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BOOK OF ABSTRACTS

# Agroecology, Climate Resilience, and Indigenous and Underutilised Crops: Rethinking Value Chains for Sustainable Food Futures

Symposium · ACRIUC 2026

**9–11 June 2026**

University of Hohenheim, Stuttgart, Germany


*With the support of*

UniversitätBund Hohenheim e.V.

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With support from
Federal Ministry of Agriculture, Food and Regional Identity
by decision of the German Bundestag

Project manager
Federal Office for Agriculture and Food

Supported by:
Federal Foreign Office

With funding from the:
Federal Ministry of Research, Technology and Space

With support from
Federal Ministry of Agriculture, Food and Regional Identity
by decision of the German Bundestag

DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service

# Symposium Programme

## Day 1 — Tuesday, 9 June 2026

*Agroecology of Underutilised and Indigenous Crops*

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| **Balcony Room** | |
| **09:30** | **Welcome** |
| | Welcome by the University of Hohenheim — Prof. Dr. Andreas Pyka, Vice President for International Affairs<br>Welcome — Prof. Dr. Christine Wieck, Prof. Dr. Ingo Grass &Dr. Sabine Zikeli, University of Hohenheim<br>Welcome by the German Federal Ministry of Research, Technology and Space — Marina Schuster<br>Welcome by the German Federal Ministry of Agriculture, Food and Regional Identity — Maja Clausen |
| **10:15** | **Keynote: Underutilised Crops for the 21st Century** |
| | Using underutilised crops for food system resilience: from agroecology to human nutrition — Prof. Ndiko Ludidi, University of Mpumalanga |
| **11:00** | **Coffee Break (Foyer)** |
| **11:30** | **D1.S1 Session 1: Agroecology of Underutilised and Indigenous Crops** |
| **Mensa** | |
| **12:45** | **Lunch Break** |
| **Balcony Room** | |
| **14:15** | **D1.K2 Keynote 2: Crop Diversity** |
| | From underutilised crop to arising agronomic importance: the examples of hemp and chickpea — Prof. Dr. Simone Graeff-Hoenninger, University of Hohenheim<br>From marginal to strategic: Climate-resilient production systems for indigenous and underutilised crops — Dr. Ethel Phiri, Stellenbosch University |
| **Blue Room and Foyer** | |
| **15:45** | **D1.P1 Poster Coffee: Poster Session 1 + Coffee Break: Agroecology of Underutilised and Indigenous Crops** |
| **17:00** | **Social Event** |
| | Tour of the Botanical Garden of the University of Hohenheim — Dr. Robert Gliniars, University of Hohenheim |
| **18:00 – 20:00** | **Dinner at Garbe Biergarten (self-paying)** |
| | Wirtshaus Garbe, Filderhauptstr. 136 |

## Day 2 — Wednesday, 10 June 2026

*Breeding, Agronomy, Climate Resilience and Information Systems*

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| **Balcony Room** | |
| **09:00** | **D2.K3 Keynote 3: Plant Breeding and Climate Resilience** |
| | Improving the potential of underutilised crops by plant breeding using quinoa and amaranth as examples — Prof. Dr. Karl Schmid, University of Hohenheim<br>The double role of underutilised crops for climate resilience and protein supply — Prof. Lembe S. Magwaza, University of Mpumalanga |
| **10:30** | **D2.S2 Session 2: Breeding, Agronomy, and Crop Diversity Conservation** |
| **11:00** | **Coffee Break (Foyer)** |
| **11:30** | **D2.K4 Keynote 4: International Organisations** |
| | Global initiatives for crop diversity — Nico Wilms-Posen, Crop Trust<br>Nourishing Diversity: Unlocking the Nutritional Power of Opportunity Crops — Simone Welte, Welthungerhilfe |
| **Mensa** | |
| **12:30** | **Lunch Break** |
| **Balcony Room / Green Room** | |
| **14:00** | **D2.S3 Session 3: Climate Resilience and Adaptation Strategies \| D2.W1 Workshop: Network and Information System Session** |
| **Blue Room and Foyer** | |
| **15:30** | **D2.P2 Poster Session 2 + Coffee Break: Underutilised and Indigenous Crops and Climate Change** |
| **17:00** | **Field Visit Kleinhohenheim** |
| **Foyer** | |
| **19:00 – 21:00** | **Conference Dinner (Hohenheim)** |

## Day 3 — Wednesday, 11 June 2026

*Creating Value Chains, Food Security and Nutrition*

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| **Balcony Room** | |
| **09:00** | **D3.K5 Keynote 5: Market Challenges and Innovations** |
| | Market challenges for niche products — Prof. Dr. Sebastian Hess, University of Hohenheim<br>Food innovations and consumer acceptance of underutilised crops — Prof. Unathi Kolanisi, University of Zululand |
| **Balcony Room / Green Room** | |
| **10:30** | **D3.S4A Session 4A: Creating Value Chains for Underutilised Crops \| D3.S4B Session 4B: Food Security and Nutrition** |
| **Blue Room and Foyer** | |
| **11:30** | **D3.P3 Poster Session 3 + Coffee Break: Focus on Value Chains** |
| **Balcony Room** | |
| **12:45** | **D3.W Wrap-up and Poster Prizes** |
| **Foyer** | |
| **13:30** | **Departure** |
| **13:30 – 19:00** | **Excursion: Beuren Open Air Museum** |

# Day 1 — Tuesday, 9 June 2026

## Session 1 — Agroecology of Underutilised and Indigenous Crops

**ORAL PRESENTATION** D1.S1: 1

### Growing more neglected and underutilized crops would reduce global food energy and nutrient supplies

Janosch Klemm[1], Matin Qaim[1,2]

*[1] Zentrum für Entwicklungsforschung, Uni Bonn, Germany; [2] Institut für Lebensmittel- und Ressourcenökonomie, Uni Bonn, Germany*

Global food systems are dominated by a few widely-grown crops, such as wheat, rice, maize, and soya. It is often argued that growing more neglected and underutilized crops (NUCs) could make food supplies more resilient and nutritious, as NUCs tend to be more stress-tolerant and nutrient-dense than conventional crops. Here, we analyze to what extent the expansion of NUCs could indeed have positive effects on nutrient supplies, using data from 181 countries. We assess the nutrient contents of ten conventional crops and 16 NUCs and adjust these for average yields. Due to yield differences, conventional crops supply up to three times more nutrients per unit of land than NUCs. Switching 10 percent of the cropland to NUCs would reduce energy, protein and micronutrient supplies by 4.5, 3.6 and 2.5 percent globally, with variations by type of crops and countries. Negative nutrition effects could only be avoided through substantial yield improvements in NUCs.

**Keywords:** *food security, yields, nutrient-density, land use*

**ORAL PRESENTATION** D1.S1: 2

### Capacity Gaps in Agroecology Transitions in Kenya: Implications for Climate-Resilient Indigenous Crop Value Chains

George Nyarigoti Mose, Dorothy Amwata, Godfrey Nambafu, Charles Orek, Benson M Mwangi

*Murang'a University of Technology, Kenya*

Transforming food systems in Sub-Saharan Africa requires embedding agroecological principles, indigenous knowledge, and diversified value chains. This study presents a multi-county Agroecology Capacity Needs Assessment across five Kenyan zones: Bomet, Homa Bay, Kilifi, Marsabit, and Vihiga, using surveys, focus groups, and key informant interviews. The FAO Tool for Agroecology Performance Evaluation (TAPE) was applied to assess transitions across the thirteen Agroecology principles, including soil health, biodiversity, diversification, participation, and resilience. The study findings showed low-to-moderate transitions, with pronounced inter- and intra-county variability shaped by climatic stress, land governance, livelihood specialization, and uneven access to extension services. While most counties occupy an 'acceptable but incomplete' transition range, arid pastoral systems face entrenched barriers linked to soil degradation, biodiversity loss, and weak ecological recycling. Critical gaps persist in knowledge co-creation, animal health, recycling, and market-oriented diversification—constraints that hinder scaling of indigenous and underutilized crops. The study underscores that agroecological transformation is non-linear and context-specific, demanding modular, regionally tailored extension strategies that integrate indigenous crops, diversified enterprises, and climate-adaptive practices. Strengthening participatory knowledge systems, reducing inputs, and advancing inclusive governance are

essential to resilient food futures. A potentially effective approach is the implementation of participatory budgeting, which allows local communities to be directly involved in budget allocation for agroecological initiatives. Additionally, establishing co-managed extension boards could facilitate collaborative decision-making processes, ensuring that local needs and knowledge are incorporated into policy actions. By situating capacity gaps within place-based transition pathways, this paper contributes empirical evidence to global agroecology debates, demonstrating how context-driven strategies can unlock the resilience and nutritional potential of indigenous crop systems in African smallholder landscapes.

**Keywords:** *Agroecology transitions, Indigenous crop value chains, Climate resilience, Capacity gaps, Smallholder systems*

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**ORAL PRESENTATION** D1.S1: 3

## Agroecological Suitability for Indigenous and Traditional Crops: Aligning Environmental Tolerances with Production Potential in Tanzania

Colleta Gandidzanwa[1], Innocensia John[2], Brad G. Peter[3]

*[1] University of Pretoria, South Africa; [2] University of Dar es Salaam; [3] University of Arkansas*

The potential of indigenous and traditional crops for food security and income generation in regions of Sub-Saharan African has historically been overlooked. This study maps the agroecological suitability of nine key indigenous and traditional crops in Tanzania by integrating remote sensing-based climate and environmental datasets (i.e., temperature, rainfall, elevation, and soil pH) and pairs them with field data from 587 farming households. Suitability thresholds were derived from ECOCROP and MARI and compared with national-scale crop presence data to systematically identify spatial mismatches between modelled biophysical potential and observed farmer cultivation. Results show extensive unexploited suitability for pigeonpea, cowpea, and groundnut, each suitable across 40–65% of agricultural land, but cultivated in a smaller geographic extent than feasible. Meanwhile, cassava and sweet potato are widely grown in zones classified as biophysically “not suitable,” indicating resilience to conditions beyond current parameter ranges or probable lowered yield potential. By linking household-level production data with spatially continuous suitability mapping, this study advances existing suitability assessments by grounding biophysical models in observed farmer practice, thereby providing an actionable evidence base for scaling indigenous and traditional crops across Tanzania. The study highlights the untapped potential of indigenous and traditional crops to enhance food security, biodiversity, and resilience in Tanzania. By identifying optimal production areas, it offers a roadmap for leveraging agroecological advantages and addressing food system challenges sustainably. The findings highlight opportunities for targeted promotion, value chain strengthening, and climate-resilient agricultural planning.

