6 JOINT RESEARCH PROJECTS
SUSTAINABLE SYSTEMS

Crop irrigation system.

Ban Ki-moon, the United Nations Secretary-General from 2007 to 2016, stated that: "We don't have plan B because there is no planet B!" (United Nations, 2016).

Sustainable systems is an age-old concept, yet this concept was relegated to the background for many decades. In the 21st Century it is emerging as the most important approach in finding solutions to complex ecosystem questions.

The world's population is growing, and energy use and environmental pollution are on the increase. At the same time, natural resources such as fossil fuels and raw materials are becoming scarce. The effects of climate change are warning us that we need to reduce our output of greenhouse gases. Environmental challenges like these impact on both developed and developing nations, and they are compounded by increasing consumption pressures. The world needs innovative leaders and researchers who can help solve these complex problems and find sustainable solutions while addressing basic human needs such as mobility, shelter, water, food and communication.

The United Nations Sustainable Development Goals (SDGs), also referred to as Agenda 2030, were adopted in 2016. This was an historic decision on a comprehensive, far-reaching and people-centred set of universal and transformative goals. The main differentiating factor between the Millennium Development Goals, the predecessor of the SDGs, and the SDGs is that the new approach is looking into systems, and is not approaching the problems in silos. It is impossible, for example, to address food security without considering climate change, health issues, eco-systems and human behaviour.

If the platform of Big Data is added to the mix of sustainable systems, there should be a positive change in finding solutions to current-day challenges. The major challenge, though, remains human behaviour.

Photograph courtesy of Peter Gonsalez on Unsplash

To change human behaviour, we have to prepare the next generation by moving away from subject-based teaching at school level to an integrated system-based and knowledge management approach to teaching and learning. Education for sustainable development, with its overall aim to develop cross-cutting sustainability competencies in learners, is an essential contribution to all efforts to achieve the SDGs. This would enable individuals to contribute to sustainable development by promoting societal, economic and political change as well as by transforming their own behaviour (UNESCO, 2017).

The adoption of the UN's Agenda 2030 has presented governments of both developed and developing countries with a challenge to align national policies with expansive global Agenda 2030 goals.

Switzerland

Switzerland is committed to working for the full implementation of the 2030 Agenda and to achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner. Implementation of Agenda 2030 provides many opportunities to advance sustainable development on a local, national, regional and global scale. However, contributing both nationally and internationally to the implementation of Agenda 2030 and the achievement of the SDGs, as well as measuring and reporting on progress in a meaningful way, will also present new challenges for the organisational structure and processes of the Swiss Confederation.

Switzerland's aim in the future is therefore to align its Sustainable Development Systems comprehensively with Agenda 2030 to secure its contribution to the achievement of the SDGs by 2030 (Swiss Confederation Report to the United Nations, 2016).

South Africa

"South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration" (National Framework for Sustainable Development, 2008).

South Africa has done well in defining sustainability and sustainable development and the adoption of its National Framework for Sustainable Development (NFSD), which commits the country to a long-term programme of resource and impact decoupling. There is, however, still significant work to be done to reverse the many prevalent negative trends identified in the measurement of environmental performance. In response, government – in partnership with community organisations, business and academia – is putting in place structures and strategies to turn the situation around.

Policymakers also face the challenge to align the country's National Development Plan (NDP) with the SDGs. The NDP is South Africa's long-term development plan, which expresses consensus on societal challenges, focuses the national planning system and has the potential to implement development priorities in a more effective way.

The NDP seeks to address injustices, including improving the poor quality of education for black people, strengthening national infrastructure, uniting the country and creating employment (Brand South Africa, 2017).

OUTCOME OF THE SUSTAINABLE SYSTEMS DOMAIN: ECONOMIC VALUE

Most of the joint research projects in the Sustainable Systems domain started in 2017, which makes it difficult to quantify the economic value and social impact. Encouraging is that Jaeger et al, 2017 reported from the World Resource Institute that the achievement of the SDGs, intertwined with sustainable systems, has the potential to not only yield economic profit but to create jobs, especially in those countries with high unemployment. It is estimated that the economic yield of only four sectors – food and agriculture, cities, energy and materials, and health and well-being – could create a $12 trillion new market opportunity by 2030 and resource savings as high as $17 trillion. It is forecast that nearly 90% of all new jobs are expected to be generated in developing countries with 85 million jobs estimated for Africa.

Joint Research Projects

Outcomes of the Sustainable Systems Domain (7 projects)

RESEARCH DOMAIN: SUSTAINABLE SYSTEMS

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:
CHF 2 548 766 ZAR 35 927 560

UNIVERSITY PARTNERS

University of Basel
University of Applied Science and Arts Northwestern Switzerland
Zurich University of Applied Sciences
Agroscope
Swiss Federal Institute of Technology Zurich

North-West University
Stellenbosch University
University of Cape Town
Agricultural Research Council

SEED FUNDING

PHASE 2008 – 2012 No projects
PHASE 2008 – 2012 No projects
PHASE 2013 – 2016 3 projects
PHASE 2017 – 2020 4 projects

Phase III projects have not as yet reached full-scale scientific outputs.

BENEFICIATION

ECONOMIC
- 20% Technology Development
- 15% Economic Platform
- 15% Contribute to Industry Development
- 20% Regional and Rural Development
- 20% Contribute to Africa Economy

GLOBAL CHALLENGES
- 5% Climate Change
- 5% Mitigation
- 10% Addressing an African Challenge
- 30% Applied Systems Thinking

NATIONAL OBJECTIVES
- 25% Policy Beneficiation
- 25% SA National Strategies
- 5% HCD of Historically disadvantaged

PUBLICATIONS

8 6 5
19 TOTAL

BOOK CONTRIBUTIONS

3

POSTGRADUATES

5	MSc	10
0	Honours	1
3	PhD	10
1	Postdoc	3
33	TOTAL	

HDI

3	MSc	3
1	Honours	0
3	PhD	1
0	Postdoc	1
12	TOTAL	

EXCHANGES

9 TO SWITZERLAND
24
15 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS

9 4 35 48

WORKSHOPS

7 5

APPRECIATION

- COLLABORATION: 10% Alignment of PI's Objectives 25% Joint Knowledge 10% Joint Exchanges 5% Workshops
- HUMAN CAPITAL DEVELOPMENT: 15% Swiss Contribution 15% Technical Transfer from Switzerland 20% HCD in general 5% Could demonstrate SA research excellence
- RESEARCH FACILITIES: 20% Opportunity for applied research
- GENERAL APPRECIATION: 5% Leverage funds from another grant

