SUMMARY SUCCESS STORIES ASSOCIATED WITH THE TIGR^{2}ESS PROGRAMME:

Each of the following pages reflects a combination of Success Stories distilled from over 35 specific Case Studies (https://tigr2ess.globalfood.cam.ac.uk/tigr2ess-case-studies) which demonstrate more specific activities, outputs and impacts. These combined Success stories represent the positive outcomes and benefits associated with the research, and also demonstrate how innovation and problem solving have led to new regional Policy formulations by state legislatures in India. We also highlight the importance of the international partnerships fostered during the programme, leading to impact for beneficiaries and associated change in practices.

SUMMARY SUCCESS STORIES: OVERVIEW OF TIGR²ESS PROGRAMME VISION, SCOPE AND CAPACITY STRENGTHENING DELIVERABLES

TIGR²ESS
Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies

The TIGR²ESS Programme, an equitable partnership with India: Context, Challenges and Deliverables

Since the 1960s, intensive agriculture in India's Green Revolution has led to multiple inequalities and unsustainable pressure on natural resources. As the climate changes, there was an urgent need for a more sustainable, resilient, and equitable food and water system for the world's fastest growing population, where fundamental agriculture is increasingly reliant on the welfare and health of female participants

Context for the TIGR²ESS Programme

- University of Cambridge Global Food Security Interdisciplinary Research Centre responded to the call from Prof M S Swaminathan (one of the leaders of the first cropping revolution in India) and Prof K VijayRaghavan to build a new, sustainable evergreen revolution with partners in India
- We created an interdisciplinarity network of collaborations across science, engineering and social science researchers.
- The GCRF Grow call provided an opportunity for outputs from fundamental, cutting edge research, to be set in developmental (ODA) translational context and compliance
- Building on established Partnerships within UK (NIAB, RR, JIC, UEA, Essex) and India (NIPGR, ICRISAT, PAU, PU, IIT Bombay, IIT Ropar, Millets Mission, MSSRF, PRADAN)

The TIGR²ESS Programme Challenge was to future-proof food-system processes across contrasting agroclimatic zones in India. We delivered these aims by:

- Integrating diverse approaches from the molecular basis to crop improvement to ancient and modern water conservation methods
- Delivering advice on alternative cropping systems whilst protecting farmer incomes.
- Developing novel interventions to improve female empowerment, education, health and nutrition
- Promoting financial independence and resilience for rural communities through equal opportunities and diversification.
- Strengthening early career researcher capacity for research and understanding of the need for translation of outputs as practical deliverables

TIGR²ESS Delivery and Outcomes

- Across the programme's 6 Flagship Projects, researchers established novel technologies and approaches, which were translated through community engagement activities, workshops and educational programmes.
- Findings were distributed through major colloquia and a series of summative workshops (Jan- Feb 2022)
- Our understanding of crop diversity and varietal traits has been advanced for intensively irrigated and semi-arid dryland staples (wheat, millets, sorghum) across India's agroclimatic zones
- Archaeological and contemporary irrigation methods complement best practices in managing common water resources.
- Outputs from the research have led directly to policies being adopted to promote water conservation, marketing diversification, female entrepreneurship and education for food and nutritional security in the communities most vulnerable to climate change.
- A brochure of 36 Case Studies, celebrating high impact outputs which have arisen across relevant fundamental science and societal research questions.
- The programme was awarded the University of Cambridge Vice-Chancellor's Collaboration Award for Research Impact and Engagement for 2021-22

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GLOBAL FOOD SECURITY

GCRF Global Challenges Research Fund

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Delivering the Grow Call: Capacity Building, Exchanges, Equality and Intersectionality

In order to deliver the capacity building challenge inherent to the GCRF Grow Call, the TIGR2ESS programme has facilitated the careers of over 33 directly employed Early Career researchers, across over 20 institutions in UK and India, with several hundred additional places being made available at workshops, conventions and through academic exchanges. A MOOC launched in 2021 will reach many thousands, and is now translated into HIndi. Highlights include the high proportion of female project leads and early career researchers, and the intersectionality arising from working to improve education, health and welfare for women and children in rural communities.

