DSI-NRF
Centre of Excellence
in Food Security

Annual Progress Report 2023

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ACRONYMS/ABBREVIATIONS

AAS	African Academy of Sciences
ACF	African Climate Foundation
ADSA	Association for Dietetics in South Africa
AFSTC	African Food Systems Transformation Collective
AVE	Advertising Value Equivalency
AHRI	Africa Health Research Institute
APR	Annual Progress Report
ARC	Agricultural Research Council
ARUA	African Research Universities Alliance
ARUA-SFS	ARUA Centre of Excellence in Sustainable Food Systems
ASSAf	Academy of Science of South Africa
BVM	Breede Valley Municipality
CA	Collaborative Agreement
CAA	Cellular Antioxidant Activity
CCRED	Centre for Competition, Regulation and Economic Development
CIRAD	French Agricultural Research Centre for International Development
CODESRIA	Council for the Development of Social Science Research in Africa
CoE-FS	DSI-NRF Centre of Excellence in Food Security
CoE-HUMAN	Centre of Excellence in Human Development
CoMPAR	Co-construction of Multi-stakeholder Partnerships for Agricultural Research
CoP	Community of Practice

DALLRD	Department of Land Reform and Rural Development
DBSA	Development Bank of Southern Africa
DDM	District Development Model
ddPCR	Droplet Digital Polymerase Chain Reaction
DHS	Demographic and Health Survey
DPME	Department of Planning, Monitoring and Evaluation
DSI	Department of Science and Innovation
DVC	Deputy Vice-Chancellor
ECD	Early Childhood Development
EDP	Western Cape Economic Development Partnership
ERA-Net	European Research Area Network
EU	European Union
FACT	Food Alliance Cape Town
FAO	Food and Agricultural Organization of the United Nations
FDA	United States Food and Drug Administration
FLRF	Family Larsson-Rosenquist Foundation
FOPL	Front of Package Labelling
FtFF	Food-to-Food Fortification
FSNet-Africa	Food Systems Research Network for Africa
GAIN	Global Alliance for Improved Nutrition
GCRF	Global Challenges Research Fund
GDARDE	Gauteng Department of Agriculture, Rural Development and Environment

GFSI	Global Food Safety Initiative
GIS	Geographic Information System
HDI	Historically Disadvantaged Institution
HSRC	Human Sciences Research Council
HSRRC	UWC Humanities and Social Sciences Research Ethics Committee
ICLEI	International Council for Local Environmental Initiatives, now Local Governments for Sustainability
IDP	Integrated Development Plan
IDS	Institute of Development Studies, University of Sussex
IF	Impact Factor
IIED	International Institute for Environment and Development
IPG	Interdisciplinary Plant Group
ISD	Institute for Social Development, UWC
IYCF	Infant and Young Child Feeding
KPA	Key Performance Area
KU-L	Katholieke Universiteit Leuven
KZN	KwaZulu-Natal
LWFH	Local Wild Food Hub
MANCO	CoE-FS Management Committee
M&E	Monitoring and Evaluation
MIS	Management Information System
MOOC	Massive Open Online Course
MoU	Memorandum of Understanding

MU	University of Missouri
NAMC	National Agricultural Marketing Council
NCD	Non-communicable disease
NDIS	National Dietary Intake Survey
NDoH	National Department of Health
NFNSP	National Food and Nutrition Security Plan
NFNSS	National Food and Nutrition Security Survey
NMU	Nelson Mandela University
NPC	National Planning Commission
NRF	National Research Foundation
NWU	North West University
OFSP	Orange-Fleshed Sweet Potato
ORC	Office of the Rights of the Child
PBMA	Plant-based meat alternative product
PI	Principal Investigator
PL	Project Leader
POPIA	Protection of Personal Information Act
R991	Regulations Relating to Foodstuffs for Infants and Young Children
SAAFFI	South African Association for the Flavour and Fragrance Industry
SAAFoST	South African Association for Food Science and Technology
SAFCEI	Southern African Faith Communities' Environment Institute
SAFL	Southern African Food Laboratory

SALGA	South African Local Government Association
SAMRC	South African Medical Research Council
SARChI	South African Research Chairs Initiative
SASM	South African Society for Microbiology
SCICOM	Scientific Sub-committee
SDG	Sustainable Development Goal
SLA	Service Level Agreement
SLF	Sustainable Livelihoods Foundation
SMART	Safe, marketable, affordable, ready-to-eat and trendsetting
SMME	Small, Medium and Micro Enterprise
SSTC	South-South and Triangular Cooperation
StatsSA	Statistics South Africa
STEERCOM	Steering Committee
STEM	Science, Technology, Engineering and Mathematics
SU	Stellenbosch University
TAFS	Towards Agroecological Food Systems
TAG	Technical Advisory Group
TUT	Tshwane University of Technology
UCT	University of Cape Town
UD	University of Delaware
UFH	University of Fort Hare
UFS	University of the Free State

UG	University of Ghana
UJ	University of Johannesburg
UKRI	UK Research and Innovation
UKZN	University of KwaZulu-Natal
UL	University of Limpopo
UMD	University of Maryland
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
UNFSS+2	United Nations Food Systems Summit +2 Stocktaking Moment
UNICEF	United Nations Children's Fund
UNISA	University of South Africa
UP	University of Pretoria
UrbanFOSC	Urban Food Resilience under Climate Change Challenges
USDA	United States Department of Agriculture
UWC	University of the Western Cape
VU-A	Vrije Universiteit Amsterdam
WC	Western Cape
WCG	Western Cape Government
WFP	World Food Programme
WHO	World Health Organization
Wits	University of the Witwatersrand
WOSA	Whole of Society Approach

WP	Work Package
WWF	World Wide Fund for Nature

DIRECTORS' REPORT

The DSI-NRF Centre of Excellence in Food Security (CoE-FS) present the Directors' Report for the 2023 academic year.

Established in 2014, the CoE-FS has grown in stature and prominence on the African continent and beyond. In 2022, the most recent report of the University of Pennsylvania's *Global Go-To Think Tank Index* once again ranked the CoE-FS in the top 100 global think tanks in food security. In addition, in 2023, UNESCO renewed our Chair in Science and Education for African Food Systems for a further three years. And in July 2023, the CoE-FS was invited to exhibit at the United Nations Food Systems Summit +2 Stocktaking Moment (UNFSS+2) in Rome, the only South African exhibitor and the only university-based institution to be included.

Figure 1: South African delegation at UNFSS+2

The CoE-FS's UNFSS+2 exhibition was visited by the South African delegation, including Ambassador Nosipho Jezile.

This showcased our work alongside that of prominent international agencies such as One United Nations for Nutrition, the Food and Agricultural Organization of the United Nations (FAO), the International Fund for Agricultural Development, the United Nations Children's Fund (UNICEF), the World Food Programme (WFP) and the World Health Organization (WHO), as well as NGOs such as the Agroecology Coalition, the Global Alliance for Improved Nutrition (GAIN), and the UK Research and Innovation Action Against Stunting Hub.

The work of individual CoE-FS researchers has also been acknowledged: Professor Rina Swart received the prestigious 2023 Nutrition Society Award, while the Association for Dietetics in South Africa (ADSA) Recognition Award was given to Dr Chantell Witten, a CoE-FS alumnus and former Project Lead (PL).

Given the socio-political shifts in 2023, these achievements are important. Record levels of acute food insecurity were noted that persist due to the protracted food crises, and which have been exacerbated by new shocks such as conflict, weather extremes, and economic and global food trade challenges. According to the *Mid-Year Update of the Global Report on Food Crises*, 48 countries and 238 million people (10% more than in 2022) are facing high levels of acute food insecurity. The economic resilience of poor countries has decreased dramatically, and they now face extended recovery periods following the COVID-19 pandemic. Further, as the timeframe for implementation of the United Nations (UN) Sustainable Development Goals (SDGs) moves towards the halfway mark, it has become clear that urgent steps must be taken to meet our food-, nutrition- and agriculture-related targets, many of which have stagnated and even reversed.

In light of these challenges, the CoE-FS is well positioned to play a leading role in the future, having completed its first 10 years of scientific excellence on the continent. What makes the CoE-FS unique is that it operates as a virtual centre of excellence hosted by the University of the Western Cape (UWC), a historically disadvantaged institution (HDI), and co-hosted by the University of Pretoria (UP), crossing traditional socio-political and disciplinary boundaries. As a result, we have been able to create new pathways to transdisciplinary research and new ways of collaborating across most South African universities and research institutes, as well as with civil society and government.

The CoE-FS has developed into a distinctive science platform where integrated research in plant and food science, political economy and development studies, as well as food safety and nutrition, can flourish. Our emerging focus on ‘One Food’ further contributes to knowledge building and addressing the persistent challenge of at-home food insecurity. Our mission has always been deeply rooted in the pursuit of the co-creation of sustainable food systems to achieve food security for all vulnerable people, aligning it with the belief that food and nutritional security are essential for human survival, dignity, and pride. We remain committed to this purpose, emphasising the right of all human beings to be free from hunger, food insecurity and malnutrition. To this end, we have also worked with human rights researchers and advocacy groups.

Overview of the CoE-FS

The CoE-FS functions as a collaborative hub, uniting expertise through Collaborative Agreements (CAs) and Memoranda of Understanding (MoUs) with universities, research institutions, public institutions and civil society organisations. With 49 of these in place, the CoE-FS is creating an opportunity to re-form as a national institute. We already work with 10 of South Africa’s 26 universities, of which seven are HDIs. We collaborate with other key stakeholders in South Africa, including the Agricultural Research Council (ARC), the Human Sciences Research Council (HSRC), the South African Medical Research Council (SAMRC), and the African Research Universities Alliance’s (ARUA) Centre of Excellence in Sustainable Food Systems (ARUA-SFS).

As examples of the benefits of these collaborations, during 2022 and 2023 Professor Julian May chaired the Technical Advisory Group (TAG) of a national survey on food security implemented by the HSRC, and serves on the Council of the Academy of Science of South Africa (ASSAf). Both directors served as mentors and advisors on the Food Systems Network (FSNet) programme of ARUA-SFS. Professor Lise Korsten was appointed as the first female president of the African Academy of Sciences (AAS); she also chaired the International Society for Plant Pathology Task Force on Global Food Security. Each of the Principal Investigators (PIs) plays similar boundary-spanning roles through their collaborations with partner universities and other stakeholders.

Figure 2: 2023 highlights

At a grassroots level the CoE-FS engages with local government, communities and NGOs, including the Breede Valley and Witzenberg municipalities, the cities of Cape Town and Johannesburg, the national fresh produce markets, the Gauteng Department of Agriculture, Rural Development and Environment (GDARDE), the Southern African Faith Communities' Environment Institute (SAFCEI) and the Western Cape Economic Development Partnership (EDP), among others.

At an international level, the CoE-FS has well-established links with the French Agricultural Research Centre for International Development (CIRAD); the World Bank; the United Nations Educational, Scientific, and Cultural Organisation (UNESCO); the FAO; the WHO; and the Global Food Safety Initiative (GFSI), as well as academic institutions such as the University of Sussex's Institute of Development Studies (IDS), Vrije Universiteit Amsterdam (VU-A), the University of Hohenheim, Ghent University, the University of Missouri (MU), and the Chinese University of Hong Kong. Elsewhere in Africa, during 2023, we built strong links with the University of Ghana, Moi University and the University of Constantine.

Capacity-building

Our commitment to capacity-building is evident in the support provided to 94 students in 2023, including NRF-funded, leverage-funded and non-bursary holders. In 2023, the CoE-FS had 116 active researchers, maintaining an almost equal representation of men and women. Notably, the number of black researchers has increased significantly, from six at our inception to 71 in 2023, enriching our research with diverse perspectives. We continue to explore avenues for equal representation. A total of 31 students graduated in 2023, contributing to our goal of growing research capacity in South Africa. In addition, seven students benefited from leveraged funding that provided them with doctoral placements in Europe and the USA.

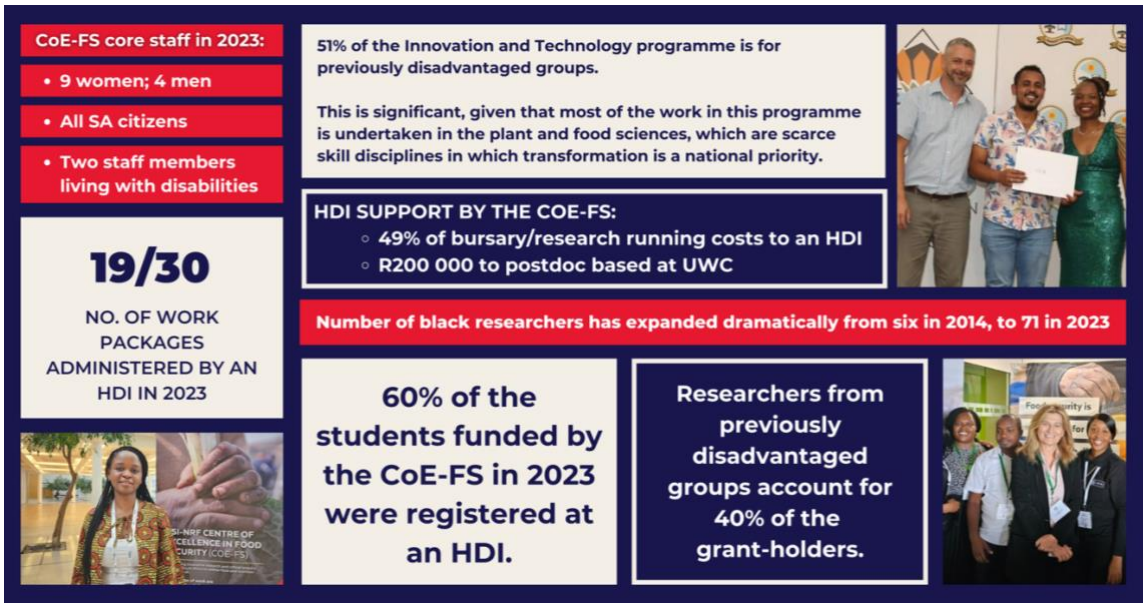

Figure 3: Capacity building, HDI support and transformation

Research output

In 2023, the CoE-FS produced 93 articles in accredited journals, chapters in peer-reviewed books, and books, with 48 having an impact factor (IF) of three or more. This remarkable output showcases our dedication to research excellence and knowledge dissemination. A review of our citations conducted in mid-2023 found that our cumulative work since inception had been cited 11 022 times in Google Scholar and 5 760 times in Scopus. The CoE-FS has exceeded its targets for the 2018–2023 review period, and excelled in areas such as face-to-face policymaker engagements (achieving 1 358% of the 2022 target), contributing more than R100 million (238% of the target) in income diversification, achieving an H Index of 56 (almost 200% of our 2022 target), publishing more than 160 accredited papers (145%), and targeting >160 accredited journals with an IF greater than three (487%).

Research impact

The most immediate impact of our research is through its use and citation by the academic community, as noted above. However, achieving a high research impact requires showing that the findings of our research have made a meaningful contribution to knowledge, practice, or decision-making in the relevant field. To this end, we are in the process of establishing a position for a monitoring and evaluation (M&E) officer using our leveraged funding.

However, some instances of our research impact can already be reported. For example, one of our recent and highly cited papers in food science was used in 2023 by research teams in India working on recent trends in food preservation, as well as by researchers in Iran working on biocontrol bacteria. Another study on food insecurity among farmworkers was used by researchers looking at the impact of socioeconomic conditions on compliance with stay-at-home rules during the COVID-19 pandemic, in a paper published in *The Lancet* that has already been cited over 400 times. Another recent paper on antibiotic resistance in the agricultural ecosystem was picked up by a Spanish research team working on antimicrobial resistance in *Escherichia coli* strains, while a paper on the use of social media platforms by breastmilk substitute manufacturers authored by one of our PhD candidates was picked up by the WHO in their 2022 report on the digital marketing of such products.

In addition to the impact of our publications on their own, much of our impact is achieved through our communication and engagement activities. During 2023, our research team served on national and international advisory groups, including the National Planning Commission (NPC), the National Food and Nutrition Security Coordinating Committee, the Global Food Equity Centre, and the scientific committee of the fifth Global Food Security Conference. Our expertise was also drawn on for the National Food and Nutrition Security Survey (NFNS) and the National Dietary Intake Survey (NDIS), as well as during an outbreak of cholera in Hammanskraal. At the local level, we have contributed towards the inclusion of the effects of climate change and support for nutrition at early childhood development (ECD) centres in the Integrated Development Plan (IDP) of the Breede Valley Municipality (BVM).

Knowledge-sharing and transfer

The CoE-FS has prioritised science communication since its inception, and has made its research, events and activities available through various communication channels, including the foodsecurity.ac.za website, social media channels (Facebook, Instagram and X, the platform formerly known as Twitter), external media, video and audio platforms (YouTube and SoundCloud), as well as media and general mailing lists. Through these channels, content is distributed to a diverse group of stakeholders, including students, researchers, host and affiliate institutions, government bodies, funding agencies and the media. In addition, our UNESCO Chair in Science and Education for African

Food Systems was an important channel for our knowledge brokerage and networking KPAs during 2023.

Highlights of our science communication work in 2023 include:

- Participation in and exhibition at the UNFSS+2
- Participation in and exhibition at national conferences including the National Nutrition Congress and SAAFoST
- Extensive external media coverage of the CoE-FS's contribution to draft regulations for front-of-package labelling (FOPL) warning labels
- Hosting the South African launch of the *2023* Lancet *Series on Breastfeeding*, and our researchers' participation in the publication itself
- A plenary presentation on the Learning Journey approach at the World Sustainability Forum held in Singapore in September.

To celebrate our achievements over the past decade, we are pleased to announce that the CoE-FS will be hosting a conference on food security in Africa as part of our 10-year celebrations. This conference will be attended by our alumni and many other stakeholders, and will be held in Cape Town on 22 to 24 May 2024. It will showcase our research, capacity building, science communication and societal engagement since our inception, and we are delighted that we will be joined by members of the board of the IDS-based Food Equity Centre and the editorial committee of the *Food Security* journal. We are already in discussion with scientific journals to identify opportunities for a special edition to commemorate 10 years of excellence in the field of food security.

Julian May

(Director)

Lisa Korsten

(Co-director)

INTRODUCTION

The CoE-FS was formed in 2014, after successfully competing for a DSI-NRF call. It is hosted by the University of the Western Cape (UWC) and co-hosted by the University of Pretoria (UP). We receive an annual core grant from the NRF and have matched this by bidding for additional research grants to increase our output and reach.

The mission of the CoE-FS is to undertake research, capacity building and dissemination on how a sustainable food system can be achieved to realise food security for poor, vulnerable and marginal populations. Our long-term goals remain to:

- Continuously build a comprehensive understanding of the changing national and global food system and how this affects the sustainability, availability, access and attributes of food in South Africa;
- Identify the 'food insecure' in South Africa; identify where they are located; identify their choices, strategies and opportunities when seeking food security, health and well-being; and understand how these change in response to the changing food system;
- Develop and promote policies, technologies, interventions and products that enable access to affordable and nutritious food in ecological, economic, social and politically sustainable ways; and
- Grow South Africa's capacity to undertake this research through training, grants and bursaries.

Over time, and with leveraged funding, our scope has expanded to research undertaken in other countries in Africa, as well as work that is of relevance to global food security. This has been facilitated through our UNESCO Chair in Science and Education for African Food Systems, and was given further impetus by the election of our co-director, Professor Lisa Korsten, as the first women president of the AAS.

Since our inception we have pursued our research goals through:

- Transdisciplinary modes of inquiry: this mode of knowledge production and cooperation offers innovative methodologies for high-impact science through understanding and acting on complex societal problems. The design of our three research programmes is further informed by direct engagement and knowledge co-production with actors in the food system, in addition to more conventional approaches to scholarly endeavour.
- A partnership approach in the organisation of our research activities: this has required building purposive strategic relationships for the co-design and co-ownership of research problems, methodologies and solutions by the host institutions and our collaborators.
- A transformative agenda in terms of the South African and African food security situation: we provide leadership, evidence for decision-making and informed debate, and critique of policies and programmes aimed at addressing food insecurity through a comprehensive and systems

approach to development that recognises the underlying causes of food insecurity, including poverty, patriarchy, unemployment and inequality.

- Research excellence: we see this as both increasing our output of rigorous fundamental and applied research, and increasing our impact as determined by citations, peer review, research ratings, alternative metrics and evidence of use of research papers and products.
- Active engagement in knowledge brokerage and science communication to contribute to policy development; and
- Our approach has taken a 'farm-to-fork' approach to the food system since our inception. Our contention is that in the African context, food security is shaped not simply by agroecological factors but also by political and economic factors, as well as the terms on which producers, processors, distributors, and consumers participate in the food system. This approach is now well aligned with the EU's Farm to Fork strategy that was released as part of the European Green Deal in May 2020.

The CoE-FS works as a multidisciplinary team of research leaders, project managers and students. In so doing we find innovative ways to apply our research at the local level and engage with policymakers, practitioners, other academics and the general public. While pursuing its mission and vision, the CoE-FS uses every effort to contribute to government initiatives, as well as to deliver on international food security priorities.

In 2023, our research activities included involvement in an ERA-NET Food Systems and Climate (UrbanFOSC) co-fund; a HORIZONS 2020 grant; the Family Larsson-Rosenquist Foundation (FLRF); the African Climate Foundation (AFC), the Töpfer Müller Gaßner Think Tank for Sustainability, and a FAO grant to analyse gender and other forms of exclusion in the food systems of Eastern and Southern Africa.

STEERING COMMITTEE AND SCIENTIFIC SUBCOMMITTEE

In 2023, STEERCOM consisted of members representing academia, civil society, and the public and private sector. A new member, Dr Lise Albrechtsen, was appointed from 1 December 2023. The members are listed in Table 1 below.

Figure 4: STEERCOM meeting

The STEERCOM met in Cape Town in November 2023, for its first in-person meeting post-COVID-19.

The CoE-FS also established a Scientific Sub-committee (SCICOM) in 2021. SCICOM focuses on the quality of the scientific output of the CoE-FS and meets bi-annually. It consists of active researchers and research users. The

appointment of the members was extended for two months so that the committee would still be constituted at the time of the STEERCOM meeting in November 2023. We received four resignations from SCICOM: one due to retirement; one member who has been posted outside of Africa; one due to personal reasons; and that of Dr Arlène Alpha who has joined the CoE-FS's Management Committee (MANCO), taking over the work of Professor Bruno Losch. New members were appointed in November 2023, and their details are provided in Table 2 below.

Both SCICOM and STEERCOM had hybrid meetings in November 2023, the first face-to-face meetings since the COVID-19 pandemic. This was the first time that MANCO joined the STEERCOM, and was able to meet and engage with STEERCOM members. CoE-FS students and postdoctoral Fellows also attended the STEERCOM meeting, as did one of our visiting scholars, who has since completed her master's degree in International Relations at the Università degli Studi di Milano. By attending these meetings, researchers and students get the opportunity to observe and understand the factors that are considered, how decisions are made, and the thought process behind them. It is also an opportunity for researchers, students and post docs to network with members, gain insights into different industries, and build valuable connections that could benefit them in their academic and professional pursuits.