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
- 5% NORTH AMERICA
- 10% EU COUNTRIES
- 10% AFRICAN COUNTRIES

UNIVERSITIES AND NETWORKS
- 25% SOUTH AFRICAN UNIVERSITIES
- 5% COLLABORATION IN SWISS-SA JOINT RESEARCH PROJECTS
- 35% CONTACTS AND NETWORKS ESTABLISHED
- 30% EXTENT COLLABORATION TO INTERNATIONAL NETWORKS
- 15% INDUSTRY NETWORKS ESTABLISHED

BENEFITS OF LINKAGES
- 15% NEW RESEARCH TOPIC
- 5% ADDITIONAL INNOVATION OPPORTUNITY FROM PROJECT
- 5% RESEARCH SUPPORT FROM INDUSTRY
- 15% EXTENT COLLABORATION WITH SWISS & SA PARTNERS
- 10% SA GOVERNMENT TOOK INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
- 5% Access to Information
- 10% Financial and Legal Administration of Project

FUNDING
- 5% Identification of suitable PhD candidates
- 15% Scholarships and Bursaries
- 5% Delayed Project Start

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Swiss Re and Sustainable Systems

While the South Africa Constitution enshrined a right of access to adequate housing, the country continues to experience a housing crisis. The numerous drivers for the housing crisis resulted in an estimated 2 700 informal settlements across South Africa. The challenge lies in developing a scalable, transparent and replicable model that addresses both real demand, market dynamics and municipal planning objectives.

In 2013 ETH Zurich teamed up with local NGO Ikhayalami to introduce an integrated approach to upgrading South Africa's growing informal settlements. The project is supported by the local architect firm Design Space Africa. By creating an interface between community, leading professionals and the state, the resulting Empower Shack project developed a pilot scheme that responds to the social, ecological and market dynamics of South African cities.

Targeting BT-Section Site C, a demarcated neighbourhood of 68 houses in Cape Town, this Swiss Re Foundation-supported project involved refining the housing prototype and reconfiguring the urban plan developed on the pilot.

Specifically, it:

- Developed new housing prototype designs, informed by current occupancy feedback, community engagement and on-site analysis of the first four pilot units.
- Developed and implemented a range of prototypes based on local construction techniques and materials, residents' spatial requirements and affordability.
- Developed a pilot legal framework with the City of Cape Town that allows for the approval of occupancy of the new units with clear pathways to formalisation and tenure security.
- Upgraded the houses in the BT-Section Site C within a new urban configuration based on participatory planning methodology.
- Designed and developed an income-generating urban agriculture scheme customised to the newly formed public spaces.

Empower Shack's overall objective was to offer a scalable methodology to reshape the informal settlement of South Africa by offering a methodology for the fair distribution of public space, a safer urban environment, improved service delivery and an urbanisation pattern that combines housing upgrades with new economic and social opportunities.

The 286 residents of BT-Section Site C benefitted directly from the project. Furthermore, employment opportunities were created through the facilitation and construction of the units, which included certified training programmes for the building industry and NGO sector. The Community Development Committees have benefitted from structured engagement

The Swiss Re Foundation has supported the Empower Shack project to develop a sustainable model for affordable housing.

on all levels of the project and should be able to exercise these skills in the further community urban management of the upgrade.

The results of this pilot have the potential to catalyse a productive new direction for South Africa's housing policy, potentially benefitting the millions of South Africans who presently live in informal settlements and are priced out of the formal housing market.

This integrated approach to planning follows principles of land re-adjustment by which a structured methodology for negotiation allows the interests of all stakeholders to be addressed. Customised digital planning tools have been developed to synthesise user inputs and preferences with micro-finance obligations and municipal planning frameworks. The building units are priced to meet meaningful financial contributions from recipients by designing generous but robust living space and service cores to meet building code obligations through fit-for-purpose bridge contracts. The long-term goals are to influence a new direction in housing policy and offer much-needed diversity and access to housing.

The resulting densification offers efficient land use to infrastructure ratio, provides cross-finance possibilities through additional rental and sales stock and, most importantly, fulfils the need to guarantee all residents the right to remain on site. Additionally, the re-adjusted building stock, new land plot sizes and allocation of public space are designed to integrate with municipal planning frameworks.

Understanding consequences of introgression of insecticidal transgenes from Bt maize into open-pollinating maize varieties

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Dr Angelika Hillbeck
North-West University
Prof Johnnie van den Berg

This grant enabled the researchers to start addressing the issue of safe and sustainable use of GM maize in Africa, since it directly addresses co-existence of Bt and non-Bt maize in Africa. The project has international significance in terms of its novel contribution to understanding the relationships regarding the effect of pollen flow between hybrid maize and open-pollinated varieties (OPVs).

The outcomes and findings of this project inspired the continuation of tracking transgene flow and its consequences for smallholder farmer communities, in particular those who aspire to capture premium prices and market access by following rules of organic production.

Genetically modified Bt-maize is widely used by commercial farmers in South Africa to control the African maize stem borer. While commercial farmers have to comply with stewardship guidelines for planting Bt-maize hybrids (i.e. adjacent refuge areas of non-Bt-maize) and are prohibited from saving maize seeds for further planting, these guidelines are impractical for small-scale farmers who mainly plant landraces, which are OPVs, and who recycle seed. Compliance with the stewardship guidelines is required to delay the evolution of pest resistance to Bt-maize.

Traditional small-scale maize farming could, unintentionally and unknowingly, become recipients of transgenes from Bt-maize fields. This "escape" and subsequent introgression of the cry1Ab transgene into local OPVs with unknown patterns of cry1Ab protein expression may, thus, facilitate the evolution of pest resistance.

The researchers elucidated the introgression of the cry1Ab transgene into OPVs and the functioning of the transgenes, and investigated the concentration of cry1Ab protein expressed and the effects thereof on the survival and development of the African maize stem borer. The collaborators did this under South African field conditions and under controlled conditions in climate chambers at ETH in Zurich. The researchers used the same varieties in the field trials in South Africa and in the climate chamber studies in Switzerland.

Professor Johnnie van den Berg (left) and Reynhardt Erasmus, a student on the project.

