

Project SASSCAL: Southern African Science Service Centre for Climate Change and Adaptive Land Management

SASSCAL ABC

Final Report 2018-2022

Part I: Brief Outline

Topic: Support for SASSCAL Science Services

Module A: WeatherNet

Module B: ObservationNet

**Module C: Support for organisational strengthening of
SASSCAL**

University of Hamburg

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Part I: Brief outline

Module A: WeatherNet

SASSCAL Regional Secretariat and University of Hamburg

Project term: 01.12.2018 – 31.08.2021

Reporting period: 01.12.2018 – 31.08.2021

1 Terms of reference

Reference is made to the SASSCAL Module A proposal for the transfer of the WeatherNet online platform and knowledge transfer from the University of Hamburg (UHH) to the SASSCAL Regional Secretariat (RS), under which a contract between UHH and SASSCAL was signed in 2019.

The SASSCAL WeatherNet was established to augment the existing national weather networks in the SASSCAL countries of Southern Africa and to make available an open online weather data resource for research and decision-making processes. A network of 164 fully Automatic Weather Stations (AWS), funded and installed through BMBF funding of SASSCAL projects or contributed by other funding sources, provides weather data at hourly intervals - provided the AWSs are technically functioning. The online platform SASSCAL WeatherNet, freely accessible at <http://sasscalweathernet.org>, has been developed and serves as the main publishing platform for the quality-controlled data recorded by the stations.

In order to ensure that the WeatherNet online platform and various supporting tools and routines (hereinafter referred to as the "WeatherNet system"), which were running on servers and workstations in Germany after several years of technical development by the SASSCAL-UHH-IT team, are transferred into African ownership, all responsibilities related to the operation of the WeatherNet system and the corresponding services were to be permanently transferred to SASSCAL and integrated into the SASSCAL Open Access Data Centre (OADC) at the SASSCAL-RS in Windhoek.

The work of the UHH IT team followed on from the work and services provided as part of the SASSCAL coordination project (FKZ 01LG1201A). To ensure this for SASSCAL Module A, the UHH team provided the necessary technical developments and services for the OADC.

2 Planning for, and course taken by, the project

For the successful transfer and operation of the WeatherNet system at the SASSCAL RS, the following preconditions needed to be met:

- Appointment and training of a WeatherNet IT team at SASSCAL
- Establishment of the operating environment at SASSCAL OADC
- Transfer of system to SASSCAL operated servers

The planned transfer project of two years aimed at ensuring that the necessary know-how and infrastructure were developed at the SASSCAL Regional Secretariat, resulting in a full transfer of responsibility from the UHH team to the SASSCAL Regional Secretariat in Windhoek, Namibia.

The work plan was split into years 1 and 2. The focus for year 1 was the knowledge and system transfer from UHH to SASSCAL OADC, while year 2 was mainly for operationalizing and improving the system by SASSCAL OADC.

As per plan in year 1, the recruitment of the WeatherNet team at SASSCAL although delayed was completed in the first half of 2019. Two full-time IT Experts, i.e. a data management officer (1 April 2019) and a programming/development officer (1 June 2019), were appointed. With the appointment of an OADC coordinator around the same time, the WeatherNet staffing plan for the SASSCAL Regional Secretariat was completed.

The appointed SASSCAL WeatherNet IT team underwent a training spanning 5 weeks at UHH on data processing, online publication, and the general architecture, design, operation, and maintenance of the system. A training plan was developed by the UHH IT team to guide the training process and ensure that all identified knowledge transfer areas were covered by the end of the training period.

A supplementary training was conducted at SASSCAL OADC through a visit by two of the colleagues from the UHH team between 15 and 24 October 2019.

Between July and August 2019, the required environment at SASSCAL OADC was procured and prepared for deployment of the system. Prerequisite libraries and server administration tools were installed.

Adaptation of the application source files to fit the operating environment at SASSCAL and the deployment involving the restoration of a database backup and configuration of the system scripts occurred during September 2019. A replica of the file server was set up at SASSCAL OADC for housing the raw data collected at the stations and a replication mechanism was developed to synchronize with the file server at UHH regularly.

By October 2019, the WeatherNet system instance at SASSCAL was up and running. For the following months, this instance was run in parallel to the production instance still hosted at UHH and subjected to rigorous testing, verification, and adjustments until it was certified fully functional.

In December 2019, after verifying that the system was running optimally at SASSCAL OADC, the domain <http://sasscalweathernet.org> was technically transferred to SASSCAL RS to point to this system. This now became the publicly accessible version of the system.

In accordance to the plan for year 2, the responsibility for operation of the system now running from SASSCAL OADC became primarily the responsibility of the WeatherNet team at SASSCAL, with extensive support of the UHH IT team. Daily operational activities including server and supporting tools monitoring, station checks, manual data download/upload, data correction and repair, as well as engagement with authorities responsible for the stations were carried out to ensure service availability.

In line with milestones lined up for the year, activities for the transfer of the FTP server began in January 2020. The various versions of the logger program running on GPRS transmission stations were cleaned up and updated so that the file server to which the station sends the recordings was changed from the UHH FTP server to the SASSCAL FTP server.

In the following months and with the support of the partner institutions in the SASSCAL countries, the logger programs were updated in the stations. The COVID-19 pandemic which also spread to Southern African countries at the beginning of 2020 severely affected the process of the FTP transfer, due to lockdowns, home office works, and limited availability of required personnel at partner institutions.

In parallel to the transfer process of the FTP server, other activities by the UHH team and the OADC team for the improvement of the system were carried out.

- The Gobabeb fog data was successfully added to the system in April 2020.
- Several tests for the supporting tools BotDat, GobDat, and SatDat were initiated. In June 2020, the tools BotDat and GobDat were successfully transferred to operate from SASSCAL and switched off at UHH. Several issues were encountered in attempts to transfer SatDat, e.g. unstable internet connection at SASSCAL RS or abnormal behavior arising during data download, and the tool was therefore left for further troubleshooting before transfer
- A first version of the Map View for the stations was developed in August 2020 and shared for input and feedback. Exploratory work was commenced around the user guide, automated data access mechanism, and a redesigned version of the system.

In October 2020, when it became clear that a number of milestones were still outstanding before the original project end date in November 2020, a cost-neutral extension of nine months until 31 August 2021 was applied for and approved for Module A OADC by UHH. Even though two technical IT staff members were no longer available in the UHH team from September and November 2020 respectively, the former scientific manager of the UHH team continued to support the OADC team.

The project course continued in accordance with the revised plan. Particular focus was directed at resolving the FTP transfer issues and concluding work on initiated enhancement features.

The legal transfer of the domain <http://sasscalweathernet.org> from UHH to SASSCAL RS took place in the form of a MoU in October 2020.

Between January and March 2021, as part of SASSCAL's infrastructure improvements, dedicated servers were procured for each or a set of closely related services to prevent single point of failure for all services. The WeatherNet was assigned a new dedicated server hosted in the cloud. The WeatherNet team prepared the server by installing all necessary requisite libraries and services before copying over databases, source code, and data files for configuration. Testing of the instance on this new server was conducted and the system was successfully transferred.

Following the implementation of an alternative data download mechanism, the supporting tool SatDat which had been developed by the UHH team was successfully transferred in May 2021.

By June 2021, the FTP server change was finally concluded for all stations and the FTP server at UHH was switched off. With this, all technical transfer activities and milestones were completed.

Between June and August 2021, the OADC team focused on the implementation of identified improvements in the areas of user interface redesign, data representation, data processing, data access, as well as the development of a user guide.

By the end of the project, all technical milestones had been met.

3 Essential results and cooperation with other institutions

The WeatherNet consists of a network of Automatic Weather Stations that record variables such as rainfall, air temperature, solar radiation, pressure, relative humidity, wind speed/direction, soil temperature, ground temperature and leaf wetness in accordance with global standards defined by WMO. An online platform consisting of a raw data store, processing tools, and a publicly accessible website publish the data collected at the stations in tabular and graphical representation and allows users access to data download. The online platform follows best practices from the fields of software engineering and makes use of open-source technologies such as PHP, MySQL, C++, Ubuntu.

As part of the uptake of the operations of the WeatherNet, SASSCAL cooperated with various partner institutions in Southern Africa responsible for the stations in the SASSCAL countries, namely Instituto Superior Politécnico Da Tundavala (ISPT) in Angola; Ministry of Agriculture, Water and Land Reform (MAWLR), Ministry of Fisheries, Ministry of Environment and Tourism, and the Namibia Meteorological Service in Namibia; Department of Meteorological Services (DMS) in Botswana; Zambia Meteorological Department (ZMD) in Zambia; and Stellenbosch University in South Africa. Other technical cooperation partners include the suppliers of the observation technologies in the field as Central Technical Supplies (Namibia), Mike Cotton Systems (South Africa), and Adcon/Ott (Germany/Austria).

Module B: ObservationNet

General terms of reference Module B

Module B of the SASSCAL ObservationNet project addressed SASSCAL's two main concerns, climate change with its impacts on biodiversity and ecosystems, and adaptive land management. The ObservationNet forms an important scientific infrastructure that gives the SASSCAL institution data autonomy in the area of changes in biodiversity and important ecosystem functions. The ObservationNet also strengthens the southern African region in terms of its obligations under international agreements and treaties.

In order to develop scientific products and practical recommendations for users from the results of ObservationNet, SP1 addressed different tasks of the observation system. Based on the assessment and continuous monitoring of 27 core biodiversity observatories (of which 6 are located in Angola, 10 in Namibia and 11 in South Africa), SP1-WP1 aimed to provide a regular scientific overview of observed trends in biodiversity change in the region. SP1-WP2's mission was to facilitate access to WP1 products by transforming the ObservationNet website into an outreach tool. SP1-WP3 and SP1-WP4 were to develop direct products for decision makers. SP2 aimed to further develop the scientific expertise of students and institutions in SASSCAL countries (SP2-WP1) and to develop more cost-effective and faster data collection through a technical upgrade of ObservationNet (SP2-WP3: UAV technology). SP3 integrated new experimental approaches into the ObservationNet to study the consequences of different land use practices (SP3-WP1: fire; SP3-WP2: bush encroachment) and use the results to enable better adaptation to the impacts of climate change and other environmental changes. The originally planned SP2-WP2 (wildlife monitoring through camera traps) could not be realised due to lack of financial resources.

University of Trier

Project term: 01.09.2019 – 28.02.2021

Reporting period: 01.09.2019 – 28.02.2021

1 Terms of reference

University of Trier was responsible for SP1–WP2: Near-real-time web presentation of phenological indices and fire events for ObservationNet.

The progressive global loss of biodiversity has been documented in many studies and is the subject of numerous international conventions. Closely linked to this is the loss of ecosystem services and functions (Butchart et al. 2010; Dinerstein et al. 2019). This loss affects both fauna and flora, and an important component for slowing down this negative dynamic or mitigating its consequences is systematic and regular monitoring. Two of the most important drivers for the development of biodiversity at a given location are climatic conditions and their changes, as well as the respective land use by humans. Especially in highly transformative regions such as southern Africa, the use of natural resources is also subject to high anthropogenic pressure.

In this context, the SASSCAL ObservationNet is the only regionally active biodiversity monitoring network in the southern African subcontinent. It is based on a consistent data collection methodology and, with some emphasis on the more arid regions to the west, covers a large area with a long monitoring history. The SASSCAL WeatherNet provides a complementary network of climate stations.

Over the past decades, various biodiversity-relevant parameters have already been collected at a number of observatories. This creates a baseline as a reference against which future developments can be compared and evaluated. However, these are associated with partly complex field campaigns and on-site measurements, so that they can only be repeated at irregular intervals.

