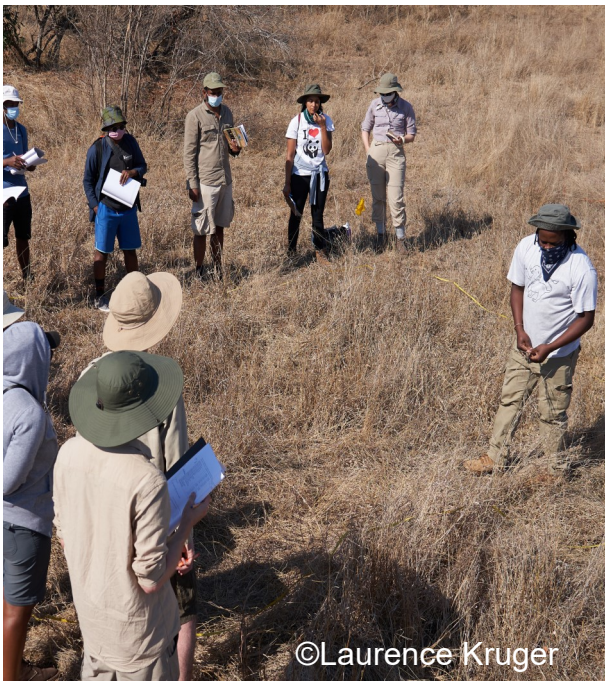

SPACES II

Science Partnerships for the Adaptation to Complex Earth System Processes in Southern Africa

Research Programme Newsletter

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Welcome to the 7th SPACES II Newsletter!

In this issue, we announce our joint final meeting, which will take place on the 14.-16.6.2022 in Pretoria. The agenda will consist of presentations of the SPACES II projects, a poster session, and a stakeholder event, as well as early-career researcher workshops. Both on-site and virtual participation will be possible. Our joint book 'Sustainability of Southern African ecosystems under global change: Science for management and policy interventions' will also be launched at the event (read more on page 2).

Within this 7th issue, you can also read about our first full field course in the training programme since the Covid outbreak: 'Field methods for plant ecology' was successfully run at the Kruger National Park in September (p. 4). The SALLnet project reports on their work in developing feasible and acceptable land-use scenarios and sustainable management options together with various stakeholder groups on p. 6-8. Furthermore, two of our brilliant DAAD doctoral researchers, Tasiyiwa Muumbe and Hilma Nghiyalwa, share the outcomes of their recent review publications on earth observation topics (p. 9-11).

Enjoy reading!

Mari Bieri, SPACES II Board, External Communications

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DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service

THÜNEN

EGU General Assembly 2022, Vienna, Austria, 3–8 April 2022 - on-site with virtual attendance option

The European Geosciences Union will organise its annual conference as an on-site meeting in 2022, after two virtual meeting years. Virtual attendance will be made possible in the new flexible meeting format. The deadline for abstract submission is 12 January 2022. Also note that the Travel Support application deadline (Early-Career researchers) closes on the **1st of December 2021**! Virtual registration fees are vaiwed for undergraduate and MSc students, as well as Scientists with a permanent affiliation in a lower-middle-income country (includes South Africa and Namibia). More information at https://www.egu22.eu/

EO college Land in Focus MOOC series: free online practical courses in remote sensing

The EO college, with many contributors from SPACES II, has released its first set of practical courses online.

Registration is open and free of cost for those who want to learn how to map land cover/use in urban spaces, hazards and disasters, or sustainability with local experts and work on real-life scenarios.

Visit https://eo-college.org/courses/

International Congress of Zoology, online, 22-24 November 2021

With the theme Zoology in the anthropocene—a holistic integrated approach to conservation, the International Congress of Zoology 2021 will be organised as a fully virtual event in 2021.

For registrations and further information, see https://icz2021.co.za/welcome/

ESA Living Planet Symposium, 23-27 May, Bonn, Germany

The European Space Agency's Living Planet Symposium is the largest Earth Observation conference worldwide. The event provides a forum for the latest research findings, and will also focus on the role of Earth Observations in building a sustainable, resilient society.

Deadline for abstracts is the **26th November 2021**.

More information and details at: https://lps22.esa.int/

Final meeting of the SPACES II projects & joint book launch 14.–16. June 2022, Future Africa Campus, UP

We are happy to announce that the final joint meeting of the SPACES II projects and stakeholders will take place as a physical meeting at the Future Africa Campus of the University of Pretoria. The core meeting days are 14.-16.6.2022.

The meeting will be hosted by Guy Midgley of the Stellenbosch University School for Climate Studies, together with Francois Engelbrecht, Director of the Wits University Global Change Institute and Barend Erasmus, Dean of the Faculty of Natural and Agricultural Sciences of the UP.