Bt and OPV maize grown in a greenhouse prior to making crosses.

Dr Angelika Hillbeck

Photograph courtesy of ETH Zurich

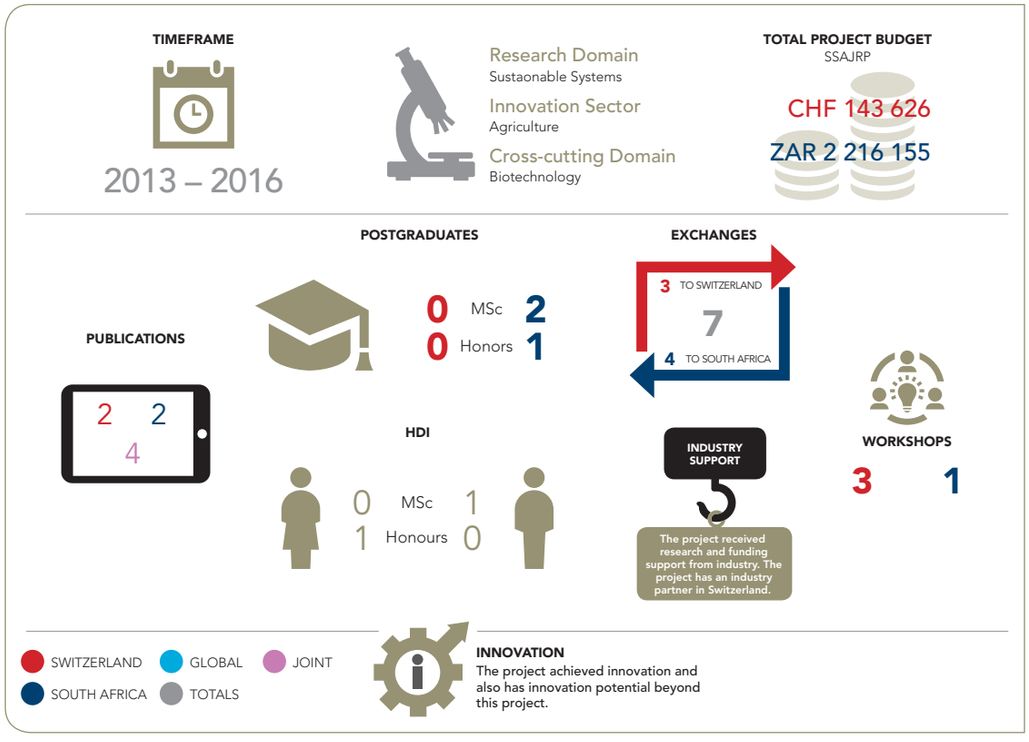
Larva of the African maize stem borer.

African maize stem borer larva damaging a young maize ear.

They determined the effect of pest damage (i.e. herbivore feeding) on cry1Ab protein expression in Bt-maize plants, and the concentration at typical stem borer feeding sites in Bt-maize plants including introgressed Bt OPVs.

The researchers showed that maize landraces and OPVs are vulnerable to foreign gene introgression. However, transgene expression did not systematically control Bt protein concentration and therefore transgene activity is no indicator for Bt concentration. Bt concentrations could be very low or nil, but were highest in outcrossed OPVs. Consequently, smallholder fields with outcrossed Bt OPVs will present themselves as highly diverse "landscapes" of maize plants with starkly fluctuating Bt concentrations and, thus, survival rates in susceptible pests.

A follow-up project was conducted with UCT researchers to study the seed selection behaviour of smallholder farmers more in depth. Linkages were established with small-scale farmers in South Africa, and collaboration linkages with the Agricultural University Uppsala in Sweden and the Centre for Gene Ecology in Norway. Follow-up funding was received from SDC to develop a larger trans-disciplinary project proposal involving smallholder farmers and researchers to allow farmer-led research with other enabling technology from ETH Zurich.



Impacts of land use patterns in South Africa (Ilupsa)

UNIVERSITY PARTNERS

Agroscope
Dr Stefan Mann
Stellenbosch University
Professor Nick Vink

From left: Siphe Zantsi, Kandas Cloete and Jan Greyling.

The research teams propose to adapt and expand the novel SWISSland approach to inform the best course of action to a country-specific, agent-based model of land reform in South Africa.

The importance of addressing the racially unequal agricultural land ownership patterns in post-transition South Africa is undisputed. However, more than 20 years after the first democratic elections, there is growing consensus that the land reform programme has failed to facilitate the intended transformation toward vibrant, equitable and sustainable rural communities. There is also consensus on a growing urgency for an expedited resolution of the "land question".

Stakeholders, while unified on the above, are not in agreement regarding the type of reform needed or the mechanisms through which these should be achieved. This has given rise to the implementation of poorly designed or unworkable programmes, and various unintended negative consequences. The apparent lack of success has also resulted in a plethora of proposals from various stakeholders, be it the state, individual farmers, organised agriculture or the academic community.

The development of a South African-specific, agent-based model could make an invaluable contribution. The proposed Integrated Land Use Plan for South Africa (ILUPSA) model would enable stakeholders to test the possible or probable outcomes of the various policies that are being

proposed in terms of their ability to transform the sector, benefit the rural poor and impact on aggregate production, employment, average farm size and land values.

The Socioeconomics research group in Tänikon has emerged as one of the leading centres for agent-based models. Its SWISSland model is the first agent-based model to make predictions about the farming sector of a whole country. It is not only regularly applied for ex-ante policy evaluations, but has also been used to explore several methodological innovations. These comprise, for example, sophisticated exchange modes for farmland and an evidence-based model validation through predictive analysis.

The Swiss experience has shown that a reliable model generates projections that enjoy a particularly high degree of credibility, providing a joint base for political discussions. Therefore, the expanded dataset on land reform, and the integration thereof with other statistical and spatial data sources, will provide the research community with an invaluable asset that will enable the testing of past and future hypotheses. More importantly, the development of the ILUPSA model will enable the quantification of the most probable outcomes of the various policy recommendations and proposed mechanisms. Such a perspective could help to direct the efforts and expenditure of several stakeholders toward the best-suited and most efficient mechanisms for realising the expedited creation of a vibrant and inclusive rural economy.