At the same time, satellite data offer a possibility to collect standardized and comparable data at regular intervals. A number of operational Earth observation systems, such as Landsat, MODIS or Sentinel, provide optical satellite data over decades, which after standardized evaluation can be placed in a direct context with the land use dynamics on site or ecologically relevant parameters such as biomass, dominant plant species, etc. The data can also be used to compare the land use dynamics on the ground.

The most important goals of this sub-project were accordingly:

1. the definition of parameters that can be collected by default from time series of satellite data
2. the identification of suitable sensor systems
3. the technical implementation of the parameters from the identified time series in near real time by means of a cloud-based service, including the possibility of regular updates

4. the graphical and quantitative provision of the parameters for the biodiversity observatories.

The quantitative use of remote sensing data is often hampered by various factors. On the one hand, there are technical limitations: due to frequent recording repetition rates, remote sensing systems - depending on their technical specifications - generate huge amounts of data. On the one hand, their download and processing requires technical resources such as appropriate data throughput rates and adequate memory sizes and processor capacities. On the other hand, data processing with methods of multi-temporal analyses, time series analyses or applications of machine learning methods requires corresponding technical expertise.

Users from administrations, stakeholders from the field of land management, users of natural resources or scientists from other disciplines often have neither the necessary technical resources nor the necessary knowledge in data processing. Nevertheless, there is a great interest in the use of remotely sensed data beyond the visual interpretation of individual satellite images.

With the opening of important archives (Landsat, Sentinel, MODIS) for free use, the phase of so-called Big Data analyses began in remote sensing, which access the full data pool instead of using individual scenes, which, however, further complicates the above-mentioned limitations in the dissemination of such analyses (Wulder et al. 2012).

In recent years, various cloud-based services have become established that host remote sensing data online and allow data access via specific interfaces or programming environments. These services are partly fully commercial (e.g. Amazon Web Services, AWS) or, even if they are scientifically oriented, follow a cost or licensing model (Earth Observation Data Cluster, EODC), or are regionally restricted, such as the German Code-DE system. The Google Earth Engine TM is a completely freely accessible platform with a large amount of available data of different processing levels and the possibility to realise even complex analyses via a Java-Script based interface (Gorelick et al. 2017).

The potentially usable methods range from the analysis of individual images to classifications and the provision of complex time series; the crucial point here is that a portfolio of possible approaches existed, but their application in the context of cloud computing follows a completely different logic of data access.

Accordingly, the focus of this sub-project was the development of a procedure to make the possibilities of cloud computing usable for different stakeholder groups. This should make it possible to supplement biodiversity monitoring with remote sensing components, but at the same time avoid the technical and conceptual limitations described above.

Scientific-technical state of the art to which it has been connected.

Around the world, forest and forest-like ecosystems are under high pressure of use, driven in particular by population growth and economic development. In Southern Africa, forests, savannas and woodlands provide a wide range of ecosystem functions and services (ESS) to local populations and national economies (timber and other products, biodiversity

conservation, climate regulation, ...) (FAO 2010; Mendelsohn and el Obeid 2005). In particular, dry forests and tree savannahs (especially the miombo system) are still considered relatively intact; nevertheless, they are also exposed to the effects of increasing population and economic development, which manifests itself in deforestation or degradation of forests due to agricultural land reclamation, legal/illegal logging and an accumulation of fires (Bond 2010). In addition, these systems are also used regionally as a grazing resource, which can affect species regeneration.

The driving factors for threats to forest ecosystem integrity are diverse and basically consist of different trajectories of land surface conversion or modification, as well as the influence of fire regimes (Flasse et al. 2004; Verlinden and Laamanen 2006). Moreover, negative effects are amplified by climate change, which urgently requires appropriate countermeasures (Allen et al. 2010; Foden et al. 2007).

The use of spectral indices has a long tradition in remote sensing (Dorigo et al. 2007; Glenn et al. 2008) and different indices exist in response to different requirement profiles. The Enhanced Vegetation Index (EVI) (Huete et al. 2002) used in the approach followed here minimises the influences of the atmosphere as well as the vegetation background and is therefore well suited for working in areas between arid and humid. For the analysis of high temporal resolution vegetation index time series, various approaches exist for deriving phenological parameters (Eklundh and Olsson 2003; Jönsson and Eklundh 2002), which can then be further analysed and classified, for example to derive functional vegetation units in spatially explicit form (Reed et al. 2003; Zhang et al. 2003). Furthermore, the MODIS fire products (Justice et al. 2002) offer the possibility to analyse the temporal dynamics of fires and to further determine their characteristics (Archibald et al. 2008; Roy et al. 2008).

With the opening of the Landsat archive and the free access to MODIS and Sentinel-2 data, the conditions for working with satellite data changed fundamentally. The associated data diversity subsequently allowed a completely different approach to the analysis of time series or the observation of large areas (Wulder et al. 2012), but also complicated the application of many established analysis methods or required the development of new, automated methods. At the beginning of the SASSCAL activities, first examples of automated data pre-processing and derivation of first large-scale data products existed (Griffiths et al. 2013; Ju et al. 2012). As part of the first SASSCAL Science Portfolio, a dedicated processing platform for optical data was developed that enabled accurate quantitative data pre-processing and generation of large-scale data composites, as well as subsequent time series analyses (Frantz et al. 2016, 2017). Various studies have been conducted based on this processing chain (Schneibel et al. 2016; Schneibel et al. 2017). However, these methods require a high technical effort, need substantial processing capacities and a technical know-how in the field of satellite data analysis.

The creation of various cloud-based processing environments offers an alternative here to at least reduce the technical requirements for the analysis of large data packages and the establishment of automatically updating applications. The Google Earth Engine TM is at the forefront here as one of the first and above all freely accessible platforms (Gorelick et al. 2017) and has already enabled a number of scientific Big Data analyses (Hansen et al. 2013; Pekel et al. 2016).

References:

- Allen, C.D., Macalady, A.K., Chenchouni, H., Bachelet, D., McDowell, N., Vennetier, M., Kitzberger, T., Rigling, A., Breshears, D.D., Hogg, E.H., Gonzalez, P., Fensham, R., Zhang, Z., Castro, J., Demidova, N., Lim, J.-H., Allard, G., Running, S.W., Semerci, A., & Cobb, N. (2010). A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management*, 259, 660-684
- Archibald, S., Roy, D.P., van Wilgen, B.W., & Scholes, R.J. (2008). What limits fire? An examination of drivers of burnt area in Southern Africa. *Global Change Biology*, 15, 613-630
- Bond, I. (2010). REDD+ in dryland forests: issues and prospects for pro-poor REDD in the miombo woodlands of southern Africa. International Institute for Environment and Development (UK)
- Butchart, S.H.M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Hockings, M., Kapos, V., Lamarque, J.-F., Leverington, F., Loh, J., McGeoch, M.A., McRae, L., Minasyan, A., Morcillo, M.H., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S.N., Symes, A., Tierney, M., Tyrrell, T.D., Vié, J.-C., & Watson, R. (2010). Global Biodiversity: Indicators of Recent Declines. *Science*, 328, 1164-1168
- Dinerstein, E., Vynne, C., Sala, E., Joshi, A.R., Fernando, S., Lovejoy, T.E., Mayorga, J., Olson, D., Asner, G.P., Baillie, J.E.M., Burgess, N.D., Burkart, K., Noss, R.F., Zhang, Y.P., Baccini, A., Birch, T., Hahn, N., Joppa, L.N., & Wikramanayake, E. (2019). A Global Deal For Nature: Guiding principles, milestones, and targets. *Science Advances*, 5, eaaw2869
- Dorigo, W.A., Zurita-Milla, R., de Wit, A.J.W., Brazile, J., Singh, R., & Schaepman, M.E. (2007). A review on reflective remote sensing and data assimilation techniques for enhanced agroecosystem modeling. *International Journal of Applied Earth Observation and Geoinformation*, 9, 165-193
- Eklundh, L., & Olsson, L. (2003). Vegetation index trends for the African Sahel 1982-1999. *Geophysical Research Letters*, 30, 1430-1433.
- FAO (Ed.) (2010). Guidelines on sustainable forest management in drylands of sub-Saharan Africa. Rome
- Flasse, S.P., Trigg, S.N., Ceccato, P.N., Perryman, A.H., Hudak, A.T., Thompson, M.W., Brockett, B.H., Drame, M., Ntabeni, T., Frost, P.E., Landmann, T., & le Roux, J.L. (2004). Remote sensing of vegetation fires and its contribution to a fire management information system. In J. Goldammer, & C. de Ronde (Eds.), *Fire management handbook for sub-Sahara Africa* (pp. 158-211). Freiburg, Germany: Global Fire Monitoring Center
- Foden, W., Midgley, G.F., Hughes, G., Bond, W.J., Thuiller, W., Hoffman, M.T., Kaleme, P., Underhill, L.G., Rebelo, A., & Hannah, L. (2007). A changing climate is eroding the geographical range of the Namib Desert tree *Aloe* through population declines and dispersal lags. *Diversity and Distributions*, 13, 645-653
- Frantz, D., Röder, A., Stellmes, M., & Hill, J. (2016). An Operational Radiometric Landsat Preprocessing Framework for Large-Area Time Series Applications. *IEEE Transactions on Geoscience and Remote Sensing*, 54, 3928-3943
- Frantz, D., Röder, A., Stellmes, M., & Hill, J. (2017). Phenology-adaptive pixel-based compositing using optical earth observation imagery. *Remote Sensing of Environment*, 190, 331-347
- Glenn, E.P., Huete, A.R., Nagler, P.L., & Nelson, S.G. (2008). Relationship Between Remotely-sensed Vegetation Indices, Canopy Attributes and Plant Physiological Processes: What Vegetation Indices Can and Cannot Tell Us About the Landscape. *Sensors*, 8, 2136-2160
- Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, 202, 18-27
- Griffiths, P., van der Linden, S., Kuemmerle, T., & Hostert, P. (2013). A Pixel-Based Landsat Compositing Algorithm for Large Area Land Cover Mapping. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 6, 2088-2101
- Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., & Townshend, J.R.G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, 342, 850-853