We have a limited number of funded positions available for each project and stakeholders. Hoping to attract a large number of stakeholders, also locally, we plan a targeted programme for the first full meeting day (15.6.). On the first meeting day, we will also organise a special event to launch the SPACES II book '*Sustainability of southern African ecosystems under global change: Science for management and policy interventions'*, which will be published open-access under the Springer premium series Ecological Studies. Lead Editor Graham von Maltitz will present this major joint milestone of SPACES II.

In addition to project partners and stakeholders, we will open registrations to a group of Southern African early-career researchers in the field of Global Change Science. Training workshops and lectures are planned for the 13th and 17th of June, and all SPACES II researchers are warmly invited to offer their topics and ideas for content.

We aim to stream all main meeting sessions online, to make full virtual participation possible to all SPACES II researchers and affiliates. Posters are invited to be presented both physically and on the web platform.

As with the Midterm Meeting, we are again looking forward to critical feedback and discussion from our SPACES II Expert Review Panel.

Registrations will be opened within the next few weeks for both, physical and virtual participants. The meeting information will again be updated on the site https://www.spaces-training.org/meetings/

If you have questions on the meeting planning and agenda, please contact mari.bieri@thuenen.de; for questions on registrations and bookings, contact ak-spaces@thuenen.de

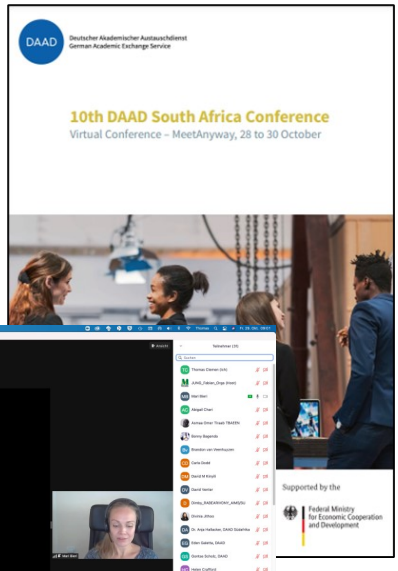
SPACES II at the DAAD South Africa networking conference

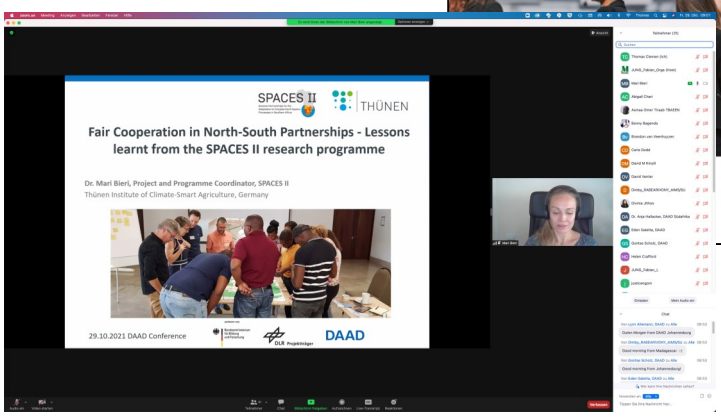
The German Academic Exchange Service (DAAD) Information Centre in Johannesburg organises an annual networking conference for Southern African scholarship holders. For the first time in 2021, this conference was organised fully virtually, under the theme 'International Research: basic foundations for fair cooperation'. The two-day event focussed on African-German scientific cooperation, with various workshops offering training on the topic of collaborations, research, publishing, and data management.

SPACES II was actively involved in this year's event. The keynote speech, held by Mari Bieri (EMSAfrica), offered a first glimpse of the results of our online survey of SPACES II researchers' perceptions on collaboration. The survey is part of a joint effort of South African-Namibian-German authors team, led by Robert Luetkemeier of ORYCS, and aims to offer concrete recommendations for the establishment of North -South research partnerships in the future. This work will be soon accessible under the title 'Lessons Learned from a North-South Science Partnership for Sustainable Development' in our SPACES II Springer open-access book on the sustainability of Southern African Ecosystems.

Jussi Baade (SALDi) provided a lecture and a workshop under the title 'Beyond Googling – More sophisticated ways to research the state of the art'. As the number of published papers is growing increasingly fast, the task of young researchers to 'sort the wheat from the chaff' and to produce comprehensive reviews on a topic is getting increasingly demanding. In this contribution general search strategies, different search engines as well as open access and restricted data bases were discussed. In the discussion it became clear that knowing how is one issue; the other issue concerning fair cooperation is equal access to data bases and publications.

In an interactive workshop 'Artificial intelligence meets sustainability', Thomas Clemen (EMSAfrica) provided a non-technical overview of the linkage between global/local challenges (UN SDGs) and artificial intelligence. It became apparent that artificial intelligence – beyond data-driven machine learning – will have a vital role in mitigating future challenges and risks.