Table 1: List of STEERCOM members

Position	Name
Chairperson	Professor Mary Scholes (University of the Witwatersrand (Wits))
DVC	Professor Barend Erasmus (UP)
DVC	Professor Jose Frantz (UWC)
Director	Professor Julian May (UWC)
Co-director	Professor Lise Korsten (UP)
DSI	Rose Msiza (DSI representative)
NRF	Dr Makobetsa Khati/Nathan Sassman (NRF representatives)
Member	Professor Patrick Caron (CIRAD)
Member	Dr Joan Matji (UNICEF) – SCICOM chairperson until 30 November 2023
Member	Professor Sagadevan Mundree (University of Queensland)
Member	Professor Bocklines Bebe (Egerton University, Kenya)
Member	Dr Mickey Chopra (World Bank)
Member	Professor Christine Foyer (University of Birmingham)
Member	Dr Lise Albrechtsen (on leave from Norwegian Ministry of Foreign Affairs) – from 1 December 2023

Table 2: List of SCICOM members

Position	Name
Chairperson	Dr Joan Matji (UNICEF) – until 30 November 2023
Member	Professor Karen Hofman (Wits) – until 30 November 2023
Member	Professor Nick Vink – Stellenbosch University (SU) -until 30 November 2023
Member	Professor Joyce Tsoka-Gwegweni (University of the Free State (UFS))
Member	Dr Arlène Alpha (CIRAD) – until 30 November 2023
Member	Professor Lia van Wesenbeeck (VU-A) – from 1 December 2023
Member	Professor Les Copeland (University of Sydney) – from 1 December 2023
Member	Professor Rose Ramkat (Moi University) -- from 1 December 2023
Member	Dr Maneshree Jugmohan-Naidu (DSI) -- from 1 December 2023
Member	Wandile Sihlobo (Agricultural Business Chamber of SA) – from 1 February 2024

COE-FS DETAILS

Director and co-director

The leadership of the CoE-FS comprises a director and co-director who are responsible for the overarching management of the CoE-FS. They are supported by MANCO comprising PIs, who lead multi-year, multi-institutional programmes of research.

Figure 5: CoE-FS MANCO and staff

The PIs are expected to be scientists who craft the research agenda, mediators who bridge gaps, PLs who manage diverse teams, knowledge brokers and

'boundary spanners' and networkers, who often assemble a Community of Practice (CoP) on specific topics of national importance.

The details of the director and co-director are listed in Tables 3 and 4 below.

Table 3: Details of the director and co-director

Details	Director	Co-director
Title	Professor	Professor
Name	Julian	Lise
Initials	JD	L
Last name	May	Korsten
Organisation	UWC	UP
Citizenship	SA	SA
Gender	Male	Female
Race	White	White
Highest qualification	PhD	PhD
NRF rating	C1	B2
Rating period	2016-2021	2013-2018

Table 4: Contact details of the director and co-director

Details	Director	Co-director
Organisation where based	UWC	UP
Department	DVC: Research & Innovation	Vice-Principal: Research, Innovation and Postgraduate Education
Primary funder: salary	NRF	UP
Faculty / School	Institute for Social Development (ISD)	Department of Plant and Soil Sciences
Work telephone	021 959 3846	012 420 3295
Mobile number	082 771 7368	079 522 8476
Website address	www.foodsecurity.ac.za	
Email address	jmay@uwc.ac.za	Lise.Korsten@up.ac.za
Contact person	Elaine Petersen	Professor Lise Korsten
Work telephone	021 959 3817	012 420 6149
Alternate email	eapetersen@uwc.ac.za	Lise.Korsten@up.ac.za

Collaborators

In addition to the 45 CA/MoUs already in place, the CoE-FS concluded four new agreements in 2023:

1. African Climate Foundation (ACF)
2. Töpfer Müller Gaßner Think Tank for Sustainability
3. The Sustainability Institute
4. University of Hohenheim.

Table 5: CoE-FS details for verification

Host institution	University of the Western Cape
Co-host institution	University of Pretoria
Year of current funding cycle	10
Gate stage	5

OVERVIEW OF ACHIEVEMENTS DURING THE REPORTING PERIOD

Achievements related to the current stage

Tables 5 to 7 below set out 2023's achievements against the targets for 2023, and Table 8 provides the specific output targets for 2023. The information pertaining to presentations; conference, workshop and seminar attendance; and publications is listed in Appendices 1 to 3 in the report.

Following the launch of the CoE-FS in 2014, a register of researchers was developed. The list of researchers for 2023 is provided in Appendix 4. This list is updated annually, and is maintained as the base for communication and identifying potential collaborators and referrals for networking opportunities.

In 2023, the CoE-FS had 116 active researchers; of these, 60 (52%) are men and 56 (48%) women. Also, 61 (53.5%) of the researchers are black (this includes Indian and coloured), and 50 are white (43.9%). The rest of the researchers are other nationalities; further details are provided in Appendix 4. The data reveal the number of black researchers has increased significantly since the inception of the CoE-FS, from six to 71.

An online management information system (MIS) was established in 2014 to record, track and monitor all projects funded and managed by the CoE-FS. This system has been integrated into a cloud-based bursary and project management information system. The current system – which includes Excel spreadsheets of the progress of projects and research outputs, and an electronic filing and administrative system – is accessible from UWC and UP. Nuggets of information are extracted from this MIS and published on the CoE-FS's website and social media pages and reported to the NRF, on a quarterly or more frequent basis. In 2023 we started a process to upgrade the MIS into a more comprehensive system that can be used for monitoring and evaluation (M&E), as well as for impact assessment. To this end, using leveraged funding we have appointed a part-time M&E officer to assist.

Table 6: Activities related to the current stage of deliverables

Output	Achieved
Participate in official events of the CoE-FS programme	✓
Continuously update the register of participants (including students) in the CoE-FS	✓
Continuously update the project register that lists all research being conducted within the CoE-FS	✓
On a quarterly basis, make 'nuggets' of information available to the NRF for publication on the CoE-FS and NRF websites	✓
Maintain digital repository of completed research outputs funded by its resources, including theses, research reports, policy briefs and published papers	✓
Submit a written claim with supporting documentation to trigger transfer payments each January	✓
Submit monthly cash flow statements, within 15 days of the end of each calendar month	✓

Collect income and expenditure reports from all collaborating partners on completion of projects	✓
Collect income and expenditure reports from all collaborating partners on completion of the 2022 and 2023 projects that have received extensions	✓
Submit Annual Progress Report by no later than 30 May each year	✓
Submit an External Audit Report by no later than 31 March each year	✓
Submit a Statement of Compliance by no later than 31 March each year	✓

Achievements related to the Service Level Agreement (SLA): 2023

Table 6 below shows the 2023 outputs and targets. The evidence for each target is provided as appendices and tables in the report.

In 2023, the CoE-FS supported 94 students; that is, 50 NRF-funded, 20 leverage-funded and 24 non-bursary holders. In terms of gender, 87 (93.5% of all students) female students were supported; 34 (68%) female students were supported from NRF funding; and 25 (50%) South African female students received NRF support. The CoE-FS also supported 19 postdoctoral Fellows in 2023.

A total of 80 (85%) black students (of all students) were supported in 2023; a total of 41 (51%) were supported by NRF funding; and 30 (81%) of the black students supported are South Africans. Due to the legacy of bursaries awarded in the first five years of the CoE-FS, and the increased value of bursaries in 2020 and concomitant reduction in the number of bursaries that could be awarded, we remain nine percentage points below our target for black South Africans. To address this, we no longer recommend NRF bursaries for South Africans who are not in the designated groups, or for non-South Africans.

It should be noted that the 2023 output targets for NRF students, as approved in the *2023 Business Plan*, were amended according to the "DSI-NRF 2023 Postgraduate Funding Policy", and Table 6 provides the student information, as guided by the funding policy. The amended information is reflected in the SLA.

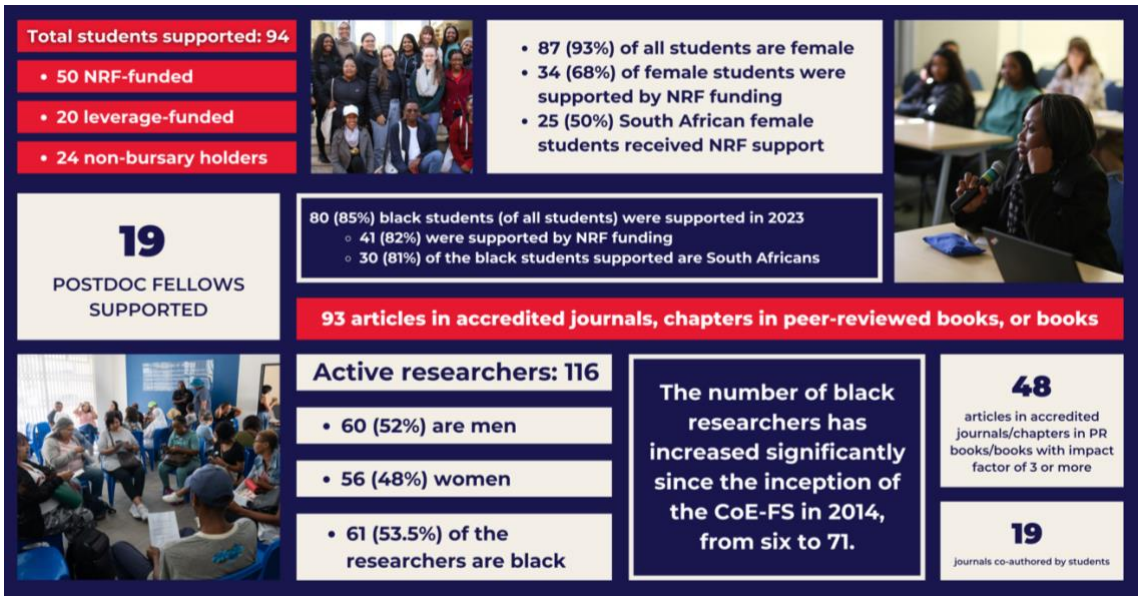

Figure 6: Highlights of CoE-FS progress in 2023

In 2023, the CoE-FS produced 93 articles in accredited journals, chapters in peer-reviewed books, or books, and 48 with an impact factor of 3 or more, and 19 of the journals were co-authored by students. Details are provided in Appendix 3.

Table 7: SLA 2023

Description	Outputs: 2023	Output targets: 2023	Appendices
Students included in projects funded by the CoE-FS (all students)	94	90	6,7,9,10,11,14,15
Women students supported (NRF funded)	34 (68%)	55%	As above
South African citizens and permanent residents (NRF funded)	37 (74%)	95%	As above
Equity distribution for South African black students ('black' refers to African, coloured, Indian/Asian) (NRF funded)	30 (81%)	90%	As above
Disabled students (NRF funded)	0[1]	1%	As above
Disabled students (all students)	1	1%	As above
Proportion of students graduating by the next Gate Review	90%	≧ 75% of all students since inception	NA
Average duration of submission of master's degrees (post honours)	24 months	≦ 24 months	NA
Average duration of submission of PhD degrees	36 months	≦ 40 months	NA
Average duration of submission of PhD degrees (upgraded from master's)	60 months	≦ 60 months	NA

[1] It is difficult for the CoE-FS to determine which students have disabilities, as the NRF's review process does not make provision for this; the CoE-FS also does not have a full record of every student's personal information.

Unrated researchers who become rated, or rated researchers who retain or improve their rating	13	5	4
Patents, products and artefacts	0	3	Section 18
Articles in accredited journals, chapters in peer-reviewed books or books	93	40	3
Articles with an Impact Factor greater than 3	48	8	3
Joint-venture student training initiatives	10	3	
Local conferences organised		1	
International conferences organised	1	0	
Presentations at local conferences	56	40	
Presentations at international conferences	20	10	NA or 5
Food security panels organised at conferences		1	
Annual social media (Facebook, etc.) views	13 968 (FB)	222	
Number of face-to-face policymaker engagements	27	10	
Annual website views	NA	4 500	

Annual Facebook likes	225[2]	100	
Annual media activities (radio, TV, press)	209	12	5
Citations of pooled articles/book chapters that acknowledge CoE-FS funding (Google Scholar)	45	6-7	NA
Additional funds raised	R44 601 115	R25 million	13

Table 8: Transformation targets

Output	Achieved
At least five senior academics from formerly disadvantaged groups have experienced further capacity development	✓
At least 15 emerging academics from formally disadvantaged groups have experienced capacity development	✓

[2] The number of times that accounts followed in the selected time period (1 January – 31 December 2023).

Specific targets for the current stage

The table below provides evidence related to achievements of specific targets for the reporting period.

Table 9: Specific output targets

Output	Achieved
Six on-line MANCO meetings have been held	✓
Two hybrid MANCO planning meetings/Lekgotla have been held	✓
Two hybrid STEERCOM meetings have been held	✓
Two SCICOM meetings have been held	✓
Annual Business Plan was submitted	✓
Annual Progress Report was submitted	✓
Clean audit was received	✓
40 nuggets per year have been provided to the NRF	✓

KEY PERFORMANCE AREA (KPA) 1: RESEARCH

The CoE-FS has contributed towards the creation and development of new knowledge and/or technology. To achieve KPA 1, three programmes of research were undertaken in 2023:

- Multi-level governance and policy dialogues to create a sound and resilient food system at global, national and local levels;
- Innovation for the sustainability, productivity and utilisation of indigenous African and other locally available foods that affect food security; and
- Quantity, quality, diversity and safety of diets in relation to all forms of malnutrition.

The three research questions that inform the scope of work for the CoE-FS's research activities for the second planning cycle (2020-2023) remained unchanged.

These are:

- How is the global and national food system changing, and how does this affect the sustainability, availability, access to and attributes of food?
- Who are the 'food insecure'; where are they located, what are their choices, strategies and opportunities when seeking food security, health, and well-being, and how do these change in response to the changing food system?
- What policies, technologies, interventions and products enable access to affordable, nutritious and safe food in ecological, economic, social and politically sustainable ways?

As 2023 was the final year of funding under the grant awarded in 2014, the programme PIs were drawn from only the two host institutions, in order to manage possible phasing-out activities. The CoE-FS supported eight NRF-funded projects and thirty Work Packages (WPs) in 2023 (these are listed in Appendix 12 in the report). Of the 30 WPs funded in 2023, 19 were administered by an HDI.

Programme 1: Governance, power and public engagement in the food systems

This programme was led by Professor Julian May (UWC), and Dr Marc Wegerif (UP) during 2023 following the retirement of Professor Bruno Losch in September, 2022. The programme consisted of four projects.

Project 1.1: Strengthening local food governance

This ongoing project adopts an action-research approach, engaging directly with the transformation of governance practice by generating knowledge to inform practice.

WP 1.1.1 Multi-level and transversal governance in practice

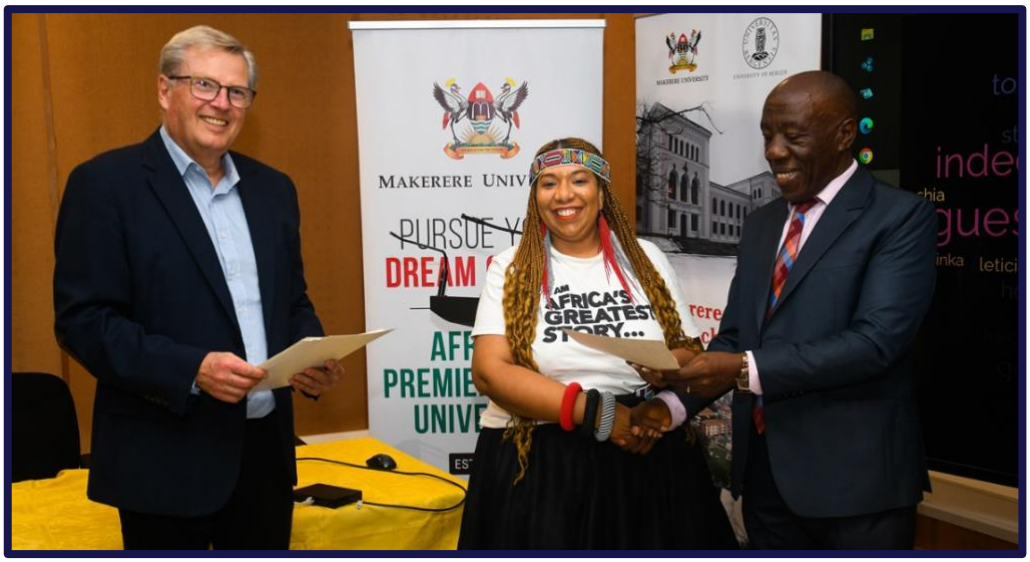

Figure 7: Bergen Summer Research School participation

PhD candidate, Keshia Hoaeane participating in the Bergen Summer Research School.

This WP has examined vertical and transversal governance structures for food security, by analysing the potential of an existing transversal governance approach to improve food governance. The WP made use of two case studies in the Western Cape (WC) in which the Whole of Society approach (WOSA) has been adopted as a way to improve local governance. Field work in Langa was completed in 2023 by a continuing PhD candidate, Keshia Hoaeane (UWC), who is supervised by Dr Camilla Adelle (UP), Professor Bruno Losch (CIRAD) and Professor Julian May (UWC). In May 2023, Keshia was provided with a doctoral placement grant to participate in the Bergen Summer Research School in Norway, where she attended a course on food and nutrition security in childhood. Keshia has submitted a first draft of her thesis, and we expect her to submit for examination in the first semester of 2024. Remaining activities at the second case study site, BVM, are reported below in Project 1.4, our flagship place-based activity.

WP 1.1.2 Food Charters and civil society engagement

This WP explored whether and how a Food Charter could be implemented in South Africa, using a case study of the Western Cape. In 2023, activities focused on finalising academic publications, and on transferring our collaboration with SAFCEI to our expanding WP on the Food Imbizo, reported below. As planned, no funding was expended on this WP in 2023, and no further activities are planned. The WP has confirmed that sub-national Food Charters are a feasible intervention, and that these do raise awareness of food system challenges and opportunities among diverse stakeholders. Nonetheless, inequalities in terms of access to economic resources, power and knowledge could perpetuate exclusion. As a result, we suggest that Food Charters are a useful but not essential step towards improving food system outcomes, and other forms of stakeholder engagement are necessary.

WP 1.1.3: Policy engagement at the municipal level

The activities within this WP began in 2018 in the Witzenberg Municipality. Municipal engagement was renewed through our collaboration with the BVM and Project 1.4, our place-based approach to analysis local food system governance. During 2023, the WP provided funding for some of the running costs to complete interviews and meetings with stakeholders in the City of Johannesburg and the City of Cape Town. Unfortunately, funding a from leverage-funded project provided by the Cooperation South Africa-The Netherlands Programme Merian Fund to expand this WP to Atlantis in the WC could not be taken up, as the student candidate withdrew for personal reasons. The WP has thus come to an end, and the remaining activities will be completed as part of Project 1.4. The WP demonstrated the potential for improving food system outcomes through municipal-level policy engagement, and identified key learnings that we have incorporated into Project 1.4. The importance of structured and ongoing engagement with municipal officials, elected councillors and ward committee members was a key finding.

WP 1.1.4: Communities of Practice on food system governance

The CoE-FS process emphasises knowledge co-production by researchers, practitioners and civil society, and a process in which stakeholders rather than researchers identify the topics to be discussed. It forms part of our networking and knowledge brokerage KPAs, and is guided by our Communications and Engagement Strategy. The CoPs are both a way to link science to society, and also a space for self-reflection and redesign. The activities under this WP in 2023 are thus discussed in detail under KPA 3 below.

WP 1.1.5: The Local Wild Food Systems Hub Community of Practice

The Local Wild Food Systems Hub (LWFH) CoP is a new initiative for the CoE-FS that was introduced in 2023. It builds on an evolving network of researchers and practitioners in this field of work that was established by civil society movements in 2017. Initially, this network aimed to co-develop practice-based knowledge and thought leadership on cultivation, access and use of edible plants in the Greater Cape Floristic Region. The movement gained institutional form when Local WILD, an NGO, partnered with the Sustainability Institute to form the LWFH.

Figure 8: LWFH focuses on the Greater Cape Floristic Region.

In 2023, Local WILD partnered with the CoE-FS to develop a new CoP that seeks to learn from the practical experience of establishing the LWFH. To this end a postdoctoral Fellow (Dr Maya Marshak, under the supervision of Professor Rachel Wynberg, SARChI Research Chair in Environmental and Social Dimensions of the Bioeconomy at the University of Cape Town (UCT)) has been analysing participant contributions, to inform the evolution of subsequent CoP engagements and the methods that future workshops might adopt. A report will be prepared in 2024 that brings together this experience, and a scientific publication will be generated. This new WP has not yet generated research findings, but has demonstrated the value of collaboration between an NGO and a university that is facilitated by the appointment of a postdoctoral Fellow.

Project 1.2: National food governance: National knowledge brokerage

This project engages with national policy through dialogue, policy analysis and systematic review; and with international experience of policies for food and nutrition security that explore national experiences of food policy dialogues.

WP 1.2.1: Food safety governance

Ntombizethu Mkhwanazi's (UP) research on food safety governance in South Africa at national level was completed in 2023, and she will be submitting her PhD thesis for examination in early 2024. This WP has thus completed its activities and will not receive further funding. A key concern identified by this research is the absence of a central authority concerned with food safety, as well as the limitations of the existing process, which is based largely on self-regulation. The CoE-FS recommends that food safety be a theme for a funded research chair.

WP 1.2.2: Engaging with the national and international level

This WP hosts several activities related to the national and international food policy space. During 2023 it continued to support policy engagement at the national level based on the FAO-European Commission-supported food system assessment, which is opening up new opportunities for collaboration. Using leveraged funding from the FAO, a report on the social exclusion of women in agriculture in Eastern and Southern Africa was completed by Professor May and Jani Truter, a PhD candidate at UWC and the Katholieke Universiteit Leuven (KU-L). This report will be part of a larger review of food systems in the region that will be released by the FAO in 2024. The work included engagement with similar research teams working in Western Africa, Latin America and the Caribbean. This activity was concluded in December 2023. A number of transition pathways were identified through which current dynamics of gendered exclusion could be addressed. These include land and policy reforms, training, and the enforcement of existing laws that seek to reduce gender inequalities,

Also supported by leveraged funding, in 2023 the CoE-FS completed research funded by the Family Larsson-Rosenquist Foundation (FLRF) on Infant and Young Child Feeding (IYCF) that targets national policy development. The work was led by Dr Chantell Witten (a CoE-FS alumnus) and completed by Carla Bernardo following Dr Witten's relocation to Wits in May 2023, with oversight provided by an

independent technical advisory group and by a steering committee that included Professor May and Professor Swart. The work supported the development of an evidence-informed advocacy and engagement campaign that counters the undue influence exerted by the marketing of infant formula on women's breastfeeding choices. The research was thus aligned with the International Code of Marketing of Breast-milk Substitutes and the "Regulations Relating to Foodstuffs for Infants and Young Children" (R991). R991 prohibits the marketing, in any form, of designated food products for children aged 0 to 36 months. During 2022 and 2023 a multisectoral engagement process using semi-structured, open-ended questionnaires was used to uncover and prioritise key areas and stakeholders that could be addressed by advocacy, direct stakeholder engagement, or further strengthening of R991. The interviews focused particularly on sectors that engage with mothers but do not focus on mothers themselves. Between August and November 2023, a short market survey was undertaken to explore, with key sectors, their experience of and engagement with the formula industry. These sectors included health professionals, academia, retail and the media. On the basis of prioritised levers that were generated from analysing over 70 interviews, the project identified the need for an advocacy and engagement strategy that is to be developed and costed to counteract the marketing of infant formula in South Africa. The research found that the main levers to be addressed are:

- The inroads made by the formula milk industry to create a positive attitude towards their products, using activities not or poorly covered by R991;
- The medicalisation of normal child behaviour, and the related false scientific claims of the formula milk industry;
- The provision of information about mother and child behaviour with mis/disinformation about infant feeding approaches embedded within it.