**Keywords:** *Indigenous crops, suitability mapping, agroecological zones, environmental tolerance*

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ORAL PRESENTATION D1.S1: 4

## Constraints and Opportunities of Cowpea and Sorghum Value Chains in the Zambian Food System

Klaus Droppelmann[1], Priscilla Hamukwala[2], Mohammad Ibrahim Akbar[1], Sheila Aketch[1], Bernice Omoghena Apemiye[1], Laura Bentz[1], Doris Musanide Kasongo[2], Zarmina Khan[1], Karl Lüneburg[1], Shadrick Nyirenda[2], Tabitha Ashley Opondo[1]

*[1] Seminar für ländliche Entwicklung (SLE), Humboldt-Universität zu Berlin; [2] University of Zambia (UNZA)*

Increasing climate vulnerability and maize-centric policies create pressing needs for agricultural diversification in the Zambian food system. This study aims to understand how Cowpea and Sorghum, as indigenous opportunity crops, can be leveraged to build a more resilient and inclusive food system, and what key constraints must be addressed to contribute to this transformation.

Using a mixed-methods approach, the research draws on Participatory Food System Mapping and Participatory Hotspot Analysis, including 18 focus group discussions with farmers across Zambia's Southern and Eastern Provinces, as well as 24 expert and key informant interviews. Findings were validated and interventions co-designed through a national stakeholder workshop.

The research identifies uncertain input and output markets for smallholder farmers and critical service and infrastructure deficits as key constraints for both value chains. Within this shared context, cowpea faces particular challenges around weak seed systems, limited processing infrastructure, and market demand largely restricted to home consumption. Sorghum, on the other hand, is constrained by intensive labour requirements, a thin certified seed supply, and market dependence on volatile industrial brewing demand.

In response, the study proposes three evidence-based interventions. The first strengthens community seed banks and multiplication systems to improve quality seed access while protecting seed sovereignty, with particular support for linking women farmer groups to these systems. Building on this, youth-led service enterprises are supported in co-creating appropriate equipment and technologies, reducing labour intensity and building community-based service capacity. Finally, facilitating direct value chain linkages between organised farmer groups and actors across the value chain improves access to both seed and grain markets.

These interventions strengthen seed and service ecosystems, reduce demand risk, and embed gender and youth inclusion. In doing so, they aim to transform cowpea and sorghum from underutilised crops into strategic pillars of a climate-resilient, nutritionally diverse, and socially equitable food system.

**Keywords:** *opportunity crops, value chain analysis, food system resilience, smallholder farmers, seed sovereignty, Zambia, participatory research*

ORAL PRESENTATION D1.S1: 5

## Groundnut, cowpea, sesame and more - Insights gained from the introduction of new crop varieties in BavariaTBA

Klaus Fleißner

*Bayerische Landesanstalt für Landwirtschaft (LfL), Germany*

Climate models foresee a drastic change in agroecological conditions in Bavaria by the year 2080. The Bavarian Forestry Institute developed maps with climate analogue regions for most areas in Bavaria. They show that by 2080 large parts of Bavaria will have a similar climate like in Balkan and Mediterranean countries. This development will not only result in changes in Bavarian biodiversity but will also result in consequences for Bavarian agricultural ecosystems. The project

FutureCrop of Bavarian State Research Center for Agriculture aims at the introduction of new crop species from warm and semiarid climatic zones to mitigate the effects of climate change for Bavarian famers. In the first phase the project investigated the agroecological feasibility of the cultivation of cowpea, groundnut, sesame, black cumin, rice and millets in Bavaria. In central Europe these crops are currently still underutilized and some of them, like cowpea, are called orphan crops. Through field trials and a participatory and value chain-oriented approach FutureCrop has identified opportunities and challenges, which are encountered with the introduction of these new crop varieties.

**Keywords:** *Bavaria, new crops, opportunities, challenges*

## Poster Session 1 — Agroecology of Underutilised and Indigenous Crops

**Poster** D1.P1: 1

### Comparative analysis of total factor productivity of neglected and underutilized versus staple crops

Perez Nuwamanya, Christine Wieck
*University of Hohenheim*

Agricultural productivity in Sub-Saharan Africa is largely focused on a few staple crops, including maize and rice, with their productivity increasingly affected by climate, soil, and resource use issues. In contrast, neglected and underutilized crops, including sorghum, finger millet, cowpea, and groundnut, have drought resistance, lower resource requirements, and high nutritional benefits, yet they have been ignored in research and policy development. While there is evidence of sustainability benefits associated with neglected and underutilized crops, there is limited evidence on their relative economic productivity to staple crops at the national level in Sub-Saharan Africa. This research aims to address this gap in knowledge with a comparative analysis of Total Factor Productivity (TFP) of neglected and underutilized crops relative to staple crops in Uganda and South Africa.

The research used a sequential mixed-methods approach with Phase I consisting of an Integrative Literature Review of 38 sources between 2010 and 2025 to provide a comprehensive synthesis of evidence on the sustainability contributions of NUCs to climate resilience, soil health, resource use, and nutrition, among other benefits. while Phase II used Data Envelopment Analysis (DEA) to estimate static technical efficiencies, with the Malmquist Productivity Index applied to estimate inter-temporal changes in TFP with components of Efficiency Change (Effch) and Technical Change (Techch).

The research shows that NUCs can produce comparable productivity at much lower input intensity, thus making NUCs economically viable components of sustainable intensification and climate-smart agriculture. By shifting the productivity debate from yield maximization to resource use efficiency, this research offers evidence to support context-specific diversification policies in Uganda and South Africa for building resilience in their food systems.

**Keywords:** *Productivity, Uganda, South Africa, staple crops, indigenous crops*

**POSTER** D1.P1: 2

## Indigenous peoples' relationship to landraces in the urban context of São Paulo

Júlia de Miranda Ruiz[1], Sukanya Basu[2], Roxane Bradaczek[3]

*[1] University of Göttingen; [2] Azim Premji University; [3] University of Göttingen*

Landraces, locally adapted and traditional crop varieties, play a crucial role for indigenous communities across the globe, shaping identity through nutritional, spiritual, medicinal, and environmental values. However, in Brazil, centuries of colonization and recent urbanization have disrupted human-nature relationships embodied in food, eroding the wealth of cultivated edible biodiversity. This is leaving many landraces as neglected and underutilized species, threatening their linked environmental interactions and traditional diets. This study seeks to understand the complex relationships of indigenous people to landraces in urban areas. Through semi-structured qualitative interviews with twenty Guarani participants, we investigate values, access, and practices, as well as barriers and enablers to the access and use of landraces in the city. Our interviews are conducted across three indigenous communities in São Paulo. We focus on selected representative landraces, neglected and underutilized varieties of maize, sweet potato, and cassava. Our interviews are analyzed with MAXQDA.

Our research takes a food systems lens to uncover how people-nature relationships of indigenous communities are transformed by dynamics of urbanization. Our results may inform the promotion of neglected and underutilized species as an entry point to integral indigenous communities in urban areas.

**Keywords:** *Urban food systems, indigenous knowledge, traditional crops, market access of landraces, neglected and underutilized species*

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**POSTER** D1.P1: 3

## Screening four Vigna species for cultivation in Germany

Clemens Baier[1], Ana Christina Eisermann[2], Matthias Kotter[2], Ulrike Lohwasser[2], Sabine Zikeli[1]

*[1] University of Hohenheim, Germany; [2] Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany*

Sufficient provision of plant-based proteins is a widely discussed topic in European agriculture, with a growing demand for such products. Commonly cultivated protein providing crops such as Field Pea (Pisum sativum) and Fava bean (Vicia faba) are increasingly impacted by climate change induced heat and drought stress under German climatic conditions. Introducing species of the genus Vigna addresses both issues at once. The species Cowpea (Vigna unguiculata subsp. unguiculata), Adzuki-bean (Vigna angularis), Mungbean (Vigna radiata) and Urad-Bean (Vigna mungo) are well adapted to high temperatures and drought conditions. They are well established crops in many countries, with value chains, ancient traditions of cultivation, dedicated breeding programs and many available genotypes. They are cultivated only to a small extent in Europe and relatively unknown amongst consumers.

To assess the suitability of these species under German climatic conditions, a screening of 81 genotypes, consisting of 68 accessions from the Genebank of the IPK at Gatersleben and 13 additional varieties was started in the year 2025 under the Project BOENLE. For each species 20 varieties and accessions were selected and cultivated in the field and a greenhouse in pots at both the University of Hohenheim and the IPK Gatersleben. Detailed data on plant development, phenotypical differences and yield were collected. Preliminary results of the first growing season

show that all four species can be established in Germany, with 5 genotypes not germinating. In the field trial at IPK Gatersleben over 90 % of genotypes reached the flowering stage and 65 % produced ripe pods. In the Hohenheim trial, 84 % of genotypes reached the flowering stage and 47 % produced ripe pods. The screening is continued in 2026 and underperforming varieties are replaced with new material.

**Keywords:** *plant-based proteins*

**POSTER** D1.P1: 4

## Investigating factors structuring Bambara Groundnut (Vigna Subterranea) seed flows in Singida, Tanzania

Eilif Ronning
*Norwegian University of Life Sciences (NMBU), Norway*

Ecological resilience plays a central role in food systems resilience, and agrobiodiversity can often (though not always) bolster resilience as it supports the principles of diversity and redundancy (Bravo–Peña & Yoder, 2024, p. 10; Folke, 2006, p. 258). In the past, value chain approaches to research and intervention have resulted in siloed and reductive problem-solving (Subedi et al., 2025, pp. 1-2). There is a need to understand what conditions foster farmers' continued management of agrobiodiversity (ABD), and circumstances that hinder it (Bellon et al., 2018, p. 8). Bambara groundnut (Vigna subterranea) is classified as an 'underutilised' crop, and researchers posit it may bolster food systems resilience as well as food security due to its drought tolerance (Jideani & Jideani, 2021, p. 2; Karl et al., 2024; Mayes et al., 2019, pp. 814-815). Following Donella Meadows, this study took a systems approach to 'zoom in' and zoom out' to investigate the dynamics of Bambara seed systems in Singida, Tanzania. At the macro-level, system maps (systemigrams) were created from a literature review and vetted through semi-structured interviews to explore how select food systems drivers in Tanzania shape the Bambara production. At the micro-level, 100 farmer surveys were collected for social network analysis to understand how gender and social identities that intersect with it affect how select farmers in Singida acquire and distribute BGN seeds. The expected results of the study are an identification of leverage points on the systems map for improving Bambara seed systems in Tanzania, as well as a clearer understanding of the social identities that structure seed flows. Overall, the study seeks to demonstrate how multi-scalar systems-informed research approaches may contribute to strengthening underutilised crop value chains and expanding our understanding of in-situ conservation of agrobiodiversity.