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South African
SALDi
Land Degradation Monitor

EMSAfrica
Ecosystem Management Support for Climate Change in Southern Africa

Field methods in Plant Ecology—studying southern African savanna ecosystems in Skukuza, Kruger National Park

EMSAfrica
Ecosystem Management Support for Climate Change in Southern Africa

Laurence Kruger, Nsasani Trust and the Organisation for Tropical studies

The Bayreuth Field Methods in Plant Ecology course, focusing on southern African savanna ecosystems, was run for the fourth time in the Kruger National Park, South Africa, in 23.9.-3-10.2021. Funded under the SPACES II training programme, the course was led by Prof Steve Higgins and Amy Schroeder from Bayreuth University/EMSAfrica, with Immanuel Zwane and Laurence Kruger from the Nsasani Trust. The two-week course, based at the Skukuza Science Leadership Initiative in Skukuza (https://tropicalstudies.org/portfolio/skukuza-research-station/) the research headquarters in the KNP, provides students with training in the fundamentals of field methods for vegetation studies for students from both Bayreuth University and South African partner institutions (South African National Biodiversity Institute, South African National Parks and Universities). The course provides field based, experiential learning opportunities, training in scarce skills and an engagement with peers, academics, and field experts.

Funding for experiential field-based education has dwindled over the last decade, which has been exacerbated by these Covid-19 affected times. For the Bayreuth students, the course offers field experience in novel ecosystems and much needed access to the field for the South African contingent. Through daily fieldtrips, the students explored a broad variety of habitats and long-term ecological experiments, coming to understand the influence of soil nutrients, rainfall, fire, and herbivores on the dynamics of savannas.

Introductory lectures into the ecology of savannas. Photo: Laurence Kruger

For many participants, this course is the first opportunity to learn practical, field-skills to scaffold their theoretical education on campus. Given the importance of understanding the dynamics in Open Ecosystems (disturbance driven) such as savannas, students acquire valuable skills in engaging in vegetation ecology:- including determinants of plant distribution, community ecology, fire and herbivore ecology and functional ecology of savanna plants. In the unique teaching spaces, without the distraction of computers and complicated data analyses, students learn about the fundamentals of vegetation ecology from first principles and how to apply these to real world conservation challenges. Students also share the responsibilities of teaching. Each group takes responsibility of the teaching of a theme and, under the guidance of the lecturers, runs the module for a day. Each day is capped with a brief analysis and presentation of the data.

One of the most important aspects of the programme is the interaction and exchange within the students group and between the students and academics/scientists. Given the difference in educational context, culture and experience, the students learn a great deal from each other. We divide the students into mixed groups for all the fieldwork, ensuring that a great deal of cultural exchange happens during the course. This results in a broadening of perspective, exchange in aspirations and a development of a peer network. In addition, the students work closely with local experts providing a richer academic experience, as well as establishing the potential for future collaborations for continued studies or research.

If enjoyment, breadth of experience and quality of engagement are good measures, the course was a huge success. Although we were working in Covid-restricted circumstances, the local measures are strict, and the course was completed with no challenges. We are deeply grateful for the funding that enabled 16 students to have an unforgettable experience in the Kruger Park.

Top left: Selina measuring thorn length as a measure of plant defenses against herbivory. Bottom left: Snethemba assessing leaf traits in the field. Right: Thapelo assessing grass biomass using a Disk Pasture Meter. Key to understanding the influence of fires in savannas is assessing fire intensity which is dependent on grass biomass. Photos: Laurence Kruger

Interaction with stakeholders at the SALLnet Annual Meeting

SALLnet is an interdisciplinary research project exploring how the resilience of the multi-functional landscapes in southern Africa can be enhanced under climate change. Among its main objectives, the project aims to provide integrative tools and modelling platforms to develop land-use scenarios (with a special focus on arable crops, rangelands and tree orchards) and management options to enhance the ecosystems' resilience.

The key to developing feasible and acceptable land-use scenarios and sustainable management options is that stakeholders are involved in the research process. In particular, the tools and findings so far developed in this project need to be evaluated by potential users, if we are to provide meaningful information to formulate sustainable land management strategies and support policy design.

Therefore, as part of our 3rd Annual Meeting on 23 September 2021, we organized a Stakeholder Day to present our work to the relevant stakeholders, engage with them and ask for their feedback. This was done in a "hybrid" format: most of the participants joined online on ZOOM but a number of them physically gathered in two locations (Maruleng and Levubu) in Limpopo. This allowed the participation of a very heterogenous group of stakeholders, ranging from the political sphere to academics and researchers, members of national and international organizations, extension officers and farmers (Figure 1).

Following short presentations by SALLnet researchers, a plenary discussion with the possibility for all stakeholders to ask questions and give feedback on the project results was held. On the basis of this discussion, parallel breakout group sessions were organized, where project members and stakeholders could meet in smaller formations for more in-depth discussions on specific topics related to the previous presentations. Finally, everybody gathered again for a synthesis and conclusion of the event.

Figure 1: *SALLnet project members and stakeholders jointly discussing on ZOOM*

Below we provide an overview on the discussion topics of the Stakeholder Day.