Figure 9: Lancet Report launch

The CoE-FS co-hosted the local launch of the Lancet Report on Breastfeeding with CoE-HUMAN.

The key stakeholders we identified to be addressed through this multi-pronged strategy (a communications and advocacy campaign, filling the material gap, and an engagement strategy) were:

- The healthcare system
- Academia and training facilities
- Government officials responsible for R991.

To act on the findings and target priorities, the project concluded that clear and concise messages for advocacy and engagement would have to be developed and pilot tested. The results of the study were presented at three workshops, which included the launch of the *Lancet Report on Breastfeeding* as well as a meeting of the Deans of Health of South African universities. The next steps will be undertaken under the direction of the FLRF, working with advocacy partners and media specialists. To this end, the CoE-FS assisted in the preparation of terms of reference before concluding the work at the end of 2023. An academic publication has been submitted for review. A master's graduate, Bonnie Evert, was employed by the project, and was also provided with mentoring support by Professor Swart in preparation for her PhD, which we anticipate will begin in 2024.

Project 1.3: Urban food systems (Project ID – 23103)

This new project was led by Dr Marc Wegerif (UP) in 2023 and contained three WPs:

- WP 1.3.1: Mapping the urban fresh produce foodscape
- WP 1.3.2: Assessing fresh produce accessibility through street traders and small-scale black farmers
- WP 1.3.3: Mapping urban governance environments of small-scale and informal sector actors

The project recognises that around the world there are pressures from urbanisation, a crisis of growing inequality, ecological breakdown, and the denial of people's right to food, increasing manifesting in the phenomena of the triple burden of malnutrition. With more than half the world now in urban centres, and urbanisation expanding rapidly, the challenge of feeding the world is increasingly becoming one of feeding the cities, with their accompanying and different logistical and social challenges.

South Africa is now a majority-urban country and is experiencing all of these conditions in extreme ways, due in part to the history of racial division and imposed inequality, and also to the current trends of corporate concentration and capturing value, alongside poverty. The country faces particular challenges in building a more inclusive economy that will bring greater opportunity for black ownership and incomes. Any sustainable food system must contribute to addressing these issues. The research continues to be on the informal food sector, due to the lack of knowledge about the sector and its key role in creating livelihoods and serving low-income communities. The focus remains on fresh produce, which is essential for balanced diets, and the importance of fresh produce to emerging black farmers. The informal trade does not operate in isolation but is closely linked to the formal sector,

with mutual trade and exchanges taking place between them. This unique landscape forms an interesting but complex backdrop to what requires context-specific interventions to address its most pressing concerns.

Work on this project undertaken in 2020/21 found that through their pricing and locations, street traders perform a key function in making food accessible to low-income communities. They have also been found to be a key market for emerging black farmers. But there is a lack of sufficient data on pricing, costs and other factors that determine the viability of trader-farmer links and the ensuring of food accessibility. From the experiences of actors in the food system it has also been found that such actors are often negatively impacted, especially under COVID-19, by regulations and their enforcement. The regulations also affect the viability of new market opportunities. More work is needed to understand what reasonable and necessary regulation is, and what can be eased to enable the food system to operate. This also requires a better understanding of the interface between forms of self-regulation in the informal sector, and government regulation.

Figure 10: Trolley sellers

Work under the "Urban food systems" project has included assessing fresh produce accessibility through street traders and small-scale black farmers.

In 2023, the project incorporated more joined-up work across Gauteng and the Western Cape, and paid more attention to sharing findings and stakeholder engagements aimed at improving food systems. The intention is to expand the project in the future, should funding permit, to include food systems in secondary cities and small towns in the highveld regions of South Africa.

The research undertaken and the highlights for 2023 are as follows:

- The project set up price-tracking of fresh produce from informal traders;
- Significant media interest garnered, and a range of engagements were held;
- Researchers worked with the National Agricultural Marketing Council (NAMC) on food markets and held discussions. An article related to this has been published.
- A submission was made on the ICLEI (Local Governments for Sustainability) document *Food for Rebuilding: A strategic framework for the development of a sustainable, resilient, and inclusive food system for South Africa;*
- Discussions were held with the Competition Commission on their work related to food;
- Part of the international initiative was to establish a programme of work on Food Systems of the Poor. It was convened by the International Institute for Environment and Development (IIED) at Bellagio in Italy in Sept 2022, and we are still working on putting together a programme of work;
- Input was provided to the Raith Foundation Board and their food security work;
- There was engagement with Statistics South Africa (StatsSA) on the food price information that they gather.

The project also conducted several media engagements, and national and international presentations; these are listed in the applicable appendices in this the report.

Research under this project will continue in 2024, and detailed information regarding its research outputs will be provided in the 2024 APR.

Project 1.4: A place-based approach in selected municipalities

The place-based approach was identified in the CoE-FS lekgotla in 2019 as a methodological tool to 1) promote transdisciplinary activities; 2) develop a holistic understanding of the operation of a food system in a specific location; and 3) improve our societal engagement using knowledge co-production tools and working with local stakeholders in government, civil society and the private sector. This approach draws on the literature on territoriality, and was initiated by Professor Bruno Losch. It is now led by Professor Julian May.

The project builds on WP 1.1.3 and previous research undertaken by the CoE-FS in the Umzimvubu Local Municipality of the Alfred Nzo District as part of the PURE Project, funded from 2014 to 2018. It commenced with the Food4Cities Project in the BVM located in the Cape Winelands District, funded by LEAP-Agri between 2019 and 2023; and now includes the ongoing UrbanFOSC project, also being conducted in the BVM, that will continue until 2024. These case-study sites present the two faces of South African agriculture and the South African food system, while also offering insights into the opportunities and constraints applicable to South Africa’s new District Development Model (DDM).

WP 1.4.1: Iterative learning and prototyping, project management and dissemination

The purpose of this WP is to connect food system analysis to the co-design of interventions that enhance food system quality and resilience. In 2022 and 2023, our massive open online course (MOOC) on urban food system governance was developed with our collaborators at KU-L and VU-A. The MOOC was launched in March 2023 (https://foodsecurity.ac.za/news/coe-fs-ku-leuven-launches-urban-food-systems-mooc/; https://ees.kuleuven.be/en/newsflash/mooc-on-urban-food-systems). Later in 2023, two new modules were developed by VU-A, UWC and the University of Constantine. These modules are titled 'Urban Food System Design and Climate Change', and 'Dietary Diversity for Urban Food Design'. They will be finalised and incorporated into the MOOC in 2024, as UrbanFOSC comes to an end.

Funding was also provided under this WP to Njabulo Mncwabe, to initiate the option of building a third site in KwaZulu-Natal (KZN). Mncwabe is a PhD candidate supervised by Dr Farai Mtero (UWC), and is working on an assessment of the nature and potential of agroecological farming in communities of KZN. In addition to its prototyping goal, this study will contribute to the learning on one of the Food Sovereignty principles: agroecology. Agroecological farming (which is practised primarily by small-scale farmers) has been used as an example to explore how viable and sustainable it is as a method of farming in small communities. This study is thus evaluating whether agro-ecological farming can be practised, and how it could promote the defined goals of food sovereignty. We expect Mncwabe to submit her thesis for examination at the end of 2024, and her work and funding will be transferred to WP 1.4.4. to allow WP 1.4.1 to be closed at the end of 2023.

WP 1.4.2: Policy engagement at the municipal level

Research and engagement activities for this WP were incorporated into WP 1.4.3 in 2023. Two continuing PhD candidates, Ashley Haywood and Zona Ndondo, received running costs for fieldwork, travel, accommodation, data processing and the purchase of data. This research and their progress are reported in WP 1.4.3, and this WP will be closed in early 2024.

WP1.4.3: Comparative evidence on food insecurity in secondary cities

This predominantly leverage-funded WP was initiated as part of the Food4Cities project funded by LEAP-Agri, a funding instrument of the EU between 2019 and 2022. Its scope and scale were significantly expanded in 2023 using new leveraged funds provided by FOSC-ERA, an instrument of ERA-NET and Horizon 2020. UrbanFOSC is a three-year collaboration between UWC, VU-A, CIRAD, Moi University in Kenya and the University of Constantine in Algeria. To support the research activities, CIRAD have seconded Dr Arlene Alpha to UWC for three years, to take over the activities of Professor Bruno Losch. UrbanFOSC runs until September 2024.

Local collaborators include the BVM, the Western Cape Government (WCG), the EDP and the Southern African Food Laboratory (SAFL) at SU. In addition, during 2023, an MoU was signed with KU-L, who will join the WP and have funded staff and students to participate in the WP in 2023 and 2024.

Figure 11: Moments from various Learning Journeys.

WP 1.4.3 is now the flagship package of Project 1.4 and seeks to include research, communication, dissemination and exploitation activities. Its aim is to assess urban food system transformations under climate and other global change in which increased production is targeting international value chains. Using systems analysis and modelling, the project is co-designing (with stakeholders in government, the private sector and civil society) possible interventions and governance processes that contribute to improved urban nutrition and a higher resilience of urban food systems to climate change.

The WP is innovative in the following ways:

- It takes a full food systems perspective, accounting for both consumer and producer behaviour;
- It integrates the temporal dynamics of food system change through explicitly addressing climate change and the internationalisation of value chains;
- We are testing a co-design approach with stakeholders that is based on joint learning of system dynamics;
- We have developed a place-based approach for food-system governance, which is being tested across the sites in Algeria and Kenya, to allow replication in different contexts;
- We have tested Learning Journeys as a method for data collection, a space for knowledge sharing and transfer, and an approach to facilitate knowledge co-production.

A number of research highlights emerged in 2023. Firstly, we have confirmed the value of the Learning Journey methodology and its application to systems problems. The methodology allowed complex ideas concerning food systems to be explored with diverse stakeholders in government and civil society. These included climate change scenarios, value chain transformation, and food system localisation. As Learning Journeys involve carefully designed conversations during a curated

transect of a physical place, the approach allows stakeholders to redefine these abstract concepts in ways that make sense to their specific context. In this way, the Learning Journey approximates the constructivist approach to learning in which the 'experts' (the researchers) and the stakeholders co-produce knowledge. The Learning Journeys undertaken by UrbanFOSC in 2022 and 2023 included officials from the BVM, the WCG, local councillors and ward committee members, national and local NGOs, and researchers from CIRAD, Johns Hopkins University, MU, VU-A, KU-L, UCT, SU and UWC. They thus served as both a meaningful way in which to engage stakeholders and as a way of generating and interpreting data on the BVM's food system.

A second highlight in 2023 follows from the ongoing work undertaken in collaboration with CIRAD on food system vulnerabilities in specific value chains operating in the BVM. Two rounds of in-depth interviews have been conducted with stakeholders in the area. The research highlights ongoing issues with the local management of water resources, as well as farmer responses to climate change in the table grape, poultry, and cucurbit value chains.

A third highlight of 2023 emerges from our analysis of secondary data and the database collected for our previous Food4Cities project. Once these were harmonised, we were able to quantify flows of food consumed and produced in the BVM and its foodshed. This analysis reveals that an average of 2 330 kcal per capita per day was consumed in the BVM per day, above the 2 100kcal per capita per day that is required to be food secure. Further, comparison with the *2017 Agricultural Census* shows that almost two thirds of the food types consumed in BVM are grown within the '100-mile' boundary often used to describe localised food systems. While this does not mean that the local products are those consumed in the BVM, this indicates the potential for increasing local content.

A final highlight from 2023 is the outcomes from the Bayesian modelling of the food system undertaken in collaboration with the VU-A. This analysis allows us to estimate the impact of alternative policy interventions on selected food system outcomes. Using dietary diversity as our indicator of interest, we have been able to compare interventions that resulted in change. We tested interventions focusing on public health (nutrition education programme), value chains (promotion of local produce), and the local food economy (support for informal outlets). Of these, the last had the most significant positive impact.

As noted above, UrbanFOSC builds on the previous Food4Cities project, and is embedded in a five-year programme of research that involves multiple studies. As a result, attribution of impact presents challenges. However, noteworthy changes to stakeholder behaviour and policy documents that can be attributed to the two projects are the inclusion of interventions and budget for ECD in the approved fifth-generation IDP of the BVM that were not previously identified in the previous IDP; the inclusion of a more detailed discussion of managing climate change in this IDP; and the identification of the BVM as a pilot site for the WCG's "Nourish to Flourish" food security strategy. Significantly, food security now features strongly in the fifth IDP of BVM, released in 2022, and the proposed actions include recognising the nature of community needs, the establishment of a food security summit, and the role of each childhood development centre. The previous IDP mentioned food

security only in terms of soup kitchens and community gardens. This IDP also barely acknowledged the need to plan for climate change; whereas the fifth IDP contains a comprehensive discussion of climate change, and includes a programme (with a budget) that explicitly includes food security as a focus.

There are also indications that the Do More Foundation, the largest NGO in the BVM working on food security, has adapted some of the Foundation's strategies, including their support of ECD centres and their engagement with local and provincial government. There are also indications that the provincial Department of Agriculture is making use of the Food4Cities and UrbanFOSC findings in the implementation of the SmartAgri Strategy, the provincial flagship policy for adapting to climate change. Of note in 2023 was the presence of Dr Mogale Sebopetsa, head of the Western Cape Department of Agriculture, who opened our Learning Journey in Touws River in March 2024, and Darryl Jacobs, the Deputy Director (Agricultural Development and Support Services) who participated in the Learning Journey.

In addition, during 2023 the BVM initiated a discussion with smallholder livestock farmers for the first time. This group had been identified as food system stakeholders during the learning journeys implemented by the UrbanFOSC project in 2022 and 2023. The municipality has informed us that they are hoping to introduce a support programme for this activity in the 2025 budget.

There have been delays in commencing fieldwork by some of the collaborating partners; this did present challenges in 2023. CIRAD only began data collection activities in March 2023, while a national funding problem has significantly impacted the activities that were planned in Kenya, and thus the comparative learning component of the project.

Although the project management support provided by the postdoctoral Fellow at VU-A was adequate, the research contribution has been less than expected. Further, the Fellow resigned her position at the end of 2023. VU-A has allocated a PhD candidate for the research activities in South Africa, who has since made a significant contribution.

Although some parts of the BVM are potentially dangerous, due to organised crime and related gang activity, this has not impacted on the data collection. However, advice received from the BVM concerning the risk of xenophobic violence resulted in the cancellation of one of the planned co-design activities for 2023 at the De Doorns site.

Finally, the Breede Valley experienced serious flooding in 2023. Planned fieldwork activities were shifted to avoid burdening the local collaborators as they responded to the impact of the flooding.

In 2023, as noted above, three PhD candidates worked on UrbanFOSC activities and benefited from capacity development.

- Zona Ndondo is a full-time employee of the City of Cape Town, but is conducting her research in the BVM. In 2023 she completed her proposal and research design, and submitted and received her ethics approval from the

UWC Humanities and Social Sciences Research Ethics Committee (HSRRC). She received training in the Learning Journey methodology and participated in two Journeys. We expect her to submit for examination in 2026.

- Jani Truter is a joint UWC/KU-L PhD candidate who is conducting her research in BVM. She received training in the Learning Journey methodology and participated in one Journey. She completed coursework at KU-L during the second semester of 2023 and submitted her proposal for review; it has been approved. In 2024, Truter will be arranging a studio workshop for 45 KU-L and 10 UWC students in the BVM as a direct follow-up of the UrbanFOSC activities. We expect her to submit for examination in 2026.
- Ashley Haywood has completed his fieldwork on food system governance practices in the BVM with his participation in the Learning Journey to Touws River, and is now finalising his analysis and write-up. We expect him to submit at the end of 2024.

In addition, there is one master's student involved in the project. Nolutando Didiza is a part-time master's student at UWC, supervised by Professor May. In 2023 she received ethics approval from HSRRC and completed most of her fieldwork. This study explores institutional arrangements in the food waste bioenergy sector. It uses the RCL bioenergy plant in Worcester to contribute towards understanding the evolving complexity and dynamics of access to and contestation over food losses and waste used in the bioenergy sector in South Africa. Embedded in a circular economy framework, the research has examined the ways through which the bioenergy companies participate in or are excluded from the use of food losses and waste as a pathway to making profit. It will compare the operation of the bioenergy plant with activities involving the sale of spent layers for food in the informal economy of Zwelethemba. To this end, Didiza received training in the Learning Journey methodology and participated in one Journey. We expect her to submit for examination in the first semester of 2024.

Training has also been provided to fieldworkers recruited from the BVM for the different research activities in 2023. This has always included: 1) completion of ethical procedures for fieldworkers, and 2) Safety when conducting fieldwork. Depending on the need, additional training is provided in 1) in-depth interviews; 2) focus group discussions; 3) structured observation techniques; and 4) use of audio recorders.

Finally, in the second semester of 2023 Dr Tsega Tefera joined this project as a postdoctoral Fellow who will continue to work in the BVM following the completion of UrbanFOSC. Dr Tefera will conduct new primary research on informal fruit and vegetable street traders and their customers in 2024, using a feminist economics approach to guide the research. Leverage funding has been committed by the Competition Commission to support this activity and to feed the results into policy debates.

WP1.4.4: Transitions to innovative food production at local level

During 2023 this leverage-funded WP 'Transition towards Agroecological Food Systems' (TAFS) concluded its investigation of crops, production methods, processing options and distribution that take into account water resilience, heat

tolerance and nutritional value. Undertaken in partnership with the SAFL, CIRAD and the CoE-FS, the case study sites were:

- Stanford, Overstrand LM and Overberg DM in the Western Cape
- Inchanga, Outer West Spatial Region and eThekwini Metro in KZN
- KwaBhaca/Mount Frere, Umzimvubu LM and Alfred Nzo DM in the Eastern Cape.

Research reports have been concluded for each area and were peer-reviewed. A policy brief has been prepared, and funds are available for a short video production.

The next activity to be undertaken for this WP, also in receipt of leveraged funding from CIRAD, is the 'Co-construction of Multi-stakeholder Partnerships for Agricultural Research' (CoMPAR) project, which began in the second half of 2023 and will continue in 2024. The objective of CoMPAR is to test the hypothesis of improved resilience of territorial food systems based on agroecological practices in the face of recent (e.g. COVID-19) and potential future crises. It builds on the TAFS and focuses on foresight for territorial food systems. The foresight process aims to co-construct different possible futures for the territorial food systems studied under TAFS, and to produce arguments in support of agroecology-based food systems. In preparation of the territorial foresight process, a complementarity analysis of Steps 1 and 2 of TAFS will focus on the impacts of current crises on territorial food systems based on agroecology and on their resilience. The CoMPAR project also encompasses a more operational dimension, which is to facilitate a policy dialogue process that enables engagement with the actors and decision-makers of the territory on the future of their food system. The output of this policy dialogue may be the production of argumentative notes, policy briefs and when possible and required, the elaboration of a territorial action plan to achieve desirable futures based on agroecological transition. For this reason, the site chosen for CoMPAR is the BVM. The bulk of the research and engagement will take place during 2024, in parallel with the other activities of Project 1.4.

Programme 2: Innovation and Technology

The PIs for this programme are Professor Naushad Emmambux (UP) and Professor Ndiko Ludidi (UWC).

This programme aims to build livelihoods and food security in the food system to be relevant for Africa, while embracing the global need for technological innovation by paying more attentionto indigenous African crops and those that are intensively consumed on the continent, as well as entrenching the importance of grain crops that are of global relevance for food security. It also focuses on the economic costs and benefits of innovation for small-scale agriculture.

This programme consisted of the following two projects in 2023.

Project 2.1: SMART Food Processing (Project ID – 23201)

Professor Emmambux (UP) is leading this project.

The primary question of the project is: what technological innovation is required for food and nutrition security in the processing of indigenous and local foods? This research project works hand-in-hand with the Climate-Smart Regenerative Agriculture Project. This is a continuation of the previous SMART foods project that started in 2020.

The objectives of this project were:

1. The creation and processing of 'SMART' foods and food ingredients from indigenous and local plants that have been enriched to combat malnutrition and diet-related non-communicable diseases (NCDs).
2. Necessary tools in terms of appropriate food processing technologies for entrepreneurs to produce affordable, safe, convenient, consumer-driven, nutritious foods and food ingredients.
3. Value additions to waste from the food processing industry for sustainable food production.

The research undertaken and the highlights for 2023 are organised under the following sequence of WPs:

WP 2.1.1 Technological innovation to reduce energy density of foods

Different types (tannin and tannin-free) of sorghum grain and flour were treated with infrared and microwave as a heat-moisture method to increase resistant starch. The grain and flour were further modified with added phenolic extract from sorghum bran. It was found that high-tannin sorghum types had the lowest starch digestibility with a medium estimated glycaemic index. Heat and moisture treatment with added phenolics also reduces sorghum starch digestibility from about 65% to 50%.

Extrusion of a sorghum snack with bran reduced starch digestibility but produced an inferiorly expanded snack. However, enzyme pre-treatment of bran improved the quality of the snack in terms of expansion ratio and sensory properties like those of snacks made from refined flour. There was an approximate 10% decrease in starch digestibility for sorghum snacks with the addition of the pre-treated bran, compared to those manufactured with refined sorghum flour. Maize starch microspheres manufactured as per UP's patent were used in drinking yoghurt, pastry dough and croissants as a fat replacer. Starch microspheres can replace up to 25% of fat in both pastry dough and croissants without any noticeable changes in techno-functional or sensory quality. In drinking yoghurt, starch microspheres can work more as a fat replacer than a stabiliser. The yoghurt with added starch microspheres showed similar lubricity properties compared to full-fat yoghurt.

The interaction of maize starch with stearic acid (a lipid) and cowpea protein isolate was investigated with the aim of producing ternary complexes that reduce starch digestibility. Maize starch forms ternary complexes with lipids and cowpea protein isolates. The nutritional implications of such a complex are being analysed.

Figure 12: SMART Foods at SAAFoST

SMART Food Processing's innovative products were on show at the SAAFoST 2023 Biennial Congress and Exhibition.