**Keywords:** *Bambara groundnut, systems approach, social network analysis, systems mapping, underutilised species*

**POSTER** D1.P1: 5

## Diverse values of underutilized crop and livestock species

Roxane Bradaczek, Tobias Plieninger
*University of Göttingen, Germany*

Mediterranean island landscapes are places of rich biocultural diversity, fostered by traditional land use practices and traditional ecological knowledge, supporting both wild and on-farm biodiversity, and an elaborate food culture. In this study, we use a social-ecological perspective to investigate neglected crop and livestock species as an anchor point for human-nature-relationships in agricultural landscapes. We choose the Mediterranean island of Sardinia (Italy) as a case study,

where intensive trade exchange, but long periods of economic and political isolation from the main land have contributed both to an especially rich food heritage, and a particularly good conservation of local landraces and cultivars. We conduct 40 qualitative interviews with farmers and shepherds, to elicit intrinsic, instrumental and relational values they associate with selected local crop and livestock breeds. Our study further identifies knowledge, practices and strategies of safekeeping agrobiodiversity. Uncovering barriers and enabling factors, we investigate conditions that support agrobiodiversity in the Mediterranean. These results can inform how to promote crop and livestock types that provide multiple values into agricultural systems.

**Keywords:** *traditional food systems, multifunctional landscapes, local crop and livestock breeds, biocultural diversity*

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**POSTER** D1.P1: 6

## Exploring the agroecological relevance of indigenous and underutilised crop

Noluthando Ngwenya
*University of Pretoria*

Indigenous and underutilised crops are plant species that have historically supported traditional farming systems and local diets for generations but receive limited attention in global agricultural research, breeding programmes, and commercial markets compared with major staple crops such as rice, wheat, and maize. Examples include quinoa, amaranth, millet etc. These crops are often, micronutrient-dense, tolerant to drought, poor soils, and other suboptimal growing conditions.

Global food systems continue to face increasing pressure from population growth, climate change, biodiversity loss, and declining availability of arable land, and heavy reliance on a narrow range of staple crops increases vulnerability to climatic shocks and threatens long-term food security. Indigenous crops presents as natural insurance for food security in adverse times and diversify agricultural production systems, particularly in marginal environments such as semi-arid regions and degraded soils where conventional staples perform poorly.

However, initiatives aimed at promoting these crops often overlook the importance of local ecological and socio-economic conditions that influence their successful integration into farming systems. Within the framework of Agroecology, crop selection and management practices must align with local environmental conditions, cultural preferences, and existing production systems.

This study examines the agroecological relevance of integrating indigenous and underutilised crops into diverse agricultural landscapes, with particular attention to context-specific factors influencing adoption and productivity. Through a synthesis of available peer-reviewed literature the study explores how environmental variables such as climate, soil characteristics, and water availability interact with socio-economic factors including farmer knowledge, market access, and dietary traditions.

The findings suggest that although indigenous crops possess adaptive traits suited to challenging environments, their successful integration depends on locally tailored strategies that reflect regional agroecosystems and community needs. Promoting these crops therefore requires place-based research, participatory approaches, and supportive policies that recognise the diversity of farming contexts.

**Keywords:** *Agroecology, underutilised crops, sustainable farming systems, UKUDLA, food sovereignty*

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**POSTER** D1.P1: 7

## The macaúba palm, an alternative oil crop in Brazil: analyzing production systems

Sai Anurag Nandagiri, Ricardo Vargas-Carpintero, Thomas Hilger
*University of Hohenheim, Germany*

The macaúba palm (Acrocomia aculeata) is increasingly recognized as a promising alternative oil crop in Brazil due to its ecological adaptability, high oil yields, and potential to generate co-products such as proteins and fibers. Unlike conventional tropical oil crops like African oil palm, macaúba can be established on degraded pasturelands in Brazil's Cerrado biome, offering opportunities for ecological restoration and rural development while reducing deforestation pressure on tropical forests.¶

This study applies an integrated multi-criteria decision analysis (MCDA) framework to three municipalities in the State of Minas Gerais, each hosting distinct macaúba cultivation and value chain initiatives. Spatial datasets were selected and organized into three MCDA pillars: (i) Biophysical–environmental feasibility combines a macaúba suitability map with pasture-degradation layer, after masking protected areas to ensure legal compliance while avoiding conflicts with biodiversity-conservation priorities; (ii) Techno-economic viability is represented by an infrastructure proximity index based on distances to warehouses, urban-centers, and highways; (iii) Socio-institutional desirability is captured through a community rural density index as proxy for rural labor and social presence. Land-use and land-cover data are used to distinguish pasture and crop systems and assess where macaúba can be integrated via silvopastoral, agroforestry, or plantation configurations. From these layers, a composite implementability index and a production system typology map were developed, classifying map cells as plantation, community/commercial silvopastoral, or agroforestry with coffee, soybean, or other-annual-crops. Results indicate that the municipalities i.e., João Pinheiro offers areas suitable for plantation-oriented models, Montes Claros supports a hybrid pattern combining

plantations and community silvopastoral systems, and Patos de Minas presents a diversified agroforestry and community silvopastoral typologies aligning with existing land-use patterns. The study shows that macaúba expansion and value chain development in Brazil should be guided by typology-aware spatial analysis rather than climate suitability or investment opportunity alone

**Keywords:** *value chain, MCDA framework, Brazil*

# Day 2 — Wednesday, 10 June 2026

## Session 2 — Breeding, Agronomy, and Crop Diversity Conservation

**ORAL PRESENTATION** D2.S2: 1

### The establishment of alternative crops is a long-term challenge along the supply chain

Friedrich Longin
*University of Hohenheim, Germany*

Alternative crops for diversified agriculture are increasingly demanded by politics and research. Since its foundation in 1905, the State Plant Breeding Institute of the University of Hohenheim works intensively on this topic with success in several crops like rye, spelt in general and regional production of durum wheat and soybean in particular. Based on this experience, we see following major keystones to be fulfilled to establish an alternative crop: (i) the generation of a cooperating supply chain, (ii) the initial access to diverse seed accessions from genebanks or breeding programs in other world regions and (iii) breeding efforts to adopt the alternative crops to regional modern farming practice.

In this talk, the successful work in spelt and emmer will be shown as a model case, which might be used for different crops and regions in the world. On the one hand, the generation of the successful supply chain is shown with major milestones, which included very open exchange of stakeholders requests and classic research on the advantages and challenges of these crops in modern farming, milling and bread baking industry. On the other hand, for all examined alternative crops the need of better adapted varieties got rapidly visible and breeding success in spelt and emmer was and still is an important pilar for their successful establishment. Nowadays, the turnover along the supply chain is for Emmer > 1 billion €, while for spelt at least ten times higher.

**Keywords:** *supply chain, alternative crops, breeding*

**ORAL PRESENTATION** D2.S2: 2

### Addressing Systemic Constraints in a Neglected Legume: Parallel Agronomic and Market Interventions for Grass Pea (Lathyrus sativus) in Temperate Europe

Tamara Lebrecht
*Getreidezüchtung Peter Kunz, Switzerland*

Neglected crops often persist in a self-reinforcing cycle of limited cultivation, insufficient agronomic knowledge, weak market presence, and low consumer awareness. Using grass pea (Lathyrus sativus), a drought tolerant neglected and underutilised crop, as a case study, this contribution presents a coordinated intervention addressing these constraints in parallel.

Multi-year field trials demonstrated that sole cropping of grass pea under temperate Central European conditions is constrained by severe lodging and harvest difficulties. Grass pea–cereal intercropping improved system robustness, but performance depended strongly on the cereal partner. Triticale enabled the highest grass pea yields, whereas oat-based systems enhanced lodging resistance and total system yield under high precipitation, albeit at the expense of grass pea yield. These results highlight a trade-off between yield maximization and risk buffering in intercrop design.

Building on these findings, the LEGU4FOOD project tested optimized grass pea–cereal combinations on commercial farms. One participating farm combined cultivation with on-farm processing, creating a vertically integrated micro-value chain. Semi-structured interviews indicate that harvestability, post-harvest handling, and market compatibility are decisive adoption factors, and that despite lower grass pea yields, farmers preferred oat-based systems over triticale due to improved risk buffering and favorable market prospects.

In parallel, collaboration with a regional processor and local restaurants enabled small-scale product development and culinary integration. Consumer acceptance data were collected through structured interviews comparing grass pea and chickpea hummus. Although initiated within a funded project context, independent farmer inquiries and emerging interest beyond project partners suggest early diffusion effects. The long-term viability of these micro-value chains beyond project-based support has yet to be evaluated.

The findings suggest that reintroducing neglected crops may benefit from combined agronomic stabilization, farmer engagement, and market experimentation to mitigate systemic lock-in effects.

**Keywords:** *grass pea, legume, drought tolerance, intercropping, on-farm trials, value chain*

## Session 3 — Climate Resilience and Adaptation Strategies

**ORAL PRESENTATION** D2.S3: 1

### Drought Tolerant Amaranth Genotypes for Climate Resilient Agroecological Food Systems.

Betty Mukuwapasi[1], Sydney Mavengahama[2], Abe Gerrano[3]

*[1] Zimbabwe Open University, Zimbabwe; [2] North-west University, South Africa; [3] Agricultural Research Council, South Africa*

Underutilised indigenous crops such as Amaranthus have significant potential to support climate vulnerable agricultural systems. Although grain amaranth is valued for its nutritional quality and resilience, limited information exists on the comparative drought performance of high yielding genotypes under moisture deficit. This study evaluated ten advanced grain amaranth genotypes—previously identified for superior grain yield—to determine their suitability for dryland production. The experiment was conducted in a rainproof shade across two seasons using a completely randomised design with well watered (WW) and water deficit (WD, 40% WW) treatments. Drought was imposed at 56 days after planting, and agronomic and physiological traits were measured, including plant height, stem girth, leaf area, biomass, and grain yield.

Moisture deficit significantly reduced growth and productivity across all genotypes ($p < 0.05$). Plant height, stem girth, leaf area, and biomass declined under WD, consistent with drought induced suppression of cell expansion and physiological processes. However, several genotypes maintained relatively strong performance under reduced irrigation. Grain yield under WD ranged from 1.52 t ha$^{-1}$ (PI633596) to 2.68 t ha$^{-1}$ (PI5116787), demonstrating that grain amaranth can still produce meaningful yields under stress. The highest WD yields were obtained in PI5116787 (2.68 t ha$^{-1}$), PI538324 (2.08 t ha$^{-1}$), PI667174 (1.94 t ha$^{-1}$), Amar (1.94 t ha$^{-1}$), and PI228279 (1.92 t ha$^{-1}$), indicating strong drought tolerance, while Arusha showed steep decline (4.47 t ha$^{-1}$ WW to 1.40 t ha$^{-1}$ WD).