The ILUPSA model is a multiperiod agent-based model that allows for a ground-up approach to modelling complex systems such as land use patterns in South African agriculture. The eventual ILUPSA model will consist of about 2 000 sub-models that represent individual farms, both smallholder and commercial, which in turn are scaled to represent the entire sector. The physical attributes and farmer objectives of each of these farm sub-models are determined by survey and all of them are linked through codified behavioural rules. The model allows the researchers to test the long-term impact (> 5 years) of various land reform scenarios on land use patterns, as ownership patterns and farms size, by changing parameters such as the rate at which land becomes available for reform, the rate at which land is subdivided, or different government expenditure levels.

Collectively, these could bring about a new period of scientific discourse and enquiry on the subject, for which numerous academic publications and dissertations will see the light. It is expected that the decision-making process in the national government can be put on much more stable ground after the most relevant scenarios have been calculated, published and discussed.

The collaboration will result in a significant expansion in the domestic knowledge base through the training of PhDs and staff exchanges, especially since an already novel approach (SWISSland) will be adapted and expanded to inform the best course of action to a national imperative.

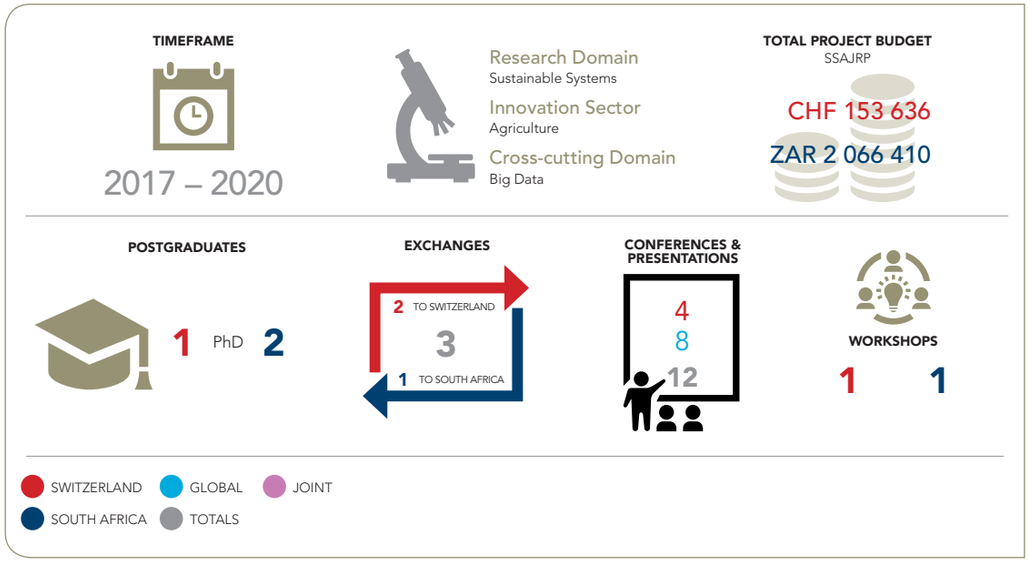
Considering that the ILUPSA model will be able to incorporate most land reform policy scenarios currently being discussed, it will serve as an invaluable resource for improved policy formation.

Photograph courtesy of Dr S Mann

Dr Stefan Mann

Photograph courtesy of Christian van Wechmar

Professor NIck Vink



South African cropland dust emission risks: physical thresholds, environmental and socioeconomic patterns

UNIVERSITY PARTNERS

University of Basel
Professor Nikolaus J Kuhn
University of Cape Town
Associate Professor Frank Eckardt

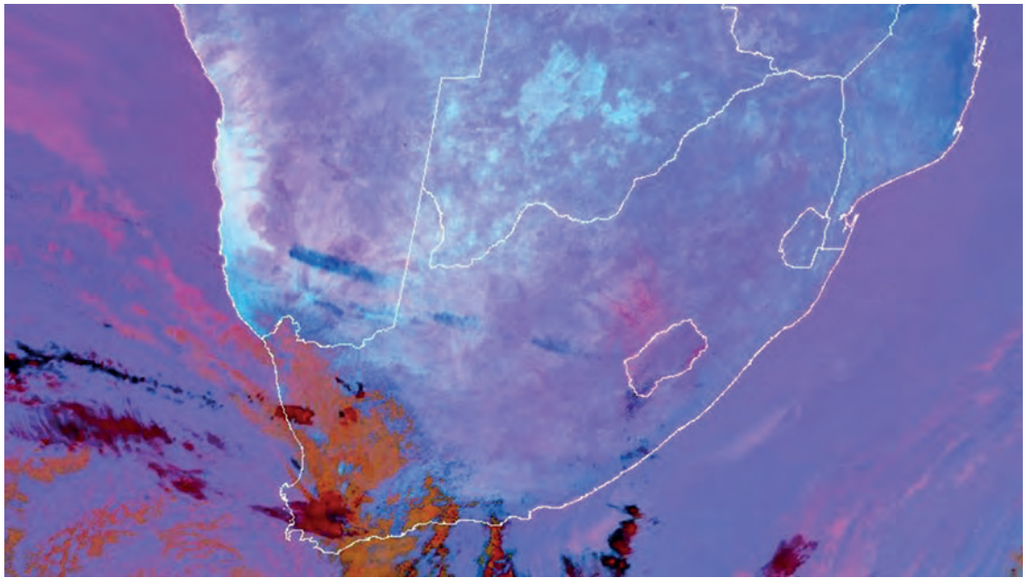
Dust emission is a growing issue affecting soil mass losses, ecosystem services, public health, and climate change. Understanding dust emission from farming in drylands is crucial not only to prepare and respond to the aforementioned impacts, but also to secure food production in the best possible conditions using marginal lands, a resource that is becoming increasingly scarce.

Southern African dust sources have been well documented, as they are among the world's dustiest regions, and disperse dust throughout the subcontinent and beyond. The west coast of South Africa produces dust from coastal pans, river valleys, and deltas in both the Namib and Northern Cape regions. Mine tailings in and around Johannesburg (Gauteng Province) are among the most studied dust sources in South Africa due to systematic monitoring efforts and immediate impact on urban air quality. However, few studies have drawn attention to dust originating from South Africa's extensive farmland. These areas appear to be most productive in early summer at the onset of the rainy season as part of cold pool outflows from convective storms over the Free State and Northern Cape.

Such ground level events have gone unmonitored due to their association with cloud and rain events. These associations are different from most other dust events that produce elongated plumes during the clear winter months, particularly in Namibia and Botswana, and disperse throughout the region. Nevertheless, the use of Meteosat MSG clearly suggests that southern African events are not infrequent and not insignificant in extent.