The topic of the first discussion group was the seasonal, climate-induced shortages in the supply of quality forage in semi-arid areas such as Limpopo. This heavily affects livestock production in the region, especially in the case of small farmers relying on communal rangelands. Farmers do receive support in feed aids, but the timing and quantity of such support is usually unsatisfactory and does not meet livestock demand. Results from SALLnet researchers indicate that winter forage such as rye, rapeseed, clover and vetch (particularly when planted early and irrigated) look like a promising strategy to respond to such livestock feed gaps. Nevertheless, limited land and water availability are often major constraints to forage production. Other possible solutions mentioned during the discussion included the provision of improved storage techniques for feed/forage and improved pasture management (e.g. rotations, selection of drought tolerant grass species).

In the second discussion group, results from a long-term experiment (DroughtAct) on the combined effects of droughts and grazing on savanna ecosystems were presented (Figure 2). These show that the impact of drought becomes particularly severe after three or more consecutive years, with valuable perennial forage grasses permanently disappearing. Grazing, although initially beneficial, amplifies the impact of prolonged drought. The implications of these results were also discussed, especially in terms of grazing management, which has to be adapted to the intensity and duration of drought. A reduction of herd sizes in times of drought usually does not take place, due to farmers' unwillingness to sell at low prices. Thus, an increase in the grazing pressure is often observed in these periods and the (although generally insufficient) feed supply provided by the Government has the side effect of maintaining such pressure high even after the end of the drought period. However, the post-drought carrying capacity of rangelands is low and the system needs time to regenerate. Options discussed to counteract these problems include, among others, the creation of a "drought insurance" to offer farmers financial compensation in times of resource scarcity, an extension of the Government feed supply also during the initial stages of rangeland recovery, and the implementation of stricter common rules for the management of communal rangelands, as a result of a participatory collaboration with cattle farmers, traditional authorities and extension services.

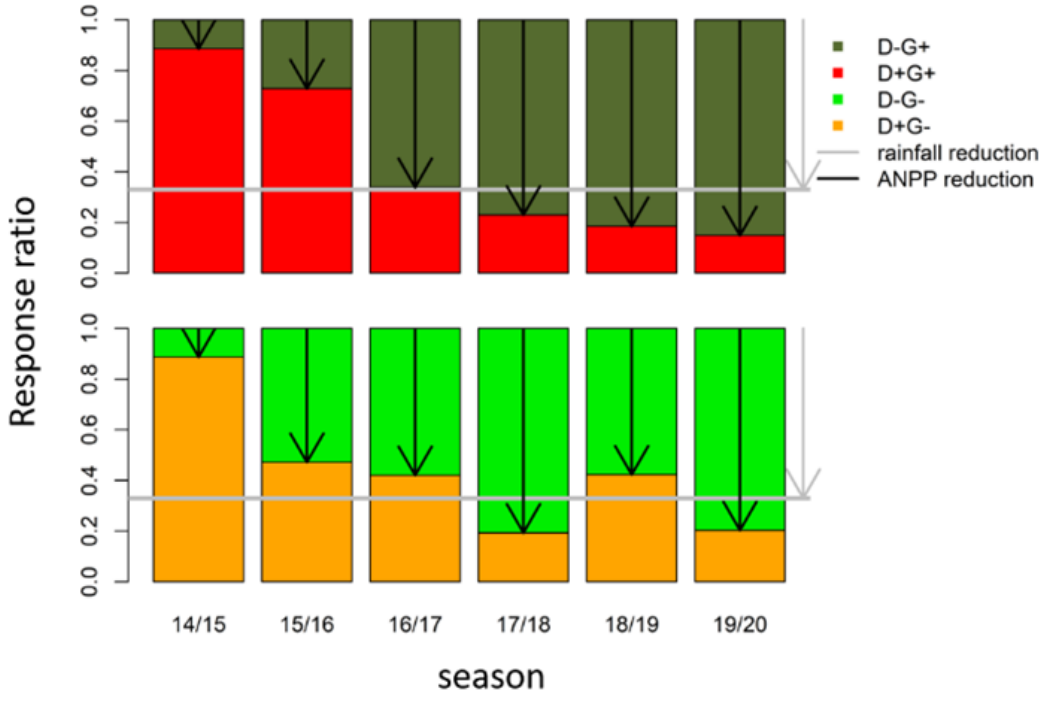


Figure 2: *Response ratio of drought (D+) compared to ambient rainfall (D-) under grazed (above) and rested (below) conditions. The black arrow indicates the relative reduction of aboveground net primary production (ANPP), while the grey line indicates the relative rainfall in the D+ plots.*

Moving from rangelands to tree orchards, the third group discussed the importance of insect pollination for macadamia production and the role of semi-natural habitats for hosting pollinators. SALLnet researchers illustrated the results of pollination experiments conducted in macadamia orchards located along a landscape heterogeneity gradient in Limpopo. They observed a decrease of 75% in the initial and 90% in the final nut set of trees where insect pollination was excluded. Nevertheless, pollination may still be substantially improved to further close yield gaps. The observed pollinators were mainly honeybees (95%) and small wild bees. Particularly the latter are known to form colonies in the semi-natural habitats adjacent to the macadamia orchards. As a result, the flower visitation rates of honeybees and other pollinators increase with the cover of semi-natural habitat in the surrounding landscape (Figure 3). These habitats function as food resource during the seasons when macadamia is not flowering, as well as a refuge from pesticide applications. Therefore, it is key for macadamia growers to maintain a high biodiversity in their orchards, including the preservation of functional vegetation and weeds in and in close proximity to them.