Onward Destinations

At the time of collating the ResearchFish submission, some 37 next destinations had been reported for research and administrative staff associated with the programme. These included:

PDRA to PI: 7 Early Career Researchers (ECR) were elected to lectureships or research fellowships in UK, Greece and India;

PDRA to PDRA: 10 ECRs moved on to additional PDRA positions, including two in Industry;

PDRA to NGO/ Administration: 7 ECR positions;

Admin Team: 5 moved to permanent positions, 3 on fixed term contracts

Capacity building Exchanges and Summer Students: Despite the pandemic, a total of 37 exchanges were undertaken, both to the UK and to India. Notably these included a number of undergraduates and postgraduates who went on to obtain either PhD or PDRA positions, or industrial startups, after training with TIGR2ESS ECRs

Policy Fellows: Advisers to state and national government ministries undertook workshops and networking events to explore key questions and frame policy solutions

Equality, diversity and inclusion

- A focus for two of the Flagship projects was Female Education, Nutrition, Livelihoods & Intersectionality- as highlighted below
- Across the programme, there were 12 female Co-Investigators and Project Partner Leads amongst the 20 partner organisations
- Over 40% of the early career researchers were female
- Statistical training workshops developed scientific and social science programme design and analysis
- Education and outreach programmes were targeted toward female participants and meeting intersectoral aims – whether through rural engagements or regional education programmes

Publications	240
Collaborations & Partnerships	34
Further Funding	14
Next Destination	37
Engagement Activities	400
Influence on Policy, Practice, Patients & the Public	32
Research Tools & Methods	37
Research Datasets, Databases & Models	14
Intellectual Property & Licensing	1
Medical Products, Interventions & Clinical Trials	0
Artistic & Creative Products	11
Software & Technical Products	2
Spin Outs	0
Awards & Recognition	51
Other Outputs/Outcomes	19
Use of Facilities & Resources	15

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SUMMARY SUCCESS STORIES: SUSTAINABLE CROPPING SYSTEMS, FEMALE ENTREPRENEURIAL OPORTUNITIES AND NUTRITIONAL SECURITY WITH A FOCUS ON MILLETS

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TIGR²ESS Policy Interventions: Millets enhance Crop Diversity, Farmer Choice, Welfare and Health

The TIGR2ESS partners worked with the **Odisha Millets Mission (OMM),** which was launched in 2017 to improve nutrition through the revival of millets on the farms and plates of tribal communities in Odisha. The program has successfully introduced millets in the Public Distribution System and other State nutrition schemes.

The project includes **partners from academia, regional government and civil society**; breaking down conventional silos to come together to combine traditional knowledge and cutting-edge science to open up new possibilities and improve the food system, from diets to farm incomes. To address a gap between producers and consumers, **the programme has worked across four vertical themes: production, processing, marketing and consumption.**

The first-year outcome, compared to a baseline, led to a doubling of output and trebling of additional value, paving the way for the Programme's expansion from 30 blocks (a block is subdivision of a rural administrative district) across seven districts in year one (2017-18) to 84 blocks

IMPACT: **The World Food Programme has entered into an agreement with the Government of Odisha to document, provide technical support and share what has been learnt from the Mission in a global platform in line with the UN General Assembly's designation of 2023 as International Year of Millets.**

Variations in Crop Diversification:

Punjab: Crop diversification requires institutional support to fulfil the needs of consumers and farmers. Engagement with farmers and farmer associations showed: when producers grew food for their own consumption, they were highly attuned to the benefits of crop diversification. However, a current problem is that extension services are short staffed and while NGOs are active, they have limited capacity for outreach.

Maharashtra: Crop diversification is the dominant cropping pattern. Farmers endowed with more wells include a high value horticultural crop along with dryland commercial crops in their crop choice. Amongst farmers with high to medium irrigation needs, 31-42% perceived the tool as useful in planning the irrigation requirements.

IMPACT: **In tribal regions, there is an opportunity to identify the drivers of dietary diversity in a transitional agriculture scenario moving gradually from subsistence toward commercial production.**

Department of Land Economy

UNIVERSITY OF CAMBRIDGE · IIT BOMBAY · ODISHA MILLETS MISSION Reviving millets in farms and on plates · WASSAN · UK Research and Innovation

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TIGR²ESS Policy Interventions: stimulating Rural Entrepreneurship and Female Empowerment

CHALLENGES AND OPPORTUNITIES for TIGR2ESS RESEARCHERS

- Many FPO initiatives tend to marginalise women: 3% of FPO-type arrangements being female-led;

capacity building support for establishing SHGs/FPOs

- The majority of women in agriculture are engaged in weeding, and low-skilled tasks

innovative thinking to save time and reduce drudgery (particularly for women)

- Farming faces social devaluation and economic distress; low motivation for entrepreneurship

skilling and entrepreneurship training required

- Knowledge exchange and constant interaction were important elements

understand and enhance local food know-how, rather than imposing outside ideas

- In some Telungana communities, 57% of adolescent girls are underweight; use participatory action research methods to identify issues involved

The communities, frontline workers and researchers worked together to design a series of nutrition education sessions tailored to each section of the community