WP 2.1.2 Nutrient density of foods with health benefits for infants and adults

Sourdough-type fermentation of sorghum flour produced better-quality flatbread than unfermented sorghum flour. This is possibly due to the structural changes in starch and protein caused by microbial enzymes and acids. The flatbread produced from fermented flour showed a lower staling rate.

In another fermentation work, the addition of a non-alcoholic yeast (*Pichia kudriavzevii*) to a fermented sorghum beverage was investigated. Inoculated yeast increased the lactic acid bacteria and decreased the number of coliforms to an undetectable value within 12 hours. This suggests a shorter time for manufacturing the beverage, and the yeast could also reduce the safety risk of coliform. To enhance utilisation of neglected and underutilised crops, it was demonstrated that protein nanofibres can be produced from sorghum kafirin, cowpea, and marama protein isolates. The research will be the first-ever report on the potential of marama and cowpea protein isolates to produce nanofibres. The nanofibres could have applications as texturised vegetable proteins and as scaffolds.

Marama bean protein concentrates have been shown to have visco-elastic properties like those of gluten. This is important as it allows the use of gluten-free flours such as cassava, sorghum, finger millet and tef to produce bread with good loaf volume. However, the amount used may not be economical. We have shown that modifications with phenolics and enzymes strengthen the viscoelastic

properties, as determined by increasing the viscous and elastic moduli during rheological measurement. The mechanism of this change and its implications for gluten-free applications are being determined.

Studies have been conducted to determine the effects of extrusion cooking and FtFF (food-to-food fortification) with moringa and baobab on the bioactive phenolic content, *in vitro* radical scavenging properties, antiglycation properties (AGEs), cellular antioxidant activity (CAA), cellular anti-inflammatory activity (inhibition of NO), and anti-obesity properties (reduction in lipid droplet formation) of wholegrain sorghum-based porridges. FtFF porridges showed greater radical scavenging properties (ABTS radical scavenging and ORAC) and a greater reduction in AGEs compared to unfortified porridges. All porridges exhibited potential anti-inflammatory effects in *in vitro* systems. The porridges also showed potential to protect against oxidative stress. FtFF (with moringa and baobab) and extrusion cooking can be used to produce instant porridges from wholegrain sorghums with targeted health-promoting properties to address rising NCDs in sub-Saharan Africa.

Pigmented flower extracts from the Geraniaceae (*Pelargonium grandiflorum* Willd. and *Pelargonium hortorum* L.H. Bailey, *Pelargonium zonale* hybrid) had higher DPPH radical scavenging activity than extracts from the Lamiaceae (*Salvia aurea dolomitica*, *Salvia dolomitica* Codd, and *Plectranthus zuluensis* T. Cooke). The pigmented extracts exhibited strong protective effects against radical damage in Caco-2 cells (an indication of their ability to protect against oxidative stress) and reduced NO production in murine RAW264.7 macrophages (an indication of anti-inflammatory effects). Interestingly, an increase in pigmented extract concentration resulted in increased NO production, which could have applications in anti-hypertension studies. The pigmented flower extracts showed the ability to reduce lipid accumulation in differentiated murine adipocyte (3T3-L1) cells, indicating anti-obesity properties. The pigmented flower extracts also showed anti-glycation activity comparable to that of aminoguanidine, especially extracts of *P. grandiflorum* and *P. hortorum*, which suggests that these particular extracts could replace aminoguanidine as an anti-diabetic medication.

Figure 13: SMART Food Processing grantees have excelled in various science communication competitions.

The pigmented flower extracts showed a wide range of health-promoting properties, which represents an additional benefit to their potential use as natural food colourants. Research work on optimisation of protein extraction conditions for enhanced complexation of Bambara protein with gum Arabic has been completed. The manuscript is currently under review. Limited enzymatic hydrolysis as a protein modification strategy produced a significant shift in the pH of the complexation of Bambara groundnut protein with gum Arabic and the production of soluble complexes, thus rendering them possible for application in an acidified food environment. The smart food project's research with an industry partner has led to a joint publication and a better understanding of consumer awareness of whole grains and their health benefits. It provided direction for consumer-focused strategies that are needed in developing countries, to increase whole-grain food consumption to help the broader population achieve a healthy and sustainable diet. Actions proposed include simple-to-understand information on whole-grain content relative to recommendations on food product labels; the provision of whole-grain foods in school nutrition schemes; and coordinated social and behaviour-change communication initiatives.

Research was done to develop a tool for measuring the food choice motives of consumers in South Africa. This could be used in various projects to address malnutrition. The insights from this study are useful for the development of an updated, quantitative food choice questionnaire for application in this and other emerging economies. The plant protein trend among consumers has prompted innovation in plant-based meat alternative products (PBMAs); however, wide nutrient ranges and higher sodium levels highlight the importance of nutrition guidelines for their development to ensure healthier product offerings to consumers. The findings of the study may assist in the exploration of consumer preferences, attitudes or engagement with PBMA products, which could in turn guide new product

development within the category. However, information about possible barriers, drivers, consumer expectations and attitudes towards these products is also required.

A decision-tree scoring system was developed to guide the selection of consumer-preferred, orange-fleshed sweet potato (OFSP) varieties for breeders. This is an important fork-to-farm approach that could affect the marketability of OFSP.

WP 2.1.3 Technological innovation for value addition to food industry waste

Cowpea and faba bean side streams (left over after harvest and removal of the grains) can be used as fillers up to 30% to reduce the cost of biodegradable packaging systems and injection-moulded materials. Although the tensile strain (extensibility) was reduced, the strength increased with adding fibre for film production. The cowpea side stream also showed good potential to produce cellulose and nanocellulose. The use of extrusion as a pre-treatment to isolate cellulose reduced the use of sodium hydroxide by 50 times.

Pectin and phytochemicals extracted from Rodiguan lime, Mauritian lime, and grapefruit peels have shown potential as coatings to increase shelf life in minimally processed pineapple.

Fibre fractions (total, soluble, and insoluble) were successfully extracted from three sugar bean varieties. The extraction pH significantly affected the fibre fraction yields; specifically affected were the proportions of soluble polysaccharides. Initial composition data showed carbohydrates (including fibre) were the major components of these grains, followed by protein (composition analysis ongoing).

Research under this project will continue in 2024, and further research outputs will be provided in the 2024 APR.

Project 2.2: Innovation for Environmental Change-resilient Agriculture Drought Responses in Cereals and Legumes (Project ID – 23202)

Professor Ludidi (UWC) is leading this project.

This project aims to prevent the negative impact of drought and heat stress on food and nutrition security, while improving soil health and reducing excessive use of limited water resources. This will be done by using technological innovations that improve soil health and support regenerative agriculture, while increasing the biodiversity of insects and the soil microbiome, resulting in benefits for crop production.

The specific objectives of the project are to:

1. Evaluate the performance of maize, sorghum, soybean, wild sweetpea, pigeonpea, finger millet and pearl millet under both drought and heat-stress conditions to ensure that lines of these crops which possess drought tolerance together with heat tolerance can be used in identifying genes that mediate the toleranceof these lines to combined drought and heat stress.
2. Conduct a breeding programme for soybean, maize and sorghum to develop

new soybean, maize and sorghum cultivars with enhanced tolerance to drought and heat stress.

3. Implement regenerative agriculture practices using crop rotation, intercropping and soil cover techniques in a cropping system that uses maize, soybean, cowpea, wheat, pearl millet, finger millet, alfalfa (lucerne), marama, *Vigna vexillata* (wild sweetpea), common bean, garden pea, *Vicia faba* (faba bean/broad bean), pigeon pea and white mustard (*Sinapis alba*). This will result in the determination of the effect of this cropping system on soil health and biodiversity concerning plant-beneficial insects and micro-organisms. It will be tied to agro-ecology policy work in the 'Governance, Power and Public Engagement in Food Systems' programme, which seeks to establish policy to promote regenerative agriculture.
4. Isolate and assess the efficacy of endophytic micro-organisms isolated from the cropping systems in c) above, and from harsh environments, in improving crop performance under limited water supply and in improving crop nutrient content.
5. Identify wheat accessions with contrasting responses (sensitive versus tolerant) to combined drought and salinity stress, in order to understand the genetic factors that determine wheat tolerance to these stresses. This will lay a foundation for future breeding efforts to produce new wheat varieties with improved tolerance to these stresses.

The research undertaken and the highlights for 2023 are organised under the following sequence of WPs:

WP 2.2.1 Drought and heat stress in cereal and legume grains

We have completed work on the identification of genes and molecular pathways conferring drought and heat tolerance in soybean, maize, sorghum, cowpea and tuber cowpea. Some students in these projects have graduated; others have submitted their theses in November and December 2023.

We are finalising the reference genome of marama bean and are using it to finalise RNA sequencing in gene expression studies for marama bean responses to drought, which will enable us to use this data for new projects for improving drought and heat tolerance in other legumes, including further development of soybean, cowpea and Bambara groundnut in collaboration with the Chinese University of Hong Kong, the University of Zurich, the University of Southampton, and the University of Mpumalanga. Our work on drought and heat tolerance in sorghum and pearl millet has provided information that will aid us in developing drought-tolerant cereal crops as part of our next phase of comparative omics technologies.

WP 2.2.2 Breeding for drought and heat stress tolerance in soybean, maize and sorghum

For soybean, this has led to the development of a new soybean variety through the crossing (conventional breeding) of a drought- and heat-tolerant genotype of soybean (HMC201) and a high-yielding cultivar routinely used by farmers in South Africa (DM 5953RSF). The F4 progeny of the new variety is in the process of being assessed for drought tolerance and agronomic traits in the field, in the Alfred Nzo

District Municipality. We have identified parental lines of drought- and heat-tolerant maize and sorghum for performing crosses with high-yielding commercial varieties of sorghum and maize, which will be done in collaboration with UKZN, the University of Mpumalanga, the ARC, and Walter Sisulu University.

WP 2.2.3 Impact of regenerative agriculture on crop yield, soil health and biodiversity

For summer crops, the main aim was the assessment of intercropping of maize with soybeans versus maize with cowpea, in relation to crop yield, soil health and soil microbial diversity. Maize yield improved in the maize-cowpea intercropping system, but was not impacted by the maize-soybean intercropping. However, soil health was improved in both cropping systems. There was a higher increase in microbial diversity in the maize-cowpea intercropping system than in the maize-soybean intercropping system. We prepared two separate manuscripts (in Agronomy for the winter crops and in BMC Plant Biology for the summer crops) describing these findings for submission in December 2023.

Figure 14: Innovation for Environmental Change activities in 2023.

We have investigated the impact of the introduction of marama on sect pest potential in a cropping system involving maize and soybean. From the work, we established that beneficial and pest insects can occur as a result of the introduction of marama in areas used for the cultivation of maize and soybean. However, the types of insect pests that would occur as a result of this already occur in fields where maize and soybean are grown, implying that no new insect pest risk would occur when marama is introduced in these cropping systems. The manuscript describing these findings was prepared and submitted in December 2023.

WP 2.2.4 Microbial endophytes and crop performance

Much of the work in this work package was meant to be carried out by the Marshall Keyster laboratory. However, due to the focus of Professor Keyster's work – which is outside of the scope of the work package – Professor Ludidi's laboratory took the bulk of the work, although some of the work was still carried out by Professor Keyster's laboratory. With regard to work in Professor Ludidi's laboratory, endophytic bacteria tolerant to salinity and drought were isolated from chicory plants growing in fields irrigated with relatively saline water and in rainfed conditions. We have assessed the ability of these endophytes to increase the tolerance of maize to salinity and drought, and found them effective compared to when maize is not amended with the endophytes. We have started to compile the results to write a manuscript for submission to *Frontiers in Microbiology.* This has also given insights that have inspired Professor Ludidi's laboratory to expand the application of microbes beyond just the endophytes in his next phase of the CoE-FS work (2024 and beyond) to rhizospheric microbes (bacteria and fungi) isolated in the rhizosphere of designated plants growing in defined environments relevant to the improvement of plant performance under drought, heat, and salinity.

WP 2.2.5 Wheat tolerance to drought and salinity

We have screened wheat accessions for their responses to drought, salinity and heat, and identified the best-performing accessions in terms of growth under these conditions. We have further introduced a combination of heat and salinity as a stress in some of the best-performing accessions where we identified contrasting accessions (sensitive and tolerant), which we have used to understand the molecular basis for the observed differences in tolerance, which will be instrumental in breeding programmes aimed at improving stress tolerance in wheat. A manuscript describing the physiological and biochemical changes that differ in the contrasting accessions was submitted to *Plants* in November 2023.

Research under this project will continue in 2024, and further research outputs will be provided in the 2023 APR.

Project 2.3 Reclamation of Heavy Metal Contamination of Soils: (Project ID – 23202 – WP 2.2.4)

Professor Keyster (UWC) is leading this research, with the support of Professor Ludidi (UWC).

The purpose of the project was to analyse soil for nutrient status, physical properties, chemical properties, biological properties and microbial diversity, before and during cultivation of the crops, to assess its soil health status. Furthermore, the soil was analysed for microbial diversity to identify plant growth-promoting bacteria in the soil. The previous work identified endophytic bacteria that promote nutrient uptake from the soil to plants while preventing heavy metal accumulation in the plant. These endophytic bacteria will be introduced to test plots in order to monitor their effect on crop yield and crop nutrient profile (only for maize, soybean and common bean).

The highlights under this project for 2023 are as follows:

- *Pantoea agglomerans* were subjected to EMS mutagenesis to study the mechanisms of heavy metal tolerance in wild-type vs mutant bacteria. We obtained more than 600 bacterial isolates from each after EMS exposure, and screened the colonies for growth promotion traits under heavy metals.
- It has been proven that our *Pantoea agglomerans* wild-type is a pathogen of *Brassica napus* (canola). Our experiments showed that *Pantoea agglomerans* R6 strongly inhibited seed germination of the canola seeds, and ongoing studies will study the mechanisms of infection under various heavy metal treatments.
- A *Pantoea agglomerans* mutant has been identified, labelled W10 and W16, which does not cause inhibition of canola seed germination. We will use this mutant in order to study the pathogenic mechanisms of R6 in Canola.
- The mutants will also be added to the list of bacteria that will be subjected to whole genome sequencing.
- Changes have been observed in the elemental profile of the endophyte-treated plants, and this will have major impacts for the human diet, as common bean biofortification is a current hot topic in science. We will continue to subject these plants to untargeted LC-MS metabolomics in order to identify other key nutriome changes with direct human nutrition impacts, such as vitamins and fatty acids.
- All of the treated and untreated plants will be used to analyse the microbiome changes, which will provide further insight into sensitivity and tolerance to various abiotic stresses through the increase and decrease of key plant bacterial genera and species.

Research under this project will continue in 2024, and further research outputs will be provided in the 2024 APR.

Programme 3: Nutrition, Health and Safety for Food Security

In 2023, the PIs were Professor Lise Korsten (UP) and Professor Rina Swart (UWC).

The spectrum of work covered by this programme includes an exploration of food consumption patterns; the safety of food on the plate; possible effects (on nutrition and health) of appropriate, affordable and accessible interventions to improve the amount and quality of food on the plate; and the impact of changing food systems in the country on the content of the ‘plate’ and the consequences for the nutrition and health of the population. This programme also explores the role of food and food systems and their responses to changes in dietary intake, which is a necessary step towards achieving the Sustainable Development Goals (SDGs). Lastly, this programme aims to create an environment in which women’s breastfeeding choices are not unduly influenced by the marketing of infant formula.

This programme consisted of two projects in 2023.

Project 3.1: Safe Food (Project ID – 23301)

This project is led by Professor Korsten (UP).

To understand the preventable disease burden of potentially unsafe food and poor-quality diets, a multipronged approach is required. Firstly, employing a risk-based approach to understanding the food products, practices and level of community exposure that contribute to poor food quality and safety, and determining the consequential health impact. Secondly, assessing and understanding how diets affect the gut microflora and influence the overall health burden and well-being of the studied community, and understanding how nutrients are being absorbed within the gut in the context of the microbiota intake, as well as the prevention of communicable diseases.

Figure 15: Unique science communication by the Safe Food group.

In addition to assessing the level of risk to the community, an essential part of the food safety and security paradigm is the prevention of communicable and non-communicable diseases, as well as assuring nutrition security. In line with global food safety authorities, three areas of priority will be addressed, ensuring excellence over the next five years and drawing on data and information collected in the previous five-year cycle. An integrated approach is therefore taken, which includes risk analysis, risk reduction and mitigation through innovation, education and communication, as well as assessing the effect of the naturally occurring micro-organisms in the prevention of disease in the hope of reducing risk within vulnerable communities, to lessen the double burden of food insecurity and communicable disease.

The highlights under this project for 2023 are as follows:

WP 3.1.1 All-inclusive One Health Risk Analysis for Community Health

Pathogens identified in previous studies include *Salmonella* spp. and *Escherichia coli* as major pathogens prevalent in the environment and informal food system; these will form part of a PhD study. Interestingly, *Klebsiella* spp. were often found in samples from the water-plant-animal-food-public health interface in all the water and food safety-related studies conducted at UP over the past 12 years. The organism also plays a significant role in the presence and dissemination of antimicrobial resistance in the environment and fresh produce supply chains (formal and informal).

WP 3.1.2 Risk assessment studies

A PhD candidate has been awarded a Fulbright Foreign Student Programme Scholarship, and she is busy with Food Safety Risk Assessment training from July 2023-April 2024 under Professor Abani Pradhan's supervision at the University of Maryland's Department of Nutrition and Food Science and the Centre for Food Safety and Security Systems. The study builds on information generated from research results in informal supply chains, including the results of the student's MSc study, which focused on the microbiological quality and safety of fresh vegetables consumed as part of school feeding programmes.

WP 3.1.3 Potential human pathogenic bacteria (including *E. coli* and *Salmonella* spp.)

This study aimed to determine the microbiological quality, sources of microbial contamination, and characteristics of target organisms within smallholder fresh produce farms. Additionally, multidrug-resistant bacteria, including ESBL/AmpC-producing Enterobacteriaceae, will be explored from selected smallholder fresh produce farms in SA.

Irrigation water (n = 44), soil (n = 85), and fresh produce (n = 95) samples from six highly diverse smallholder farms were analysed for hygiene indicator bacterial counts and the presence of shigatoxigenic *E. coli* (STEC) and *Salmonella* spp. using standard microbiological methods. The identities of the isolates were confirmed using matrix-assisted laser desorption ionisation time-of-flight mass spectrometry (MALDI TOF MS), and the genetic relatedness of the E. coli isolates was determined using Enterobacterial Repetitive Intergenic Consensus Polymerase Chain Reaction (ERIC-PCR) analysis. Irrigation water *E. coli* levels ranged between 0 and 3.45 log MPN/100 mL, with five farms having acceptable levels according to the WHO limit (3 log MPN/100 mL). Fresh produce samples on four farms (n = 65) harboured *E. coli* at low levels (<1 log cfu/g), with the exception of one sample each of kale, spring onion, green pepper, onion, and two tomato samples, which exceeded international acceptable limits (100 CFU/g). Only one baby carrot fresh produce sample tested positive for *Salmonella* spp. Of all 224 samples, *E. coli* isolates were identified in 40% (n = 90) of all water, soil and fresh produce types after enrichment. Additionally, the DNA fingerprints of *E. coli* isolates from the water-soil-plant nexus of each respective farm clustered together at high similarity values (>90%). The results emphasise the need to investigate the presence of potential foodborne pathogens throughout the fresh produce supply chain in South Africa, particularly at the primary production level. Identifying contamination hotspots in these smallholder farms

allows for the introduction of proper intervention strategies to limit the spread of potential MDR pathogens in food-producing environments.

WP 3.1.4 Cryptosporidium detection

The current study is evaluating selected irrigation water sources, soil, and associated fresh produce on smallholder farms in South Africa that are contaminated with Cryptosporidium, using molecular detection methods (i.e. real-time PCR and/or ddPCR). This study includes spiking experiments with water, soil and fresh produce, with live Cryptosporidium oocysts for validation of the methodology used during the course of this study.

Environmental (water, soil) and fresh produce samples have been collected from six smallholder farms selected in collaboration with Ali Makgato from the Gauteng Department of Land Reform and Rural Development (DALRRD). Inoculation studies, optimising DNA extraction methods for isolating *Cryptosporidium* DNA from three different matrices (water, soil and fresh produce), and real-time PCR analysis has been completed. The analysis of water, soil and fresh produce inoculated with known concentrations of *Cryptosporidium* has been completed. Unfortunately, ddPCR analysis of the samples has been delayed, as the machine used had to be sent to be repaired; the repair has taken almost five months to date. The student who is doing this study travelled to the Africa Health Research Institute (AHRI) in Durban, KZN, to complete her analysis in the second week of November 2023.

WP 3.1.5 Risk Reduction through Innovation

Food production is the largest consumer of water globally, with ground-, river and rainwater used for agriculture around South Africa. In urban and rural farming sectors, safe water and water of acceptable quality remain a challenge impacting the safety of fresh produce, and therefore the best way to further assure food security is to find affordable and effective water treatment measures for improving water quality. Moreover, municipal water in South Africa is often not potable or reliable for many rural households, so water is often stored in water holding tanks. In addition, water is often harvested from roofs for irrigation and animal watering. Developing an affordable and effective means of water treatment for small and medium-sized producers, as well as family farmers and school and household gardens, is essential. This research is investigating using *Moringa oleifera* seeds as part of a filtration system, in combination with zero-valent iron sand filters, which have been shown to be effective for water treatment as they reduce the pathogen loads in water. The filtration system is aimed at small-scale producers, in order to ensure their safe water quality, as well as at producers and households using roof-harvested rainwater as a means of irrigation and animal watering.

The student doing this research has completed all her analysis and is in the final stages of compiling her thesis. The results show improvement in the microbiological quality of the irrigation water through using filtration systems. The sand-zero-valent iron-*Moringa olifeira* filtration systems were the most effective, followed by the sand-zero-valent iron system, and lastly, the sand filtration system. This project is an extension of the previous USAID PEER project on assessing water quality for

irrigation. An outflow of this project is the development of a practical water purification system for irrigated crops that can be implemented in rural households to ensure safe food.

WP 3.1.6 Assessing the microbiota of fruit and vegetables, and how that affects the gut microflora of selected communities

The student is progressing well with her study, titled ‘Prevalence and characterisation of foodborne pathogens in small-scale and commercially integrated vegetable-pig production ecosystems’. She has collected samples from two informal and two commercial pig farmers, and analysis is in progress. Another student is also progressing well with her study, titled ‘Microbial quality of plant-based feed and the commercial pig production environment in South Africa’.

The food safety ‘One Health’ approach incorporates the three main interlinking facets of animal, plant and human health with the crosscutting facets of water and environment. This approach is critical to addressing the control of contagious infectious agents that spread from vertebrate animals to humans and vice versa, posing a health risk, i.e. zoonosis. This work therefore focuses on the microbiome of fresh and dried produce, in smallholder and commercial farming settings, consumed by humans and animals, in this case pigs. This forms a part of the One Food microbiome research domain, which aims to characterise the microbiomes of fresh commercial produce and thereafter correlate this data with pathogen detection to understand the zoonotic importance of these diseases that spread from vertebrate animals to humans and vice versa. An example is small-scale pig farming and crop production for farmers and its health impact on the broader community.

