the project has aimed to reach 16,000 beneficiaries across three Integrated Tribal Development Agencies: Utnoor, Bhadrachalam, and Mannanur.

The intervention is a testament to innovation and collaboration, channeling nutritious food products crafted from millets and pulses into the diets of tribal communities through *anganwadi* centers*. In areas where *anganwadi* centers are absent, self-help groups step in, cooking and serving meals in villages, ensuring no one is left behind.

Telangana's tribal communities, despite constitutional safeguards, face significant barriers to economic, social, and political mobility. Recognizing this reality, the project focuses on Particularly Vulnerable Tribal Groups, including children aged 3 to 6 years, pregnant women, lactating mothers, and adolescent girls. Through a holistic convergence model, all stakeholders unite to address malnutrition among these groups.

Each day throughout 2023, beneficiaries received two nutritious products – breakfast and an evening snack – six days a week. Rigorous impact assessments, conducted through baseline, midline, and endline surveys, capture vital data, including anthropometric measurements and hemoglobin levels.

The results speak volumes. The Giri Poshana program demonstrates the efficacy of supplementing children's diets with millet-pulse-based foods alongside their regular *anganwadi* meals. This intervention has not only lifted malnourished children into the normal category but has also effectively addressed prevalent issues of anemia among tribal populations, particularly children and women.

** Anganwadi centers are rural childcare hubs in India that serve as a pivotal point for delivering basic health care, nutrition, and early childhood education services to children under the age of six and their mothers.*

3.4 ICRISAT's Dryland Academy: Empowering South-South Collaboration

ICRISAT's Dryland Academy conducted 134 knowledge and skills transfer activities covering various disciplines, engaging 593 participants from National Agricultural Research Systems, 351 students and research scholars and 698 workforce members. Additionally, the Academy organized several awareness sessions on millets to mark the International Year of Millets 2023.

Highlights

Specialized Training for National Agricultural Research Systems: Various specialized topics were covered, including bio-economic modeling, next generation sequencing, millet sensitization, new crop breeding technologies, value chain programs, climate smart agriculture, genebank management, and scientific practices in agriculture. A total of 295 NARS members were trained over 62 days, with a gender split of 36% female and 64% male across different training modules.

Training for ICRISAT's Workforce: Eight awareness sessions were conducted specifically for temporary farm labor. A total of 698 participants attended these sessions, with a significant majority being female (580 female and 118 male).

Research Training for Students and Scholars: A total of 351 students and research scholars participated in trainings. This includes 245 interns, 45 research fellows, 59 research scholars, and 2 visiting fellows.

134
Capacity building activities implemented

351
students trained

Cultivating Collaboration: Equipping Scientists from Iran, Kenya, and India in Conservation Agriculture Practices

Through a dynamic collaboration between ICRISAT and the Food and Agriculture Organization of the United Nations (FAO), a transformative 21-day "International Training Course on Conservation Agriculture for Sustainable Intensification of Drylands" was hosted by ICRISAT's Dryland Academy. This immersive course brought together scientists from Iran, Kenya, and India, equipping them with advanced tools and techniques in conservation agriculture.

In an era marked by escalating climate crises, soil degradation, and diminishing agricultural biodiversity, global agricultural productivity has seen a concerning decline of 21% over the past six decades. Recognizing the critical role of conservation agriculture in fostering sustainable agri-food systems, especially in drylands, the training course was carefully designed to address these pressing challenges.

Participants were immersed in a comprehensive curriculum covering various aspects of conservation agriculture, including water management, small-scale mechanization, soil health and nutrient management, pest and weed control, genotypes and seed systems, geospatial tools and expansion strategies. Through a blend of theoretical insights and hands-on experiences, the course bridged knowledge gaps and fostered in-depth discussions and collaborations among scientists from diverse backgrounds.

The course exemplifies the role of ICRISAT's Dryland Academy in not only delivering world-class dryland agricultural training through a vibrant exchange of knowledge, ideas, and best practices in dryland farming but also catalyzing South-South collaboration.

Engaging ICRISAT's Outsourced Workforce with Millet Awareness Sessions

As part of the International Year of Millets 2023 activities, the Dryland Academy at ICRISAT orchestrated a series of engaging awareness sessions on millets for ICRISAT's outsourced workforce including a majority of tribal women. These sessions, reaching approximately 800 participants, offered invaluable insights into the diverse world of millets.

The primary objective was to educate participants about millets, emphasizing their nutritional benefits and their pivotal role in promoting health and well-being. Attendees received practical guidance on preparing millet-based dishes using the provided products, enhancing their culinary skills and nutritional awareness.

In addition to the informative sessions, participants had the opportunity to taste and provide feedback on a selection of ready-to-cook millet-based products developed by ICRISAT's Agribusiness Incubation Platform. This hands-on experience not only enriched their understanding but also fostered a deeper appreciation for the versatility and taste of millets.

ICRISAT's initiative not only empowered the outsourced workforce with knowledge about healthy eating but also championed the cultivation and consumption of millets, renowned for their nutritional richness and environmental sustainability. Taking place during the International Year of Millets in 2023, this timely initiative underscores the significance of knowledge sharing in promoting healthier dietary choices.

Publications, Knowledge Transfer and Training

237 Research and review papers

3 Conference outputs and **12** monographs

21 Book chapters

2 Books edited

About **369,608**

farmers and stakeholders reached through field visits, training, demonstrations and climate information services

2 Books published

Jointly by:

- *ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India*
- *ICAR-National Bureau of Plant Genetic Resources, New Delhi, India*
- *International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Telangana, India; and*
- *FAO on behalf of the International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy.*

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The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering, international non-profit scientific research for development organization, specializing in improving dryland farming and agri-food systems. The Institute was established as an international organization in 1972, by a Memorandum of Agreement between the Consultative Group on International Agricultural Research and the Government of India. ICRISAT works with global partners to develop innovative science-backed solutions to overcoming hunger, malnutrition, poverty, and environmental degradation on behalf of the 2.1 billion people who reside in the drylands of Asia, sub-Saharan Africa, and beyond.

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