- Gender research - women farmers provided unique insights on emerging FPO could help to shape equity and inclusivity in rural areas
- Self Help Groups were an effective collective enterprise: (6 champions of one Mobile Teaching Kitchen (MTK) feeding 100 persons can impact 24000 in a year)
- Empowerment came through a combination of education, training in substantive skills and capacity building for resilience.
- Bank linkage and collaborations with federated collectives provided critical support

IMPACT PUNJAB:

- **Delivery of entrepreneurship training and SHG clusters**
- **Adopt NNEdPro Mobile Teaching Kitchen knowledge based micro-entrepreneurship and public advocacy model**
- **Developed Kitchen Gardens for Nutrition and Livelihood; Basic Nutrition Curriculum adopted**

IMPACT TELUNGANA:

- **Better nutrition knowledge from interactions between communities, frontline workers and researchers**
- **Developments for digital apps (in local language)**
- **Regional policy framed to use knowledge exchange to improve female dietary expertise**

MOOC: Creative Communication, Extension and Community Resource Management developed by TIGR2ESS partners at UEA in collaboration with the Indira Gandhi National Open University, New Delhi; developed and translated into Hindi

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SUMMARY SUCCESS STORIES: ADVANCES IN WATER MANAGEMENT AND FARMER-PRODUCER CO-ORDINATION ADOPTED AS STATE GOVERNMENT POLICIES

TIGR²ESS Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies

Department of Archaeology

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

CIPT Centers for International Projects Trust

TIGR²ESS Policy Interventions in water use and cropping systems

Insights from Historical Archaeology inform Today's Food Security Agenda

South Asia's unique combination of semi-arid and monsoonal environments has historically given rise to diverse cropping systems and water management strategies.

- TIGR2ESS research has drawn attention to the history of crop diversity and water storage and distribution systems
- Diversity evidence contributed to a 4* Impact Case Study for REF2021 for the Department of Archaeology
- Water management evidence lead to stakeholder consultation and identification of strategies for establishing new policies for water management in the contrasting agro-climatic regions of Punjab, Haryana and Telangana
- CSaP Policy Fellows - Mr Suresh Kumar and Mr Anirudh Tewari

IMPACT

- **Policy Framework for Water Conservation Management in Punjab and Haryana informed by Archaeology**

Breaking the circle: intensive agriculture makes unsustainable demands on water and energy resources

- Annual dual cropping of wheat and the use of rice paddy systems are highly productive practices, but create substantial pressure on limited water resources in arid regions of India.
- TIGR2ESS researchers used direct engagement with farmers and policy makers in Punjab, to introduce new technologies and provide evidence for good-practice, saving over 80 billion litres of water.
- Crop diversification is needed, but it is clearly an expensive option
- Water sensors provide a cost-effective smart solution for the ground water and energy problems that call be rolled out through large-scale replication

IMPACT

- **Large-scale roll-out programs are being adopted as policy support by the Punjab government**

Proposed Program Districts

CIPT Footprint in Punjab

IfM Centre for International Manufacturing

TIGR²ESS Policy Interventions in Food Supply Chains

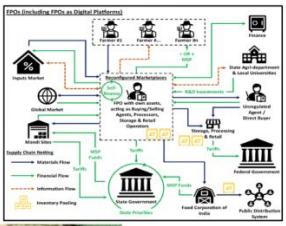
Punjab Agricultural University 1962

Driving equity, scale and resource efficiency through Farmer Producer Organisations (FPOs) and Digital Platforms

- Climate stability, social and political interactions influence food production and distribution
- Instability creates uncertainties throughout the entire agricultural supply chain market
- Evidence for this occurred in 2021, when newly implemented Farm Bills in India provoked disputes between India's farmers and the federal government.

IMPACT

- **Contributed to a Punjab Policy Notification (2021)**
- **Future modelling aimed at identifying the ideal FPO size**



Sub-surface Drip Irrigation and Potential for Diversification in Cropping Systems

- Targeted irrigation and crop diversification could maintain farmer incomes and meet consumer demand
- Despite the immediate challenges of reducing water used in the dual cropping wheat and rice paddy system, there is a need to sustain farmer incomes and meet consumer demand
- Research being undertaken at PAU under the programme has identified alternative cropping systems which could meet the expectations for increased profitability and reduced water use.

IMPACT:

- **Cropping combinations produce scenarios producing markedly increased financial returns.**
- **All cropping systems benefitted from sub-surface drip irrigation, which reduced groundwater water demand by between 34 and 46%.**

Creating value from waste – opportunities and challenges from the valorisation of rice straw

- In India, rice straw stubble burning is practised by farmers to clear fields for the next crop
- Harmful pollutants are released with detrimental effects on health and the environment
- Rice straw valorisation is seen as a solution for sustainable rice straw management providing economic, environmental, and social benefits.