Specific objectives will be to map out and monitor the microbiome of fresh produce that is being produced on a small scale and consumed in specific communities at sites in the Mpumalanga, KZN and Gauteng Provinces; to monitor the microbiome of fresh and dried produce (e.g. cabbage, apple, tomato, leafy greens and grains); to monitor the microbiome shifts throughout the commercial and informal chains; and finally, to identify bacterial and fungal pathogens (*E. coli*, Salmonella spp., *Listeria monocytogenes*).

Sample collection from commercial farms in Mpumalanga and KZN Provinces (environmental, produce and faecal samples) was completed in October 2022. Sampling from small-scale farms was achieved by December 2022, via agricultural extension officers in Gauteng and Mpumalanga. Commercial farm microbiome data processing for all sample types has been completed, as has primary data analysis. Results interpretation and compiling the two master’s theses are in progress.

Presumptive positive isolates have been isolated, identities confirmed, and characterisation results briefly summarised below:

Detection and isolation of potential human pathogenic bacteria on small-scale farms:

- *Salmonella* spp. was only detected in animal feed from Farm A_S.

- *Listeria monocytogenes* was not detected at all farms.
- Presumptive Extended-spectrum β-lactamase Enterobacterales were present in all sample types in all farms.
- Presumptive Shiga-toxigenic *E. coli* (STEC)/non-STEC were present in faeces from Farm A_S, fresh produce, animal feed and faeces from Farm B_S, and in all sample types from Farm C_S.

Commercial farms:

- *Salmonella* sp. was only detected in soil from farm A_C.
- *L. monocytogenes* was not detected at all farms.
- Presumptive Extended-spectrum β- lactamase Enterobacterales were present in all sample types in all farms.
- Presumptive Shiga-toxigenic *E. coli* (STEC)/non-STEC were present in soil and faeces from Farm A_C, in irrigation water, faeces and slurry from Farm B_C, and finally in irrigation water, soil,faeces and slurry from Farm C_C.

Project 3.2: Nutrition and Health (Project ID – 23302)

The projects for 2023 were a continuation of the 2022 projects. The Nutrition and Health component of the CoE-FS continues to focus on the key question: “What is on the plate of South African consumers?” and “How does the food on that plate impact on the health of South Africans?”. To this effect, three areas were explored:

- “Food Consumption, Gut-Microbiome and Chronic Disease” explores the relation between the composition of the gut-microbiome and lifetime cardiovascular disease risk profile among a sub-sample of participants in the PURE study with a particular focus on obesity, type 2 diabetes mellitus and colon cancer.
- “Food Consumption Patterns” contribute students to a leverage-funded national food consumption study (NDIS 2022) which assesses the nutritional status and dietary intake of different age and gender groups in South Africa. This work package also includes a complementary qualitative study to the NDIS 2022 on the drivers of food choice
- “Maternal health and nutritional status of mothers” was explored through funding a postdoctoral fellowship towards the exploration of maternal nutritional status and birth outcomes in a study on *Cardiovascular, haemostatic and micronutrient status of pregnant women in urban food environments*.

WP 3.2.1 Food Consumption, Gut-Microbiome and Chronic Disease

This research complete detailed habitual dietary intake in assessment in case-control studies to explore associations with the gut-microbiome and individuals who are healthy, obese, or suffering from NCDs (specifically diabetes and colon polyps). The gut-microbiome studies are done by researchers at the African Microbiome Institute (AMI) at SU. No additional funding was requested from the CoE-FS for 2023.

Data collection is still ongoing thus feedback on the gut-microbiome of participants is not yet available. However, the daily monitoring of blood glucose and blood pressure of the obese diabetic (type 2) participants has provided very interesting observations. The intervention diet can be described as cooked meals high in legumes, vegetables and fruit along the lines of traditional Xhosa eating practices. To date none of the participants lost weight during the two weeks observed feeding (no dietary intake restrictions placed on participants), but all of them experienced drastic reduction in their blood glucose and blood pressure levels. Participants described their experience of the intervention as a "training period" for diabetics and suggested that all newly diagnosed diabetics should be considered to benefit from such a two-week intervention to i) assist them in understanding the practical requirements for type 2 diabetes; and ii) demonstrate to them the ideal diet to follow for good blood glucose control.

S Joni, a bursary beneficiary from the CoE-FS in 2018 and 2019, was initially involved in dietary intake assessments with this project in 2021 (and listed as a co-author on the publication), successfully completed his masters in 2023. The title of his MSc Nutrition thesis is "The influence of 2018 listeria outbreak on the nutrition quality and dietary patterns of Langa township".

WP 3.2.2 Food Consumption patterns (National Dietary Intake Study 2022)

Data cleaning and analyses of the NDIS 2022 was completed in 2023. The final report is awaiting submission to the Director General Health for final sign-off once some governance matters have been resolved. Findings from the NDIS 2022 cannot be reported until the report is signed off by the Director General. However, feedback on anthropometric component (funded by the CoE-FS in 2022) can be reported at high level indicating that the prevalence of stunting in school going adolescents and children enrolled in ECDs was much lower than previous national statistics whilst overweight and obesity has continued to increase in children and adults.

One paper produced from the NDIS desktop review has been published in 2023. Other publications from the desktop review are still under review by scientific journals.

The NDIS team are from the following 13 HEIs: UWC, SU, University of Limpopo, SAMRC, University of Zululand, Nelson Mandela University, Durban University of Technology, University of Venda, UP, University of South Africa, North West University, University of the Free State, and Sefako Makgatho University.

Several students who were beneficiaries of CoE-FS scholarships in earlier years, completed their theses and will graduate in April 2024 (as part of the 2023 cohort):

- **Zintle Nelani**, MPHN mini-thesis (funded 2019 & 2020): Exploring caregivers' perceptions about the influence children have on food purchase choice at grocery stores.
- **Adilah Petersen**, MPHN mini-thesis (leveraged funding): Exploring food security and resilience among youth aged 18-24 in Fisantekraal, South Africa

- **Makoma Bopape**, PhD (leveraged funding): The effectiveness of front-of-pack warning labels in assisting South African consumers to identify unhealthy packaged foods.
- **Marieke Theron**, PhD (funded 2020 – 2022): Predictors of harmful alcohol use and the influence of commercial determinants of health: A hybrid mixed methods study.

Two more students have submitted their reports for examination and is likely to complete as well:

- **Nerisa Pilime**, PhD (leveraged funding): An evaluation of the impact of care groups in Malawi, Ntchisi district, on improving nutrition practices and nutrition outcomes.
- **Morongoa Tlhako**, MPHM mini-thesis (funded 2019 & 2020): Food insecurity among university students in the Western Cape (2021).

Several papers from funded student research, and two papers from leverage funded research were published in 2023; these are listed in Appendix 3 in the report.

WP 3.2.3 Food Consumption patterns (Drivers of Food Choice)

With South Africa's high double burden of disease, increasing attention has been given to improving food environments to facilitate healthier food access. An understanding of the main drivers of food choice and barriers in consuming healthier foods, can assist in the formulation of nudge strategies to improve the quality of food supply and food intake.

The objectives of this study were to describe the main drivers of food choice; assess if health considerations were a driver; ascertain foods considered healthy and unhealthy; determine the barriers and enablers to selected foods; and identify strategies employed and suggestions to improve the intake of nutritious food. Ethics approval was obtained from the Humanities and Social Sciences Research Ethics Committee of the University of the Western Cape. The study was qualitative and cross sectional in three urban sites. Trained fieldworkers recruited eligible participants and conducted focus group discussions. Nine focus groups with 68 participants were completed. MS Excel was used to code the data and for thematic analysis.

Financial considerations, household/family factors and the shop/food retail factors were the key drivers of food choice identified. Health considerations were present, but not prevailing. Enablers of healthy food consumption included: cost, recognized health/nutrition benefits, and good taste. Barriers were unavailability and unknown preparation, beliefs, and disliked taste. Respondents felt they engaged in activities to improve the intake of nutritious food, but that government could do more. Interventions at the retail level and pricing strategies have the potential to nudge consumers to purchase healthier food, but needs testing in the South African context.

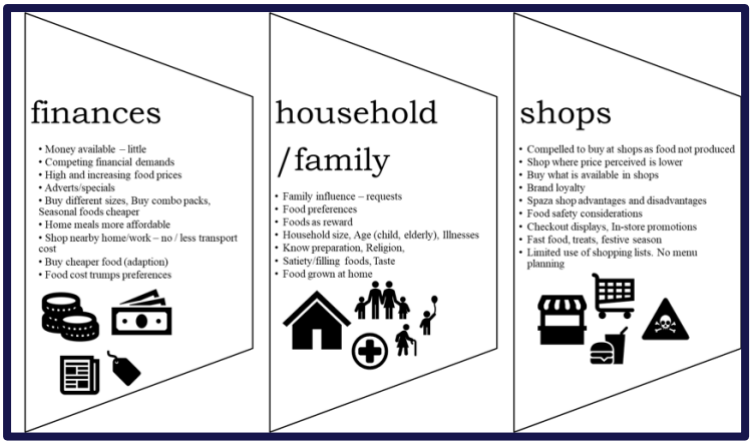

Figure 16: Drivers of food choice

Drivers of food choice in three urban sites in South Africa.

The team includes Dr Nazeeia Sayed (postdoctoral Fellow), Professor Rina Swart, with one fieldworker recruited from each of the three urban sites. A research paper entitled “Drivers of food choice in three urban sites in South Africa” is currently under review.

WP 3.2.4 Maternal health and nutritional status of mothers

This project only received funding of R200 000 for a postdoctoral candidate (Xolisa Nxele) from the CoE-FS. The postdoctoral Fellow assisted during data collection and quality assurance of the follow up phase (to collect information on birth outcomes and birthweight of the new-borns of the pregnant women) in the CHAMP study. She also managed the administration of fieldworkers during this data collection. The response rate was low (57%).

The aim of this projects which is funded under the NRF Thuthuka post-PhD track of Dr Elize Symington is to explore the cardiovascular, haemostatic and micronutrient health of pregnant (as well as non-pregnant) women and birthweight in the context of local food environments in Regions B and C of Johannesburg, Gauteng.

The objectives of this continuing study are:

1. To explore the link between oxidative stress and the cardiovascular system of pregnant women and non-pregnant counterparts in Regions B and C of Johannesburg, Gauteng.
2. To assess basic haemostatic parameters of normotensive and pregnant women with HDP based on HIV status in Regions B and C of Johannesburg, Gauteng.
3. To explore the scope and determinants of anaemia prevalence among pregnant and non-pregnant women of reproductive age in Regions B and C of Johannesburg, Gauteng.
4. To assess the availability of healthy and unhealthy foods in the community, as well as the consumer retail food environment.

The postdoctoral Fellow assisted with data cleaning and analyses. She drafted a scientific paper which is currently being edited. She also attended and presented at the UNISA journal club meetings as well as at the weekly UWC Food Environment research group meetings.

Dr Elize Symington and Dr Bianca van der Westhuizen also contributed to the chapter on infant and young child feeding practices of the NDIS 2022. Once the final report from the NDIS 2022 has been released later in 2024, they plan to collaborate on a scientific paper to explore associations between infant and young child nutrition status and feeding practices.

Figure 17: Nutrition at Food Dialogues 2023

CoE-FS Nutrition and Health lead Prof Rina Swart shares research findings with youth at Food Dialogues 2023.

Research outputs

Table 10 provides the cumulative total of peer-reviewed and other recognised research outputs.

Table 10: Research output

Output	Output
Articles in refereed/peer-reviewed journals	77
Books/chapters in books	5
Conference output (presentations)	76
Other significant conference output (seminar, workshop attendance)	68
Working papers/technical/policy reports	11
Other recognised research outputs (communication and visibility)	188

KPA 2: EDUCATION AND TRAINING

Education and training numbers

Student records are updated each year with the acceptance of new students to the CoE-FS's programmes. Appendices 6 and 7 reflect details of 29 continuing and 21 new NRF students and Fellows for the reporting period. Appendix 8 provides a detailed summary of the NRF-funded students since inception. Appendix 9 provides the information of 20 students who were supported with bursaries through leveraged funding in 2023. Appendix 14 provides information of 24 students who did not receive bursaries from the CoE-FS (non-bursary holders), but who were included in projects (supervision and work studies) in 2023. The information for seven NRF and five leverage-funded students who graduated in 2023 is provided in appendices 10 and 11 in the report, and the information for 13 non-bursary holders who graduated is in Appendix 15. Further information in terms of student support of postgraduate and postdoctoral Fellows is provided in KPA3.

In total the CoE-FS thus supported 94 students in 2023 (NRF-funded, leverage-funded, and non-bursary holders).

Appendix 6 outlines the continuing students and postdoctoral Fellows who were supported through NRF funding in 2023, and Appendix 7 outlines the new students and postdoctoral Fellows who were supported through NRF funding. Appendix 9 outlines students who were supported through leveraged funds, and Appendix 14 outlines students who were not funded by the CoE-FS but who were supported.

Breakdown of CoE-FS students

Table 11 presents the spread of NRF bursary holders, and Table 12 provides the information of students across the collaborating institutions. Table 13 provides information on leverage-funded students. Table 14 presents information on students who were supported by the CoE-FS but who did not receive bursaries.

Table 11: Record of NRF bursary holders

Category	Total
Honours students	0
Master's students	13
Doctoral candidates	18
Postdoctoral Fellows	19
Total postgraduate students	50
Total NRF women students	34 (68%)
Total NRF SA women students	25 (50%)
Equity distribution of all NRF black students ('black' refers to African, coloured, Indian/Asian)	41 (82%)
NRF South African citizens and permanent residents	37 (74%)

South African equity distribution of black NRF students ('black' refers to African, coloured, Indian/Asian)	30 (81%)
Students from other African countries	11 (22%)
Master's graduations	3
Doctoral graduations	4
Postdocs completed	5

Table 12: NRF bursary holders across collaborating institutions

2023	Level				
Institution	**Doctoral**	**Honours / B Tech**	**Master's – Research-based**	**Postdoc**	**Total**
SU	-	-	-	-	-
UCT	-	-	-	1	1
MRC	-	-	-	-	-
UP	7	-	9	4	20
UFH	-	-	-	-	-
UKZN	-	-	-	1	-
UL	-	-	-	-	-
UWC	11	-	4	13	29
Wits	-	-	-	-	-
Total	18	-	13	19	50

These data show that 60% of the students funded by the CoE-FS in 2023 were registered at an HDI.

Table 13: Record of Leverage funded bursary holders

Category	Total
Honours students	0
Master's students	10
Doctoral candidates	10
Postdoctoral Fellows	0
Total postgraduate students	**20**

Table 14: Record of non-funded students

Category	Total
Honours students	1
Master's students	9
Doctoral candidates	14
Postdoctoral Fellows	0
Total postgraduate students	**24**

Graduations/Fellowships completed

In 2023, a total of 31 bursary holders graduated or completed their studies, made up of 12 NRF-funded students, five leverage-funded students and 14 non-bursary

holders. See tables 15, 16 and 17 below. Appendices 10, 11, and 15 provide the details for these graduates.

Table 15: Record of NRF degrees conferred and postdoctoral fellowships completed

Degree	Total
Master's	3
Doctoral	4
Postdoctoral Fellows	5
Total	**12**

Table 16: Record of leverage-funded degrees conferred and postdoctoral fellowships completed

Degree	Total
Honours	1
Master's	1
Doctoral	3
Total	**5**

Table 17: Record of non-funded degrees conferred and postdoctoral fellowships completed

Degree	Total
Honours	8
Master's	3
Doctoral	3
Total	**14**

Education, training and capacity building highlights

The education and training of students and postdoctoral Fellows is a core activity through which the CoE-FS works towards systematically developing a creative research training environment that is internationally competitive. Most of the research undertaken by the CoE-FS takes place via student research training at the postgraduate level. It thus creates a conducive and collaborative environment in which students are exposed to experts from various fields of research under the food security umbrella.

However, opportunities for training and education take place not only through bursaries; students are also developed through various workshops, conferences, and meetings, which are forums for student development. The CoE-FS engages in a broad range of capacity-building activities, some of which have already been reported for the WP activities above. Our training highlights include our Imbizo meetings, which involve civil society and the private sector (especially from the informal economy). These meetings include a co-production of knowledge component explicitly focused on transformation and capacitation. We have also undertaken learning journeys that have a similar function. In addition, all PIs serve on mentoring programmes at their universities.

Not only has the CoE-FS provided opportunities and incentives for academics based at various institutions (both local and international) to work together; additionally, students associated with the projects have also been exposed to a range of experts from other institutions, as well as other disciplines, through participation in research meetings, conference presentations and seminars

Examples of education and training highlights are:

1. Honours students under the SMART Foods project attended the South African Association for the Flavour and Fragrance Industries (SAAFFI) Flavour Seminar; this is an important platform for meeting potential employers and assisting students with food product development projects. UP is a member of SAAFFI. Attending the seminar also provided opportunities for hands-on learning and development of skills, for example in research methods, communication and problem solving, as well as technical skills.
2. Two students under the SMART Foods project have received extra support in supervision, which has improved their slow progress such that they submitted their PhD theses in November 2023.
3. Lee-Ann Niekerk presented an invited talk at the Interdisciplinary Plant Group (IPG) symposium held at the University of Missouri (USA), and attended a sequencing workshop at UWC.
4. Adele Barker presented a poster at the South African Society for Microbiology (SASM) 2023 conference held in Stellenbosch. This practical application of knowledge is very important, as it enhances the student's competence and proficiency. The involvement of students in CoE-FS-related symposiums provides an opportunity to receive feedback on their work and ideas, and constructive feedback helps students to identify areas for improvement and refine their skills.
5. The CoE-FS is part of the global consortium of higher education institutions that is driving the "Feed, Protect, Care Collaborative PhD Platform". This consortium, headquartered in Montpellier, France, has developed an initiative aimed at building a globally connected community for future sustainability science leaders. Two PhD candidates of the CoE-FS were selected in 2023 to be part of this initiative and will attend a training programme in March 2024 at the University of Montpellier, France.
6. In 2023, three PhD candidates worked on UrbanFOSC activities and benefited from capacity development.
7. Training has also been provided to fieldworkers recruited from the BVM for the different research activities in 2023. This has always included: 1) completion of ethical procedures for fieldworkers, and 2) safety when conducting field work. Depending on the need, additional training has been provided in 1) in-depth interviews; 2) focus group discussions; 3) structured observation techniques; and 4) use of audio recorders.

In addition to the training of students, capacity building for emerging researchers is essential to foster their skills, knowledge and capabilities, enabling them to contribute effectively to the research community.

1. Mobility support to facilitate training and development (nationally and internationally) was given to Dr Ali Elnaeim Elbasheir Ali (University of

Missouri, Agricultural Research Council, Stellenbosch University) for training in various genomics, transcriptomics, and proteomics technologies.
2. Mobility support was provided to Musa Akanbi (Agricultural Research Council and University of Zurich) for training in various genomics and transcriptomic technologies.
3. Mobility support was provided to Ruvimbo Mhari (Agricultural Research Council) for training in various genomics and transcriptomic technologies; and to Eden Keyster (University of Zurich) for training in various genomics and transcriptomic technologies. This development ensures that emerging researchers have the necessary skills and knowledge to conduct high-quality and rigorous research, which leads to reliable and credible scientific findings.
4. Dr Anton Venter, a postdoctoral Fellow, worked on manufacturing phenolic-enriched pasta under the supervision of Professors Duodu and Ludidi. He has completed this task. He was also instrumental in working with honours and master's students working on CoE-FS projects.
5. Remoneilwe Mogatosi completed his master's in 2022 and is preparing for his PhD studies. He was provided with an internship and mentored by Dr Arlene Alpha, senior research from the collaborating partner, CIRAD. As part of this internship, he was given an extended postgraduate placement grant to spend two months at CIRAD in Montpellier, France. During this time, he was giving training in a Systems Network analytical tool. He also received training in the Learning Journey methodology and participated in one Learning Journey. We expect Mogatosi to register for his PhD studies in 2024.
6. Dr Zeinab Asadi, a postdoctoral Fellow, has refined the starch and protein digestibility protocols. She has been instrumental in training various postgraduate students working on SMART foods. She is also working on the oral processing of various SMART foods.
7. Postdoctoral Fellow Dr Kenechukwu Ikebuaku has been working on the SARChI research project 'Food Systems Failure and the Normalisation of Hunger in South Africa'. Continuous capacity development for both postdoctoral Fellows and postgraduate students is vital for professional growth and career progression of researchers; it provides them with opportunities for advancement, recognition and increased responsibilities.
8. Dr Ikebuaku, a postdoctoral Fellow, recruited, trained and supervised three teams of research assistants who have just completed primary data collection in three provinces: the Western Cape, the Eastern Cape and Gauteng.
9. An emerging researcher, Dr Mehlomakulu, received a Fulbright scholarship and is currently spending six months on a doctoral placement in the USA.
10. Since 2021, the FSNet-Africa Fellows, including two CoE-FS researchers, Professor Amiena Bayat and Dr Frederic Isingizwe, have been working jointly with their mentors from African institutions and the University of Leeds and UP to implement a transdisciplinary research project focused on African food systems. In October 2023, the Fellows presented their research findings to a stakeholder group that included policymakers, civil society organisations, experts and others. They also participated in a policy impact training workshop.
11. A leverage-funded doctoral placement enabled the participation of our PhD candidate, Florian Kroll, at a South-South and Triangular Cooperation (SSTC)/INSSPIRE workshop in July 2023 at VU-A that was supported by

ERASMUS mobility funds. The purpose of this workshop was to develop a module on food systems (transformation) and climate change.

12. Training in the Learning Journey methodology was provided to five facilitators from the BVM, and to Dr Elaine Sinden and S'celo Madondo from the CoE-FS, who participated in one of the journeys. Investing in the capacity development of researchers is an investment in the future of scientific discovery, innovation and the betterment of society as a whole. It strengthens the foundation of research ecosystems, making them more resilient, collaborative and impactful.

KPA 3: INFORMATION BROKERAGE AND RELATED ACTIVITIES

The CoE-FS provides access to knowledge, maintains databases, and promotes knowledge sharing and knowledge transfer. All of these activities fall under our KPA 3: Information Brokerage. Most of the knowledge sharing and transfer activities are undertaken as part of our Communication and Engagement Strategy, for which our Communications and Engagement Manager, Carla Bernardo, provides oversight.

Communication and engagement

Digital communication

Digital communication is the workhorse of our knowledge sharing and transfer KPA. We are pleased to report that 2023 saw consistent stability and security for the website, following the improvement of the host server. The process to revamp the website is also under way, including updating the look and feel of the site, improving the user and client experience, increasing the speed of loading time on the site, enabling greater shareability of content, and providing greater access for the client (i.e. the CoE-FS) to action changes without additional payments to the site management service provider (external to the CoE-FS). The intention is for the revamped website to be ready and launched at the CoE-FS's 10th anniversary in 2024.