Exposed agricultural lands are thus important dust sources in South Africa, and the supply of fine dust material may be even more pronounced during drought cycles. Such events represent a loss of soil mass at the site of origin, but also impact ecosystem services further afield and, potentially, contribute to climate change. Microbial and chemical contaminants transported by dust from cropland add to the public health concerns when this dust originating from farms reaches urban areas.

The research questions of the proposed four-year project thus are: what are the environmental thresholds for generation of dust (wind, soil moisture, soil crust) in relation to farmland



Photograph courtesy of Imperial College London

False colour thermal Meteosat satellite image depicting purple dust plumes in the middle of South Africa. These plumes originating in the Free State are common in late winter and early summer imagery.

Photograph courtesy of Frank Eckardt

While spending time in the field the research team consisting of Nikolaus Kuhn from Basel, Anthony Palmer and Thantaswa Zondani from the Agricultural Research Council came across this road sign indicating that they are indeed getting close to the source of the dust in the Free State.

Heleen Vos from the University of Basel

Photograph courtesy of Frank Eckardt

University of Cape Town measuring atmospheric dust concentration and transport in a fallow field, a typical dust source for this region.

Wolfgang Fister from the University of Basel

Photograph courtesy of Frank Eckardt

Fence lines do not contain the mobile sand streaks which destroy surface crusts and crop stubble.This in turn promotes fine dust material essential to maintain moisture and nutrient content in agricultural soils.

management; and, to what extent do farmland dust sources impact ecosystem services, public health and, potentially, climate?

This research aims to fill this knowledge gap by using a holistic and interdisciplinary approach spanning geomorphology, land management, and microbiomics. A Swiss-South African partnership of four institutions (University of Basel, Agricultural Research Council, University of Cape Town, and University of Pretoria), which encompasses the necessary expertise, has been formed. They have divided activities and methods into four work packages. The results of these will be synthetised in a fifth one, leading to publication of holistic scientific contributions on South African cropland dust emissions, identification of farmland management best practices, and informing policy.

TIMEFRAME

2017 – 2020

Research Domain
Sustainable Systems

Innovation Sector
Social Impact Innovation

Cross-cutting Domain
Public health, Ecology, Climate change

TOTAL PROJECT BUDGET
SSAJRP

CHF 520 186

ZAR 6 996 497

POSTGRADUATES

2	MSc	2
1	PhD	1

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Sustainable honeybush plant-production - product nexus

UNIVERSITY PARTNERS

University of Applied Sciences Northwestern Switzerland
Professor Veronika Butterweck
Agricultural Research Council
Professor Elizabeth Joubert

Honeybush, an indigenous South African fynbos shrub endemic to the Eastern and Western Cape and commonly processed as a herbal tea, shows promise and opportunity for South Africa to capitalise on its biodiversity and capture niche markets. The tea is renowned for its rich flavour and high levels of antioxidants.

The participants in this study aim to enhance the sustainability of honeybush production in South Africa to reduce its vulnerability to risk. Sustainability focuses on both plant and product, addressing relevant aspects of sustainable production, consumption and value-addition in the form of a nutraceutical (having medicinal or health benefits) extract.

The collaborators anticipate that their research will provide improvements in the sustainability of honeybush (the common name for 23 species of *Cyclopia*) production and processing, which is urgently needed to reduce environmental impact and lessen dependence on scarce resources. Additionally, by demonstrating the herbal tea and nutraceutical potential of *C. pubescens*, the number of *Cyclopia* species suitable for cultivation and commercialisation could be increased, which will lower dependence of the honeybush industry on wild-harvesting. The dependence on wild-harvesting to meet demand results in significant stress on the *Cyclopia* species in the wild, to the point where extinction is possible.

Before commercial cultivation of under-exploited *Cyclopia* species, e.g. *C. pubescens*, assessment of their value-addition potential as herbal tea and nutraceutical is needed. *C. genistoides*, one of the major cultivated species, suitable for cultivation in sandy coastal areas, is prone to a bitter taste, limiting consumer acceptance. By identifying major bitter compounds, future selection of plant material for commercial propagation could be directed towards genotypes that have inherent low levels of these compounds, ensuring greater consumer acceptability as a herbal tea. The researchers will also revisit the energy-intensive, high-temperature oxidation processing step of conventional "fermented" honeybush tea with the aim to reduce energy use.

The team's investigation of the physiological responses and biochemical processes of honeybush

Plant Photograph courtesy of Agricultural Research Council

Cyclopia pubescens honeybush

Photograph courtesy of Prof Matthias Hamburger

Professor Veronika Butterweck

Photograph courtesy of Agricultural Research Council

Professor Elizabeth Joubert

Photograph courtesy of Prof Matthias Hamburger

Professors Joubert and Butterweck with their team.

Photograph courtesy of Agricultural Research Council

Joubert laboratory.

under drought stress as it relates to survival of the plants and ultimately also the quality of the final product, will provide much-needed information on the suitability of micro-climates and dryland cultivation for honeybush production.

Human well-being also comes into play as it is a main driver for honeybush production and consumption: it is rich in polyphenols well-known for their antioxidant and anti-inflammatory properties. The group will therefore investigate honeybush extract and isolated compounds, since they may represent a promising alternative to protect the gastrointestinal barrier against inflammation-induced side-effects, as well as their possible neuroprotective effects and prevention of brain ageing.

These experiments will not only enhance the scientific knowledge on the nutritional value of the honeybush, but will also enhance public health recommendations and, consequently, nutritional requirements.

The advantage of the proposed project is its multidisciplinary approach, combining agricultural, botanical, chemical, analytical, pharmacological, and biopharmaceutical knowledge. Therefore, it is of high scientific interest for each discipline itself but also for a broader scientific community.

TIMEFRAME

2017 – 2020

Research Domain
Sustainable Systems

Innovation Sector
Pharmaceutical

Cross-cutting Domain
Biotechnology

TOTAL PROJECT BUDGET
SSAJRP

CHF 537 188

ZAR 7 225 175

POSTGRADUATES

0	MSc	1
0	PhD	3

EXCHANGES

1 TO SWITZERLAND

2

1 TO SOUTH AFRICA

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

INNOVATION
The project has innovation potential and also beyond the lifespan of the project.