The Drought Tolerance Index showed substantial genotypic differences (0.27–1.32). PI633596 exhibited the highest stability, followed by PI5116787, Amar, and PI667174. Seed size remained stable (0.4–0.7 mg), indicating genetic buffering. Gas exchange traits varied by genotype and moisture level, with WD reducing photosynthesis and transpiration.

Overall, several high yielding amaranth genotypes maintained reasonable yield under moisture deficit, with PI5116787, PI538324, PI667174, Amar, and PI228279 emerging as promising candidates for dryland cultivation.

**Keywords:** *Amaranthus. Food security, drought, nutritional security, agroecology*

**ORAL PRESENTATION** D2.S3: 2

## High throughput phenotyping of chickpeas for photosynthetic performance under combined drought and heat stress

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Climate change has intensified the occurrence of drought and heat stress, posing significant challenges to global agriculture. In arid and semi-arid regions, these stresses often occur simultaneously, highlighting the need for climate-resilient crop cultivars with combined drought and heat stress (CDHS) tolerance. High-throughput phenotyping (HTP) systems offer a rapid and precise approach for evaluating dynamic traits related to CDHS tolerance. Chickpea (Cicer arietinum L.) is a legume crop valued for its high nutritional content and ability to thrive under low-input conditions but its response to combined stress is not yet known. In this study, 200 single-seed descent-derived chickpea genotypes from the INCREASE T-Core diversity panel (Rocchetti et al., 2022), consisting of an equal number of kabuli and desi types, were evaluated using an RGB image-based HTP system in a climate-controlled greenhouse for 61 days. The study aimed to: (i) assess the impact of CDHS on chickpea's photosynthetic performances, (ii) compare the responses of kabuli and desi types under CDHS, and (iii) screen the genotypes for CDHS. Plants were subjected to varying levels of CDHS stress for 4 weeks, followed by a recovery phase under optimal conditions. Photosynthetic efficiency, measured by the operating efficiency of photosystem II and the maximum quantum yield, declined under CDHS stress but recovered under optimal conditions, indicating the effectiveness of the applied stress. On the other hand, theoretical non-photochemical quenching (NPQt) increased under CDHS. Desi type showed a higher level of NPQt under CDHS, coupled with grain yield superiority compared to kabuli. This could be a stress protection strategy for the desi types that are regarded as more tolerant to drought stress than the kabuli. All three traits exhibited higher heritability values (>0.6) and considerable genotypic variance, indicating their usefulness for selection in breeding for CDHS tolerance in chickpeas.

**Keywords:** *chickpeas, Fv/Fm, quantum efficiency, drought, heat*

**ORAL PRESENTATION** D2.S3: 3

## Nitrogen-Cycling Bacteria and Mycorrhizal Fungi Underpin Sorghum Tolerance to Combined Drought and Heat Stress

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Drought and heat waves are becoming more frequent and severe, placing major pressure on farming systems across Africa and other dry regions. Underutilised crops such as sorghum offer real hope for building more resilient and sustainable food systems. Sorghum is naturally tolerant to harsh conditions and is highly nutritious, yet we still do not fully understand why some genotypes perform better than others under combined drought and heat stress. Increasing evidence suggests that soil microbes may play an important role in shaping plant stress responses.

In this study, we explored how the rhizosphere microbiome contributes to stress tolerance in two contrasting sorghum genotypes: a tolerant line (P158690) and a sensitive line (PI682164). Plants were grown under well-watered, drought, heat, and combined drought plus heat conditions. Rhizosphere soils were analysed using 16S rRNA and ITS amplicon sequencing to profile bacterial and fungal communities. Microbial functions were predicted and compared between genotypes and treatments.

The tolerant genotype consistently hosted more bacteria linked to nitrogen cycling processes and maintained arbuscular mycorrhizal fungi under drought and combined stress. These microbial groups are known to support nutrient uptake and plant performance under stress. In contrast, the sensitive genotype showed higher levels of fungi associated with decomposition and opportunistic growth. Importantly, the combined stress triggered unique microbial shifts rather than simply adding the effects of drought and heat.

Our findings suggest that stress tolerance in sorghum is not only a plant trait but also a microbiome-supported trait. Understanding and harnessing these beneficial plant–microbe partnerships could help develop climate-resilient sorghum systems and strengthen sustainable food production in water-limited environments.

**Keywords:** *Sorghum, rhizosphere microbiome, Nitrogen-Cycling, Mycorrhizal Fungi, Combined Drought and Heat Stress*

**ORAL PRESENTATION** D2.S3: 4

## Cultivation performance and overwintering ability of artichoke (Cynara scolymus L.) varieties in organic farming in Brandenburg

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Organic vegetable farming in Brandenburg faces considerable challenges due to climate change-induced droughts, rising temperatures, and poor soil quality. One promising crop for these challenges is the artichoke (Cynara scolymus L.). It has several ecological advantages: As a member of the Asteraceae family, it contributes to the diversification of crop rotations, promotes soil structure with its deep root system, extracts nutrients from deeper layers, and acts as a valuable food source for pollinators during flowering. In addition to the use of the bud as a delicacy vegetable, the leaves can also be used in medicine and the flowering buds in floristry for added value.

To assess its suitability for cultivation, 2025 field trials were set up at two locations – the Leibniz Institute of Vegetable and Ornamental Crops (IGZ) in Großbeeren (with irrigation) and the HNEE teaching and research station in Wilmersdorf (without irrigation). Cultivation was carried out using precultivated young plants with organic fertilization (horn meal, 130 kg N $ha^{-1}$) and a practical planting density (1 × 1 m). Harvesting took place weekly over eight weeks from mid-July.

Initial observations indicate that artichokes can also be cultivated in the continental climate of northern Germany. In a comparison of varieties, Violet de Provence had the highest bud weight.

However, the Green Globe and Imperial Star varieties propagated in Germany produced significantly more marketable buds over the entire harvest period. Winter hardiness is currently being tested for the perennial cultivation of artichokes in northern Germany, and the results will also be presented at the conference.

**Keywords:** *horticulture, organic farming, temperate climate, variety testing*

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**ORAL PRESENTATION** D2.S3: 5

## ICT adoption, commercialization, household livelihood and welfare: Evidence from Kenyan vegetable farmers

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While information and communication technologies (ICTs) are widely promoted as drivers of agricultural transformation in Sub-Saharan Africa (SSA), understanding how different forms of ICT engagement translate into household welfare remains an important empirical question. This study examines the welfare implications of ICT engagement among smallholder producers in the underutilized African Indigenous Vegetables (AIV) value chains in Kenya, with particular attention to heterogeneity across gender. ICT adoption is measured multidimensionally, capturing mobile phone ownership, functional use of mobile phones for communication and digital services, and the intensity of ICT use based on the number of tools utilized. Welfare outcomes are assessed along four dimensions: commercialization, household income, food security, and asset accumulation. Using survey data from vegetable-producing households, the study employs machine learning-based treatment effects LASSO for covariates selection, followed by inverse probability weighted regression adjustment (IPWRA) to estimate causal effects while using propensity score matching (PSM) for robustness checks. The results indicate that ICT engagement is positively associated with commercialization, income, and asset accumulation, while effects on food security are more heterogeneous. Functional use and higher intensity of ICT engagement yield stronger welfare associations than phone ownership alone, underscoring the importance of moving beyond access-based measures of digital inclusion. Gender-disaggregated analyses reveal differential effects depending on whether gender is measured by the sex of the producer or the sex of the household head, highlighting distinct pathways through which ICTs influence livelihoods. By situating the analysis within underutilized crop value chains, this study extends the ICT and agriculture literature to a context that remains underexplored. The findings contribute to ongoing debates on digital agricultural transformation by demonstrating the importance of how ICTs are used, rather than simply owned, and by emphasizing the need for gender-sensitive and context-specific digital policies to support inclusive welfare gains.

**Keywords:** *ICT, commercialization, AIV, household welfare, gender, heterogeneity.*

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## Workshop — Network and Information System Session

**ORAL PRESENTATION** D2.W1: 1

### Developing a farm-to-fork information system for Indigenous and Neglected Crops promotion and utilization

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Research data holds an integral part of scientific progress and discovery and has fueled data-driven approaches to applied research towards fast and high-impact outcomes. However, for data to be useful in such a way, it should be findable, accessible and stored in reusable format. Various initiatives to curb global information accessibility challenges have led to the creation of databases for collaborative research, monitoring and evaluation of progress and outputs, particularly in food systems. The aspects of production, market intelligence and food security remain with large data gaps, especially in Sub-Saharan Africa. It has been established that various crops that are indigenous to Sub-Saharan Africa present a great opportunity to boost food availability and nutritional diversity in local agriculture despite climate change; however, information and/or data gaps about their farm-to-fork activities and challenges remain, while they are underutilized, unsubsidized and unmarketed. This work is part of a larger project that intends to establish facts on the utilisation of indigenous and neglected crops and build the foundations for promoting their reintegration in the food value chains across the southern African region. It aims to develop a farm-to-fork information system (FIS) to collect, store and share research data, findings and other relevant information pertaining to indigenous and neglected crops from farm to fork. The FIS is based on a relational database to be flexibly searchable and interactive dashboards for ease of data visualization Data pertaining to the agroecology, production, processing and value addition, storage, distribution, market access, nutritional value, household utilization as well as relevant policies and governance will be at the core of the FIS. Local and international partnerships will be leveraged to extend its potential impact. The FIS for the indigenous and neglected crops conceptualised and developed in this project is a novelty in the literature and practice.