In terms of social media, the CoE-FS's audiences on Facebook, X and Instagram continue to grow (Table 18 illustrates the comparative growth). A request for a LinkedIn page has been made, and after consideration will be proposed in the new communication strategy, to be presented to the various committees in 2024. There has also been discussion about our continued participation on the X platform, following widespread concerns over its role in the spread of dis- and misinformation. Again, these matters will be presented to and decided on in the various committees – where appropriate – with the newly created communications strategy.

Turning to multimedia production, views have seen a 33% decrease in comparison to the previous year, and a 26% decrease in watch time, compared to 2022. Less of a focus was placed on multimedia production in 2023, this will need resolution in the new year, and in the new strategy. To address this, we are planning to commission new videos in 2024 using leveraged funding.

Table 18: CoE-FS comparative growth on social media

Platform	Growth by year								
	2014-15	2016	2017	2018	2019	2020	2021	2022	2023

Facebook page (likes)			936	1610	2303	2604	2694	2945	3061
Facebook page (followers)	245	469	-	-	-	-	-	3244	3443
Facebook group	190	258	317	409	526	736	799	819	828
X (Twitter) followers	245	640	1134	1714	2099	2541	2604	2753	2862
Instagram	-	-	-	-	-	-	-	116	196

Table 19: CoE-FS comparative watch time

YouTube	2018	2019	2020	2021	2022	2023
Views	1287	1607	1993	1887	2331	1779
Watch time	25.5	47.2	56.4	61.7	63.1	50.1

Nuggets and external coverage

As required by the SLA, the CoE-FS is to share a total of 40 nuggets with the NRF on an annual basis. In 2023, the CoE-FS exceeded this target and shared a total of 42 internal nuggets to the NRF; these are pieces of content produced by the CoE-FS (website postings and YouTube videos), and there have also been 209 external nuggets (external media mentions).

Notable nuggets, both internal and external, include the following:

1. Extensive coverage of the CoE-FS's contribution to the draft regulations on front-of-pack warning labels, from the beginning of the year to present. The two researchers involved are Professor Rina Swart and Dr Tamryn Frank. The combined Advertising Value Equivalency (AVE), which is the estimate amount of revenue attributed to an article, is R470 116.82.
2. Coverage of the launch of the 2023 *Lancet* Series on Breastfeeding, with a combined AVE of R219 243.71.
3. Professor Lise Korsten's media engagement on loadshedding and food safety. A longer interview with CapeTalk garnered numerous call-ins while live on air, and the interview was then made available as a podcast and republished on various external media platforms. For the CapeTalk interview alone, Professor Korsten had access to an estimated audience of 19 449.

For a third year in a row, CoE-FS postdoctoral researcher Dr Nazeeia Sayed's piece on eating healthily during Ramadan received impressive traction, and was published by The Conversation Indonesia, among others, and by Eyewitness News in South Africa. We also created a video on Dr Sayed's original article, which was posted during the month of Ramadan.

Another significant media engagement opportunity was Professor Julian May's input on the latest census, and on the flooding and subsequent food security crisis in the BVM. For the former, Professor May was able to draw on his years of experience in the census process, as well as platforming both the CoE-FS and the National Planning Commission. For the latter, Professor May was able to draw on and showcase the work of the CoE-FS, namely its place-based research, positioning the CoE-FS as an authority on the impact of climate change on food security. This was done across broadcasting tiers.

Additional external media coverage highlights in 2023 included the single ‘nugget’ with the highest AVE, Professor May’s interview with Newzroom Afrika on the role of women in Africa’s food security (R169 166.67); the CoE-FS lending its voice to calls for child health services to be protected from austerity cuts; frequent contributions to discussions on food price hikes; maternity protection (ongoing content emanating from CoE-FS grantee Dr Catherine Pereira-Kotze’s PhD research); and seven CoE-FS researchers being featured in the UWC Research and Innovation publication *Future Researchers*.

Events

Events provide the CoE-FS with the opportunity to engage directly with its various stakeholders, including the public. In 2023, strategic participation in conferences and the ongoing support of the annual Food Dialogues through WP 1.1.4 provided the CoE-FS with the chance to share its research, and translate it to multiple stakeholders in a variety of ways.

UNFSS+2

The highlight in terms of events was certainly the CoE-FS’s participation in and exhibition at the UNFSS+2 in Rome. The CoE-FS was the only South African exhibitor and the only university entity, showcasing alongside the FAO, the international Development Law Organisation, the WFP and GAIN. During their tour of the exhibition area, UN Deputy Secretary-General Amina J Mohammed and FAO Director-General Qu Dongyu, accompanied by an international media entourage, made a stop at only one exhibition stand for a photo opportunity: that of the CoE-FS, with a brief discussion and handshaking with the CoE-FS Finance Manager and Communication Manager. From a brand awareness and marketing perspective, this was arguably a major milestone in the CoE-FS’s communication and engagement work since inception.

Figure 18: CoE-FS at UNFSS+2

UN Deputy Secretary-General Amina J Mohammed and FAO Director-General Qu Dongyu visit the CoE-FS exhibition.

Additionally, various CoE-FS-branded videos were shown throughout the conference, and throughout the conference venue. Conference delegates (in-person and virtual) were also introduced to the CoE-FS’s work and website via the UNFSS+2 ‘virtual campus’ (essentially the digital version of the exhibition floor).

Professor Korsten attended and participated in sessions on behalf of the CoE-FS, the highlights of which were shared with the CoE-FS MANCO, and followed up on networking opportunities after the conference.

Food Dialogues 2023

Food Dialogues, co-sponsored by the CoE-FS under WP1.1.4 and co-partnered by the UNESCO Chair, is an annual programme that focuses on the local food system and broader ecosystem in ways that are locally relevant. In this year's edition of the Food Dialogues, the central premise was 'Our Food System in Polycrisis', which acknowledges the multiple interconnected, overlapping crises that affect us all. The climate crisis, energy and water scarcity, disease, environmental degradation, armed conflict, etc. leave us living from crisis to crisis, in what seems like a perpetual state of emergency – where hunger, food insecurity, malnutrition, food price inflation and uncertainty are increasingly common.

Figure 19: CoE-FS at Food Dialogues
Prof Julian May was one of the CoE-FS researchers who participated in the 2023 Food Dialogues, pictured here alongside past CoE-FS grantee, Dr Wanga Zembe.

The first-ever all-day Polycrisis Conference, with UNESCO Chair Professor Julian May serving as meta-facilitator, took a deep dive into understanding and addressing the 'polycrisis' affecting our food system – the impact polycrisis has and will have – and debated ways to strengthen Cape Town's food system/s and food environments. Also participating in this event was former CoE-FS grantee Dr Wanga Zembe, and co-organising was CoE-FS grantee Sheeham Moosa.

The CoE-FS also participated in Food Dialogues' 'Black Girls Rising Teens and Nutrition Workshops'. These were hosted by the teenagers from the Black Girls Rising initiative, and were hosted at activist centres Bertha House and Philippi Village. They explored the nexus of teen agency, access to healthy food, and academic research into adolescents and food, with the latter covered by Professor Rina Swart and two CoE-FS grantees, Dr Sicelo Sethu and Dr Tamryn Frank.

Figure 20: CoE-FS grantee's youth work

Dr Sicelo Sethu participated in Food Dialogues' 'Black Girls Rising Teens and Nutrition Workshops'.

Professor Swart had recently conducted nutritional surveys on adolescents in South Africa, and food environments in schools, and this provided a backdrop and contextualised the event. Along with Dr Sethu and Dr Frank, Professor Swart shared and relayed the research findings in creative and engaging ways, through 'gamifying' labelling and nutrition. In her feedback, Black Girls Rising's Anelisa Mgedezi noted that "it is very important for teenagers to participate in Food Dialogues; it gives us an idea – where does our food come from, what are we eating?".

Nutrition Congress

The CoE-FS Nutrition team participated in the 2023 Nutrition Congress, the first congress since COVID-19. The purpose of the congress was to bring together nutrition and dietetic collaborators from South Africa, Africa and further afield to deliberate the nutrition-related challenges that impact heavily on the health and quality of life of so many, and to consider potential relevant and practical solutions. The CoE-FS also hosted an exhibition at the Congress. CoE-FS researchers (Professor Rina Swart, Dr Tamryn Frank, Dr Catherine Pereira-Kotze, Dr Chantell Witten and Dr Nazeeia Sayed) all participated in the main programme as speakers, moderators and in the poster sessions. Certainly, the highlight of the conference was the awarding of the prestigious 2023 Nutrition Society Award to Professor Swart, the ADSA Recognition Award to Dr Witten, and the runner-up award for best presentation to Dr Frank.

SAAFoST

The CoE-FS collaborated on an exhibition with InnoFood Africa, our partners through the SMART Foods project, with Professor Naushad Emmambux as principal investigator for both. CoE-FS grantees, all embedded in the SMART Foods project, participated in SAAFoST, and helped manage the exhibition stand. The students also participated in the oral and poster presentations, where they excelled, with Daddy Kgonothi and Rose Baah being awarded for their presentations.

Local launch of the 2023 *Lancet* Series on Breastfeeding

The CoE-FS was requested to organise the local launch of the 2023 *Lancet* Series on Breastfeeding. The launch took place in February 2023, at UWC, and was co-hosted with the CoE-HUMAN. Speakers included Professor May, the Family Larsson-Rosenquist Foundation's Dr Katharina Lichtner, MRC Professor Tanya Doherty, the Healthy Living Alliance's Nzama Mbalati, and UCT's Dr Tracey Naledi. Participants at the hybrid launch came from academia, civil society and grassroots organisations, and government.

Figure 21: 2023 Lancet Series on Breastfeeding

Moments from the local launch of the 2023 Lancet Series on Breastfeeding.

Science Forum South Africa

To end off the CoE-FS's year of events, grantees and researchers from UP joined the CoE-FS exhibition at Science Forum South Africa, the country's biggest public science event. Grantees from Professor Korsten and Dr Wegerif's teams, as well as postdoctoral Fellow Dr Eness Mutsvangwa-Sammie, immersed themselves in the communications and engagement activities of the CoE-FS, from stand build-up, to encouraging SFSA attendees to participate in our activities, all the way to stand break-down and assisting with logistics to return our branded material to Cape Town. It was both a moment for CoE-FS staff and researchers to watch the grantees in action, and also a chance for the grantees to put their science communication skills, acquired through the support of their CoE-FS supervisors, to the test.

The CoE-FS also participated in and hosted numerous online events, including WILD Feast's online panel discussion/dialogue, 'Expanding markets for indigenous crops – A sustainable pathway to food systems transformation: The case for sorghum'; the National Agricultural Marketing Council's seminar, 'Fresh produce market challenges and opportunities: A case for the Johannesburg Municipal Fresh Produce Market'; Local WILD and the Sustainability Institute's 'Reintegrating Cape indigenous foods into our lives'; a National Science Week webinar on 'Science communication'; and participation in the World Food Prize Foundation's Norman E. Borlaug International

Dialogue, on ‘Harnessing science innovations for a sustainable, equitable and nourishing food system’. The CoE-FS’s Food Imbizo, led by PhD researcher Florian Kroll, continued to provide a platform for its various stakeholders, with hybrid discussions held throughout the year focusing on topics such as the risk and potential of indigenous food revival, community-based food security research, democratising food governance, and strategies to build food systems resilience.

Knowledge and databases

The databases collected for research are maintained by the responsible researchers, in line with the requirements of most ethics review committees and the Protection of Personal Information Act (POPIA). Although some of the smaller databases are discussed in KPA1 above, notable examples that were added to in 2023 include:

- **The Breede Valley Living Laboratory**: these data include a dietary intake survey based on a probability sample of 900 households; a vendor survey of formal and informal enterprises; a food system map; a localised food balance sheet; a Geographic Information System (GIS) based on satellite imagery, administrative data and our surveys; value-chain mappings of the table grape, pumpkin/butternut and poultry sectors; and a social network mapping of water management. The last two elements were added in 2023. These data are co-hosted by UWC and our collaborators at VU-A and KU-L.

- **The National Dietary Intake Survey**: This survey was commissioned by the National Department of Health (https://ndis2022.co.za/). Data was collected from over 15 000 households on dietary intake, anthropometry measurements and general health of the citizens of South Africa. Data collection was completed in 2023 and the reports have been completed. Once approved, the database will be available to researchers and students for analysis, probably at the end of 2024. No similar database has been collected in South Africa in the past. These data are hosted at UWC.

- **Endophytic Bacterial Library**: This database hosted at the Faculty of Science at UWC has been expanded to more than 300 isolates, of which several are completely unknown, and some with novel genus as well as novel species.

- **Food Safety Culture Collection**: This is a collection of over 500 foodborne pathogens and water, soil, plant and food microorganisms. The collection is hosted at UP.

In addition to these research resources, the Centre Manager, Dr Elaine Sinden, maintains the CoE-FS management information system, a relational database that contains information on research projects, published outputs and student progress, and which includes demographic and institutional information. This database is used for our M&E activities and will be used for research planned for 2024 on the impact of the centre of excellence approach to knowledge building and capacity development in the field of food systems analysis.

Finally, we in addition to digital communication, nuggets and events, we have adopted an additional component to achieve the knowledge sharing and transfer aspects of this KPA, CoPs/the Food Imbizo.

Communities of Practice (CoP)/Food Imbizo

In our Business Plan for 2018, we introduced a new project in our Governance Programme that established our CoP. We defined these as being formed by people who engage in a process of collective learning in a shared domain of human endeavour. For the CoP project we initially focused on researchers, practitioners, civil society representatives and government officials interested in local food governance in the informal economy. The concept has evolved over time. The CoP project was discussed briefly under WP 1.1.4 above; this section goes into further detail.

The CoE-FS CoP project was converted to the larger initiative of the Food Imbizo from 2022 onwards. The new branding was completed in 2023 (https://foodimbizo.org/who-we-are/), with the first Imbizo taking place thereafter. The rebranding was both in recognition that the original design had envisaged a more limited process than that eventually implemented, and to avoid confusion with the NRF's Community of Practice framework that is part of the activities of the South African Research Chair Initiative (SARChI).

The Food Imbizo has opened up opportunities to further promote the platform nationally, and especially in other metros such as Gqeberha and eThekwini. Unfortunately, Dr Brittany Kesselman was offered a position at Wits and decided not to take up the CoE-FS postdoctoral fellowship. However, Dr Wadzanai Mafunga (a postdoctoral Fellow at UKZN under the supervision of Professor Tafadzwanashe Mabhaudhi) and Dr Eness Mutsvangwa-Sammie (a postdoctoral Fellow at UP under the supervision of Professor Lise Korsten) were appointed in 2023 and have been working with Florian Kroll at UWC. In 2023 the WP benefited from leveraged funding received from the ACF and has expanded further to include the African Food Systems Transformation Collective, a pan-African network of researchers and practitioners.

Under this umbrella, we have convened three webinars in partnership with the Centre for Competition, Regulation and Economic Development (CCRED), and provided examples of the process and contributions made during two of the Imbizos.

Grace Nsomba from CCRED presented data on agri-food commodity price movements. Data on chicken feed and agrochemical input prices revealed evidence of collusion and anti-competitive behaviour among large agri-food input supply companies in several African countries including Kenya, Zambia and Malawi. This results in higher food prices for poor consumers, as well as reduced agricultural productivity and earnings for small producers. In part, this is attributable to high levels of concentration and a lack of access to market information. Yohane Kalinde (Community Agribusiness Partners) has shared his experiences of working with smallholder farmers in Malawi to form larger co-operatives. These co-operatives enabled farmers to aggregate produce in order to reliably supply market agents with bulk produce, while also negotiating better terms. Having a stronger collective voice

also translated into access to finance at lower interest rates, and lower transport costs.

Korkor Cudjoe of the Graça Machel Trust has presented on the barriers facing women entrepreneurs, including regarding access to markets, finance and property rights. She has highlighted the power of women organising collectively to negotiate better terms to participate in various parts of agri-food value chains. Access to market information is especially empowering, enabling women entrepreneurs to identify and leveraged opportunities.

Online participants in the various Imbizo have noted that global market structures favour powerful players and enable collusion and concentration. They have also critiqued the underlying paradigm of food and agricultural products as market commodities. Each Imbizo concluded with recommendations, for example the proposal to build an ecosystem of institutions and approaches that would enable greater participation and access to information for smaller food entrepreneurs.

As another example, in November 2023 the Food Imbizo convened an online dialogue on the risks and potential of an indigenous food revival. This was contextualised by Dr Chantell Witten (Wits). To set the scene, Dr Witten referred to a recent news report of hungry children eating grass, in the context of widespread child malnutrition. Yet despite an abundance of indigenous foods, lack of awareness, knowledge and resource access constrain their potential contribution to people's nutrition. Simultaneously, there is increasing interest from large food corporations in indigenous foods, with a drive to capitalise on them and on the knowledge systems which developed and preserved them.

Professor Vanessa Mbhatsani (University of Venda) presented her research on indigenous foods from Limpopo province. Micronutrient analysis revealed that many of the indigenous crops had very high nutritional density, making them a valuable addition to child nutrition.

Ausi Shihaam Domingo, a food activist and chef, highlighted the ways in which traditional food, indigenous knowledge, and intergenerational learning can re-weave relations of care and familiarity between the people with the land and their ancestors. She reflected on how people divorced from traditional knowledge of food are often malnourished, even though surrounded by nutritious food. She spoke of how 'dreamwalks' provide a direct and immersive ritual and oral way of learning about the landscape and its plants, and how this is contributing to a revival of Khoisan cultural knowledge and identity in the Western Cape.

Professor Jeremy Klaasen (UWC) reflected on the regulatory context of traditional and indigenous food plants. He made particular reference to the United Nations Declaration on the Rights of Indigenous People, and explained that the notion of indigenous people and their knowledge systems is clearly set out in these global conventions. He noted that South African legislative frameworks have neglected to protect and promote these rights and serve the interests of indigenous people. Instead, private property regimes and environmental conservation law have tended to prevent access to the land and to criminalise people for accessing ancestral landscapes to harvest and utilise the plants.

Loubie Rusch, a researcher and wild food advocate and the Research Leader of WP 1.1.5, pointed out that the vast majority of food consumed in South Africa is based on global commodities, and is thus fundamentally disconnected from the land. While acknowledging the role of the state, she emphasised the role of people in cultivating, marketing and preparing local wild foods using interactive, practical learning experiences. Further comments highlighted the connection of indigenous food consumption to more diversified microbiomes, as well as the difficulties of land access, of value chain development to enhance market access, and of provision of funding and training to promote broader cultivation and uptake. The lack of state recognition of indigenous crops by the minister hampers access to support services from the NAMC.

KPA 4: NETWORKING

The CoE-FS actively collaborates with a wide network of individuals, groups, and institutions. In addition, we have contributed towards the formation of national, regional, continental and international partnerships.

A few networking examples from 2023 are:

1. The CoE-FS had collaborations with Purdue University (USA), the University of Eldoret (Kenya), and the ITA Food Technology Institute, in a USAID project under a continuing Feed the Future programme. This collaboration helped to build a research team with diverse expertise that will lead to more comprehensive and innovative solutions.
2. The SMART food project collaborated with food industry giants such as Tiger Brands, PepsiCo and Nestlé. The research work supported by the funding contributes to multi-institutional research with the InnoFood EU project with universities in African countries (Uganda, Kenya and Ethiopia) and European countries (Finland, Norway and France). The funding contributes to the development of a substantial number of female researchers and research students. This networking is important, as researchers can share insights, findings and methodologies with their peers, promoting the exchange of knowledge. It also paves the way for networking events, conferences and workshops that provide platforms for researchers and students to present their work and receive feedback.
3. Professors Ndiko Ludidi (Plant Stress Tolerance Laboratory), Marshall Keyster (Environmental Biotechnology Laboratory) and Ashwil Klein have collaborated on the use of endophytes in alleviating drought, salinity and disease in alfalfa. This has led to a transfer of skills between the three laboratories, and facilitated the recent completion of the PhD degree of Gerhard Basson and the upcoming submission of the PhD thesis of Ziyanda Mmango-Kaseke, which will be converted into three separate papers in accredited journals. The interactions with other researchers are of vital importance, as they often spark new approaches to resolving research challenges.
4. Professor Ndiko Ludidi and Dr Ifeanyi Egbichi are working together on aspects relating to regenerative agriculture, which facilitated much of the stakeholder engagement while enabling skills transfer between UWC and

WSU in terms of plant responses to stress, cropping systems, and insect diversity. This is evident in the co-supervision of two UWC PhD candidates who submitted their theses in November 2023, and the planned co-supervision of one WSU MSc student. This collaboration contributes to career development by establishing connections with mentors.

5. The collaboration between Professor Ndiko Ludidi and the ARC has allowed the exchange of plant genetic resources (especially soybean, cowpea, and Bambara groundnut) and the co-supervision of students. Some of the work on sorghum, finger millet and pearl millet finalised in 2023 is the result of collaboration between Professor Ndiko Ludidi, Dr Andrew Nkomo and Professor Hussein Shimelis from the University of Zululand and UKZN. This collaboration provided insight into sorghum and pearl millet responses to abiotic stresses.
6. Professor Ndiko Ludidi and his research team worked closely with the University of Missouri (especially Professor Robert Sharp and Professor Scott Peck) on plant physiological responses to drought and heat stress, and this has enabled our then-PhD candidate and now postdoctoral student (Ali EE Ali) to spend time in the laboratories of these two collaborators, which was instrumental to the completion of his PhD and the advancement of his postdoctoral work. Their collaboration with the Centre of Biotechnology of Borj Cedria in Tunisia has yielded several papers in accredited journals and several conference presentations, together with a very good impact on skills transfer between students in these labs, which has contributed to the completion of PhD degrees between the two laboratories (e.g. Gerhard Basson's recently completed PhD). This global exchange of ideas could contribute to a broader perspective and the enrichment of research outcomes.
7. The collaboration with the University of Zurich's Professor Ueli Grossniklaus has resulted in the sequencing of a reference genome for the marama bean, which will serve as the basis for improving legume tolerance to drought and heat stress. This has exposed two UWC students to state-of-the-art plant omics technologies, which they will bring back to the CoE-FS.
8. The role played by the collaboration with Chinese University of Hong Kong Professor Hon-Ming Lam continues to be crucial in developing drought- and heat-tolerant soybean varieties, and this is exemplified by the F4 generation crosses. Continued collaboration with Professor Joyce Soulange-Govinden at the University of Mauritius has facilitated great progress with a PhD thesis on drought responses in pigeon pea, which is expected to be completed in July 2024 but likely to yield one paper in a peer-reviewed journal by February 2024, followed by another in August 2024.
9. The collaboration between Professor Rogerio Chilulele at Eduardo Mondlane University on cowpea has positively impacted a PhD (submitted in November 2023) and the postdoctoral work of Dr Mandilakhe Naku, from which we envisage a paper submitted to a peer-reviewed journal (*Plants*) in November 2023. Other current national collaborations include those with Walter Sisulu University (Dr Egbichi (biochemical assays)), the University of North-West (Dr Billibana (field trials and nanotechnology)), the University of Pretoria (Professor Makhalanyane (soil metagenomics)), and the University of the Free State (Dr Gokul (ionomics) and Dr Du Plessis (transcriptomics,

genomics, and bioinformatic analysis)). These collaborations led to various joint publications and the joint supervision of students.