- Huete, A., Didan, K., Miura, T., Rodriguez, E.P., Gao, X., & Ferreira, L.G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. *Remote Sensing of Environment*, 83, 195-213
- Jönsson, P., & Eklundh, L. (2002). Seasonality extraction by function fitting to time-series of satellite sensor data. *IEEE Transactions on Geoscience and Remote Sensing*, 40, 1824-1832
- Ju, J., Roy, D.P., Vermote, E., Masek, J., & Kovalsky, V. (2012). Continental-scale validation of MODIS-based and LEDAPS Landsat ETM+ atmospheric correction methods. *Remote Sensing of Environment*, 122, 175-184
- Justice, C.O., Giglio, L., Korontzi, S., Owens, J., Morisette, J.T., Roy, D., Descloitres, J., Alleaume, S., Petitcolin, F., & Kaufman, Y. (2002). The MODIS fire products. *Remote Sensing of Environment*, 83, 244-262
- Mendelsohn, J.M., & el Obeid, S. (2005). Forests and woodlands of Namibia. Windhoek/Namibia: RAISON
- Pekel, J.-F., Cottam, A., Gorelick, N., & Belward, A.S. (2016). High-resolution mapping of global surface water and its long-term changes. *Nature*, 540, 418-422
- Reed, B.C., White, M.A., & Brown, J.F. (2003). Remote sensing phenology. In M.D. Schwartz (Ed.), *Phenology: an integrative science* (pp. 365-381). Dordrecht, The Netherlands: Kluwer Academic Publishing
- Roy, D.P., Boschetti, L., Justice, C.O., & Ju, J. (2008). The collection 5 MODIS burned area product - Global evaluation by comparison with the MODIS active fire product. *Remote Sensing of Environment*, 112, 3690-3707
- Schneibel, A., Stellmes, M., Röder, A., Finckh, M., Revermann, R., Frantz, D., & Hill, J. (2016). Evaluating the trade-off between food and timber resulting from the conversion of Miombo forests to agricultural land in Angola using multi-temporal Landsat data. *Science of the Total Environment*, 548-549, 390-401
- Schneibel, A., Stellmes, M., Röder, A., Frantz, D., Kowalski, B., Haß, E., & Hill, J. (2017). Assessment of spatio-temporal changes of smallholder cultivation patterns in the Angolan Miombo belt using segmentation of Landsat time series. *Remote Sensing of Environment*, 195, 118-129
- Verlinden, A., & Laamanen, R. (2006). Modeling woody vegetation resources using Landsat TM imagery in northern Namibia. *South African Forestry Journal*, 207, 27-39.
- Wulder, M.A., Masek, J.G., Cohen, W.B., Loveland, T.R., & Woodcock, C.E. (2012). Opening the Archive: How Free Data has Enabled the Science and Monitoring Promise of Landsat. *Remote Sensing of Environment*, 122, 2-10
- Zhang, X.Y., Friedl, M.A., Schaaf, C.B., Strahler, A.H., Hodges, J.C.F., Gao, F., Reed, B.C., & Huete, A. (2003). Monitoring vegetation phenology using MODIS. *Remote Sensing of Environment*, 84, 471-475

2 Planning for, and course taken by, the project

The sub-project was set up as a sub-contract and under processing of three clearly defined work areas. These initially included 1) the precise specification of user requirements, possible satellite systems and suitable analysis procedures. In the 2) next step, these should first be technically realized, before 3) in the last step, the implementation via a web interface as well as simple possibilities for data download were the focus.

In the first block, two ecologically relevant domains were first identified, the characterisation of vegetation dynamics and the assessment of the respective fire dynamics. For the former, a large number of suitable vegetation indices exist in remote sensing. These are directly correlated with a variety of relevant parameters such as vegetation density, biomass, etc., while their seasonal variation allows conclusions to be drawn about the prevailing vegetation types in each case. At the same time, many of the indices are defined in such a way that they can be derived from different systems and are thus also comparable across systems.

For the evaluation of these indices, it was decided to focus on direct interpretability of the data instead of more conceptual parameters such as phenological predictors, and therefore to present complete vegetation index time series for selected areas. In addition, a relative evaluation should be realised by a comparison with long-term vegetation behaviour, in order to assess, for example, the influence of land use processes or climatic features.

Finally, it should be possible to record the fires that occurred at a particular point in time for the complete time series and to present these directly together with the vegetation dynamics.

The second block then aimed at the technical implementation of the criteria mentioned. In the end, the current data of the European Copernicus-Sentinel-2 mission and the MODIS mission hosted by NASA and USGS were chosen as sensors because they represented a contrast between very high geometric resolution in the first and a high temporal repetition rate with somewhat lower geometric resolution. Accordingly, different ways of accessing data, quality control and construction of the time series had to be tested and implemented for the two systems. The comparative representation of the long-term mean, dynamically adjusted to the time under consideration, required a statistical estimation of the population from the observation data.

In contrast, the fire events were identified solely by means of a database query and a corresponding location in the vegetation time series.

The third major task area was developed in parallel with the second block, as there is a direct connection between the cloud-based derivation of parameters and the respective possible representation via a graphical user interface. First of all, all derived information was displayed via an app in the browser, and a simple download option for the underlying values was realised for each of the various options. In addition, for even more targeted data access, a possibility was created to enable direct access to a specific sensor and a specific observatory via the call.

All of the above steps required a continuous exchange between the technical development group in Trier (M.Sc. M. Gilcher, Dr. A. Röder) and users from the field of biodiversity research and land management. For the latter, regular meetings were organised with the University of Hamburg (Dr. M. Finckh, Dr. G. Muche), which took place on site at the start of the project and later online due to the pandemic. Further feedback from other users was also obtained and integrated into the development process.

3 Essential results and cooperation with other research institutions

As already mentioned, the customized development of the user-adapted app required a permanent exchange between the development and application levels. This continuous exchange was organized between the University of Trier and the University of Hamburg, and feedback from other user groups was also obtained via the University of Hamburg.

No further cooperation took place beyond this work within the direct framework of the project partners.

Namibia University of Science and Technology (NUST)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 Terms of reference

The present SASSCAL ObservationNet has been developed since 2001 during the BIOTA-Africa and later the SASSCAL Research Portfolio projects. By the start of the project, time-series data of near enough 17 years of largely annual data has been collected. NUST aimed at regularly resurveying the existing Namibian Biodiversity Observatories in order to continue with the long-term data series, as well as analysing the wealth of data already collected.

2 Planning for, and course taken by, the project

NUST was involved in four work packages as follows:

SP1-WP1: Scientific analyses and academic publications of existing time series and regional transects

Plan: The main purpose of this work package was the analysis of the wealth of data which has been collected over the past two decades on the observatories.

Accomplishment: We modelled the likelihood of vegetation composition shifts under climate change scenarios along a climatic gradient in Namibia a presented long-term results of the project at the following scientific conferences:

- Grassland Society Congress, Upington, RSA, July 2019
- International Symposium of the Vegetation Scientists, Bremen, July 2019
- 2nd Drone users conference for Agriculture and Nature Conservation, Stellenbosch / online, November 2021
- South African Association of Botanists, Potchefstroom / online, January 2022

MSc-theses related to this work package:

Naftal, L. (2022) Assessing the likelihood of vegetation composition shifts under climate change scenarios along a climatic gradient in Namibia. Master-thesis at Namibia University of Science and Technology

SP1-WP4: Sharing research outcomes with land-management stakeholders in arid rangelands

Plan: Within Namibia, the Namibia Rangeland Forum and the “Restoring Namibia’s Rangelands” project will be targeted in addition to the farmers associations and conservancy members that are directly involved. In addition, to reach a broader audience, informative articles on the research outcome will be written for popular-scientific journals for southern African farmers, specifically the *Farmers Weekly*, the *Landbou Weekblad* and *Agri-Forum* that reach a great number of farmers in southern Africa.

Accomplishment: Due to lockdown and social distancing in response to Covid-19 pandemic, the planned stakeholder workshops had to be cancelled. The outreach activities were limited to media like radio or newspaper. In 2020 B. Strohbach gave a short interview on long-term trends in vegetation for the *Landboujournaal* (a farmer's information programme) on a local radio station (*Kanaal 7*). Ms Nambwandja (working on SP2-WP3) shared her research activities and findings in the Afrikaans *Republikein* Newspaper on the 29th of May 2020.

SP2-WP1: Continuation and streamlining of the annual vegetation assessment at the Observatories

Plan: In WP 1 we aimed at implementing and further improving new technology for easy assessment and fast processing of the annual vegetation monitoring data, which after nearly two decades of continuous monitoring, now comprises a time series that is long-enough to provide insight into key vegetation processes.

Accomplishment: We managed to resurvey the following Biodiversity Observatories:

- 2019: Erichsfelde, Gellap Ost and Nabaos
- 2020: Mile 46, Mutompo, Sonop, Erichsfelde, Omatako Ranch, Gellap Ost and Nabaos
- 2021: Mile 46, Mutompo, Sonop, Erichsfelde, Omatako Ranch, Gellap Ost and Nabaos
- 2022: Mile 46, Mutompo, Sonop, Erichsfelde and Omatako Ranch

The data has been digitalised, cleaned and shared with the University of Hamburg.

SP2-WP3: Technical innovation: biodiversity monitoring using UAV technology

Plan: Throughout the existence of the biodiversity observatory network, large emphasis was placed on the monitoring of floristic diversity on the observatories. Additionally to the ground-based field surveys, we started with annual high-resolution aerial surveys of all biodiversity observatories, in order to get a comparable series of baseline data of the observatories.

Accomplishment: We were able to do repeat aerial surveys of most of the Biodiversity Observatories as follows:

- 2019: 10 Observatories
- 2020: 14 Observatories
- 2021: 17 Observatories
- 2022: 18 Observatories
- In addition, several auxiliary observatories associated with the FogNet array in the Central Namib have been resurveyed repeatedly.
- We have also undertaken an in-depth survey of tree and shrubs (including a monthly-repeated aerial imagery of the site) at the Erichsfelde Observatory (S05) and a number of associated study sites on the farm.

We are in the process of establishing a meta-database of available aerial imagery with the help of the SASSCAL OADC and will in due course share this data with the OADC.

Published output from this work package:

Treichel, C., Strohbach, B.J., Carr, S., Loots, S., Neckel, A. (2021) *Euryops walterorum*, a declining restricted-range endemic of the Greater Gamsberg. *Namibian Journal of Environment*, 5, A-38.

MSc-theses related to this work package:

Nambwandja, A. (2022) The assessment of UAV-based multispectral imagery to monitor lichen-dominated biological soil crusts response to fog and disturbances, Central Namib. Master-thesis at Namibia University of Science and Technology.

SP3-WP2: Bush encroachment, water distribution and soil erosion at the landscape level

Plan: Water flow, water redistribution and erosion at a landscape level are closely interrelated, and have severe effects on vegetation composition, including bush encroachment. With this subtask we wanted to establish whether targeted debushing in omirimbi can assist in the establishment of perennial grasslands in these ephemeral wetlands.

Accomplishment: During the course of the project we established a series of ground-water monitoring stations in a river catchment on the farm Erichsfelde. Within this catchment, we cleared a portion of a temporary wetland of encroaching shrubs, using the cut branches as a weir to reduce water flow and allow both sedimentation and infiltration of water into the soil profile. Baseline data was collected, covering soil types, vegetation composition, and, the topography of the catchment, covering roughly 650 ha. We established a monitoring system on this catchment, which can run for a number of years, to monitor the effect of debushing in such a catchment system, as well as the overall dynamics of both the phanerophytic and graminoid vegetation.

In addition, we collected grass composition data on a number of farms within the arid Thornbush savanna of Namibia to study the effect of bush clearing.

3 Essential results and cooperation with other research institutions

Essential results

For the most essential results of the research activities of the NUST team in Namibia we refer to the implementation of the drone technology (UAVs) to advance the assessment and the monitoring of the vegetation at the observatories. The drones allowed monitoring of phenological dynamics and their spatial patterns in the landscape. This was successfully applied for both, the vegetation of higher plants in general as well as the lichen vegetation at the observatories in the Central Namib. Based on the experiences and know-how, the technology can also be adjusted to and employed for the remaining observatories along the transect.

For detailed information on the research results please refer to part II of the report.

Cooperation with other research institutions:

- Gobabeb Namib Research Institute: monitoring of lichen fields with UAV's
- Ministry of Environment, Forestry and Tourism, National Botanical Research Institute: Baseline survey of *Euryops walterorum* population on the Gamsberg Plateau, with the aim to establish a long-term monitoring project.
- Ministry of Agriculture, Water and Land Reform, Division Pasture Science and GIZ Bush Control Project: Quantifying shrub biomass with the aid of UAV imagery
- Namibia Statistical Agency: Supply of baseline data on vegetation structure forms for Land Cover mapping project.

Instituto Superior de Ciências de Educação da Huíla (ISCED-Huíla)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 Terms of reference

The SASSCAL Research Portfolio project established six biodiversity observatories in Angola, which have been integrated into the regional biodiversity monitoring network. After characterising the baseline situation of these observatories, the next steps under the SASSCAL ABC project were to consolidate the monitoring system in the country, provide scientific products and practical recommendations to decision-makers and stakeholders, and improve the technical and scientific skills of Angolan researchers and students.