**Keywords:** *Information system, Research database, Underutilised crops, information gaps, Farm-to-fork*

## Poster Session 2 — Underutilised and Indigenous Crops and Climate Change

**Poster** D2.P2: 1

### Role of arbuscular mycorrhizal fungi in enhancing phytochemicals and salt stress tolerance in Moringa oleifera

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Indigenous and underutilized crops can play a vital role in building climate-resilient systems. Moringa oleifera is an indigenous and widely recognized medicinal plant known for its high levels of bioactive chemicals, including total phenols and total flavonoids. These chemicals play an important role in a plant's adaptation to drought, salinity, and extreme temperatures. Climate variability, because of climate change, exacerbates biotic stressors such as soil salinity. This study

investigated whether arbuscular mycorrhizal fungi (AMF) can enhance phytochemical accumulation and improve salt stress tolerance in M.oleifera. Two experiments were conducted at the University of Mpumalanga utilizing a 4x4 factorial arrangement in a randomized complete block design. Treatments included 4 salinity levels (0, 0.25, 0.5, and 0,75dS/m. and for AM inoculum levels (0, 10g, 20g, and 30g). The Total phenolic content (TPC) and total flavonoid content (TFC) were quantified 110 days after treatment initiation using standard colorimetric methods. Data were analysed using ANOVA, and total treatment variation was partitioned to assess the contributions of each treatment. The results revealed that the interaction between AMF and Salinity treatments had a significant effect on TFC in experiments 1 and 2, with TTVs of 4.07% and 15.17%, respectively. While the TPC was influenced with a TTV of 6.25 and 4.60% in Exp 1 and 2, respectively. This highlights the role of AM fungi in mitigating the effects of salinity stress and stimulating secondary metabolite synthesis

**Keywords:** *Moringa oleifera, phytochemicals, salinity stress, AMF*

**Poster** D2.P2: 2

## PHYSIOLOGICAL AND BIOCHEMICAL ADAPTATION OF VEGETABLE AND GRAIN AMARANTH TO DROUGHT STRESS

MULISA NKUNA

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Drought is a major environmental factor limiting crop production worldwide, threatening food and nutrient security in South Asia and Sub-Saharan Africa (SSA). In SSA, drought caused over 50% yield loss in commercial crops, with severity intensifying due to climate change. Exploring neglected underutilized crops offers a sustainable strategy to diversify food systems, eradicate hunger and improve nutrient security. Amaranthus, a C4 highly nutritious crop, rich in antioxidants, holds potential to serve as a climate-smart alternative crop. However, cultivation practices and underlying drought tolerance mechanisms in amaranth remain poorly explored. This study screened six amaranth genotypes, including vegetables (A. tricolor: Ames1980, PI702915 & VI044431) and grain (A. caudatus: Love-lies-bleeding, Ponytail & Red garnet) amaranth under greenhouse conditions. Sixty days-old plants were subjected to well-watered [~80% field capacity (FC)] and 7-days drought stress (~20% FC) conditions, followed by assessing morpho-physiological, biochemical and recovery traits. Results showed genotype-specific responses to drought, through reduced growth, and relative water content, and induced oxidative damage. The genotypes demonstrated drought resilience through osmotic adjustment, achieved by the over-accumulation of proline, which increased by over 5-fold in vegetable amaranth and by 2-fold in grain amaranth. Similarly, total amino acids and total soluble sugars increased by approximately 4-fold and 2-fold in vegetable, and by about 6-fold and 3-fold in grain amaranth, respectively. Among vegetable amaranth Ames1980 and PI702915 demonstrated enhanced tolerance, maintaining higher fresh leaf weight and reduced lipid peroxidation, while VI044431 was moderately tolerant. For the grains, Love-lies-bleeding exhibited a higher fresh leaf weight through better osmotic adjustment, whereas Ponytail and Red garnet were more sensitive as seen by higher oxidative stress levels. Additionally, all genotypes recovered immediately upon rewatering, indicating amaranth's potential as a drought-tolerant crop for sustainable agriculture. Therefore, preliminary, the study recommends Ames1980 and Love-lies-bleeding as an alternative crop for cultivation in drought prone regions.

**Keywords:** *Amaranthus, Climate change, Drought, Food security, Underutilized crops, Oxidative stress.*

**Poster** D2.P2: 3

## Mapping Climate-Smart Futures for Indigenous and Underutilised Crops in Southern Africa Using Species Distribution Models

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Indigenous and underutilised crops (IUCs) offer significant potential to strengthen agroecological transitions, diversify diets, and build climate resilience in southern Africa, yet their cultivation and value chains remain constrained by limited spatial planning under climate change. This study assesses current and future climatic suitability and distribution shifts of priority IUCs across southern Africa to inform targeted investment in seed systems, extension, and resilient value-chain development. We modelled the potential distributions of two widely referenced IUCs representing grains (sorghum and cowpea). Occurrence records were compiled from GBIF, national herbarium databases, and published agronomic surveys, then filtered for geospatial error, sampling bias, and spatial autocorrelation. Species distribution models (SDMs) were fitted using an ensemble approach (MaxEnt, Random Forest, and Boosted Regression Trees) with bioclimatic predictors (temperature and precipitation seasonality and extremes), soil proxies, and topographic variables. Models were evaluated using spatial block cross-validation, AUC, TSS, and Boyce index, and projected to mid-century and late-century climates under CMIP6 scenarios (SSP2-4.5 and SSP5-8.5). Ensemble SDMs performed robustly (median AUC > 0.85; TSS > 0.60), identifying present-day suitability hotspots concentrated in semi-arid to sub-humid zones spanning parts of Botswana, Zimbabwe, Zambia, northern South Africa, Malawi, and Mozambique. Future projections indicate heterogeneous responses: drought-tolerant grains and legumes generally maintained or expanded suitability into higher elevations and poleward margins, while several leafy vegetables exhibited localized contractions in hotter, drying lowlands. Across taxa, suitability tended to shift southeastward and upslope, with increasing fragmentation under SSP5-8.5. Priority “no-regret” corridors, areas stable across scenarios, were consistently detected in the central plateau and selected riverine/agro-ecological transition zones.

These results provide a spatial evidence base for climate-smart scaling of IUCs, guiding where to strengthen seed multiplication, climate-resilient agronomy, and localized processing. Embedding SDM-informed targeting into agroecological value-chain redesign can accelerate sustainable food futures while safeguarding biocultural diversity in southern Africa.

**Keywords:** *Agroecology, Climate Resilience, Crop suitability mapping, Ensemble modelling, Adaptation planning*

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**Poster** D2.P2: 4

## Compositional evaluation of Ethiopian cassava leaves for climate-resilient and diversified food systems

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Cassava(Manihot esculenta) is widely recognised for its tolerance to drought, low soil fertility, and climatic variability. However, research and utilisation remain predominantly root-focused, leaving cassava leaves comparatively underexplored despite their nutritional potential. Limited compositional data on locally adapted varieties restricts their integration into agroecological diversification strategies and climate-resilient food systems. This study addresses this gap through a detailed nutritional evaluation of leaves from two Ethiopian varieties (Qulle and Kello) cultivated

under controlled greenhouse conditions at the University of Hohenheim. Fresh leaves were analysed using AOAC (2006) standard methods and results expressed on a dry-matter (DM) basis. The ash content ranged from 11.37 ± 0.09 to 12.81 ± 0.55 g/100 g DM, and total solids reached 23.63 ± 0.25 g/100 g FM (Qulle) and 20.40 ± 0.22 g/100 g FM (Kello), indicating substantial mineral concentration. Crude protein levels were also high (28.52 ± 0.36–30.90 ± 0.88 g/100 g DM), confirming both varieties as strong plant-based protein sources. Vitamin C concentrations were (745.22 ± 17.53–948.67 ± 10.57 mg/100 g DM), while β-carotene values (107.59 ± 18.38–131.37 ± 31.33 mg/100 g DM) demonstrate significant provitamin A potential. Total phenolic content (12.21 ± 0.05–15.62 ± 0.16 mg/g DM) further indicates antioxidant functionality. Fibre fractions (ADF 14.42 ± 0.09–17.70 ± 0.11; NDF 20.60 ± 0.12–22.00 ± 0.19; ADL 2.99 ± 0.02 g/100 g DM) highlight contributions to dietary fibre. However, Phytate (4.14 ± 0.02–5.16 ± 0.12 g/100 g DM) and total cyanide (1264.57 ± 7.92–1772.82 ± 4.23 µg/g DM) emphasise the need for appropriate processing and informed varietal selection. Overall, Ethiopian cassava leaves emerge as a nutrient-dense, underutilised component of resilient cropping systems. Their strategic inclusion in agroecological value chains can enhance dietary diversity, optimise resource use, and strengthen climate-resilient food systems without expanding cultivated land, provided safe processing practices are applied.

**Keywords:** *Keywords: Cassava leaves, underutilized crops, Climate resilience, Manihot esculenta, Nutritional composition*

**Poster** D2.P2: 5

## Investigating the role of biliverdin a heme oxygenase gene product in enhancing salinity stress tolerance of sorghum bicolor

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Plants are sessile organisms; thus, they are affected by environmental factors including drought, salinity and extreme temperatures. These factors pose as a threat to crop growth and agricultural yield, widening the food insecurity gap. It is therefore crucial to devise strategies to mitigate the effects of salinity to improve plant growth. Biliverdin (BV IXα), one of the products of heme oxygenase have potential to serve as a phyto-protectant in stress adaptive responses. This study investigated the role of BV in mitigating the effect of salt stress on sorghum seedlings during germination and its mechanism of stress tolerance. Sorghum seedlings were germinated under 0 mM and 200 mM NaCl conditions, with and without varying concentrations of BV (0.25, 0.5, 0.75 µM) and the elicited responses were assayed based on physiological, biochemical and molecular traits. Salt stress negatively impacted germination index resulting in a 28.4% decrease, and 30% decrease in root length, while increasing hydrogen peroxide (149.3% increase) and proline (494% increase) contents. Treatment with BV increased germination index by 10% (0.25 µM BV), 31% (0.5 µM BV) and 25% (0.75 µM BV), whereas root length increased by 22% (0.25 µM BV), 37.2% (0.5 µM BV) and 18% (0.75 µM BV) under salt stress. While $H_2O_2$ decreased in the presence of BV by more than 20%, non-significant changes were observed in proline content under salt stress. Furthermore, BV upregulated genes involved in ion transport, including Sorghum bicolor vacuolar Na+/H+ exchanger antiporter (SbNHX4) and potassium ion transporter (SbKT1) and the antioxidant defense genes including Sorghum bicolor heme oxygenase 1 (SbHO1), Iron superoxide dismutase (SbFeSOD), manganese (SbMnSOD), and catalase (SbCAT). Overall, this study demonstrated the potential of BV to enhance salt stress tolerance in sorghum through various mechanisms, including osmoregulation, upregulation of ion transport genes, and activation of antioxidant systems.

**Keywords:** *biliverdin; heme oxygenase; sorghum; salinity; oxidative damage.*

# Day 3 — Thursday, 11 June 2026

## Session 4A — Creating Value Chains for Underutilised Crops

**ORAL PRESENTATION** D3.S4A: 1

### Value Chain Functionality under Policy and Market Signals: Explaining the Marginalization of Indigenous Crops in Tanzania's Transforming Food System

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Indigenous crops remain marginal within formal food markets and national agricultural transformation strategies despite their recognized contributions to climate resilience, nutrition, and livelihood diversification. This study examines how indigenous crop outcomes are shaped by the interaction between household capabilities, value chain functionality, market demand signals, and institutional policy visibility. Using harmonized cross-sectional data from 1,305 households across six regions of Tanzania Dar es Salaam, Pwani, Morogoro, Dodoma, Iringa, and Njombe collected under the Food Systems Research Network for Africa (FSNet-Africa) and Indigenous Food Transformation (IFT) programs between 2023 and 2024, the analysis integrates micro-level production and processing behavior with meso-level market participation patterns and macro-level trade and policy dynamics. The findings indicate that household decision-making strongly influences engagement in indigenous crop production and marketing activities, with women playing a central role in processing and informal market participation. However, value addition remains constrained not by technical capacity but by weak market incentives, limited aggregation systems, and inconsistent demand signals. Indigenous knowledge related to crop production and utilization is predominantly concentrated among older cohorts, raising concerns regarding intergenerational knowledge transfer and long-term sustainability. Trade and policy assessments further reveal that despite widespread household engagement in indigenous crop production, these crops remain weakly represented in formal markets and receive limited prioritization within national agricultural and trade policy frameworks. Taken together, the results suggest that the continued marginalization of indigenous crops within transforming food systems is driven less by supply-side limitations than by systemic misalignment between household production incentives, value chain coordination mechanisms, market signals, and policy support instruments. The study contributes empirical insights linking micro-level behavioral responses to macro-level institutional and market dynamics, highlighting the need for coordinated interventions that strengthen processing infrastructure, market incentives, and policy visibility to support the integration of indigenous crops into climate-resilient and inclusive food system transformation pathways.