Finally, the fourth group focused on suitable options to link crop simulation modelling with agro-hydrological models. Results from the long-term simulation (using the agro-hydrological SWAT model) of rainfed and irrigated maize yields in the semi-arid Olifant River Basin and their effect on groundwater depletion at catchment scale were presented (Figure 4) and used as a basis for discussing the long-term sustainability of groundwater use for irrigation in Limpopo. In particular, crop water requirements in the region are expected to increase in the near future, thus making supplementary irrigation an option to be considered. Groundwater is mostly available for local smallholder farmers from boreholes, but currently there is not enough information on the water table recharge to support decisions leading to a sustainable irrigation water usage. Finally, modelling studies at regional and catchment level were judged as important and informative, but to address specific hydrological issues, a greater focus on local situations and detailed analyses is also needed.

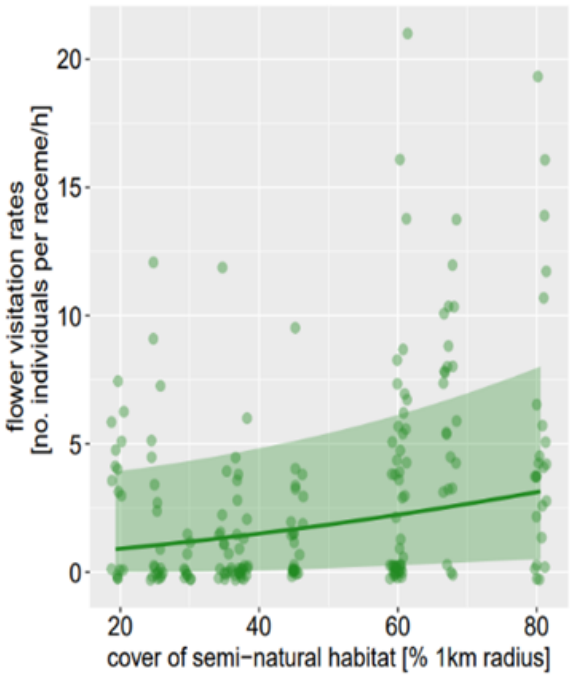
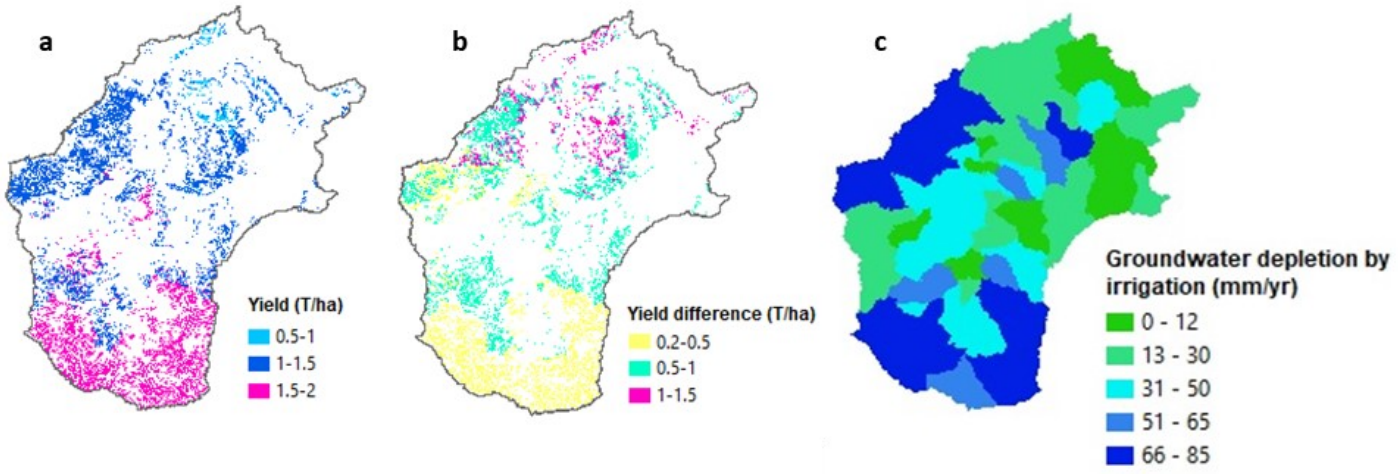


Figure 3: *Macadamia flower visitation rates by pollinators increase with higher cover of semi-natural habitats in the surrounding landscape .*