Applying life cycle assessment to mitigate environmental impacts of South African agri-food

UNIVERSITY PARTNERS

Zurich University of Applied Sciences
Professor Deborah Scharfy
University of Cape Town
Professor Harro von Blottnitz

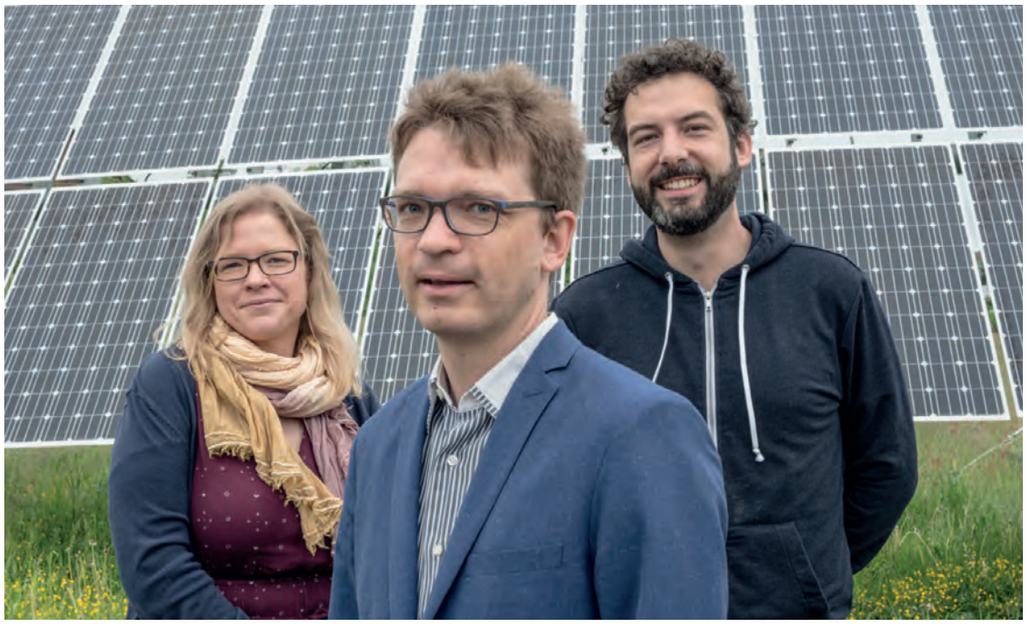
The project contributed to the important global question of how to reduce environmental impacts from food production, with a focus on South African food value chains.

Its goals were the identification of environmental hotspots in the life cycle of the most relevant agri-food products in South Africa; quantification of environmental mitigation potentials from applying green and clean technologies in the South African agri-food sector; development and dissemination of sustainable practice recommendations for public authorities and the agri-food industry; and the farm-stage and post-farm value chain for maize, dairy, beef, pork, pome fruit and soft citrus. They also gave some consideration to stone fruit, table grapes and animal feed. Life cycle datasets for South African agri-food products had to be developed, which they achieved through multiple student research projects to gather the data or model the systems in question.

The project team joined forces to ensure basic data collection for South African maize, dairy and fruit production, life cycle inventory generation, and subsequent environmental hotspot analyses. The main results generated were:

- Photovoltaic installations to generate electricity for irrigation in irrigated maize production would reduce the carbon footprint of such maize by 33%, making it comparable to the carbon footprint of dryland maize.
- Biogas production from feedlots and of slaughterhouse waste to generate electricity and heat could reduce the carbon footprint of beef by 10% and pork by 30%.
- Using feed additives as methane inhibitors potentially reduces the carbon footprint by 18% of raw milk from dairy cows.
- Renewable energy use, e.g. solar power, could effectively reduce the environmental impacts from South African fruits. They also quantified environmental benefits of other clean technology innovations, such as organic fertilisers, different forms of packaging and targeted pesticide application. Efficient water usage would have multiple environmental benefits in the fruit industry.

The project enabled data generation and modelling on a set of food production domains in



Researchers of the Life Cycle Assesment Research Group with agri-photovoltaics. From left: Karen Muir, Matthias Stucki and René Itten (all ZHAW).

The research team. From left: Dr Valentina Russo UCT, Lesley Sibanda UCT, Dr Philippa Notten UCT, Prof Deborah Scharfy ZHAW, Matthias Stucki ZHAW and Prof Harro von Blottnitz UCT.

Photograph courtesy of Prof Harr von Blottnitz

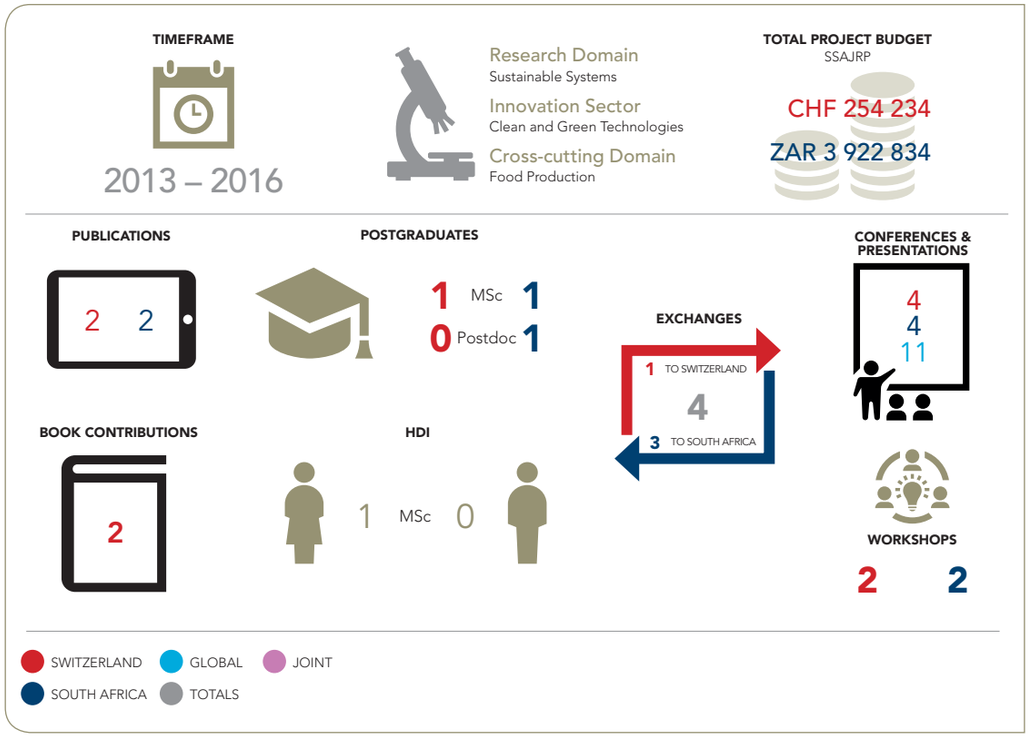
Fruit cultivation experiments.