**Keywords:** *Indigenous Crops, Value Chains, Policy Alignment, Market Incentives and Food System Transformation*

**ORAL PRESENTATION** D3.S4A: 2

## Integrating sustainability concerns in the value chain analysis of wild fruits: The case of Tamarind in Zambia

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In sub-Saharan Africa (SSA), indigenous wild fruits (WF) have become a niche and emerging market, driven by their potential for local value addition and the growing awareness among urban consumers of their nutritional and health benefits as superfoods. Global demand for WF products is also rising, creating new opportunities for commercialization and value chain development. Yet, knowledge remains limited about the market barriers and opportunities for building sustainable WF value chains, the key actors involved, and the emerging sustainability concerns among stakeholders. Using tamarind in Zambia as a case study, this study explores the potentials and constraints for developing a sustainable value chain around an emerging WF in SSA. Qualitative data from key informant interviews, focus group discussions, and visual network mapping were analyzed through content and social network analysis. The findings reveal two distinct value chains: traditional and modern. The traditional chain is long, market-driven, and involves mostly small-scale actors targeting rural and peri-urban consumers. The modern chain is shorter, managed through both market and relational contracts, and composed mainly of small and medium enterprises serving urban markets. Although expansion opportunities exist, the sector remains fragmented and poorly coordinated. Actors face multiple constraints, including weak entrepreneurial skills, limited market information, poor harvesting methods, frequent human-wildlife conflicts, and low access to finance and technology. Sustainability concerns also persist. Harvesters highlight economic and social issues such as exploitative labor and unsafe working conditions, while experts and stakeholders emphasize environmental challenges, including unsustainable harvesting, ecosystem degradation, and biodiversity loss. These findings point to the need for upgrading processes, products, and functions along the tamarind value chain to enhance its sustainability and inclusiveness.

**Keywords:** *wild fruits, tamarind, value chains, value chain analysis, sustainability, social network analysis, Zambia, Africa*

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**ORAL PRESENTATION** D3.S4A: 3

## Estimating efficiency among baobab processors, retailers and traders: A double bootstrap DEA approach

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Although baobab has emerged as a commercially promising indigenous crop with expanding domestic and export demand, limited evidence exists on how efficiently value chain actors convert resources into marketable outputs and whether performance varies systematically across actors and along the efficiency distribution. Understanding these patterns is critical for identifying resource misallocation and designing effective upgrading strategies. Using a sample size of 871 value chain actors, this study estimates technical efficiency among baobab processors, retailers, and traders using a double-bootstrap Data Envelopment Analysis (DEA) framework and examines heterogeneity in efficiency drivers through quantile regression. The double-bootstrap procedure corrects bias in efficiency estimates and enables consistent inference. The results reveal

substantial efficiency disparities both across actor categories and within performance tiers. Among processors, business training, market awareness, and formal registration significantly enhance efficiency, while greater processing experience is associated with marginally lower efficiency. Distributional analysis shows that these gains are strongest among lower-performing processors. For retailers, training consistently improves efficiency, whereas education, gender, and distance to markets exert heterogeneous effects across quantiles. Among traders, efficiency is strongly associated with network size, baobab-derived income, and trading volume, with stronger effects at the median and upper quantiles. These findings highlight actor-specific and distribution-sensitive constraints shaping upscaling in indigenous crop value chains.

**Keywords:** *Baobab, technical efficiency, processors, traders, retailers, DEA, quantile regressions*

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**ORAL PRESENTATION** D3.S4A: 4

## Strengthening the value chain of Iranian indegionus Saffron: A SWOT-Based Assessment and Conceptual Model for Climate-Resilient Development

Arezou Babajani[2], Senour Ahmadi[1], Azad Ahmadi[3]

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Abstrac

Saffron is a unique indigenous crop of Iran and, while a relatively high value export, contributes significantly to the economy and is a critical crop for climate-resilient agriculture in the arid and semi-arid regions of Iran. Although Iran is the world's largest saffron producer and exporter, the majority of its saffron is exported in bulk, and as a result, Iran is unable to capture value from processing, and it also presents a challenge to the long-term viability of the industry.

Research Question:

This study seeks to explain the strategic strengthening of the Iranian saffron value chain within the existing domestic value addition, competitiveness and resilience in the context of climate and market uncertainty.

Methodology:

This study utilizes a qualitative SWOT approach using secondary data, reports, and previous empirical research on the production and marketing of saffron and the governance of the supply chain. The internal and external factors concerning the production, processing, marketing and export of the value chain were identified and analyzed in order to formulate strategic directions.

Findings

Strengths include saffron’s high value density, drought tolerance, adaptability to smallholders, and strong international reputation. Major weaknesses include fragmented production systems, poor coordination at institutional levels, weak processing and branding, inconsistent quality control, and poor systems of traceability. The global demand for organic, functional, and traceable products is an opportunity. With increasing control and varying demand, competition from emerging producing nations is a growing threat. The diversification into high-value derivatives such as extracts, nutraceuticals, and certified organic geographical indication labels is a growing opportunity.

The overall analysis suggests that important strategies to enhance value chain performance and sustain production include improved systems of traceability and certification, integrated branding and processing in developing value chains, and the integration of saffron into the climate-resilient rural development of the country.

**Keywords:** *climate-resilient agriculture, indigenous crops, organic saffron, saffron value chain, sustainable rural development, SWOT analysis*

## Session 4B — Food Security and Nutrition

**ORAL PRESENTATION** D3.S4B: 1

### The role of nostalgia in consumers' acceptance of food produced from underutilized crops

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Globally, food systems depend heavily on a narrow range of staple crops, exposing agricultural production to climate risks, biodiversity loss, and supply chain vulnerabilities. This requires adaptation in the agricultural system, such as focusing on indigenous or underutilized crops, including hemp, heritage grains, and legumes (McClatchie et al., 2025).

This project focuses on the consumer side and the challenges related to the duality of foods produced from underutilized crops. On the one hand, food made from underutilized crops draws on a long tradition. On the other hand, these crops have long been forgotten about, thus presenting today's consumers with unfamiliar ingredients and novelty (McClatchie et al., 2025). This duality of tradition and future has already been investigated for traditional food products (Benninger & Roosen, 2025). Still, more research is needed for the special case of foods produced from underutilized crops, as they are novel in their ingredients and thus less tangible for consumers. To make the past component of these ingredients more accessible to consumers, this project considers nostalgia, a sentimental feeling for the past, as an essential mechanism for consumer acceptance. Prior research has shown that nostalgia and nostalgic labels can foster a sense of security, thereby enhancing the consumption of traditional products (Zhou et al., 2019) and agricultural heritage products (Tang et al., 2023).

This research project builds on these prior findings and aims to test the effects of nostalgic priming, labels, and information treatments on foods produced from underutilized crops. The experimental setting is embedded in an online supermarket to better understand how these food products can stand out amid the extensive product selection in a realistic retail environment. The project aims to develop clear marketing implications for promoting food products produced from underutilized crops to help transform the food system for the future.

**Keywords:** *nostalgia, consumers, food products, underutilized crops*

**ORAL PRESENTATION** D3.S4B: 2

### Socioeconomic factors influencing smallholder farmers' willingness to cultivate neglected legumes and their selection of suitable planting dates

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Neglected legumes are fundamental to global food systems, contributing to agricultural sustainability, enhancing food security, and strengthening the resilience of smallholder farming systems. However, they remain underutilized and have historically received limited attention in terms of cultivation, research, and market development, despite their significant nutritional,

agronomic, and environmental potential. This study assessed socioeconomic factors influencing farmers' willingness to cultivate neglected legumes and their selection of suitable planting dates in South Africa. A simple random sampling procedure was employed to collect data from 150 farmers specializing exclusively in crop production. An action research design was implemented, comprising structured training sessions on neglected legumes and trial demonstrations. Data were collected through a structured survey questionnaire, focus group discussions, and key informant interviews. Descriptive statistics were used for analysis, and a multivariate probit model was employed to determine the socioeconomic factors influencing farmers' willingness to cultivate neglected legumes including Bambara groundnut, cowpea and pigeon pea, and their selection of suitable planting dates. Findings confirmed that most smallholder farmers primarily focus on vegetable cultivation, followed by cereals, while a smaller proportion engage in legume farming. The results also revealed that limited knowledge and resources, along with the lack of training programs and extension services specifically targeting neglected legumes, are significant barriers hindering their adoption and cultivation. Furthermore, the study showed that training on legumes, marital status, farm size, market access, and water sources for irrigation were significant socioeconomic factors influencing farmers' willingness to cultivate neglected legumes, while household size, legume training, and water sources for irrigation had a significant effect on farmers' selection of suitable planting dates. These findings underscore the need for targeted interventions, including tailored training programs, improved access to resources, and enhanced extension services, to overcome these barriers and promote the adoption of neglected legumes into smallholder farmers' cropping systems.

**Keywords:** *Underutilized legumes, sustainable agriculture, farming systems, multivariate probit regression model, socioeconomic factors*

**ORAL PRESENTATION** D3.S4B: 3

## Integration of Cowpea and Sorghum in the Zambian Food System: Perceptions, preferences, affordability and the role of nutrition awareness

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Historically, Zambia's food system has been shaped by several factors, such as structural dependence on maize and consumption patterns. While maize remains central to national food security strategies, its dominance has led to dietary homogenisation and increased nutritional vulnerabilities. This has shaped food preferences and practices around maize, leading to poor dietary diversity and nutrition insecurity. That is, high dependency on a maize diet has led to minimal consumption of alternative staples. Zambia currently faces a "serious" hunger situation and continues to face significant nutritional challenges, with rising cases of child malnutrition and stunted growth remaining above regional targets.