10. A new national collaboration with the laboratory of Professor Charles Laubscher from the Cape Peninsula University of Technology has led to a submission accepted for publication by the *Russian Journal of Plant Physiology,* and a manuscript under revision in the *Annals of Botany (AoB) PLANTS*.
11. The CoE-FS developed a collaboration with researchers at UKZN (led by Dr Tafadzwanashe Mabhaudhi and postdoctoral researcher Dr Wadzanai Mafunga) to extend the Food Imbizo activities into KZN. This partnership is providing capacity development opportunities to early career researchers and extending the policy advocacy reach of the CoE-FS policy and governance programme, thereby contributing to the emergence of a better-informed food policy environment in key metros of KZN (Ethekwini and Pietermaritzburg).
12. The CoE-FS also developed a partnership with Think Tank for Sustainability and Food Alliance Cape Town (FACT) to collaboratively conceptualise, plan and facilitate Food Imbizo events. These are research and knowledge co-creation platforms that are solution oriented. They contribute to food governance processes that are more effectively informed by grassroots concerns and will enhance community-based organisations' capability to engage with food policy deliberations. Over and above these activities on the ground, Dr Chantell Witten and Professor Julian May both serve on committees/task teams of the Office of the Presidency, where they draw on project research to provide guidance in high-level state forums. The research and support of the team and its Technical Working Group has been both sought by and offered to bodies such as UNICEF and the WHO.
13. Deliberations from the above partnership with Think Tank for Sustainability and FACT are being translated by FACT colleagues into the local vernacular (isiXhosa and Afrikaans), thus contributing to greater mutual understanding between diverse stakeholder groups. The partnership with TMG has also contributed to co-funding, which will enhance the financial sustainability of the Food Imbizo as well as ensuring that these German partner organisations (including the German International Development Agency, GIZ) achieve greater governance impact and are better informed about local priorities, concerns, needs and capabilities.
14. The CoE-FS also developed a collaboration with VU-A and the INSSPIRE/South-South Triangular Co-operation project to contribute to curriculum enrichment, highlighting the impact of climate change on food systems. The collaboration has established a collaborative network with leading food security researchers from several African countries, including Kenya, Uganda, Benin, Ghana and South Africa.
15. The CoE-FS also developed a collaboration with FSNET project leads at the UP and ARUA to present and discuss food governance issues at the FSNET stakeholder engagement event, and to develop a call for action together with a broad group of stakeholders. This ensured a greater reach and impact of CoE-FS research findings, while also ensuring that FSNET deliberations are informed by the several years of research and knowledge co-creation that the CoE-FS has cultivated. Presentation and collaboration have established

networks with researchers who have expressed interest in future collaborations on other projects.

16. The CoE-FS also developed a collaboration with the ACF to convene the African Food Systems Transformation Collective, with the initial aim of developing a series of issue briefs to inform more coherent, appropriate and impactful philanthropic strategies to promote transition to sustainable, equitable and resilient food systems across Africa. Following its inception workshop, the project has already established a network of over 200 researchers and civil society representatives from countries in four African regions (North Africa, West Africa, Southern Africa and East Africa). The network is developing a shared language and understanding of the expected impacts of climate change on food systems and the challenges and opportunities facing African Food System Transformation. The network is also becoming a resource to help identify partners to collaborate on funding proposals and research projects. The partnership has provided leveraged funding to cover the project lead's salary for 18 months.
17. The CoE-FS made contact with an extension officer, Ali Makgato from GDARD, who guided us with the identification of suitable smallholder fresh produce and animal husbandry farms for sampling purposes, to achieve the research goals of the CoE-FS and other leverage-funded projects that also contribute to addressing food safety and security challenges in the informal sector. We have established a collaboration with the National Institute of Communicable Disease's Sequencing Core Facility to begin exploring the genomes of selected isolates through the supply chains.
18. The CoE-FS identified parental lines of drought- and heat-tolerant maize and sorghum for performing crosses with high-yielding commercial varieties of sorghum and maize, which will be done in collaboration with the University of KwaZulu-Natal, the University of Mpumalanga, the Agricultural Research Council, and Walter Sisulu University. This is in parallel with multiple other CoE-FS national and international collaborations, as well as inter-disciplinary and inter-institutional as well as inter-departmental collaborations. Such examples include but are not limited to the Impact of Regenerative Agriculture on Soil Health, Crop Nutrient Profile and Biodiversity project with its endless list of collaborations with Walter Sisulu University (Dr Egbichi (biochemical assays)), North-West University (Dr Billibana (field trials and nanotechnology)), the University of Pretoria (Professor Makhalanyane (soil metagenomics)) and the University of the Free State (Dr Gokul (ionomics) and Dr Du Plessis (transcriptomics, genomics and bioinformatic analysis)) together with delivering various services for the University of the Free State to the value of R60 373. These collaborations led to various joint publications and the joint supervision of students. In addition, Professor Keyster started a new national collaboration with the laboratory of Professor Charles Laubscher from the Cape Peninsula University of Technology, which has led to a submission accepted for publication in the *Russian Journal of Plant Physiology* and a manuscript under revision in *Annals of Botany (AoB) PLANTS.*
19. In November 2023, the CoE-FS hosted a hybrid workshop on the development of a digital twin for food system analysis. Our collaborators at VU-A provided a venue and audio-visual support in Amsterdam and the

participants in the workshop included representatives from UWC, UP, VU-A, KU-L, the City Support Unit of the South African National Treasury, CIRAD, the BVM, and the University of Hohenheim. The group comprised modellers, urban designers, computer and information scientists, data scientists and economists. We noted that digital twins make use of several technologies, including the Internet of Things (IOT); Artificial Intelligence (AI); Extended Reality (XR), and Cloud Storage. Different Application Programming Interfaces (API) will be required to manage the transfer and processing of information between the components of the twin. We explored FIWARE, a platform promoted by the European Union for the development and global deployment of Future Internet applications. FIWARE attempts to provide an open, public and free architecture and set of specifications that can be used to build a digital twin (https://www.fiware.org/). We noted that the CoE-FS and our collaborators have made progress towards a digital twin in the BVM using our Food4Cities and UrbanFOSC projects. A model has been prepared based on our household and vendor surveys that enables estimation of the changes in selected food system outcomes arising from a suite of policy options. This workshop informed the development of the CoE-FS Business Plan for 2024.

20. In July 2023 the CoE-FS researchers at UWC met with representatives of the World Food Programme (WFP) and a high-level delegation from the National Food and Strategic Reserves Administration of the People's Republic of China, led by the Vice Administrator, Dr Lu Jingbo. Information concerning our work on plant breeding and food safety was shared.
21. We also have a FAO/ICLEI Food for Re-building report that is anticipated to inform government deliberations throughout the country. Collaborations with civil society through FACT, WC Food Forum, and Food Imbizo meetings are informing food-related advocacy and mobilisation as well as government policy development and implementation. The AFSTC is anticipated to lead to more coherent and appropriate funding approaches and mechanisms that will catalyse and accelerate agroecological transitions, empowering currently disadvantaged and marginalised food system stakeholders.
22. UrbanFOSC directly involves collaboration between UWC, VU-A, CIRAD, Moi University in Kenya, and the University of Constantine in Algeria. CIRAD has seconded Dr Arlene Alpha to UWC for three years. Bi-annual meetings have been held with the collaborators, with a hybrid meeting held in November 2023 in Amsterdam at which Professor May, Mogatosi and Truter were present as part of their exchange visit to VU-A. The formal collaboration includes the BVM, the WCG, the Western Cape Economic Development Partnership (EDP), and the Southern African Food Laboratory at the University of Stellenbosch. During 2023, an MOU was signed with KU-L, who will join the longer-running place-based programme in the BVM.
23. In December 2023, our UNESCO Chair co-hosted a workshop on bridging the world of practice and the world of knowledge, towards a re-imagining of the global South agenda in a transforming world. This 'Africa Dialogue' was held in Nairobi with our partners, BRAC (the world's largest NGO, which focuses on sustainable livelihoods) and Adeso, a Kenyan NGO working on food security. It was attended by representatives from Oxfam, Amnesty International, the Network of African Science Academies (NASAC), the African Visionary Fund and the Council for the Development of Social Science

Research in Africa (CODESRIA). The objective was to commence preparatory work towards a global summit on science-to-society approaches from a South perspective that is planned for 2025.

The CoE-FS's local, national and international collaboration not only enhances the quality and impact of scientific discoveries but also promotes global cooperation, understanding and progress towards addressing shared challenges. It is a crucial component in advancing knowledge and solving complex problems that transcend national boundaries.

KPA 5: SERVICE RENDERING

Service rendering is defined by the NRF as any services rendered to policymakers, civil society or industry as a research activity and/or affiliation with the CoE-FS. Many of our networking and knowledge brokerage activities are related to our service-rendering KPA and have already been reported on. However, since the launch of the CoE-FS in 2014, most of the researchers have directly engaged in policy assignments with national government and are committed to providing services and sharing their expertise with local organisations, industry, institutions of learning and others, to ensure that the knowledge produced contributes to policy and translates to knowledge for the public.

A partial list of our service-rendering activities in 2023:

1. Professor Julian May continues to serve as a commissioner with the National Planning Commission (NPC) in the Office of the Presidency; serves on its Council and Audit and Risk Committee; served as Chair of the Board of Trustees of the Dullah Omar Institute from 2012 to 2023; and serves on the Scientific Advisory Committee of the Centre of Excellence in Human Development hosted by Wits. The bulk of his service rendering focuses on his NPC activities, where he is the spokesperson for matters concerning child rights, chairs a Task Team on strategies to increase the income and food security of the poorest 40 percent of South Africans, and serves on task teams concerned with climate change, agriculture and bulk infrastructure.
2. During 2023, Professor May led engagements with the Office of the Rights of the Child (ORC), National Treasury and the Trade and Industrial Policy unit (TIPS), and participated in engagements with SALGA, the Development Bank of Southern Africa (DBSA), and the Department of Monitoring and Evaluation (DPME) in the Office of the President. In August 2023 the NPC met with President Cyril Ramaphosa, and Professor May was invited to speak on the findings of the CoE-FS concerning child malnutrition in South Africa. This was followed up by presentations at a Child Rights Indaba and a meeting with Rose September, the director of ORC.
3. In 2023, Professor Lise Korsten was elected as president of the African Academy of Sciences, its first female president. She also established a Food Safety Science Platform for South Africa, which will be an open resource for government and industry and will be used to drive policy change in terms of food safety test methods and regulations.

Figure 22: First female AAS president

Prof Lise Korsten was elected as president of the African Academy of Sciences, its first female president. Pictured here with the AAS Board of Directors. Photo: AAS Twitter/X.

4. Professor Lise Korsten was appointed to the chair of the International Society for Plant Pathology Task Force on Global Food Security; addressed a parliamentary session on food security regarding the status of food safety in South Africa; served as a technical expert on the SABS ISO standards committees; and served on the ministerial commission on antimicrobial resistance (AMR), contributing towards the Stewardship technical working group representing environmental and plant health within AMR One Health.
5. Among the many examples of service rendering by Professor Lise Korsten's researchers is a study led by a young SA woman, Thabang Nora Msimango (a PhD candidate), who was awarded a Fulbright Foreign Student Programme Scholarship. Msimango is busy with Food Safety Risk Assessment training from July 2023 to April 2024, under Professor Abani Pradhan's supervision at the University of Maryland's Department of Nutrition and Food Science and the Centre for Food Safety and Security Systems. Through her work, Msimango escalates and strengthens the ability of the CoE-FS to conduct and assess qualitative and quantitative microbiological risks of dark leafy green vegetables commonly consumed in South Africa, in order to build expertise regarding hazard assessment and exposure assessment, which are critical elements in developing and implementing risk mitigation strategies in the formal and informal supply chains. In addition, this will provision support for our broad-based capacity of zooming in to the microbiological quality and safety of fresh vegetables consumed as part of the school feeding programmes, for example.
6. The CoE-FS also works with Dr Elisabetta Lambertini, who is currently a Senior Technical Specialist and Head of EatSafe (Evidence and Action Towards Safe Nutritious Food) Research at GAIN, where she oversees research activities in their food safety portfolio in low- and middle-income countries and is a food-risk assessment specialist. Her work provides information on how leafy green vegetables are handled, transported, prepared and stored by farmers, retailers and consumers, in order to complete the risk ranking and quantitative risk assessment parts of the research.

7. The CoE-FS funding is of great value for the continued development of sensory and consumer testing services for food companies at UP. Funding was used to renew the licence for dedicated XLStat software used for the analysis of sensory data. The SMART food project joined hands with the InnoFoodAfrica EU-sponsored project to exhibit at the exhibition at SAAFoST in August 2023, and Africa Week on 22-26 May 2023. The developed food ingredients and food prototypes were exhibited. Delegates were interested in the various prototypes, and looked forward to seeing them on the market soon.
8. The CoE-FS reviewed the ICLEI/FAO Food for Rebuilding Policy Recommendations Report: 'RSA. 2023. A Framework towards a National Food System Strategy, First Draft, ICLEI Africa, October'. It helped to refine and improve the final draft of this report, incorporating more coherent systemic analysis informed by food justice, sovereignty and agroecological concerns.
9. The CoE-FS co-hosted a food imbizo stakeholder engagement process with ICLEI to evaluate the Food for Rebuilding report. This report reviews the current state of the South African food system and its policy environment, aiming to guide national, provincial and local governments to develop food systems that produce just and sustainable outcomes and that are more resilient to external shocks.
10. The CoE-FS participated in the Western Cape Food Forum strategic deliberations on a continuity strategy for the food-focused civil society networks established as a consequence of the COVID-19 lockdown. These networks represent a key societal resource for responding to food access crises and for building awareness of food issues towards more equitable and sustainable food governance.
11. Professor Stephen Devereux is a founding member of the Food Equity Centre, along with Professor May. This is a global network of researchers hosted by IDS Sussex, with partners in the UK, Brazil, Thailand and South Africa (Centre of Excellence in Food Security, African Centre for Cities). In May 2023, Professor Devereux visited partners in Brazil and presented seminars at universities in Brasilia and Rio de Janeiro. Further collaboration is ongoing.
12. Professor Rina Swart leads the National Dietary Intake Survey (NDIS) project, which is conducted as a tender from the NDoH, and presented the findings of the study on the impact evaluation of the HPL to Treasury as well as to the chief directors of Non-Communicable Diseases and Health Promotion and Nutrition.
13. Professor Naushad Emmambux was involved in a cellulose nanofibre project from the South African Pulp and Paper Industries Limited, which engages with the food industry in terms of communication and frequent virtual meetings, and has a good relationship with Tiger Brands, PepsiCo and RCL Foods in South Africa, and RISE Sweden and Puratos Belgium at an international level. Professor Ndiko Ludidi has been working with smallholder farmers in rural villages of the Eastern Cape, such as Lukholweni Village in the Matatiele Local Municipality, Ngqandulo Village in Ingquza Hill Local Municipality, and Mqhekezweni Village near Mthatha.

14. Since inception, the IYCF Advocacy Project has engaged with, sought the input of and shared project progress and findings with (among others) the SAMRC; ADSA; UCT, in the form of the Children's Institute; Wits and the CoE-HUMAN, which it hosts; Stellenbosch University; HEALA; the Food Justice Coalition; and the Black Sash. The research and support of the team and its Technical Working Group have been both sought by and offered to bodies such as UNICEF and the WHO.

FINANCIAL INFORMATION

Funding flows

Table 20: Funding received and spent from NRF in the reporting period

Commitment	Released	Expenditure
R2 779 565.53	R2 779 565.53	R2 779 565.53
R15 315 378.75	R13 243 31.50	R12 530 872.62

The 2022 carry forward amount of R2 779 565.53 was spent as per the annual report submitted. The 2023 unspent balance of R712 438.88 is made up 20% project committed funds and operational funds reserved for the annual report and updated branding. The difference between the NRF commitment and the amount released are the allocation reserved for the approved student linked grants, which were managed by the NRF. The CoE-FS would like to request a carry forward for the available balance.

The centre disbursed 80% of project expenditure at the signing of the project agreement and the balance of the funds will be released once we have received the final project reports. This process usually happens before June in the ensuing year.

Table 21: Breakdown of NRF funding expenditure

Commitment	Budget	Spent	%Budget
Research	R5 191 R974.00	R4 554 535.12	33.90%
Bursaries	R5 579 674.00	R5 579 674.00	36.43%
Salaries	R3 733 317.00	R3 733 317.00	24.38%
Running costs (Operational)	R510 413.75	R510 413.75	3.33%
Conferences, webinars and media	R300 000.00	R225 000.00	1.96%
Equipment	-	-	0%
Total income	**R15 315 378.75**	**R14 602 939.87**	**100.00%**

HDI Support

The CoE-FS has allocated R5 346 746 which is 49% of the bursary and research running costs budget to UWC. An amount of R200 000.00 was transferred to a postdoctoral Fellow based at UKZN.

Direct[3] and leverage funds (funding received by PIs/PLs)

The CoE-FS has managed to raise a total amount of R44 601 115.11 in additional funding as listed in Annexure 16 of this report. This amount is made up of R16 941 115.11 in direct funding and R27 660 000.00 in leveraged funding.

[3] Any financial contribution other than the funding received from the CoE-FS to the project, which is auditable and managed by the PL and the collaborating institution.

Return on investment

The CoE-FS publication list and students registered for 2023 as outlined in Tables 5, 6 and 7 of this report, represents a significant return on investment, and once the published output has been verified and converted into subsidy income, this will represent a considerable income for the universities at which research is taking place. It is difficult to accurately estimate the value of the expenditure in terms of subsidy income since this varies year-on-year and is affected by the number and location of co-authors. Since its inception in 2014, the CoE-FS published over 350 journal articles, book chapters, and books, with the highest cumulative citation of 55. It has also supported more than 350 students, which is viewed as a long-term economic and societal investment.

The establishment of the CoE FS has also resulted in considerable additional funding in 2023, amounting to R44 601 115.11. However, the greatest return on investment is the networking and collaborations that have taken place within the projects supported by the CoE-FS and the findings that are emerging. As mentioned above, the CoE-FS currently has 49 CAs in place, with more than 100 international and national collaborators since 2014.

HUMAN RESOURCES

As a virtual centre, the CoE-FS has a small permanent staff complement, who have direct and indirect management responsibilities over service providers and support staff at UWC, UP and our collaborators. The researchers who received funding from the CoE-FS in 2023 are listed in Appendix 4.

Table 22: Management and professional support staff

Full name	Institution	Sex	Race	Citizenship	Role	% time
Prof Julian May	UWC	M	W	SA	Director	100
Prof Lise Korsten	UP	F	W	SA	Co-director	20
Dr Elaine Sinden	UWC	F	C	SA	CoE-FS Research Manager	100
Carla Bernardo	UWC	F	C	SA	Communications Manager	100
Elaine Petersen	UWC	F	C	SA	Finance Manager	100
Nolutando Didiza	UWC	F	B	SA	Administrative assistant (Contract)	100
Robyn Engelbrecht	UWC	F	C	SA	Administrative assistant (Contract)	100
Florian Kroll	UWC	M	W	SA	Researcher (Contract-leveraged funding)	100

S'celo Madondo	UWC	M	B	SA	M&E Officer (Contract)	100
Jane Fourie	UP	F	W	SA	Administrator (Student admin support)	Hourly
Suzette Seymour	UP	F	W	SA	Administrator (Finance admin support)	Hourly
Andrea du Toit	UP	F	W	SA	Admin Assistant (Minute taking support)	Hourly
Remoneilwe Mogatosi	UWC	M	B	SA	Research Assistant (Contract-funded by CIRAD. UrbanFOSC	6-month contract

SOCIETAL AND KNOWLEDGE IMPACT

This section should be read in conjunction with the various KPAs in this report as well as the appendices, where specific evidence of the work of the CoE-FS in 2023 is provided. KPA 5, for example, explicitly highlights a few of the CoE-FS's contributions to bringing change to society and advancing knowledge on food security and other related aspects. KPA 3, KPA 4 and Appendix 5 highlight the CoE-FS's efforts in sharing knowledge with local, national, and international communities. The deliverables described in the various KPAs in the report also have a direct or indirect impact on both societal influence and societal knowledge.

In line with NRF Vision 2030, which is grounded on Transformation, Impact Excellence and Sustainability, the NRF has developed a 'Framework to Advance the Societal and Knowledge Impact of Research'. This framework outlines how through its core mandate areas the NRF can best advance the impact of research. The framework is intended to promote, support, identify and communicate the impact of research on the research enterprise (Knowledge Impact) and in society (Societal Impact). According to this framework, Knowledge Impact is described as scientific advances in understanding, interpretation, methods, theory application and related advances that bring positive change within and/or across disciplines and fields. Societal Impact refers to the value that research adds to society across various spheres, whether social, economic or environmental.

The role that the CoE-FS plays in disseminating food security knowledge can be seen in its information brokerage platform, and it does this through a focus on public awareness of and engagement with society for the benefit of society. The science engagement model of the CoE-FS follows an integrated, interdependent and inclusive approach, with emphasis on both the national multi-stakeholder coordination function and the leadership of the internal cross-cutting CoE-FS engagement portfolio. The CoE-FS executes a range of engagement interventions or initiatives in partnership with stakeholders in the sciences, education and communication areas, through grants, joint activities and exhibitions at engagement events. Also, interactions with core team members, postdoctoral Fellows and students provide an opportunity for knowledge generation and sharing. Such direct interaction takes place in meetings, lectures and workshops. The CoE-FS has also made use of other forms of interaction – such as publications, and traditional and

new media platforms – to get the food security message to all levels. All these engagement efforts help increase our footprint, improve awareness about the work of the CoE-FS, drive website traffic to where people can access various resources, including research publications, and help expand our social media followers for enhanced engagement.

Further, the CoE-FS is continuously adapting and exploring new ways to promote science communication and engagement. This is done particularly to open the research space to members of the public who otherwise would not have access. Among the ways we've been able to achieve this is by partnering with multimedia professionals to stream live sessions during international conferences.