The implementation of Module B was supported by three sub-projects that, using innovative methodologies and approaches, aimed to provide a science-based vision of the trends of biodiversity changes in the SASSCAL region.

To meet the project's objectives, our scientific responsibilities were:

- Processing and analysing data from Angolan Biodiversity Observatories to obtain results that can be converted into scientific products and recommendations for decision-makers.
- To conduct annual vegetation assessments on Tundavala Biodiversity Observatory to ensure uninterrupted time series, to understand the trends in plant diversity and cover, and also the potential sustainable land management in the region;
- To ensure the improvement of the capacity for scientific research and biodiversity monitoring, through training in fieldwork methodologies and data analysis.

2 Planning for, and course taken by, the project

ISCED was involved in five work packages as follows:

SP1-WP1: Scientific analyses and academic publications of existing time series and regional transects

Plan: Compilation and analysis of data from regional observatories for the production of informative material and academic publications; article on distribution, plant functional types and dynamics of phanerophytic Fabaceae and grass species along the southern African transect.

Accomplishment: Most of the activities were carried out successfully. The planned publications on distribution, plant functional types and dynamics of phanerophytic Fabaceae and grass species along the southern African transect are, however, delayed due to more difficult academic support conditions of the PhD student in charge. Travel conditions during COVID-19 periods inhibited her participation in training courses and summer schools. The triangle of Angola (research site), Lisbon (place of residence), and Hamburg (University for PhD) turned out to be particularly difficult under these conditions.

SP1-WP3: Recommendations for decision makers on fire management in the Angolan Miombo region

Plan: Assemble and structure previous research results on wildfires in Angola; hold a fire workshop with national, provincial and technical authorities.

Accomplishment: Activities mostly ran as planned; the fire awareness movie was made and edited in English, Portuguese and German; the sole exception was the fire workshop: our attempts to bring the relevant stakeholders for a fire workshop together were frustrated by the interruptions and unpredictability caused by the COVID-19 situation in 2020 and 2021 (for the post-project realization of the fire workshop please see below).

SP2-WP1: Continuation and streamlining of the annual vegetation assessment at the Observatories

Plan: To continue and optimize the monitoring process at Tundavala Biodiversity Observatory to ensure uninterrupted time series of vegetation data and to support the vegetation assessment at the other Angolan biodiversity observatories; seasonal surveys of vegetation and data processing and analysis.

Accomplishment: All botanical surveys in Tundavala Observatory were conducted on time, as well as data processing and analysis. The support to the vegetation assessment at the other Angolan biodiversity observatories was given as far as possible under the COVID-19 restrictions in 2020 and 2021. Three of the five other Angolan Observatories have been monitored at least once during the project period.

SP2-WP2: Upgrading the observatory network using camera traps for wildlife monitoring in Angola

Plan: Implementation of camera trapping schemes at 3 Angolan observatories and training of staff in camera trapping techniques and analytical methods.

Accomplishment: The training of staff was fully completed. The implementation of animal monitoring with trap cameras could not be realized due to difficulties in their purchase in Angola and COVID-19 travel restrictions that prevented the planned purchase in Germany and transport to Angola.

SP3-WP1: Fire experiments in Angolan grassland-woodland ecotones

Plan: Support for the implementation of fire experiments at 3 Biodiversity Observatories (Tundavala, Bicuar NP and Cusseque).

Accomplishment: All activities went as planned. The Cusseque-site was damaged by an early wildfire while the German team was still in Immigration-quarantine in 2021. However, first results of the experiments have already been published and the Angolan staff has been trained in fire handling and related vegetation assessment methods.

3 Essential results and cooperation with other research institutions

The Fabaceae data were aggregated with those of the SASSCAL regional network to support the **SP1-WP1** milestones 7, 9, 11 and 12. Towards the end of the project phase, we were re-examining the grass IDs at Lubango (LUB) and Hamburg (Herbarium Hamburgense), whose data will be used for the same purpose.

The production of a film on the role of fire in Angolan grasslands by the UHH Team (**SP1-WP3**) was supported during field work and Portuguese language editing.

The floristic characterization of the Tundavala Observatory (**SP2-WP1**) was completed, which included the species identification and their morphological and functional characterization, the determination of diversity indices, the land cover (10x10m² - 20x50m²) and land use. Some important findings:

- a high number of endemic species, some of them with a known distribution (known collecting points) restricted to the region where the Observatory is located. This may eventually point to a situation of vulnerability of these species, seeing that the ecosystem is exposed to increasing human pressure.
- The level of anthropization in the Observatory is high – on the grasslands mainly due to the presence of cattle throughout the year and the fires induced by shepherds in the dry season; on the rocky area due to the felling of trees characteristic of this habitat. The main activities affecting the area's ecological integrity are trees felling for firewood and charcoal, increase in density of livestock, exploitation of rocks, poaching of small animals, urban waste disposal, regular fires and the introduction of exotic species.

Training of a MSc student in camera trapping techniques and analyses (**SP2-WP2**) was done in cooperation with CIBIO-Porto in Bicular National Park and Iona National Park.

The fire experiments in Angolan grassland-woodland ecotones at Tundavala, Bicular and Cusseque (**SP3-WP1**) which were coordinated by UHH have continuously been supported by ISCED-staff which was trained in the field in techniques of fire handling, related vegetation measurements, and data analyses.

University of Hamburg (UHH)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 Terms of reference

The working group at University of Hamburg worked on a) scientific analyses and academic publications of existing time series and regional transects (SP1-WP1), b) recommendations for decision makers on fire management in the Angolan Miombo region (SP1-WP3), c) sharing research outcomes with land-management stakeholders in arid rangelands (SP1-WP4), d) continuation and streamlining of the annual vegetation assessment at the Observatories (SP2-WP1), and e) fire experiments in Angolan grassland-woodland ecotones (SP3-WP1). (For details please refer to general terms of reference Module B).

2 Planning for, and course taken by, the project

The working group at UHH was involved in five work packages.

SP1-WP1: Scientific analyses and academic publications of existing time series and regional transects

Plan:

For South Africa and Namibia: In this task we planned to process, analyse and publish time-series data on the vegetation at Observatories and Auxiliary Observatories in South Africa and Namibia. The time series on plant species, plant traits and plant population dynamics were to be analysed against time-series of seasonal and annual weather data (generated by the SASSCAL weather stations), herbivore density and habitat data (topography and soil). Further planned analyses included the role of soil characteristic and topography for the spatial distribution of plant species and plant functional traits, based on which the vegetation time-series data were to be evaluated.

For Angola: Compilation and analysis of data from regional observatories for the production of informative material and academic publications; article on distribution, plant functional types and dynamics of phanerophytic Fabaceae and grass species along the southern African transect.

Accomplishment:

The South African research activities from UHH successfully achieved the following goals: The timeseries data of South African Observatories have been analysed and presented at regional and international conferences (AZEF, GEO BON GEOSS Open Science Conference, GfOe, IAVS) and were published in international journals. Drivers of plot-related species richness and cover-based diversity indices at plot scale of the Observatories (S22, S23, 24, S25) have been analysed for climatic and land-use drivers. Responses of species germination,

species composition and functional plant traits to edaphic drivers were analysed to understand the spatial patterns underlying the temporal dynamics.

The planned publications on distribution, plant functional types and dynamics of phanerophytic Fabaceae and grass species along the southern African transect are delayed due to difficult academic support conditions of the PhD student in charge. Travel conditions during COVID-19 periods inhibited her participation in training courses and summer schools. The research and support triangle of Angola (research site), Lisbon (place of residence), and Hamburg (University for PhD) turned out to be particularly difficult under these conditions.

Published output from this work package:

- Eibes, P., Schaffrath, F., Oldeland, J., Thormählen, W., **Schmiedel, U.**, Irl, S. (2022). Testing the concept of edaphism for the quartz island flora of the Knersvlakte, South Africa. *South African Journal of Botany*, 151, 555-64.
- Schmiedel, U.** (2022): Drivers of spatial patterns and long-term dynamics of arid rangelands in southern Africa. Habilitation thesis. MIN Faculty, University of Hamburg, Germany
- Eibes, P.M., Oldeland, J., Irl, S.D.H., Twerski, A., Kühne, N., **Schmiedel, U.** (2021). Partitioned beta diversity patterns of plants across sharp and distinct boundaries of quartz habitat islands. *Journal of Vegetation Science*, 32. <https://onlinelibrary.wiley.com/doi/abs/10.1111/jvs.13036>.
- Godlee, J., Ryan, C., Bauman, D., Bowers, S., Carreiras, J., [...] **Finckh, M.**, [...], Dexter, K. (2021) Structural diversity and tree density drives variation in the biodiversity-ecosystem function relationship of woodlands and savannas. *New Phytologist*, 232 (2), 579-594. <https://doi.org/10.1111/nph.17639>
- Aleman, JC, Fayolle, A, Favier, C, Staver, AC, Dexter, KG, Ryan, CM, Azihou, AF, Bauman, D, te Beest, M, Chidumayo, EN, Comiskey, JA, Crooms, J, Dessard, H, Doucet, J-L, **Finckh, M.**, Gillet, J-F, Gourlet-Fleury, S, Hempson, GP, Holdo, RM, Kirunda, B, Kouame, FN, Mahy, G, Gonçalves, FMP, McNicol, I, Quintano, PN, Plumptre, AJ, Pritchard, RC, Revermann, R, Schmitt, CB, Swemmer, AM, Talila, H, Woollen, E, Swaine, M.D. (2020) Floristic evidence for alternative biome states in tropical Africa. *Proceedings of the National Academy of Sciences*, 202011515. www.pnas.org/cgi/doi/10.1073/pnas.2011515117
- Sabatini, F.M., Lenoir, J., Hattab, T., Arnst, E., Chytry, M., [...], **Finckh, M.**, [...], **Jürgens, N.**, [...], Bruehlheide, H. (2021) sPlotOpen – An environmentally-balanced, open-access, global dataset of vegetation plots. *Global Ecology and Biogeography*, 30, 1740-1764. <https://doi.org/10.1111/geb.1334>
- Schmiedel, U.**, Siemen, S.-E., Dlodlu, M.N. & Oldeland, J. (2021). Germination success of habitat specialists from the Succulent Karoo and Renosterveld on different soil types. *South African Journal of Botany*, 137, 320-330. <https://doi.org/10.1016/j.sajb.2020.10.030>
- Schmiedel, U.**, Jacke, V., Hachfeld, B., Oldeland, J. (2021). Response of Kalahari vegetation to seasonal climate and herbivory: Results of 15 years of vegetation monitoring. *Journal of Vegetation Science*; e12927; <https://doi.org/10.1111/jvs.12927>
- The SEOSAW partnership [...], **Finckh, M.**, ..., Gonçalves, F.M.P., ..., Revermann R., ...] (2020) A network to understand the changing socio-ecology of the southern African woodlands (SEOSAW): Challenges, benefits, and methods. *Plants, People, Planet*, 3, 249-267. <https://doi.org/10.1002/ppp3.10168>
- Valencia, E., De Bello, F., Galland, T., Adler, P.B., Lepš, J., E-Vojtkó, A., Van Klink, R., [...], **Jürgens, N.**, [...], **Schmiedel, U.** [...], et al. (2020). Synchrony matters more than species richness in plant community stability at a global scale. *Proceedings of the National Academy of Sciences*, 117, 24345-24351. <https://doi.org/10.1073/pnas.1920405117>
- Bruehlheide, H., Dengler, J., Jiménez-Alfaro, B., [...], **Finckh, M.**, [...], **Jürgens, N.**, [...], Revermann, R., [...], **Schmiedel, U.** [...] & Zverev, A.A. (2019) sPlot – a new tool for global vegetation analyses. *Journal of Vegetation Science*, 30, 161-186. <https://doi.org/10.1111/jvs.12710>
- Fayolle, A., Swaine, M.D., Aleman, J., [...], **Finckh, M.**, Gonçalves, F.M.P., [...], Revermann, R., [...], Woollen, E. (2019) A sharp floristic discontinuity revealed by the biogeographic regionalization of African savannas. *Journal of Biogeography* 46(2), 454-465. DOI: 10.1111/jbi.13475

Valencia, E., De Bello, F., Lepš, J., Galland, T., E-Vojtkó, A., Conti, L., Danihelka, J., [...], **Jürgens, N.**, [...], **Schmiedel, U.** [...], et al. (2020). Directional trends in species composition over time can lead to a widespread overemphasis of year-to-year asynchrony. *Journal of Vegetation Science*, 31, 792-802. <https://doi.org/10.1111/jvs.12916>

SP1-WP3: Recommendations for decision makers on fire management in the Angolan Miombo region

Plan: It was planned to evaluate the knowledge gained within the SASSCAL 1.0 portfolio on causes, patterns, and dynamics of wild fires in the Angolan Miombo region systematically and to turn it into products for decision makers and land users. WP 3 aimed at looking deeply into the benefits of fire for rural smallholders and the ecological consequences and losses for silvicultural production through wild fires.