Experimental greenhouses at the Zurich University of Applied Sciences campus in Wädenswil.

South Africa for life cycle assessments. This served to build significant capacity and opportunity and to discuss the value of such science-based, systems descriptions of food production with industry, societal actors and, to some extent, government.

The exchanges allowed Swiss researchers and students to understand the diversity and challenges of South African agriculture, and learn to view it as more than the carbon footprint of an apple or bunch of grapes in a Swiss university canteen. For the South African participants it served as a lens on how the science is practised and used, and facilitated interaction with global experts in life cycle analysis such as Prof Stefanie Hellweg and Dr Stefan Pfister.

Close interaction remained with the Swiss ecoinvent who has appointed UCT and the South African National Cleaner Production Centre to be the regional coordinators for a global life cycle data extension project funded by SECO. Close collaboration was established with WWF-SA and Woolworths as a retailer provided context for research and access to some farmers for project activities. Contributing to the outcomes of the project were the Confronting Climate Change in the fruit and wine industry project and Green-Cape with a focus on the green economy in the Western Cape.



Discovery of factors regulating carbohydrate storage in plants

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The South African and Swiss laboratories instigated the discovery of novel genes involved in starch metabolism in plants. This work revealed a previously unknown link to human genes coding for glycogen dephosphorylating proteins that perform their task during glycogen metabolism.

Groundbreaking research into the mechanism by which glycogen and starch phosphorylation occur in bacteria, plants and mammals will strengthen the previous discoveries in this exciting new research field. The greatest impacts will be in demonstrating the biological importance of phosphate in glycogen metabolism in humans and in successfully controlling starch levels in crops.

Most living organisms store carbohydrates to provide an energy source. In humans the principal storage carbohydrate is glycogen, which is generated after meals and used during exercise or fasting. This carbohydrate storage process is essential to manage blood glucose levels and thus for a healthy lifestyle. Diseases resulting from faulty glycogen storage or blood sugar regulation, such as diabetes, are serious and debilitating.

In plants, starch is the ubiquitous form of carbohydrate storage. It is equivalent to glycogen in animals, though unlike glycogen it is insoluble. The starch granules found in the seeds, roots and tubers of crop plants form the basis of nutrition for humans. Starch extracted from these and other plant types is used as an industrial raw material and as feedstock for biofuel production. Increasing the starch content in plants and modifying starch properties are thus important biotechnological goals.

The novel genes discovered by the researchers involved code for starch phosphorylating and/or dephosphorylating proteins and enable the breakdown of the starch and subsequent use of the glucose products for the plant's own growth. To decipher the importance of carbohydrate phosphorylation and dephosphorylation, they are employing *Arabidopsis thaliana* and *Escherichia coli* – plant and bacterium model organisms that

accumulate starch and glycogen, respectively. These model organisms were selected because it is possible to conduct complete studies of gene function. Results can then be related to the metabolic machinery possessed by humans and relevant starch crops, which are themselves much more difficult to study.

They have successfully established a functional screen for identifying carbohydrate kinases in *E.coli*, along with a method for virus-induced gene silencing (VIGS) in plants. The latter has enabled functional characterisation of tobacco plants lacking carbohydrate dephosphorylating enzymes and other proteins that participate in the same biochemical pathway. This approach complements the work done with gene knockout mutants of *Arabidopsis*.

During the next phase of the project the researchers studied the role of putative glycogen phosphorylating genes from *E. coli* and identified genes playing the analogous role in humans. This is an essential process. Defects in the glycogen phosphorylation system in humans result in the debilitating and terminal syndrome, Lafora disease. Identification of the genes involved in glycogen phosphorylation and dephosphorylation in different organisms will shed light on the fundamental importance of this metabolic step, helping to explain Lafora disease and other glycogen storage disorders.

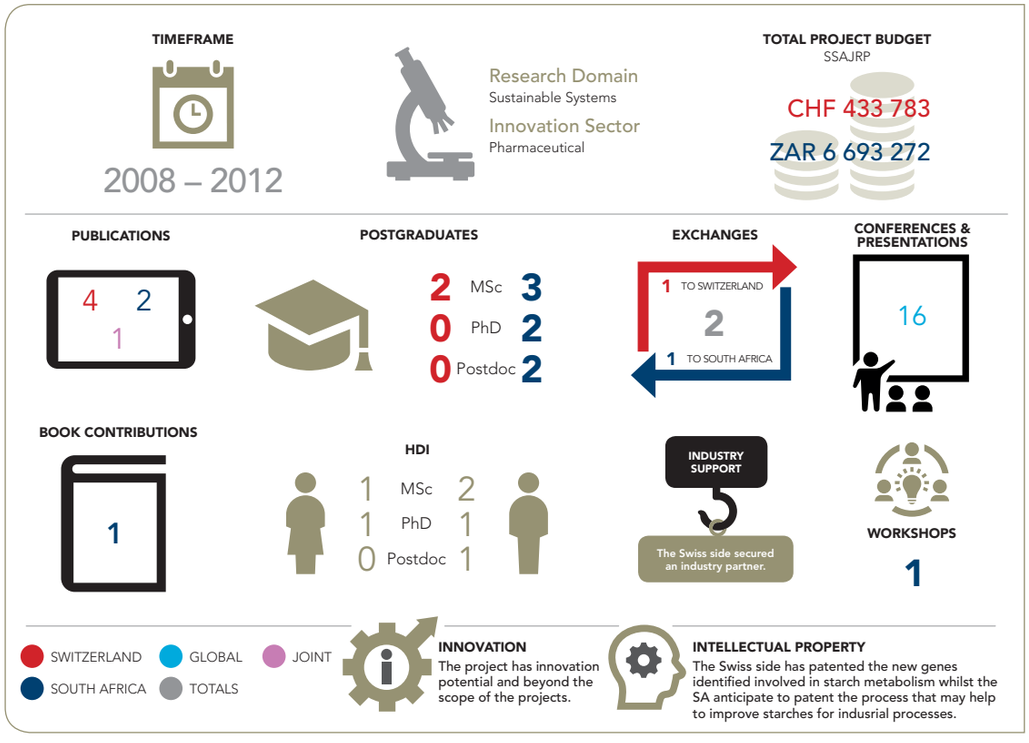
Work from the two laboratories has laid the foundation for complementary work to pursue a complete understanding of starch phosphorylation in plants. Its completion will explain at the molecular level the interdependencies between starch phosphorylation and its subsequent metabolism. Such a level of understanding will allow the rational control of starch levels and properties in plants. This is crucial to implement biotechnological improvements in starch crops.