IMPACT

- **Commercial Feasibility explored and validated across supply chain actors**
- **IIT-Ropar technical testing of Straw panel board for commercial use**

SUMMARY SUCCESS STORIES: FUNDEMENTAL SCIENCE INFORMS ADVANCES IN THE DEVELOPMENT OF CLIMATE RESILIENT CROPS

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University of Essex

NIPGR

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

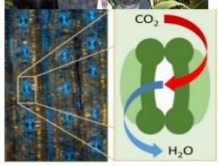
Towards Climate Resilient Crops: genome modelling, phenotyping trials and plant physiology identify traits for heat and drought tolerance

Advances with Sorghum and Pearl Millet

- Climate smart lines with drought resilience identified from diversity panels as valuable QTL donors.
- GWAS and transcriptome profiling identified candidate genes, QTLs and gene networks related to drought adaptation and water use efficiency
- infra-red thermography allows high throughput screening to indicate water use as evaporative cooling
- Speedy stomata: Measurements of stomatal sensitivity provide a mechanistic basis drought tolerance found in phenotypic screens.

IMPACT:

- **Farmer participatory approaches for adoption of new varieties and improved crop management practices in the tribal village of Adilabad.**
- **Capacity development: Training workshops for ECRs, graduate and postgraduate students on Genomic & Transcriptomic database management**



Understanding the genetic regulation of photosynthetic mechanisms for enhancing plant productivity

- Food security for a burgeoning global population, facing the threat of a changing climate, will require a paradigm shift in crop production and stress resilience.
- Research at Cambridge and NIPGR, New Delhi has defined novel highly productive algal traits prior for possible transfer into higher plants.
- new algorithms and computational methods identified key regulators in millions of transcriptional reads, sorted via spatial-temporal mapping of key regulatory hubs

IMPACT

- **outputs from the Gene Regulatory Networks (GRN) have identified key molecular factors which helps to turbocharge photosynthesis**

DEPARTMENT OF Plant Sciences

UNIVERSITY OF CAMBRIDGE

Outreach and Societal engagement

IMPACT: Student Interns from Rajesthan undertaking AI training programmes at NIPGR won an IPCC Hackathon Semantic*Climate category

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ROTHAMSTED RESEARCH

NIAB

University of Essex

Towards Climate Resilient Crops: Recreating Wheat to enhance Genetic Diversity for Drought Tolerance

The Challenge: Heat and Drought Resilience in Wheat

Wheat forms 20% of human calorie consumption and in India has a value of ₹1.29 trillion India (£12.5 billion, 2019) and £2.5 billion in the UK (2019). Predicted effects of climate change will cause a 23% production gap in India by 2050.

- As part of TIGR2ESS wheat genotypes were shared between partners and screened (i) under field conditions during multiple seasons by PAU in India (ii) during vegetative heat stress at Rothamsted Research, (iii) under drought conditions at NIAB.
- A wheat diverse panel was monitored for performance using the field-system phenotyping platforms developed by partners at NIAB and ICRISAT.

IMPACT:

- **Phenotyping studies identified stress-tolerant line which produced larger yields compared to current commercial varieties under both stress and non-stressed conditions.**
- **Novel mechanisms of heat tolerance were identified**

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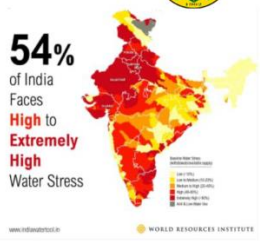
Sustaining wheat yields under drought and heat stress

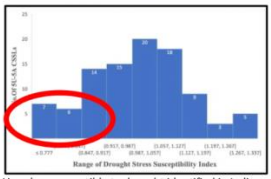
Pioneering researchers at PAU are contrasting approaches to increase genetic diversity and screen drought tolerance traits

- Synthetic wheats (recreating the diploid-goatgrass x tetraploid cross to develop novel hexaploid lines with a broad genetic base)
- Chromosomal segmentation (copies of genes from a wild grass relative are crossed into elite wheat varieties).
- Mapping Populations- phenotype multiple crosses to identify trait locations
- Selecting for previously neglected root traits to identify better water foraging strategies

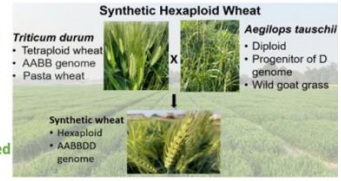
IMPACT

- **modern genetic approaches can be allied with traditional breeding and field evaluation lead to more rapid development of resilient wheat varieties**
- **advanced wheat varieties arising from novel pre-breeding can either be delivered direct to farmers or to commercial seed companies.**





Lines less susceptible to drought identified in India



GCRF Global Challenges Research Fund