Opportunity crops such as sorghum and cowpea are widely recognised for their climate resilience and nutritional value. However, scholars have largely focused on production and agronomic performance, with limited attention to consumption patterns. This study addresses this gap by examining the integration of these crops into the Zambian food system. Hence, analysing how perceptions, preferences, affordability and nutrition awareness shape the consumption of both crops.

Using mixed methods, the study draws on cross-sectional consumer surveys in urban Lusaka, complemented by semi-structured expert and key informant interviews. The findings indicate that although both crops are perceived to be healthy food alternatives, their consumption remains limited. While taste and nutritional benefits motivate consumption, non-consumption is influenced by affordability, unawareness and insufficient knowledge of preparation methods. Additionally, perceptions showed mixed signals, implying both positive and negative associations of both crops.

These findings suggest that food system diversification in Zambia is not only a production issue but rather a socio-cultural and institutional issue shaped by the historical dietary policies and legacies. Efforts should prioritise awareness creation around their nutritional value and their broader significance. Alongside diversification of product offerings through blended flours and institutional procurement channels to increase consumption and awareness.

**Keywords:** *Zambian food system, Food security, Nutrition, Opportunity crops, Diversification.*

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**ORAL PRESENTATION** D3.S4B: 4

## Food safety, packaging, and shelf-life innovations and their effect on profitability among African Indigenous Vegetable producers and retailers

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Smallholder vegetable value chains are characterized by substantial post-harvest handling constraints and heterogeneous marketing practices, yet limited empirical evidence exists on how food safety practices, packaging innovations, and shelf-life extension methods translate into economic returns across value chain actors. This study analyzes the relationship between these practices and profitability using cross-sectional data from 445 African Indigenous Vegetable (AIV) producers and 320 retailers, while controlling for socio-economic, structural, and institutional characteristics. Descriptive evidence indicates widespread adoption of basic hygiene practices but relatively low use of advanced packaging and storage innovations. Regression results reveal that among producers, packaging and shelf-life extension practices are positively associated with profitability, whereas reliance on fresh sales and longer transport times are negatively related to earnings. For retailers, routine hygiene practices show no statistically significant association with profits, while selected packaging methods and storage technologies exhibit positive and economically meaningful effects. Access to credit is positively correlated with retailer profitability, whereas market type and location are associated with systematic differences in returns. The results imply that not all post-harvest and food safety practices generate comparable economic returns, and that profitability effects differ systematically across value chain nodes and types of innovation.

**Keywords:** *African Indigenous Vegetables, food safety, packaging, shelf-life, innovations, profitability*

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## Poster Session 3 — Focus on Value Chains

**Poster** D3.P3: 1

### An Assessment of Agribusiness Fragility: A Case Study of South African Agribusinesses

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Agribusinesses currently operate in a volatile, uncertain, complex, and ambiguous environment, severely impacted by factors such as globalisation, climate change, geopolitical tensions, and systemic shocks. As agribusiness value chains continue to increase in complexity as interconnectedness advances, so too does the potential of risk contagion throughout the value chain. As a result, agribusinesses and by extension the broader food system are subject to cascading, non-linear impacts that pose an existential threat to achieving their goals. Despite the growing concern expressed for the impact of these challenges, a systematic and comprehensive framework for analysing agribusiness's fragility, risk exposure, and interconnectedness in the South African context is yet to be completed.

The aim of this research is to address this gap by developing a comprehensive framework to characterise, assess, and measure the fragility, risk exposure, interconnectedness, and contagion within South African agribusinesses and their value chains. Grounded in the concepts of antifragility and the action domain in the institutional environment, the conceptual foundation positions agribusinesses as nested, goal-oriented entities whose vulnerabilities are amplified by the dynamic interdependencies of modern value chains.

The study will employ a combination of heuristic stress testing and a dynamic risk assessment to assess the vulnerability of the system. Primary data will be collected by surveys across agribusinesses in various agricultural sectors, industries and regions in South Africa to ensure a representative sample is obtained.

The study will to contribute to literature by 1) Quantifying and mapping the risks faced by South African agribusinesses; 2) Analysing the causes of the fragility of South African agribusinesses while determining the level of interconnectedness and contagion of the risks identified; and 3) Developing recommendations and strategies to improve the resilience and robustness of South African agribusinesses.

**Keywords:** *Agribusiness fragility, VUCA environment, Risk exposure, Systemic vulnerability, Agribusiness resilience, South Africa*

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**Poster** D3.P3: 2

### Integration of indigenous and neglected crops into food systems of three provinces in South Africa: a systematic map

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Indigenous and neglected crops (INC) have been studied in several contexts for their potential in the transition to more resilient food systems. Existing research highlights the potential of INC in climate change adaptation based on their abiotic stress tolerance characteristics. Also, INC are considered a key element of nutrition-sensitive food systems. Some INC have shown higher levels of fiber, essential amino acids, and micronutrients compared to the most common commercial crops. In the case of South Africa, research highlights the potential of INC to provide food and

nutrition security, especially in disadvantaged areas. Nevertheless, existing research focuses on INC potential only at specific levels. Therefore, the objective of this study is to map the existing evidence on INC in South Africa using a food systems perspective. Our aim is to provide an integrative view of what has been researched at production, marketing and utilisation levels with environmental, economic, social and health implications. For this systematic map, we followed the Guidelines and Standards for Evidence synthesis in Environmental Management developed by the Collaboration for Environmental Evidence (CEE). We developed a comprehensive overview of research topics, description of the most studied and under-researched areas, distribution of research across the three South African provinces of the Eastern Cape, Mpumalanga and KwaZulu-Natal. We identify research gaps and analyse their implications for the promotion of INC. Our preliminary results suggest that most research is concentrated at the production level and that there is limited integrative food systems evidence to inform policy.

**Keywords:** *Indigenous crops, neglected crops, systematic map, food system, South Africa*

**Poster** D3.P3: 3

## Harnessing Indigenous Crops to Address Hidden Hunger in Southern Africa

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Hidden hunger remains a persistent and often overlooked challenge in Southern Africa. Deficiencies in iron, zinc and vitamin A coexist with adequate or even excessive caloric intake. This paradox reflects the region's double burden of malnutrition, marked by rising obesity alongside insufficient micronutrient consumption. Indigenous and underutilised crops such as sorghum, bambara groundnut and amaranth present a promising yet underexploited solution. They are nutrient-dense, resilient to drought and marginal agroecological conditions and are deeply embedded in local food cultures.

However, these nutrient-dense crops remain marginalised within formal markets, research agendas and policy frameworks. This poster asks: To what extent can indigenous crops contribute to reducing hidden hunger while strengthening climate-resilient and sustainable food systems? The objectives are to (1) assess the micronutrient density of selected indigenous crops relative to dominant staples, (2) examine their role in enhancing dietary diversity and nutrition security and (3) analyse value chain and institutional constraints limiting their wider utilisation.

The poster will adopt a conceptual synthesis approach from existing knowledge and draw on regional food composition tables, peer-reviewed nutrition studies and literature on neglected and underutilised species (NUS) in Southern Africa. Comparative nutritional evidence will be used to illustrate how crops such as sorghum, Bambara groundnuts and leafy vegetables like amaranth outperform refined maize and wheat in key micronutrients linked to hidden hunger. A food systems and value chain lens will then be applied to illustrate how weak market development, limited processing infrastructure and negative consumer perceptions restrict their integration into mainstream diets.

By bridging nutrition science with value chain analysis, the poster will help advance the argument that diversifying beyond a narrow staple-based food system is essential for climate-resilient nutrition security. This poster contributes a conceptual framework linking indigenous crop promotion to nutrition-sensitive value chain development.

**Keywords:** *UKUDLA, Hidden Hunger, Indigenous crops, Southern Africa, Value chain analysis*

**Poster** D3.P3: 4

## Food sovereignty is a local solution to global challenge of food insecurity within Indigenous Ovazemba communities in Namibia

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*University of Hohenheim*

Food sovereignty is a resilient strategy to global food crises in Indigenous communities. Indigenous crops are integral part of the consumed food of indigenous communities. However, food sovereignty is criticised and needs locally based solutions for an equitable transition. Based on the food sovereignty framework, this paper provides a data-driven understanding of culture-based principles of food sovereignty.

We examine the extent to which Ovazemba's resilient mechanisms promote nutrition and food security amid overlapping global crises. 60 key informants knowledgeable in Indigenous food systems from 8 Ovazemba communities in rural northwest Namibia were interviewed. A semi-structured questionnaire guided face-to-face interviews conducted following snowball sampling. A convergent parallel design enabled the analysis of frequencies of culturally informed practices and food consumption patterns.

Results suggest that, despite external stressors, including climate change, Ovazemba demonstrated a strong capacity to adapt and achieve nutrition and food security. Their adaptive capacity is centred on five culture-based principles of food sovereignty. These principles, rooted in ‘humanism’ and coexistence with nature, include Indigenous knowledge and ancestral wisdom, farming gender roles, manual and organic food production practices, food sharing initiatives, and biodiversity conservation.

The generalisability of the results is limited due to the small sample size. However, the results are reliable, valid, and provide a unique contribution to scientific discourse and policy reform to achieve food security and sovereignty within Indigenous communities. Food sovereignty can be achieved through locally based, culture-led principles, suggesting that Ovazemba’s adaptive capacity can be replicated as a potential solution for global populations facing food insecurity and diet-related deficiencies.

**Keywords:** *Food autonomy, Indigenous people, nutrition, staple food, food security, adaptive capacity, zero hunger*

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**Poster** D3.P3: 5

## Constraints and Opportunities of Cowpea and Sorghum Value Chains in the Zambian Food System

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The effects of climate change put agricultural production systems increasingly under stress and amplify concerns about shrinking agrobiodiversity. In this research, we investigated how two indigenous opportunity crops, cowpea and sorghum, could strengthen resilience, and thus, contribute to a more diverse, sustainable and inclusive food system in Zambia

We applied a mixed-method research approach, starting with a participatory food system mapping workshop and concluding with a validation workshop. We conducted 24 individual semi-structured expert interviews with downstream value chain actors and stakeholders and captured the

perceptions of smallholder producers in 18 gender differentiated focus group discussions. The interviews were analysed using a reflective thematic analysis framework.

Our results point to two policy spheres at the government's disposal to unlock the potential of opportunity crops like sorghum and cowpea. Conserving the agro-biodiversity of opportunity crops is currently largely left to informal farmer-managed seed systems. However, these systems need to be effectively supported through participatory breeding programmes and complemented by ex-situ conservation institutions to harness their potential. Also, diversification efforts need to be supported and backed by seed regulations that recognise the smallholder community as an equal partner. Second, government procurement of agricultural produce remains strongly biased towards maize. Including sorghum and cowpea in the portfolio of the Food Reserve Agency will send a strong market signal to smallholder producers by providing a stable and reliable market through their network of rural satellite depots.