Figure 4: *Simulated average annual maize yields distribution for (a) rainfed cultivation and (b) yield difference between the rainfed and deficit irrigation; (c) simulated groundwater depletion due to irrigation*



Savanna Vegetation Analyses using Terrestrial Laser Scanning – A Review

Tasiyiwa Priscilla Muumbe, Department for Earth Observation, Friedrich Schiller University Jena

EMSAfrica
Ecosystem Management Support for Climate Change in Southern Africa

EMSAfrica's subproject on *Remote Sensing based ecosystem monitoring* aims to develop novel approaches and improve techniques for the monitoring of savanna ecosystems. A recent outcome of the activities was a publication by Muumbe et al. (2021), which established the current state of art in the application of Terrestrial Laser Scanning (TLS) for vegetation analyses in the savanna. This was achieved by conducting a comprehensive literature review. The review identified the need for the application of high resolution three-dimensional remote sensing data for the accurate extraction of savanna vegetation parameters for accurate estimation of above ground biomass (AGB).

The literature review was done using 18 attributes from 113 relevant research articles. The global distribution of TLS studies, vegetation parameters retrieved, retrieval methods and overall accuracy in parameter extraction was assessed. The results revealed that TLS has mainly been used to characterize vegetation in the temperate, boreal and tropical biomes, with research lacking in the savanna. The few studies from the savanna did not consider the shrub contribution to the overall AGB estimation and extracted only a few vegetation parameters.

Future research in the savanna should improve AGB estimation by accounting for both tree and shrub layers through the application of 3D reconstructions methods, adjust and develop new algorithms for savanna vegetation extraction and account for seasonality changes by the application of multi-temporal TLS. Furthermore, TLS presents an opportunity for mapping the savanna at large spatial scales through the use of TLS as a calibration and validation tool for satellite products.

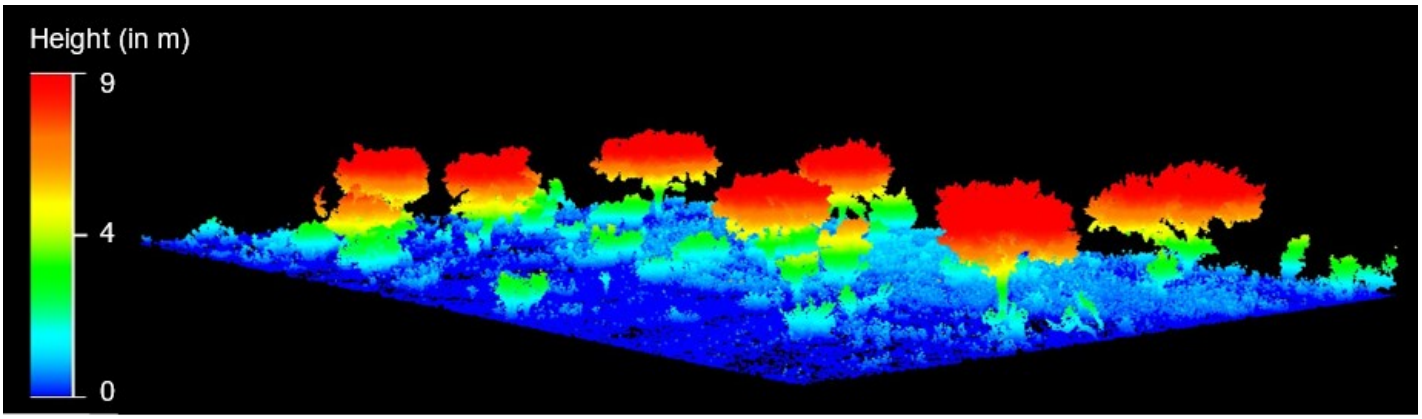


Figure: *3D point cloud of a typical savanna landscape derived from a multi-scan TLS. The point cloud was captured near the Skukuza Flux Tower in Kruger National Park, South Africa, using a Riegl VZ 1000. The colour represents height in metres above ground. Data Source: Jussi Baade (2015).*

Muumbe, T.P.; Baade, J.; Singh, J.; Schmullius, C.; Thau, C. Terrestrial Laser Scanning for Vegetation Analyses with a Special Focus on Savannas. *Remote Sens.* **2021**, *13*, 507. https://doi.org/10.3390/rs13030507

About the Author: Tasiyiwa Priscilla Muumbe is a DAAD Doctoral Researcher under EMSAfrica, Sub-project on Remote sensing-based ecosystem monitoring. She is based at the Friedrich-Schiller- University Jena, Earth Observation Department. Her research focuses on the application of Terrestrial Laser Scanning (TLS) for vegetation analyses in savanna ecosystems.