Accomplishment:

We assembled and reviewed most published information on wild fires in Angola and the relevant studies on wild fires in the wider Miombo region (Milestone M1). We also produced the awareness film on wild fires in Angola (Milestone M4).

Due to travel and meeting restrictions imposed by COVID-19, it was so far not possible to realize the planned Angolan fire workshop with Angolan national, provincial and technical authorities (Milestone M2). The Higher Polytechnic Institute of Tundavala (ISPT) agreed to host the workshop in the first half of 2023, taking the opportunity to disseminate the awareness-raising film on wildfires in Angola produced by P. Meller. The planned technical framework for sustainable fire management in central Angola (Milestone M3) was to be developed based on the stakeholder Feedback on the workshop and, thus, has neither been realized so far.

Published output from this work package:

Conservation or destruction? The future of the Uíge mountain ranges. A film by **Paulina Zigelski**. University of Hamburg, 2020. English: <https://vimeo.com/405416258>; Deutsch: <https://vimeo.com/404927217>; Portugiesisch: <https://vimeo.com/405444927>

Tool or disaster? Fires in Angola. A film by **Paulina Meller**. University of Hamburg, 2022.

Meller, P., Frazão, R., Lages, F., **Jürgens, N.**, **Finckh, M.** (2022) Tipping the scales: How fire controls the balance among functional groups in Angolan grasslands. *African Journal of Range & Forage Science*, 39, 56-69.

SP1-WP4: Sharing research outcomes with land-management stakeholders in arid rangelands

Plan: Meetings with farmers associations, extension service as well as conservation agencies as well as farmers' field days will be held in conjunction with the NGO Conservation South Africa (CSA) that is working with land users in Namaqualand and is reaching a broad range of commercial and communal farmers in the area. Recent farmers' field days (e.g., Genis 2018) revealed the advantage of exchange and demonstrations onsite compared sharing of information in writing.

In addition, to reach an even broader audience, informative articles on the research outcome and on the discussions with farmers during field days will be written for the popular-scientific journals for southern African farmers, specifically the *Farmers Weekly*, the *Landbou Weekblad* and *Agri-Forum* that reach a great number of farmers in southern Africa.

Accomplishment:

Due to the Covid-19 pandemic and related travel restrictions during most of the funding period, the planned community workshops had to be cancelled completely. Instead, two meetings with conservation managers, land users, representatives of farmers' associations were held in the Knersvlakte in 2021 and 2022. During these meetings U. Schmiedel shared the findings from the long-term monitoring studies and other research activities in the area with the above-mentioned audience (Milestone 4). Several public talks (e.g., by Schmiedel at the Johannesburg Succulent Society, British Cactus and Succulent Society), articles authored by Schmiedel and co-authors or based on information shared in interviews on vegetation patterns and population dynamics and threats in the Succulent Karoo were published in journals and newspapers that reached the general and interested public (e.g., *Canadian Botanical Association Bulletin*, 2x *Landbouweekblad*, *The Guardian*, *Veld & Flora*).

To discuss the value and strategies of the involvement of grassroots scientists into transdisciplinary research projects, U. Schmiedel was invited by the Teaching and Learning and the Citizen Science Special Interest Groups of the British Ecological Society for a workshop in July 2022 to talk about her experience with the involvement of paraecologists as citizen scientists into environmental monitoring projects in southern Africa.

A report on the meeting has been published on the 1st of September 2022 in the Blog of the British Ecological Society's Teaching and Learning Special Interest Group (<https://besteachingandlearning.wordpress.com/2022/09/01/upskilling-citizen-scientists-for-future-professions-a-meeting-report/>).

N. Jürgens shared the time-series data on population dynamics of species of the genus *Aloe* / *Aloidendron* (see also report on SP2-WP1) with the research community and the Species Survival Commission of the IUCN during a workshop in February 2021.

Published output from this work package:

In total, the following articles were published over the project phase with the direct collaboration or authorship of the team members:

- Genis, A. (2022 in prep.). Karooveld herstel stadig. Wetenskaplikes wat die veld in die Karoo en Namakwaland oor die langtermyn moniteer, vind 'n agteruitgang in plantbedekking en ook dat sowat 10% van plante, veral bosse en bome wat baie oud is, gevrek het gedurende die droogte. *Landbouweekblad* (2022 in preparation)
- Elliott, T. (2022). South Africa – a growing plant poacher's paradise. - With input from Muthama Muasya and Ute **Schmiedel**. *The Canadian Botanical Association Bulletin*, 55(1), 20-23.
- Dall, N. (2021) Succulent smuggling: why are South Africa's rare desert plants vanishing? *The Guardian* [Internet]. 2021.
- Genis, A. (2020) Planteprojekt help vir verandering voorberei. *Landbouweekblad*; 2nd July 2020, 58-60.
- Helme N, **Schmiedel**, U. (2020) Namaqualand nightmare. *Veld & Flora*; June 2020, 14-9.

Schmiedel, U. (2022) The Ecology of Mesembs on Quartz Fields in Southern Africa. Public talk at the British Cactus and Succulent Society (BCSS) 9th of January 2022.

Schmiedel, U. (2022) The Ecology of Mesembs on Quartz Fields in Southern Africa. Public talk at the Johannesburg Succulent Society, South Africa 2nd of February 2022.

SP2-WP1: Continuation and streamlining of the annual vegetation assessment at the Observatories

Plan: To continue and optimize the monitoring process at the South African, Namibian and Angolan Biodiversity Observatories to ensure uninterrupted time series of vegetation data and to support the vegetation assessment at all Angolan Observatories.

Accomplishment: The South Africa team of UHH continued the vegetation monitoring on the South African and Namibian Observatories. Only in 2020 the field work activities had to be skipped completely due to the Covid-19-related travel restrictions worldwide. The electronic data capturing was introduced to all team members, which speeded up the data processing significantly (Milestone 1 and 2). The trends in rainfall and vegetation on the observatories were presented at SASSCAL ObservationNet website (Milestone 3 and 4).

The time series analyses of the vegetation data have produced new insights into vegetation dynamics and its controlling factors in the study area. Quantitative timeseries analyses for Observatories in the Succulent Karoo and in the Savanna have confirmed that vegetation dynamics are habitat-specific. In the Kalahari, these are the soil-water enriched dune crests or slopes compared to the shallow and drier dune valleys. In the Succulent Karoo, the dynamics of vegetation crest or upper slope sites can be distinguished from those of lower slope and valley sites.

The permanent observation plots in the South African Richtersveld are among the longest documented vegetation timeseries on the continent. Twelve of the plots were first surveyed in February 1980 and provide information on the development over a period of 42 years. Currently, 58 plots of 100 m² area each are being revisited regularly; 18 of the plots were established as adjacent contrasts of (a) plots fenced in and (b) plots freely accessible to game and grazing animals. For the international conference on global Mediterranean ecosystems (Medecos) held in South Africa in September 2022, N. Jürgens evaluated some of the plots exemplarily and presented the dramatic collapse of the biotic communities of at the conference. The collapse was the results of 10 consecutive years of severe droughts, i.e., years with total annual rainfall far below the long-term mean of 85 mm. The presented data will now be analysed with the replicates and then published. As far as we know, no such dramatic collapse of such species-rich vegetation (up to 72 species per 100 m²) has been documented anywhere in the world before.

The auxiliary observatories in the drylands of Namibia Dieprivier (A01), Giribesvlakte (A02), Leopard Rock (A03), Featherlion Hill (A04), Marienfluss (A05), Hartmann Plains (A06), Welwitschia Vlake (A09), Rössing Mountain (A10), and Tses have been documented botanically and with regard to termites and ants by Norbert Jürgens in recent years. For Dieprivier (A01), Giribesvlakte (A02), Leopard Rock (A03), Featherlion Hill (A04), Hartmann Plains (A06) and Tses, extensive surveys with game trap cameras and time-lapse cameras were also carried out.

All botanical surveys in Tundavala Observatory, Angola, as well as data processing and analysis were conducted on time, led by ISCED. The vegetation assessment at the other Angolan biodiversity observatories was done as far as possible under the COVID-19 restrictions in 2020 and 2021. Three of the five other Angolan Observatories have been monitored at least once during the project period.

Published output from this work package:

- Lautenschläger, T., Göhre, A., Ditsch, B., Baumgärtel, C., Monizi, M., [...], Lages, F., [...], **Jürgens, N., Finckh, M., Meller, P.** (2022) Sixty-seven species newly recorded for the flora of Angola: recent findings from vegetation surveys and herbarium collections. *Check List* 18 (5), 1203–1230. <https://doi.org/10.15560/18.5.1203>
- Meller, P.**, Stellmes, M., Fidelis, A., **Finckh, M.** (2022) Correlates of geoxyle diversity in Afrotropical grasslands. *Journal of Biogeography*, 49, 339–352. <https://doi.org/10.1111/jbi.14305>
- Rodríguez-Caballero, E., Reyes, Andrés, Kratz, A., Caesar, J., Guirado, E., Schmiedel, U., Escribano, P., Fiedler, S., Weber, B. (2022) Effects of climate change and land use intensification on regional biological soil crust cover and composition in southern Africa. *Geoderma* 406, 115508. <https://doi.org/10.1016/j.geoderma.2021.115508>
- Finckh, M.**, Wendefuer, J., **Meller, P.** (2021) Frost-driven lower treelines in Angola and their implications for tropical forest-grassland mosaics. *Journal of Vegetation Science*, 32 (5). <https://doi.org/10.1111/jvs.13084>
- Godlee, J., Ryan, C., Bauman, D., Bowers, S., Carreiras, J., [...] **Finckh, M.**, [...], Dexter, K. (2021) Structural diversity and tree density drives variation in the biodiversity-ecosystem function relationship of woodlands and savannas. *New Phytologist*, 232 (2), 579-594. <https://doi.org/10.1111/nph.17639>
- Gomes, A., Revermann, R., Gonçalves, F., Lages, F., Aidar, M., Sanguino Mostajo, G., **Finckh, M.** (2021) Suffrutex grasslands in south-central Angola: Belowground biomass, root structure, soil characteristics and vegetation dynamics of the ‘underground forests of Africa’. *Journal of Tropical Ecology*, 37(3), 136-146. doi:10.1017/S0266467421000298
- Gomes, A.L., Revermann, R., **Meller, P.**, Gonçalves, F.M.P., Aidar, M.P.M., Lages, F., **Finckh, M.** (2021) Functional traits and symbiotic associations of geoxyles and trees explain the dominance of detarioid legumes in miombo ecosystems. *New Phytologist*, 230, 510-520. <https://doi.org/10.1111/nph.17168>
- Schmiedel, U.**, Jacke, V., Hachfeld, B., Oldeland, J. (2021). Response of Kalahari vegetation to seasonal climate and herbivory: Results of 15 years of vegetation monitoring. *Journal of Vegetation Science*; e12927; <https://doi.org/10.1111/jvs.12927>
- Baptista, N.L., Tolley, K.A., Bluhm, M., **Finckh, M.**, Branch, W.R. (2020) Rediscovery, range extension, habitat and phylogenetic relation of the endemic Scaled Sandveld Lizard *Nucras scalaris* Laurent, 1964 (Sauria: Lacertidae) in the central Angolan plateau. *African Journal of Herpetology* 69(1), 12-28. <https://doi.org/10.1080/21564574.2020.1778108>
- Gomes, A.L., Revermann, R., Gonçalves, F.M.P., Lages, F., Aidar, M.P.M., **Finckh, M.** & **Jürgens, N.** (2019). Tree or not a tree: Differences in plant functional traits among geoxyles and closely related tree species. *South African Journal of Botany*, 127, 176-184.
- Zigelski P.**, Gomes A., **Finckh, M.** (2019) Suffrutex Dominated Ecosystems in Angola. In: Biodiversity of Angola (ed. by Huntley B., Russo V., Lages F. & Ferrand N.), pp. 109-121, Springer, Cham. https://doi.org/10.1007/978-3-030-03083-4_7