A few examples of how the work of the CoE-FS was instrumental in bringing about social change and advancing knowledge in 2023 (in addition to the information provided in KPAs 3 and 4):

1. During the reporting period, the CoE-FS made significant strides; there were 30 instances of media engagement (knowledge brokerage) in 2023, including TV and radio broadcasts, online news articles, social media and print media.
2. With almost 10 000 media coverage items, our science communication activities have contributed towards widening engagement with food systems, and debates over how outcomes from this system could be more sustainable, inclusive and efficient.
3. The food safety 'One Health' approach incorporates the three main interlinking facets of animal, plant and human health with the cross-cutting facets of water and environment. This approach is critical to addressing the control of zoonosis and of antibiotic resistance. A 'One Health' approach is critical, due to the fact that the same microorganisms infect animals and humans, and are often disseminated on plants as well as through water, resulting in a need for trans-/inter-/intra-disciplinary research. Such outputs become really crucial in times when pandemics spread across communities, such as during the recent cholera outbreak.
4. The CoE-FS's engagement with the private sector and technology developers facilitates the transfer of innovative technologies and practices to improve food production, distribution and storage. This contributes to increased agricultural productivity and resilience in the face of changing environmental conditions.
5. Publications are one of the primary means by which the CoE-FS shares its findings with the global scientific community; they contribute to the accumulation of a collective knowledge base. In light of this, since its inception the CoE-FS has published over 600 articles, book chapters and research reports, which have been cited more than 11 000 times. Of our peer-reviewed journal articles, 77% were written or co-written by black researchers, with 187 having female co-authors (50%); and 265 publications (51%) include researchers affiliated with historically disadvantaged institutions (HDI). We have co-authored papers with 21 of the 29 HEIs and research councils in South Africa, and with 871 collaborators from 49 countries. Publications, therefore, are integral to the scientific process, serving as a mechanism for sharing knowledge, validating research, fostering collaboration, inspiring innovation, and contributing to the overall advancement of human understanding. They play a central role in

science engagement by connecting researchers, educators and the public with the latest discoveries and insights.

6. We engaged with local communities and various stakeholders (e.g. provincial and local government, civil society, non-governmental organisations, other universities, and farmers) through Imbizos and the 'learning journey' approach to empowering communities to actively participate in finding solutions for their unique challenges. This is evident in the work with ACF, Think Tank for Sustainability and BVM. Documented research on emergency food relief such as during COVID-19 has shown the potential of collaborative governance between different groups of stakeholders and levels of government to address specific place-based problems. It paves the way for further engagement in food system sustainability. Through our Imbizos and learning journeys we create and strengthen collaboration among stakeholders; this platform brings researchers, policymakers, practitioners and community members together to discuss challenges, share insights, and co-create solutions.
7. The CoE-FS supports training capacity-building efforts by helping communities and stakeholders, especially those in less research-intensive environments, understand and utilise research findings. This includes providing training, workshops and resources to empower individuals and organisations to engage with research effectively. To this end, fourteen Small Micro-Medium Enterprises (SMMEs) in Limpopo province were trained on product development, prototyping and Food Safety (GMP and HACCP). This process produces different types of products, such as *mageu* (a fermented sorghum drink), herbal tea, indigenous mouthwash, vegetable atchaar, cashew milk, tinned mopani worms, medicinal herbal juice, instant porridge, and seasonings.
8. Most of the SMMEs in Limpopo province lack understanding of the GMP and HACCP. This is of concern in the agro-processing sector. Adequate protection of the consumer against foodborne illness can be achieved by personnel training based on good manufacturing practices and hygienic food preparation. Fifty-six (56) SMMEs in Limpopo province were trained on food safety (GMP and HACCP). This will help the SMMEs process and manufacture hazard-free and safe products. The SMMEs produce different types of products: yoghurts, termite bars, confectionery, sauces, mayonnaise, ready-to-eat fast foods and atchaars. The clients were recommended and advised to follow strict hygienic practices and adhere to food safety practices to reduce the risks of contamination and avoid compromising the quality of their products.
9. About 50 farmers in the Mpumalanga area of Mzinti and Makoko were trained in the valorisation of cowpeas, orange-fleshed sweet potatoes, and Bambara groundnuts. The easy-to-read manual for manufacturing solar dryers was translated into three different South African languages for easy access by various South African farmers and food processors. This can contribute to reducing food loss, as farmers can dry their produce to make shelf-stable fruits and vegetables.
10. The CoE-FS held several meetings and workshops with local government officials (the Eastern Cape Department of Rural Development and Agrarian Reform, the Department of Social Development, and the Eastern Cape Rural Development Agency) and farmers (smallholder and medium-scale commercial farmers) in the Alfred Nzo District Municipality, with a focus on the Matatiele Local Municipality, to engage in the adoption of regenerative agricultural

practices and the cultivation of underutilised crops of African origin as a way of building sustainable agriculture and climate resilience in the municipality.

11. The CoE-FS also involved smallholder farmers in the actual field work done by our student in Matatiele in crop cultivation practices pertaining to regenerative agriculture as part of the experiments on intercropping, in an effort to familiarise them with the work of the CoE-FS and to demonstrate its benefit. Some of the smallholder farmers have started adopting these practices as part of their crop production system (e.g. Mzimasi Mtumtum and Nzwanenkulu Makanda in Lukholweni village).
12. The CoE-FS was involved in a Kenyan community engagement project entitled “Adoption of an integrated crop-dairy goat production system and the promotion of value-added techniques in dry areas, Kenya." We assessed the factors influencing the adoption and implementation of improved dairy goats and climate-smart crops among farmers in Elgeyo Marakwet County. This collaborative approach helps empower local populations by providing them with the knowledge and tools to enhance their own food production, leading to increased self-sufficiency.
13. The research led by Dr Wegerif includes civil society, including the East and Southern African Farmers Forum, the Masifundise Artisanal Fishers Organisation (South Africa), the Association for Rural Advancement (South Africa), the Environmental and Management and Economic Development Organisation (Tanzania), and the Network for Women’s Rights in Ghana. They also interacted and shared information with the South African Informal Traders Alliance and the Women in Informal Employment: Globalising and Organising network.
14. As a result of its engagement with smallholder farmers, the project led by Professor Ndiko Ludidi led to the adoption of regenerative agriculture practices that have increased yields while preserving natural resources (using less water and reducing environmental impact) for a smallholder farmer co-operative in the Eastern Cape named DI Farms.
15. The CoE-FS’s research done by SARChI in Social Protection for Food Security provides an evidence base for social protection systems that build resilience to environmental, economic and social disasters. Our research also focuses on the feasibility and appropriateness of a system of basic income support in South Africa, which can help alleviate poverty and reduce inequality.
16. The IYCF advocacy project has been recognised by the NDoH as an undertaking that will positively influence the breastfeeding landscape in South Africa, through the work of the CoE-FS. Through the development of campaign messaging, the project has contributed to counteracting the myths of the commercial infant formula companies and to raising awareness thereof among the practitioner target groups (nurses, sisters, midwives, lactation consultants, nutritionists, dieticians, paediatricians, gynaecologists and pharmacists). Through identifying a material gap (e.g. the need for better maternal and child well-being material, a lay-language translation of R991, and a lay compendium on the medicalisation of child behaviour and false scientific claims), the project has bridged an information gap in the field. The research findings have been shared with the WHO and UNICEF, as well as with drafters involved in the revision of R991. The project has also laid the groundwork for further and pointed engagement with the government, hospital head groups, deans, and professional bodies such as the HPCSA, Nursing Council and Pharmacy Council. Lastly, a handbook will be

produced in 2024 to guide others in the process of research, and counteracting through communication the undue influence of the commercial infant formula industry, and more broadly, industry influence on public health.

17. Through our work on policy and governance, we have contributed towards building the capacity of policymakers and institutions at municipal, provincial and national level to engage with the systemic dynamics of food systems change. We thus speak directly to the need for 'improved, science-based information to direct development-oriented decision-making'. By linking food security to health, livelihoods, productivity and employment, we are supporting the different spheres of government in attaining their key social development outcomes. These include "a long and healthy life for all South Africans"; "a skilled and capable workforce to support an inclusive growth path"; and "sustainable human settlements and improved quality of household life".

TRANSFORMATION GOALS

Transformation is a corrective action necessary to deal with the past injustices of colonialism and apartheid. It is also necessary to create a critical diversity of perspectives that will produce new insights and a healthier education.

Transformation also involves developing food security as a transdisciplinary field of study. We have made good progress in this regard. For example, one of our projects promotes transdisciplinary research by bridging plant science with animal science, and is working towards the inclusion of indigenous knowledge systems from a social sciences point of view to address the mainstreaming of indigenous grain crops in the South African food system. In this regard, it is noteworthy that since our inception, CoE-FS researchers have participated in most major policy initiatives concerning food security in South Africa. We were activity involved in both the development and the critique of the National Food and Nutrition Security Plan (NFNSP) in 2017; we contributed towards the development of the Western Cape's provincial security strategy, Nourish to Flourish; we were involved in the Demographic and Health Survey (DHS) of 2016 and the Living Conditions Surveys of 2015 and 2017. We also prepared the South African Rapid Food Systems Assessment for the UN Food Systems Summit in 2022.

At the level of our projects, the Safe Food project involved various disciplines such as microbiology, veterinary public health, social sciences, food science, epidemiology, consumer science and bioinformatics. Also involved in this research were UP's Department of Plant and Soil Sciences, Food Safety Team, Animal Sciences, Veterinary Sciences, UFH's Animal Sciences, UD, UMD, USDA's Agricultural Research Services, and the FDA's Centre for Food Safety and Applied Nutrition. Various black South African students are funded through this programme.

Since its inception, the CoE-FS has taken into account both transformation and gender equality, in the sense that we provided opportunity and capacity development for women, and equal opportunities are encouraged through its projects. This is done to strengthen equal opportunities for both men and women. For example, our partner, FACT, is predominantly led by women, and the partnership with this community network is growing capacity among these women and building a platform

for them to articulate their concerns and contest their interests with researchers, officials, and civil society organisations. Gender concerns are a cross-cutting theme in all of the work conducted by the AFSTC, so this research and advocacy project will raise awareness of these dynamics among philanthropic organisations, researchers, and civil society partners. Finally, the Food Imbizo Theory of Change is explicitly informed by intersectional feminist theory, ensuring that the particular challenges and opportunities presented to women inform the policy engagement narrative throughout.

The Food Imbizo activities and the AFSTC are inherently transdisciplinary, as they involve knowledge co-generation incorporating diverse knowledge from multiple stakeholder groups. Moreover, they all leverage research partnerships with multiple institutions and are aimed at advocating for and promoting the interests of Designated disadvantaged groups, especially women, infants and young children, the elderly, the unemployed and the poor.

Our research focusing on creating an environment where women's breastfeeding choices are not unduly influenced by the marketing of infant formula is another example of transformative research. The design of science communication strategies empowers women to make informed decisions regarding infant feeding, promoting gender equality in the context of maternal and child health. Also, we are doing research that focuses on the gendered nature of food production, processing, and utilisation in Africa. Other research activities focus on addressing gender disparities in the Science, Technology, Engineering, and Mathematics (STEM) fields related to the food system.

The growing transformation initiatives are even reflected beyond the borders of SA, for example, through the Technological Innovation programme with its research work supported by CoE-FS funding that contributes to multi-institutional research with the InnoFood EU project with universities in various African countries, including Uganda, Kenya and Ethiopia, as well as in three European countries: Finland, Norway and France. The funding contributes to the development of a substantial number of female researchers and research students.

The CoE-FS also provides direct support, empowerment and representation of women in its research, through the provision of grants and training, capacity building, graduate supervision and knowledge brokerage, to grow the human resources needed for these activities. Food security is often linked to gender dynamics. In many societies, women are responsible for food production and distribution in a family. Improving food security through the work of the CoE-FS can positively impact gender equality by empowering women in agriculture and ensuring they have access to resources.

With regard to its management and support structure, our core staff in 2023 consists of nine women and four men, all of whom are South African citizens, made up of six whites, four coloureds, and three blacks. Two staff members are living with disabilities. We are also among the minority of CoEs to have a female co-director, and an entirely female professional support staff.

As stated elsewhere in the report, we also had 116 active researchers, with a nearly equal mix of males and women. Notably, the number of black researchers has expanded dramatically from six at the start to 71 in 2023, enhancing our research with different viewpoints. Researchers from previously disadvantaged groups account for 40% of the grant-holders. All programmes have approximately the same division by race, although 51% of the Innovation and Technology programme is for previously disadvantaged groups. This is significant, given that most of the work in this programme is undertaken in the plant and food sciences, which are scarce skill disciplines in which transformation is a national priority.

Although progress has been made to include black researchers, we will need to do more to expand this profile as we move further into the 'performing' stage. To increase the number of black researchers, the CoE-FS's Sustainable Plan targets black South African senior researchers to replace PIs who have resigned and identifies successors to the incumbent director and co-director from within this group.

By raising over R350 million from the NRF and other funders, we have supported more than 500 postgraduate students and postdoctoral Fellows. With regard to the student gender profile, good progress has been made in the inclusion of women, with more than 65% females (all sources of funding) and 59% females (CoE-FS/NRF funding only). 'Students living with disabilities' is an area that needs attention. We will continue to carefully monitor applications from disabled students, and implement measures to provide support where appropriate to make it easier for disabled students to gain access to the CoE-FS.

In addition to developing the capacity of senior and emerging researchers, the CoE-FS encourages its staff and students to strengthen their individual skills. For example, Elaine Petersen's role over the last few years has developed from a finance and administrative role into a coordinating role. The benefits offered in terms of staff rebates assisted her with building her knowledge and skills in the specific field. The skills and knowledge she gained enabled her to make better strategic decisions and apply the knowledge she had learned. The projects increased her knowledge of the various funding instruments. She has also completed various in-house finance and human resources training courses, and successfully completed her honours (in the finance stream) in 2022. She is now registered for a master's degree in this field, and plans to complete this degree in 2024.

Nolutando Didiza graduated with an honours degree in Development Studies at UWC, and also completed various in-house training courses in the university's Finance and Human Resources Developments. She is currently enrolled for a master's in development studies at UWC, and will be given the opportunity to participate in our research projects once she has completed the coursework for her master's degree in 2023.

Finally, Carla Bernardo's master's in Political Communication from UCT is financed through the staff rebate, and she intends to complete the degree in 2024.

SCIENTIFIC CONTRIBUTIONS

Achieving great research impact requires showing that the findings of our research make a meaningful contribution to knowledge, practice and/or decision-making in the relevant field. Although a number of our research impact areas have already been described in this report, as well as in Appendices 3 and 5, a few highlights from our contributions are provided below.

The comparative proteomics work that Professor Ndiko Ludidi has done between sorghum and maize has opened new avenues for the use of comparative omics to rapidly identify markers that can be used for crop improvement. This recognition of this approach as having great potential for these purposes has led to interest from leading institutions in Europe in working closely with Professor Ludidi on its adoption, and consequently has resulted in collaborative agreements for 2024 and beyond between his laboratory, the Technical University of Munich, and the University of Zurich, in order to capitalise on this approach.

The journal article ‘Resilience and emergency statecraft in the Cape Town food system’ made a significant contribution to the scientific understanding of how policies emerging through gradual, incremental statecraft are embedded through crisis-triggered policy windows such as the COVID-19 lockdown.

The Food Imbizo project has pioneered an innovative hybrid workshop process that included strong community participation and the online presence of the wider Food Imbizo network. This required skilful facilitation and translation of conversations into vernacular languages. Benefits include greater transcultural understanding, and challenges include technical difficulties with the online platform, as well as slower progress in the discussions and the potential risk of officials feeling threatened by confrontational dialogue.

Another highlight was the transition of the food industry to a more democratic and participatory format and governance structure, with the involvement of Food Agency Cape Town. An additional milestone was the successful conclusion of a contract with TMG to leverage external funding for the food industry. Finally, the signing of a funded contract with the African Climate Foundation to convene the African Food Systems Transformation Collective was a key milestone, enabling another milestone, the inception of the AFSTC.

The Urban Food Systems programme led by Dr Marc Wegerif has set up research exercises for scientific price tracking of fresh produce on the ground from informal traders, as well as engaging with a range of media and interest groups on scientific outputs in this regard. Simultaneously, the programme is working with the NAMC on food markets, and there are wide systemic and technical sector discussions. An article in relation to these topics is in the pipeline and due for publication soon.

The Urban Food Systems programme also has a submission to the ICLEI: Local Governments for Sustainability. This is a global network working with more than 2 500 local and regional governments, and we have submitted a document titled ‘Food for Rebuilding: A strategic framework for the development of a sustainable, resilient, and inclusive food system for South Africa’. There are also ongoing

discussions with the Competition Commission on their food work; and in late 2023, the Competition Commission awarded the CoE-FS a grant to support our collection of food price data in the informal economy. Likewise, the programme is part of an international scientific initiative to establish an agenda platform for work on food systems. It was convened by IIED at Bellagio in Italy in September 2022.

To tackle the triple burden of malnutrition, the SMART food project looks at producing nutrient-dense food. A particular challenge that plagues many regions is the high viscosity of porridge-like staples, which can inhibit infants, the elderly and those with compromised health from consuming adequate nutrients; most indigenous and locally available porridges are far too viscous (or thick) to attain the proper nutrient density. The team has tackled this issue ingeniously by devising simple and effective technologies to reduce the viscosity of such foods, making them more accessible to vulnerable populations. Simple technologies, for example microwave and infrared treatment, can reduce viscosity, increasing the nutrient density of indigenous and local grain. These innovations are testament to the profound impact that simple technologies can have on complex problems. By employing straightforward techniques, the team managed to enhance the nutritional value and accessibility of staple foods. This not only aligns with the goal of reducing malnutrition, but also makes it easier for diverse groups of individuals to benefit from these essential nutrients.

During the period under review, three PhD candidates won the sorghum challenge at the sorghum conference in Montpellier, with a prize of 5 000 euros. A PhD candidate was the runner-up for the Ginsburg award at SAAFoST Congress in August 2023 for her poster presentation, and another PhD candidate was the runner-up for the three-minute impact of his research work at UP. There are also multiple other work packages and ongoing programme activities that will yield results soon, most of which are in the process of being applied for while others have received ethical approval from different universities, e.g. our Nutrition, Health, and Safety for Food Security programme received at least four ethics approvals recently. Thus, our researchers and students are continuously at work to produce cutting-edge research, broker knowledge, and communicate information and findings in credible journals.

1. Our scientific research helps in developing genetically modified crops that are resistant to pests, diseases and environmental stress. These improved crop varieties can enhance productivity, increase resilience to changing climatic conditions, and contribute to overall food security.
2. Our research publications have also highlighted noteworthy contributions to the science-policy interface concerning food issues, such as:
3. Side stream from cowpea can be used as a filler in biodegradable packaging films and injection-moulded materials.
4. Heat and moisture treatment with phenolics can reduce the glycaemic index of sorghum flour.
5. The successful preparation of natural food-grade pigments from the flowers of indigenous South African plant species.
6. The potential of food-to-food fortification as a sustainable strategy for the promotion of enhanced nutritional status and health among consumers in sub-Saharan Africa.

As stated elsewhere, during 2023 our research team served on national and international advisory groups, including the National Planning Commission (NPC), the National Food and Nutrition Security Coordinating Committee, the Global Food Equity Centre, and the scientific committee of the 5th Global Food Security Conference. Our expertise was also drawn on for the National Food and Nutrition Security Survey (NFNS) and the National Dietary Intake Survey (NDIS), as well as during the outbreak of cholera in Hammanskraal.

As indicated, at local level we have contributed towards the inclusion of climate change and support for nutrition at early childhood development centres in the Integrated Development Plan (IDP) of the BVM.

DATA STORAGE, UTILISATION, AND ACCESSIBILITY

Administrative data on students, grants, projects, financial information and all other information relevant to the management of the CoE-FS is kept on cloud storage and is backed up manually onto external hard drives. The CoE-FS is also using the Data First facility at UCT to access large social survey datasets, and will deposit its datasets and Stata Do files on this service in future.

Effective management of the CoE-FS is required to ensure data is stored securely, utilised effectively, and accessible to authorised users when needed.

PATENTS, PRODUCTS AND INTELLECTUAL PROPERTY

None.

SUMMARY AND WAY FORWARD

The CoE-FS champions the goal of promoting transdisciplinary research and is committed to contributing towards the targets of the SDGs. We have always been and will remain an engaged CoE in which the achievement of societal impact is central to all of our activities.

Over the last 10 years, the CoE-FS has contributed significantly to the positioning of UWC and UP as research-led universities through both the publication of research findings and the graduation of master's and PhD candidates. Furthermore, the CoE-FS has built on existing collaborations and created new ones. We are especially pleased with the maturation of the relationship between UWC and UP. The CoE-FS has also generated leveraged funding that matches that provided by the NRF. More importantly, the CoE-FS has provided a safe space for engagement between researchers and different universities and in different disciplines, the different government departments with which these researchers have been working, and the civil society organisations that engage with the food system as consumers and producers of food.

Although much has been achieved, food systems are constantly changing. Climate change, a global pandemic, food safety crises and wars have added to the complexity and pace of this change. In the immediate term we can expect escalating food prices, outright shortages, new products and processes, and changing systems

of governance and innovation. Discipline-specific research and training will remain essential, as will the need to increase both the diversity and the output of those producing this knowledge. However, the achievement of FNS requires more than scientific inquiry. Critically, transdisciplinary approaches must be mainstreamed so that environmental, social, cultural, economic and political drivers of change can be better understood and leveraged in a manner that achieves positive outcomes.

The CoE-FS is well placed to contribute towards this. By accepting that research output is a prerequisite rather than a goal, that science communication is embedded rather than desirable, and that impact is a value and not an aspiration, the CoE-FS is a fit-for-purpose institution to further contribute towards the knowledge and innovation infrastructure of South Africa and the continent. The ambitious model in which an HDI has led a co-hosted CoE has been challenging, but has endured.

Going forward, we believe that the CoE-FS should expand its capacity as a catalyst and as an incubator, in addition to its existing focus on research and training. Food security is a complex, multi-dimensional field of work, requiring a mix of cutting-edge disciplinary expertise, the capacity for the communication of science and also the science of implementation, and the ability to engage in knowledge co-production with practitioners and communities. This requires a different focus from that of a conventional research institute, in which the CoE-FS is a hub that builds and links multiple spokes. The CoE-FS is already operating in this fashion; our activities have served as a catalyst that builds links between existing institutes. An example has been our work on indigenous grains and legumes, which brings together our Department of Biotechnology with the Department of Food and Consumer Science at UP, the Tsolo Agricultural and Rural Development Institute, the Centre of Biotechnology of Borj Cédria in Tunisia, and UWC's long-standing collaborator, the University of Missouri.

The CoE-FS has also served as an incubator, generating start-up funding, assisting with capacity building, and then assisting with the establishment of a new centre. We see this as a critical role to be played by the CoE-FS should the grant be renewed for the full five years. We are still hopeful that the German government will issue a request for proposal for a CoE in Agrarian Studies and Data Science; but regardless of their decision, we have included a new programme of research that brings together our expertise in food systems analysis and data science with the intention that this may grow into its own research centre. We are also planning to introduce a joint advanced diploma in food system analytics, which we believe will attract both full-time and part-time students.

We will continue to promote collaborative work among researchers within and across universities and disciplines, making it possible for researchers to work in teams. We intend to identify joint training opportunities for postgraduate students and early-career researchers across faculties and institutions. We continue to build and expand our science communication activities to contribute towards knowledge translation and utilisation.