Spatio-temporal mixed pixel analysis of the Savanna Ecosystems: A Review

Hilma S. Nghiyalwa, Department for Earth Observation, Friedrich Schiller University Jena

The main objective of the SALDi subproject on *radar and optical remote sensing* is to develop high-resolution spatio-temporal methods to analyse ecosystem changes and dynamics of the savanna ecosystems in South Africa. A review publication on the spatio-temporal mixed pixel analysis of the savanna ecosystems is one of the recent outcomes of SALDi remote sensing sub-project activities (Nghiyalwa et al. 2021). The savanna is a complex heterogenous ecosystem which is influenced by key local and global drivers, and therefore difficult to monitor. The use of remote sensing therefore enables the estimation of savanna ecosystem components which are essential to quantifying environmental change. A comprehensive literature review process was conducted to establish the spatio-temporal mixed pixel analysis current state of the art.

The review process was conducted by entering a set of key words in the Web of Science. A total of 197 peer reviewed articles were retained, and a total of 16 parameters were extracted and further analysed. These parameters include e.g. the year of publication, journal name, geographic location of the study area, spatial extent of the study area, type of remote sensing data used (i.e., sensor mission name, sensor platform type, spatial resolution, temporal resolution), method of estimation, type of biophysical parameters estimated, characteristics of the input data, remote sensing data used for validation, and the overall accuracy of the remote sensing data used for mixed pixel analysis in savanna ecosystems.

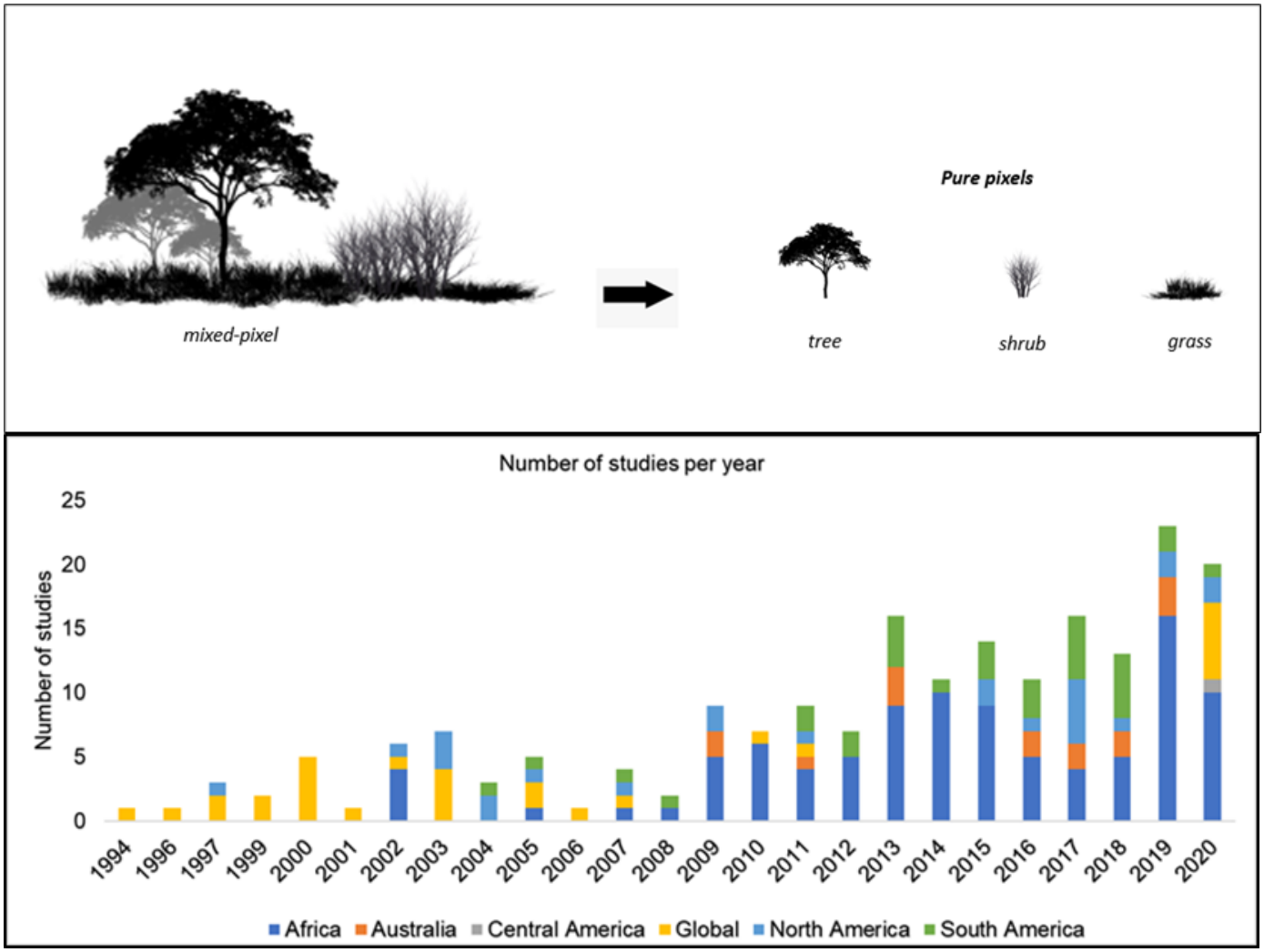


Figure 1 *Above: A typical mixed pixel within the savanna, further expanded to illustrate the ideal separation with distinction between typical covers within the earth observation mixed pixel. Below: Number of studies included in the review and their geographic focus.*

The review found that spatio-temporal mixed pixel analysis studies were mainly conducted in Africa and South American savannas. Furthermore, there is a gap for spatio-temporal mixed pixel analysis studies at global and continental scales. The most used remote sensing data are medium and low spatial resolution optical data. The review therefore identified the need for application of high spatial resolution optical and radar remote sensing data for spatio-temporal mixed pixel analysis.