SP3-WP1: Fire experiments in Angolan grassland-woodland ecotones

Plan: We aimed to establish systematic fire experiments on geoxylic grassland or woodland habitats of the Angolan Observatories Tundavala, Cusseque, Bicular NP and eventually Cameia NP. The fire experiments were to follow a randomized block design with 3 different treatments (early dry season fire / “cold fire”; late dry season fire / “hot fire”; fire enclosure /

“control”) and 12 repetitions. The experiment were to be done at a 1 ha plot (each) with 36 permanently marked subplots of 15 m x 15 m each and a 5 m firebreak along the outer edge of the experimental plot.

Accomplishment: Systematic fire experiments have successfully been established on geoxylic grassland habitats at the Angolan Observatories Tundavala (S72), Cusseque (S74), and Bicuar NP (S75). Experimental treatments have been realized in 2019 and 2021, measurements were done in the rainy seasons 2020 and 2022. The field campaigns from mid-2020 to mid-2021 had to be cancelled due to Covid-19. Results from the Cusseque fire experiment have already been analysed and published by Meller et al (2022a), other data from the sites have contributed to the publications by Lautenschläger et al. (2022) and Meller et al. (2022b). Fieldwork on and results of the experiments have also contributed to the fire awareness film (Tool or disaster? Fires in Angola. A film by **Paulina Meller**).

Published output from this work package:

- Lautenschläger, T., Göhre, A., Ditsch, B., Baumgärtel, C., Monizi, M., [...], Lages, F., [...], **Jürgens, N., Finckh, M., Meller, P.** (2022) Sixty-seven species newly recorded for the flora of Angola: recent findings from vegetation surveys and herbarium collections. *Check List* 18 (5), 1203–1230. <https://doi.org/10.15560/18.5.1203>
- Meller, P., Frazão, R., Lages, F., Jürgens, N., Finckh, M.** (2022a) Tipping the scales: How fire controls the balance among functional groups in Angolan grasslands. *African Journal of Range & Forage Science*, 39, 56-69.
- Meller, P., Stellmes, M., Fidelis, A., Finckh, M.** (2022b) Correlates of geoxyle diversity in Afrotropical grasslands. *Journal of Biogeography*, 49, 339–352. <https://doi.org/10.1111/jbi.14305>

Film products

Tool or disaster? Fires in Angola. A film by **Paulina Meller**. University of Hamburg, 2022.

3 Essential results and cooperation with other research institutions

Essential results

Based on the continued long-term observations at the standardised biodiversity observatories and so-called auxiliary observatories, essential insights into the relative role of climatic and land-use-related drivers could be gained. Among the weather variables, seasonal conditions (e.g. temperature and precipitation during the respective growing season or at the end of the dry season) are of critical importance for the vegetation cover and number of individuals of perennial shrubs or grasses. Total annual precipitation, on the other hand, has a much smaller effect on the vegetation dynamics. These findings are important for the projections of vegetation change under climate change conditions. Changes in the rainfall patterns will have a very strong impact on the vegetation composition, even if the total annual precipitation may remain unchanged.

For detailed information on the research results please refer to part II of the report.

Cooperations with other research institutions

- Plant Conservation Unit of the University of Cape Town, South Africa: Exchange of weather and land use data for the observatories Paulshoek (S24) and Remhoogte (S25). Exchange and discussion of concepts and hypotheses on vegetation change in the Succulent Karoo.
- Bolus Herbarium, University of Cape Town, South Africa: Exchange of plant specimens and plant species identifications
- Department of Conservation Ecology, Stellenbosch University, South Africa: Joint supervision of MSc student, joint field trips, exchange of concepts and data.
- School of Climate Studies, Stellenbosch University, South Africa: Sharing of spare parts, tools and know-how for the maintenance of the SASSCAL weather stations in South Africa
- Agricultural Research Council (ARC), South Africa: Exchange of data and concepts, sharing of research infrastructure (accommodation).
- South African Environmental Observation Network (SAEON), Arid Node, South Africa: Exchange of data and concepts; joint field visits.
- Institute of Physical Geography, Goethe Universität Frankfurt, Germany: Joint field trips, joint supervision of students
- Namibian Botanical Research Institute, Namibia: Identification of herbarium specimens, discussion of conservation status of selected species. see under 2
- INBAC Angola & Bicular National Park

Module C

SASSCAL Regional Secretariat

Project term: 01.01.2019 - 31.12.2019

Reporting period: 01.01.2019 - 31.12.2019

1 Terms of reference

The project “Support for SASSCAL Science Services – Module C; Support for Organisational Strengthening of SASSCAL” aims at completing all necessary steps and provisions towards strengthening SASSCAL in terms of systems and human capital towards the realization of its goals as a Regional Science Service Centre.

The aim of the project was

- 1) Providing support for administrative operations and other institutional activities through budget support of approximately fifty percent of the 2019 operational budget,
- 2) Establishing and further implementing the SASSCAL Open Access Data Centre (OADC) incl. App-Development and internal infrastructure (LAN, WLAN, workstation computers),
- 3) Full support for the WeatherNet in terms of technical support, data collection and transfer, training of staff,
- 4) Service development for integration in the Climate Service Centre SASSCAL,
- 5) Full support of implementing new SASSCAL Graduate Schools incl. support for coordination of graduates and academic staff,
- 6) Coordination of all further research activities.

2 Planning for, and course taken by, the project

SASSCAL was established in 2012, with the Regional Secretariat based in Windhoek, Namibia and National Nodes in the member countries Angola, Botswana, Namibia, South Africa and Zambia. SASSCAL is administratively and technically operated by the Regional Secretariat. A total of 28 full-time staff members are employed to ensure the operational and administrative business of SASSCAL. In addition, four (4) staff are funded through external sources such as collaborative projects, to support the activities of the Open Access Data Centre. Three additional technical, scientific and administrative staff members were employed on externally funded projects, SEACRIFOG and WeMAST. In 2016, the re-structuring of the institution and its transformation in an international organisation started and is currently ongoing.

The overall project was guided by the SASSCAL Strategy 2.0, which provides the SASSCAL strategic roadmap. The duration of the project was scheduled for the calendar year 2019. An annual operational plan was developed at a planning meeting was held by the SASSCAL team to ensure well-coordinated implementation of SASSCAL operational, research coordination,

human capacity development and product and service provision. The annual operational plan was developed to schedule the implementation of activities and set performance areas and indicators on which project progress was benchmarked and monitored. Further activity implementation plans were developed at departmental levels.

An annual budget was developed and approved by the SASSCAL Governing Board. The budget served as the tool for resource allocation, control and monitoring. A total global budget of 2.2 million Euros was approved and funded through 50 percent contributions from BMBF and the balance from the member state contributions, fund raising efforts, African Union and European Union. By year end 92 percent of the budget was utilised on various SASSCAL activities as detailed below.

A communication and marketing strategy and plans were developed to guide the visibility efforts. A fund-raising strategy was also put in place to guide resource mobilisation efforts. These efforts were complimented by the establishment of the technical committees tasked with implementation of the strategy.

The science plan was another toll that was used to give direction to the scientific execution of the SASSCAL mandate.

3 Essential results and cooperation with other institutions

The following main results were achieved:

- 1) all administrative operations and other institutional activities were successfully performed and reported,
- 2) the SASSCAL Open Access Data Centre (OADC) incl. App-Development and internal infrastructure (LAN, WLAN, workstation computers) was strengthened by recruiting of staff, procuring of additional hard- and software as well as operating and implementing existing and new products and services,
- 3) transfer and operation of the WeatherNet in terms of technical support, data collection and transfer as well as tailored training of staff,
- 4) development of new products and services such as climate data analysis (Fact sheet) from EO-based products and WeatherNet operations and the SASSCAL Reservoir and Dam Atlas for integration in the Climate Service Centre SASSCAL,
- 5) implementing new SASSCAL Graduate Studies Programme incl. support for coordination of graduates and academic staff by conceptualising a framework programme and drafting a proposal for the implementation of the SGSP 'IWRM',
- 6) coordinating and supporting of all further research activities, including all steps towards the implementation of the SASSCAL 2.0 Research Call as well as strategic partnerships asuch as WeMAST (AU-funded), SEACRIFOG (EU-funded) and IneCRes (BMEL-funded).

During the project period, SASSCAL strengthened its collaboration with National Governments which provided co-funding to the institutions' operations by membership contributions. Here, a close working relationship was established in order to meet needs of

decision makers at policy level, national priorities and to support cross-fertilisation between ministries at national and regional level.

With the successful implementation of the 88 research projects, over 150 graduates, the establishment of the OADC, the accomplished services and the founding of a research network and infrastructure, SASSCAL has been recognised as a reliable collaboration partner.

By leading the AU-funded WeMAST project, SASSCAL works closely with the African Union Commission and contributes to continental efforts in promoting the utilization of Earth Observation Technologies for improving decision making and living standards across the continent to which SASSCAL provides technical infrastructure and capacity development support.

Based on a Memorandum of Understanding, SASSCAL works closely with the Climate Service Center Germany (GERICS) in order to benefit from experiences in climate service development and data dissemination.

Project SASSCAL: Southern African Science Service Centre for Climate Change and Adaptive Land Management

SASSCAL ABC

Final Report 2018-2022

Part II: In-Depth Description

Topic: Support for SASSCAL Science Services

Module A: WeatherNet

Module B: ObservationNet

**Module C: Support for organisational strengthening of
SASSCAL**

University of Hamburg

Project coordinator:

Prof. Dr. Norbert Jürgens

Recipient of the grant:

University of Hamburg, Hamburg**FKZ: 01LG1201N**

Module A:

Project term: 01.12.2018 - 31.08.2021**Reporting period: 01.12.2018 - 31.08.2021**

Module B:

Project term: 01.12.2018 - 31.05.2022**Reporting period: 01.12.2018 - 31.05.2022**

Module C:

Project term: 01.01.2019 - 31.12.2019**Reporting period: 01.01.2019 - 31.12.2019**

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Part II: In depth description

Module A: WeatherNet

SASSCAL Regional Secretariat and University of Hamburg

Project term: 01.12.2018 – 31.08.2021

Reporting period: 01.12.2018 – 31.08.2021

1 The achieved results

The first achieved result of the project was the establishment of an OADC WeatherNet team comprising of a data management officer and a programming/software development officer at the SASSCAL RS.