Hence, we advocate for a policy shift that firmly integrates opportunity crops into the national food system by devising a holistic framework that sets shared objectives, establishes coordination mechanisms, and provides cross-cutting enablers. Within this framework, sorghum and cowpea specific value chain development strategies need to be developed that are aligned to their distinct production and processing requirements, and target identified end-markets, including school and hospital feeding programmes.

**Keywords:** *resilience, value chains, Opportunity crops, food systems*

**Poster** D3.P3: 6

## Evaluating livelihood diversification strategies and food security of rural households: Insights from a microlevel survey in Nkomazi Local Municipality, South Africa

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Livelihood diversification strategies (LDS), which include a combination of on-farm strategies involving mixed cropping and the cultivation of indigenous and underutilized crops, as well as off-farm strategies, are often said to yield synergistic benefits for improving food security and establishing resilient rural households. However, the adoption rate of these strategies remains low, especially among rural households in many emerging nations, and the relationship between food security and LDS remains unexplored in many parts of South Africa. Thus, this study focuses on assessing the livelihood diversification strategies employed by rural households, examining the socio-economic determinants of these strategies, and investigating the relationship between these strategies and rural households' food security status in Nkomazi Local Municipality, South Africa. A cross-sectional survey research design was used to collect data from 111 rural households selected through a two-stage random sampling procedure, using a structured questionnaire administered by trained enumerators. Descriptive statistics, binary logistic regression, and multiple linear regression were employed for data analysis. The findings revealed that only one-third (33.3%) of the rural households practiced livelihood diversification. The findings also revealed that the most dominant livelihood strategy among the rural households was off-farm activities (78.4%). Despite a medium dietary diversity score (63.1%) in most households, more than half (54.1%) were food insecure. The binary logistic regression identified farming experience ($p<0.05$), access to credit ($p<0.05$), and marital status ($p<0.10$) as significant socio-economic determinants of diversification. Furthermore, the multiple linear regression showed that livelihood diversification positively influenced rural household food security. The study recommends that promoting livelihood diversification, particularly through improved access to credit and leveraging the farming

experience of rural household heads, is essential for reducing reliance on government grants and improving food security. Furthermore, targeted extension-led training programs that promote and support both

on-farm (conventional and underutilized crop cultivation) and off-farm livelihood diversification strategies are recommended for implementation in the area.

**Keywords:** *food security, rural households, South Africa*

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**Poster** D3.P3: 7

## Patterns of millet commercialization in semi-arid Tanzania and consequences for food security.

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Millet is a nutrient-dense, climate-resilient crop vital for food security amid prolonged droughts. Yet research on barriers to millet commercialization and its implications for household welfare remains limited. This study examines how institutional factors, such as market information, extension services, group membership, and access to credit, influence commercialization and its effects on household food security.

Using cross-sectional data from 417 millet-farming households in Singida and Dodoma, Tanzania, we applied fractional logit regression. Results show that credit or market information alone does not significantly affect commercialization, but their combined availability does ($p < 0.001$). Integrated access encourages greater farmer participation. Group membership also has a positive effect ($p < 0.05$), likely reflecting gathered social capital, trust, and shared knowledge. By contrast, extension services alone show no significant effect. When combined with credit and market information, however, the interaction is negatively associated with commercialization ($p < 0.05$). This may reflect the perception that millet is a subsistence crop, limiting extension's focus on market development.

To assess dietary diversity, we used Inverse Probability Weighted Regression Adjustment (IPWRA). Commercialized households reported a 0.55-point higher Household Dietary Diversity Score (HDDS) and 9.67 points higher Food Consumption Scores (FCS) than non-commercialized ones, after controlling for covariates. Landholding, market access, and off-farm income consistently enhanced food security in both groups.

Overall, millet commercialization is associated with improved household food security. Policy should strengthen institutional support, especially coordinated provision of credit, market information, and targeted extension, recognizing the interdependence of bundled interventions.

**Keywords:** *millet, commercialization, institutional correlates, bundled intervention, food security.*

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**Poster** D3.P3: 8

## Leveraging Data Science for Nutritional Analysis and Dietary Strategies in South Africa

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South Africa has a substantial body of research on dietary intake and nutritional status; however, much of this evidence remains fragmented across regions, populations, and time periods. While the National Department of Health & DSI-NRF Centre of Excellence in Food Security Desktop Review (1997–2020) has compiled existing studies, the evidence remains largely static and difficult to interrogate spatially. This study asks: How can integrated geospatial analysis transform fragmented nutrition evidence into a dynamic tool that supports research prioritization and targeted food system interventions?

The primary objective is to develop an interactive geospatial platform that consolidates findings from the Desktop Review into a structured, visual map of nutritional indicators across South Africa. The platform enables identification of geographic research gaps and highlights areas where limited data exists, thereby guiding future research efforts. To demonstrate applied value, the study includes a focused adolescent obesity case study using data from the National Dietary Intake Survey 2022 (NDIS2022). For adolescents aged 10–19 years, anthropometric measures (e.g., height, weight, mid-upper arm circumference) are integrated with contextual variables such as household food security and local food environments. Spatial analysis is used to examine how proximity to different food outlets may influence dietary behaviors and nutritional outcomes.

The expected outcome is a functional interactive map that allows researchers to visualize existing nutritional evidence, identify under-researched regions, and prioritize further investigation. For policymakers, the tool provides spatially grounded insights to support targeted, nutrition-sensitive interventions in vulnerable communities. By transforming static evidence into an integrated and policy-relevant analytical platform, this study strengthens food security analysis and contributes to more sustainable and climate-responsive food system strategies in Southern Africa.

**Keywords:** *Food Security and Nutrition, Geospatial Analysis, Adolescent Obesity, Data Integration, Food Environment*

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**Poster** D3.P3: 9

## Integrating IoT and Data Science in Post-Harvest Technologies for Sustainable Food Chains

Pascal Nsunba Kanuayi, Jean Frederic ISINGIZWE NTURAMBIRWE, Clement Nthambazale NYIRENDA
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Post-harvest handling and storage losses in the fruit sector can reach as high as 44%. While general environmental monitoring exists, it often fails to capture the precise micro-climatic conditions and mechanical stressors experienced by individual produce items during transit. This research asks: How can an "apple-mimicking" IoT sensor combined with Artificial Intelligence provide actionable recommendations to extend and predict produce shelf-life? The primary objective is to utilize real-time data from a specialized sensor—monitoring temperature, ethylene, and acceleration—to build predictive models that offer proactive management strategies for the cold chain.

The research adopts a Digital Twin methodology powered by an Actor Model framework to ensure high fault tolerance and responsiveness. A physical sensor, designed to mimic the dimensions,

weight and thermal behaviour of a real apple, travels within produce pallets to experience the "physical world" environment. The data serves as the input for a processing pipeline where machine learning algorithms analyse environmental fluctuations to predict metabolic deterioration and shelf-life.

By monitoring ethylene concentrations to control ripening and acceleration to identify mechanical injuries, the system aims to move beyond simple data collection toward intelligent recommendation. The expected outcome is a scalable, AI-driven framework that enables agro-businesses to prioritize distribution based on predicted freshness rather than just "first-in, first-out". This integration of IoT and Data Science offers a cost-effective path for small and medium-sized enterprises to minimize food waste, ensure regulatory compliance, and enhance the sustainability of the global food chain.

This research directly addresses food security by transforming the supply chain from a reactive to a predictive system. By using AI to provide real-time recommendations—such as adjusting storage temperatures—the system minimizes the volume of nutrient-dense produce lost to spoilage. Ensuring that high-quality, un-bruised fruit reaches the consumer.

**Keywords:** *IOT, Real-Time, Cold Storage, Cold Chain Logistics, Horticultural, Sensors, Digital Twin, Actor Model.*

**Poster** D3.P3: 10

## Semi-empirical prediction of dust soiling effects on Agri-PV output power: Particle size effect and implications for adaptive maintenance

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Dust soiling is a persistent operational factor that reduces photovoltaic (PV) output by attenuating incident irradiance and shifting the electrical operating point under load. In agri-photovoltaic (Agri-PV) systems, where on-farm energy supports climate-resilient production and value-chain activities for indigenous and underutilized crops (including irrigation, cooling, and small-scale processing), quantifying soiling effects is important for establishing evidence-based maintenance and cleaning criteria. This study investigates PV performance under controlled laboratory conditions using three dust types: (i) very fine sand, (ii) medium sand, and (iii) coarse sand applied in incremental masses (0–5000 〖g/m〗^2) to a PV module operated with a fixed electrical load. The disparity in load voltages between the clean and soiled states was quantified and used to establish a power ratio metric. Subsequently, a semi-empirical predictive model was formulated by fitting the data for each dust category. To estimate the power output under soiled conditions, the soiling model was integrated with a parametric curve PV I-V and a numerical load line intersection technique, allowing the operating point to be determined. For an untested particle size, the associated model parameters can be derived through interpolation between the calibrated sand fractions, enabling the assessment of user-defined scenarios. The measurement indicates clear dependence, with fine sand producing a stronger power reduction per unit mass than medium and coarse fractions and a nonlinear response with an apparent threshold region at higher deposition. By linking soiling to predictable power losses and conditions-based cleaning decisions, this work supports climate adaptive Agri-PV management aimed at maintaining energy reliability while reducing unnecessary water consumption, labor and downtime. In the future, camera-based dust assessment will be integrated with these measurements to train a deep learning model for automated cleaning triggers.

**Keywords:** *Dust soiling, Agri-PV, Modeling, Cleaning, Climate adaptation*

**Poster** D3.P3: 11

## Hybrid Deep Learning with PCA and Fuzzy Logic for Multi-Pest Classification in Maize-Based Food Systems

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Maize-based food systems in sub-Saharan Africa are threatened by destructive pests, including Fall Armyworm (Spodoptera frugiperda), African Armyworm (Spodoptera exempta), and Maize Stalk Borer (Busseola fusca), with serious implications for yield stability and food security. This study asks: how can early multi-pest identification be improved while maintaining interpretability for agricultural decision-making? The objective is to develop an explainable hybrid deep learning–fuzzy logic framework that distinguishes these visually similar pests using field-style imagery. Secondary image data sourced from publicly available datasets used in previous studies were compiled and preprocessed using augmentation to reflect real-world variability (e.g., illumination and orientation changes). A VGG16-based feature extractor is combined with fuzzy logic membership functions to enhance class separability and provide interpretable inference alongside model predictions. Expected results are improved discrimination among pest classes compared to conventional deep learning baselines. The study aligns with symposium themes by supporting timely pest management and strengthening maize-based food security and sustainable value chains.

**Keywords:** *Food Security, Explainable AI, Fall Armyworm*