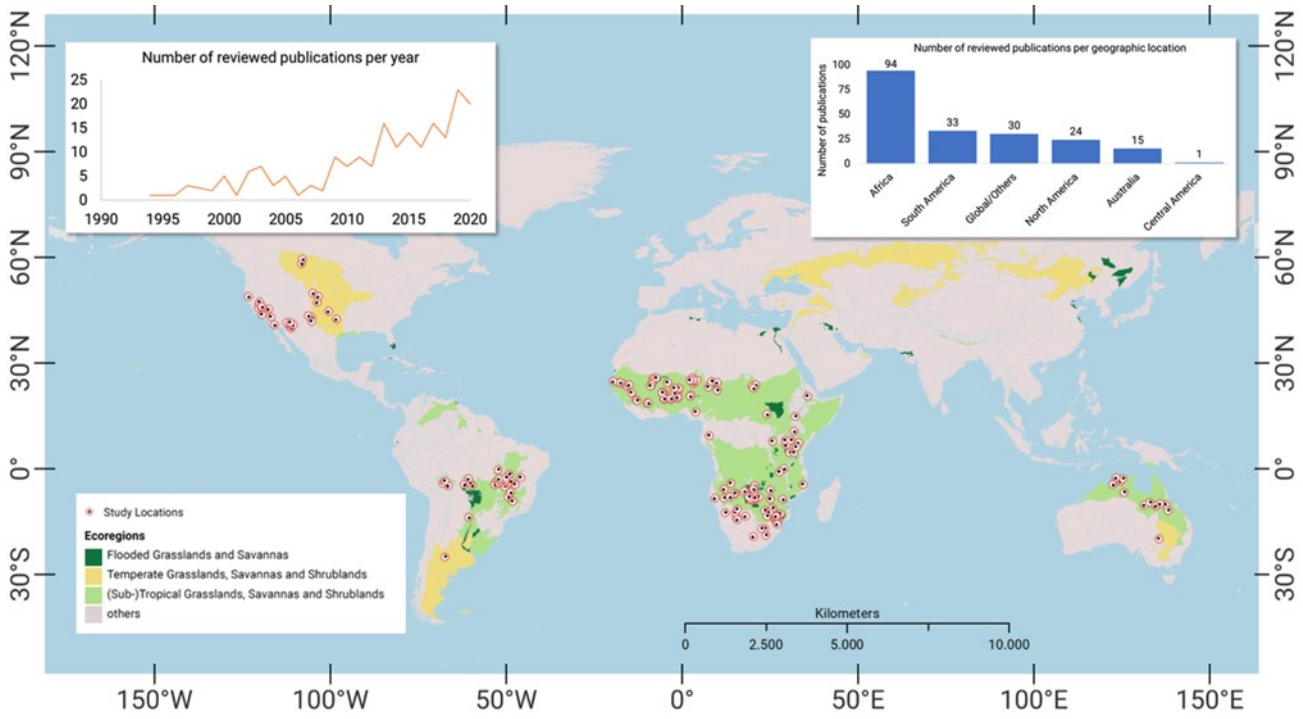


Figure 2 *Global distribution of savanna biomes, study sites, and number of studies per geographic area (Terrestrial ecoregions of the world map is modified from Hengl et al., 2018).*

The recommendations for future research are to i) use a combination of ready to analyse high spatial and temporal resolution optical and radar remote sensing data on cloud platforms and ii) apply a combination of parametric and non-parametric methods to produce more accurate spatio- temporal mixed pixel data for savanna ecosystems. Big data and open source tools present an opportunity for monitoring the spatio-temporal mixed pixel analysis over complex savanna ecosystems at global and continental scales.

Nghiyalwa, H.S.; Urban, M.; Baade, J.; Smit, I.P.J.; Ramoelo, A.; Mogonong, B.; Schmullius, C. Spatio-Temporal Mixed Pixel Analysis of Savanna Ecosystems: A Review. Remote Sens. 2021, 13, 3870. https://doi.org/10.3390/rs13193870

About the Author: Hilma S Nghiyalwa is a DAAD Doctoral Student under the South African Land Degradation Monitor (SALDi), and is currently on staff development leave with the support of University of Namibia. She is currently based at the Friedrich-Schiller-University Jena, Earth Observation Department, where her research focuses on the analysis of spatio-temporal mixed pixel in savanna ecosystems.