The SASSCAL UHH IT team had already been established as part of the SASSCAL coordination project (FKZ 01LG1201A) to support the implementation, operation and management of the OADC in the SASSCAL RS. The UHH IT team was primarily responsible for setting up and providing scientific/technical services in the above project. In Module A, the focus was on training measures for the OADC and ultimately the successful transfer of the entire system to the SASSCAL OADC.

Through trainings facilitated by the UHH team, maintenance and installation field trips, and self-study, the capacity of the team to assume full responsibility for the sustainable and independent long-term operation of the WeatherNet system was developed. As part of maintaining the service, the SASSCAL team supported by the UHH team was regularly involved in the following activities:

- Continuous system and infrastructure maintenance, such as operating system, application, and underlying services integrity monitoring, creating system and database backups, and implementing system fixes as required
- Data management tasks, such as data and data flow verification from AWS to the WeatherNet FTP server, data quality control and data completeness checks, committing of clean data to the web app database system and publishing of verified data of monitored climate variables to the website to enable end user access
- Supporting partners responsible for AWS in fixing data gaps, provide advice regarding possible faulty sensors, support troubleshooting activities during maintenance tours, as well as integration of new stations.
- Responding to data requests and queries from consumers
- Developing improvements to the entire system
- Preparation of reports for management and donors

Another achievement of the project was the successful transfer of the entire WeatherNet system from the UHH IT to the SASSCAL OADC. The required technical environment was

procured and configured. Several adjustments to application source code, routines and processes were undertaken to align them with the reality of the new operating environment. In steps, the online platform, FTP server, supporting tools, domain name and all the aspects of the system were operationalized in the SASSCAL environment. It's based on the success of this transfer that all services relating to the operation of the WeatherNet have been shut down in the UHH environment.

Within the scope of the project, an improved test version of the system was developed with the aim of improving user experience and data access as well as easing future maintenance of the online platform. A summary of the developed enhancements is as follows:

- Reorganized application source into Model-View-Controller design pattern which is standard in software engineering and greatly improves the maintainability of the system in the future
- Responsive user interface design that adequately caters for mobile and desktop
- A user guide accessible at <https://docs.sasscalweathernet.org/weathernet-user-guide> which gives an overview of the system and guidelines on how to use it
- Data cleaning tool for simplified and error-free cleaning of improbable data values from the administrative portal MyWeatherNet
- Sensor reactivation suggestion added to MyWeatherNet based on scheduled verification of status of sensor data for malfunctioning sensors
- Map of stations accessible at <http://dev.sasscalweathernet.org> with country filter, info box for all active (data records in the last 24 hours), and popup info box for each station with expanded information and links to other pages
- Improved data visualization through features such as custom time span views, custom parameter views, interactive charts
- Simplified data download mechanism directly accessible from the data visualization pages
- Application Programming Interface (API) for facilitated access by defined consumers such as CHC for CHIRPS, TerraClim
- Integration with OpenWeather for 48 hours and 4 days forecasting
- Integration of Analytics for impact and outreach visibility

Two by-products have resulted from the WeatherNet transfer process. A brief summary of these is as follows:

- Eumetsat Website Data Download Tool – in response to circumstances present in the WeatherNet environment for which no control is exercised such as the internet connection and a Windows version different from the Workstation in which the tool was run at UHH, a robust, platform independent tool was developed to download the

data for satellite transmission and complement SatDat in processing the data for those stations that transmit data through Eumetsat.

- WeatherNet inventory tool – in collaboration with the Ministry of Agriculture, Water and Land Reform, discussions were held with the Namibia Meteorological Service (NMS), the Ministry of Fisheries, and the Ministry of Environment and Tourism, around data exchange between the station networks of these institutions and skills exchange in the areas of station maintenance. As a starting point, an inventory tool was developed to allow the capturing of all stations by each institution so that an overview of what is present in the country can be determined. While the data sharing process is ongoing, the developed tool has been availed for similar exercises in the countries as a probe of the existing possibilities for the expansion of the network.

In summary, the project succeeded in building the necessary capacity for managing the WeatherNet system by SASSCAL OADC. The system which had been developed by the UHH IT team was successfully transferred from UHH to SASSCAL OADC and full responsibility for its operations now lies with SASSCAL OADC. Additionally, improvements to the usability of the online platform in the areas of user interface design, data representation, data access, as well as data processing from the administrative backend have been developed within the scope of the project. These improvements hold the potential of unlocking improved access and use of the WeatherNet system.

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

The relevance of the project results from the description under 1.

4 Expected benefit

There exists potential benefit for increased usage and expansion stemming from the African ownership of the platform as well as the steps already being taken to increase the usefulness of the system. The data sharing cooperation initiated with the Namibia Meteorological Service, Ministry of Fisheries, and Ministry of Environment and Tourism is a first step into capitalizing on the existing infrastructure in the countries that could benefit the WeatherNet network.

From presentations of the system to organizations such as the African Union, there is also indications of interest in collaboration that could see the platform grow into a continental service.

From the web analytics, the estimated 8,500 users visiting the WeatherNet online platform between February 2020 and October 2021 is a strong indication of the benefit and interest in the service provided.

5 Progress made at other agencies/institutions

In Angola, Botswana, and Zambia, the Departments of Meteorological Services have incorporated WeatherNet AWS into their national observation networks.

Organizations such as the Climate Hazard Center and the Centre for Geographical Analysis in the Department of Geography & Environmental Studies at Stellenbosch University have initiated exploration of the WeatherNet data for product developments.

6 Publications

Conducting presentations for potential users:

In response to an opportunity that arose during the transfer process, a poster and abstract entitled “SASSCAL WeatherNet- a Key Near Real-Time Weather Monitoring Resource for Climate Service Provision in Southern Africa” was developed and presented at the 21st WaterNet/WAFSA/GWPSA Symposium.

A presentation of the system and an accompanying comparison of data quality with other global products such as the CHC dataset CHIRPS was made at the SASSCAL Science Exhibition 2020.

An introduction to the system was given to the delegation of the African Commission during a visit in the framework of the GMES Africa programme.

Module B: ObservationNet

University of Trier

Project term: 01.09.2019 – 28.02.2021

Reporting period: 01.09.2019 – 28.02.2021

1 The achieved results

The task of developing complex data analysis tools for use by non-(remote sensing) experts basically required a large number of tests and many iterations. As a result of the different access strategies to different data types in the Google Earth Engine, this necessitated both the parallel development of different variants and frequently the revision of previously implemented procedures. Accordingly, the presentation of the results here presents the options ultimately chosen, but not the multitude of intermediate steps required for this.

Aim 1: Specification of system elements

From the possible satellite archives mentioned above, MODIS was selected as an alternative with high temporal resolution and available up to 2000, and Sentinel-2 as a recent variant with very good spatial resolution. The decisive factor here is that the data structure for different sensors in the Earth Engine is different. Therefore, for each sensor type, separate routines have to be developed to access time series, read out the respective quality flags for each scene and pixel, and so on. These scripts were developed and tested for both target sensors.

The Enhanced Vegetation Index (EVI) was chosen as the target variable to be used, which, in contrast to older vegetation indices, is more robust against surface background and atmospheric influences. It can be calculated on the basis of all sensors that have channels in the visible blue and red as well as in the near infrared, thus allowing a cross-platform analysis. To keep the temporal resolution as high as possible, the identical sensors on the Terra and Aqua platforms were also used for MODIS. Since these platforms orbit the Earth at different times, this results in a higher temporal coverage. Thus, for MODIS, the EVI product contained in the MYD13Q1 product (Collection 6) was used directly as in the Earth Engine, while for Sentinel-2 the index is calculated individually from the atmosphere-corrected Sentinel-2 Level 1-C product.

Feedback from potential users showed that the interest was less in highly complex time series analyses or the analysis of derived metrics. Rather, parameters should also be directly ascertainable and interpretable for users with less technical affinity. Accordingly, the EVI was used directly. In order to enable a relative evaluation, the seasonal, long-term reference frame was also to be derived dynamically.

For the embedding of the fires, it was defined as an important point that their occurrence should take place as directly as possible with the representation of the vegetation dynamics. After evaluating different options, the MODIS Burned Area product MCD64A1 was selected, which identifies fire-influenced regions at monthly resolution and 500*500m². The different temporal resolutions of the vegetation and fire parameters made a temporal adjustment necessary.

Aim 2: Technical implementation

The technical implementation of all necessary steps was carried out using the object-based programming language Javascript, for which the Google Earth Engine provides a variety of data objects for accessing different data pools and using raster and vector structures. In addition, there are options for visual representation or graphical export of data, although these options are not the focus of the cloud functionality and are therefore somewhat reduced.

The previously defined use of vegetation index data and fire data initially required the implementation of special access routines. Here, it was particularly important to realise options for the selection of certain time periods as well as the limitation of the evaluated spatial section. It should be possible to view the complete SASSCAL area as well as a defined area around certain observatories.

Regarding the selection of target parameters, feedback from potential users showed that they were less interested in highly complex time series analyses or the analysis of derived metrics. Rather, parameters should also be directly ascertainable and interpretable for users with less technical affinity. Accordingly, the EVI was used directly; however, in order to ensure a relative evaluation, the seasonal, long-term reference should be presented. This allows a better assessment of the ecological status, but requires the statistically exact estimation of this long-term average with dynamic adjustment to the corresponding seasonal period. The necessary estimators were implemented in such a way that for each period the 5% percentile is estimated as the lower limit and the 95% percentile as the upper limit, and this again for both sensor types. Another representation option based on this is the calculation of the temporal residuals, i.e. the direct representation of the respective deviation from the seasonal mean. This allows a direct identification of extreme events, which can then be analysed further.

The representation of the flagged fire events was then carried out by assigning the detected month to the respective midpoint of the month in order to enable a direct combination with the EVI time series.

Aim 3: Implementation of a web-based user interface and download option

The Google Earth Engine is designed as a platform for accessing very large data archives and their server-side processing, while its use as a graphical user interface takes a back seat to specially configured solutions. Nevertheless, it is possible to develop and configure so-called apps. Various adjustments were necessary, especially for the presentation of the time series, in order to keep the integrated time series plots clear and comprehensible. Individual elements of the central app are illustrated below.