A mechanistic understanding of the metabolism of glycogen will unlock the potential for biomedicines to treat energy metabolism diseases, the burden of which is increasing worldwide. It could also specifically aid in the development of a gene-therapy based treatment of Lafora disease. The interaction between world-class scientists and students facilitated by this joint research project will ultimately enrich the research environment of both countries and, in the longer term, could benefit the respective economies by taking research to the market.

The project also contributed significantly to capacity development in South Africa by promoting interaction between the research team members.

Photograph courtesy of ETH Zurich

Professor Samuel C Zeeman



Space in time: landscape narratives and land management changes in a southern African cross-border region

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Historical Namaqualand in the South African/ Namibian border region is experiencing a new chapter in a long and complex history of changing land use and resource management. The area, which includes parts of the Northern Cape Province in South Africa and the Karas Region in southern Namibia, is dissected by the perennial Orange River (Gariep), a vital water artery in an otherwise semi-arid landscape. The region has seen a number of different land use and resource management systems over the past 200 years.

Currently, large-scale agriculture and nature conservation projects dominate land use. These are contested by people who claim their own rights to land and land use, among them formerly disadvantaged and often very poor communities living in Namaqualand.

The region provides an ideal starting point for an analysis of different narratives around land use and management. Placing these narratives in a broader historical and socio-political perspective furthermore allows for a more balanced discussion of land use that aims to transcend some of the antagonisms between the various stakeholders at local, national and international levels.

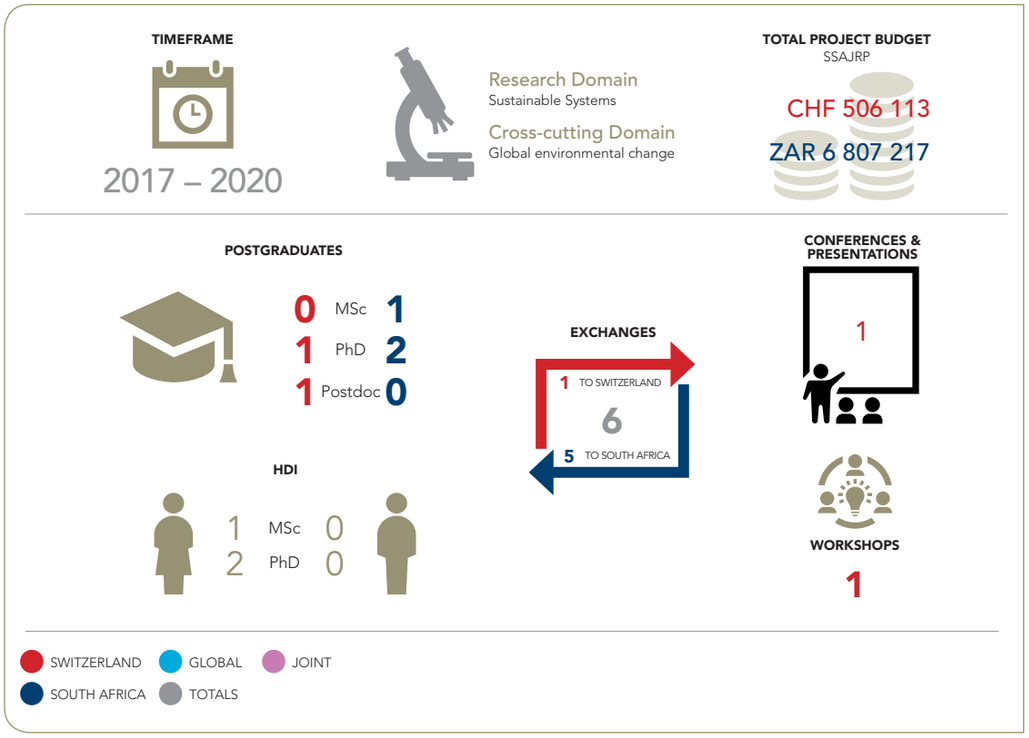
The researchers are aiming to develop a feasible, interdisciplinary methodology that merges different data produced by distinct research practices (history, geography, environmental science). They intend to, firstly, analyse the history of land use, land management and land claims and its changes. Then, how these changes inscribed themselves onto the landscape and how transformations of landscape reflected changes in land use. Pivotal are, for example, environmental changes, especially with regard to soils, vegetation and water resources. In order to account for these diverse short- and long-term transformations, and in an attempt to synthesise their analysis, the participating researchers will theorise so-called integrated "landscape narratives".

Central in this respect are interdisciplinary "landscape archives", a conceptual and practical tool that looks at evidence of landscape narratives and representations, the physical environment (soil profiles), archival documentation (written, visual and map material), oral recollections and local/ indigenous knowledge.

The collaborators propose that such an archive becomes an integrated research tool, for example as a (theorised) digital platform and database. The "landscape archive" could generate and supply scientific data gathered in close communication with selected local and regional stakeholders. They intend to design it as a tool applicable and accessible beyond the limitations of the research project itself and regard such a theorised "landscape archive" as a particularly innovative proposition and outcome of the overall research project.

Based on the findings of their research, they want to question and reassess current land and resource management regimes and challenge dominant "landscape narratives". Such a platform to different and differing claims (e.g. those of marginalised communities), can serve as a basis for future negotiations on sustainable and inclusive land use. This is of particular importance as recent initiatives, such as trans-frontier parks, generally justify their land use policies through references to the environmental and socio-political history of the cross-border landscape that are often rather based on imaginary than solid evidence.

Professor Maano Ramutsindela



Photograph courtesy of Wynand Uys on Unsplash