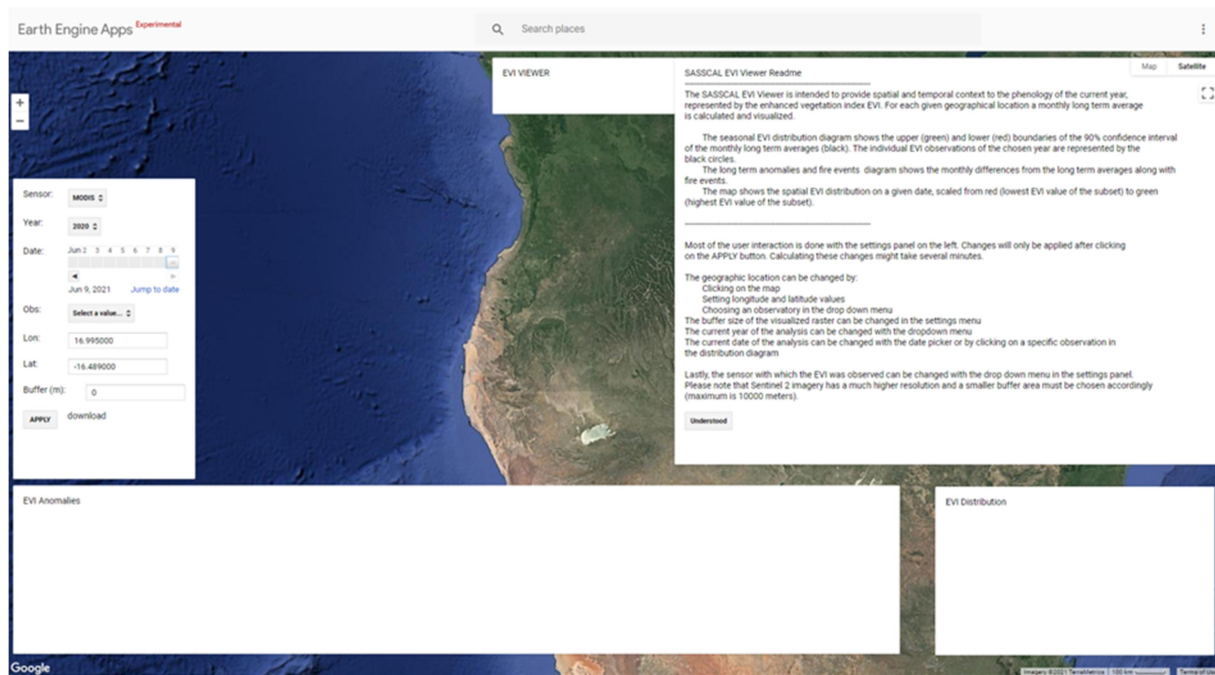


Figure 1: Start screen of the app with opened explanation infobox.

Figure 1 shows the start screen of the EVI Viewer. The two plot windows are empty without selecting a target region; the start text is displayed as a readme and explains basic functions of the app.

The central control element is located on the left side of the window and is shown enlarged again in Figure 2.

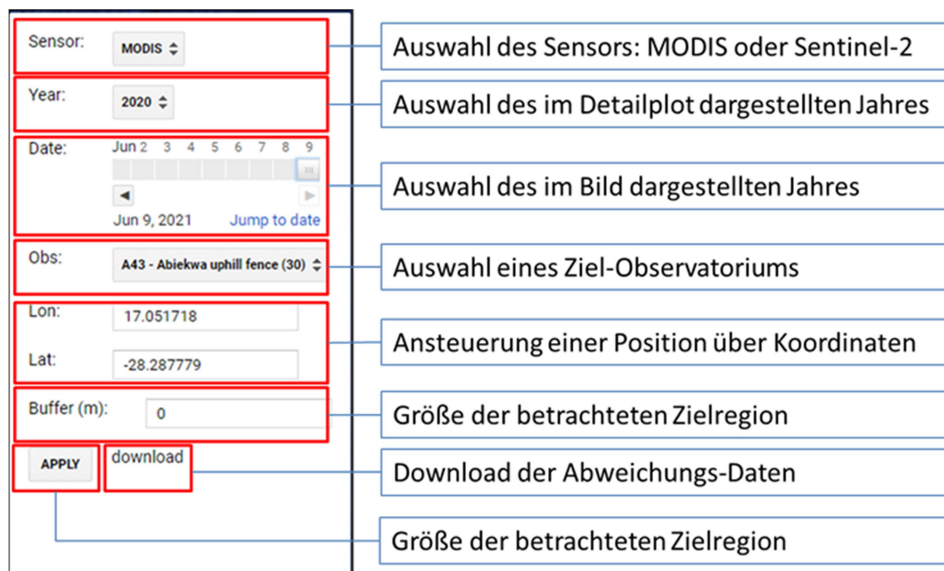


Figure 2: the central control element of the EVI Viewer for the selection of sensors, target regions and time periods.

All currently existing biodiversity observatories are stored with their ID in the corresponding drop-down menu, while alternatively the selection of a target region can also be made by

directly entering geographical coordinates or by clicking on a location on the map. Likewise, it is possible to use Google's location search and then click on the corresponding destination point. The buffer function is important to avoid selecting unnecessarily large areas and thus long processing times. However, if the buffer remains at the value 0, the EVI image shown is calculated for the entire SASSCAL space (compare Fig. 3).

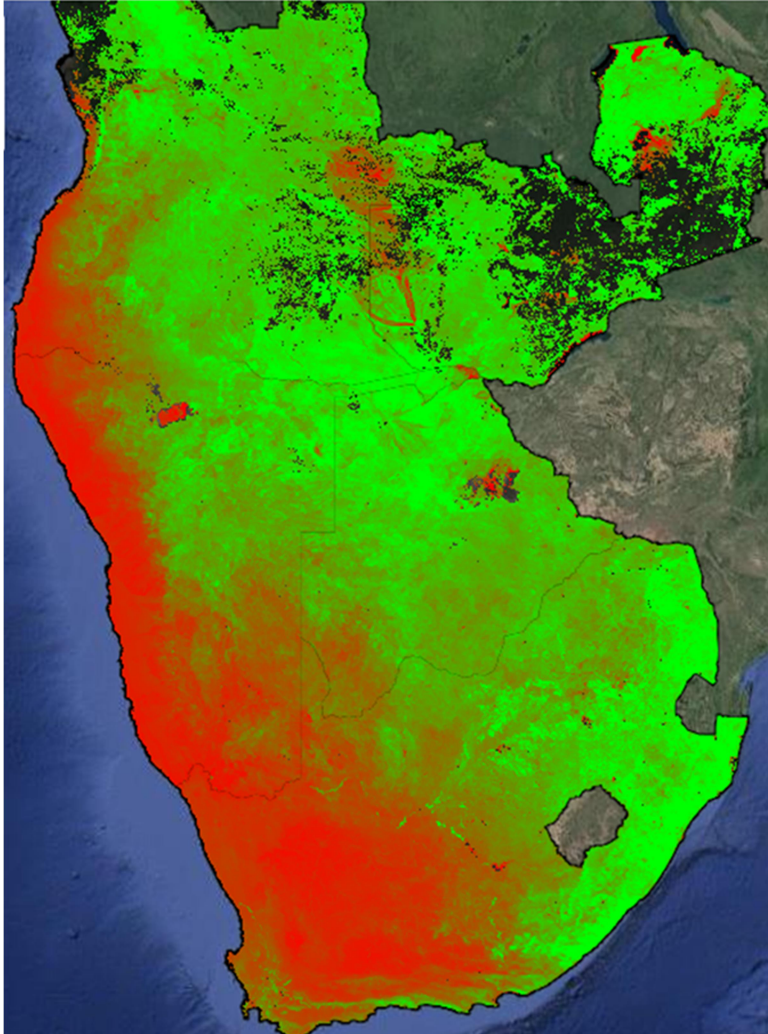


Figure 3: Exemplary EVI presentation of the SASSCAL region.

For a detailed assessment of more precisely defined points, coordinates, map points or the observatories can be used as mentioned. Figure 4 shows the corresponding screen for the example of Observatory S53 - Kafue National Park and for the 10*10m2 resolved Sentinel-2. This national park in Zambia is dominated by extensive grasslands, individual tree and shrub savannahs and the central Lake Kafue. Directly adjacent to the national park, smallholder agriculture has been expanding in recent years. In addition, Figure 5 and Figure 6 show the time series plots already described.

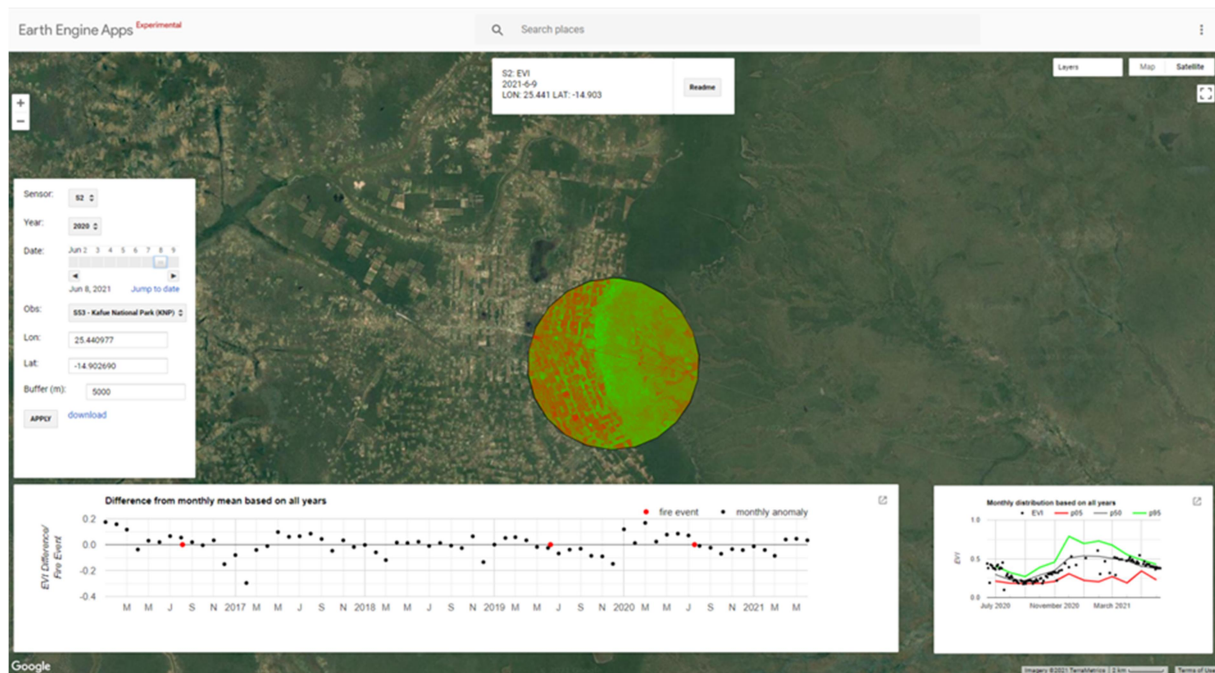


Figure 4: EVI Viewer start screen for Observatory S53 - Kafue National Park.

In contrast to the very high temporal resolution of the MODIS-based series, the advantage of the Sentinel-2 data shown here is above all the significantly higher geometric resolution, which is able to clearly reproduce the landscape structures.

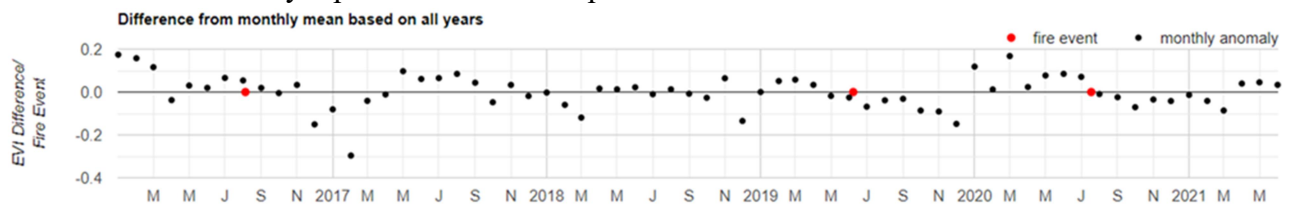


Figure 5: EVI trend since 2016 - monthly deviations from the long-term average and occurrence of fire events.

Figure 5 shows the so-called anomalies, i.e. the respective deviation of the monthly aggregated EVI value relative to the long-term average.

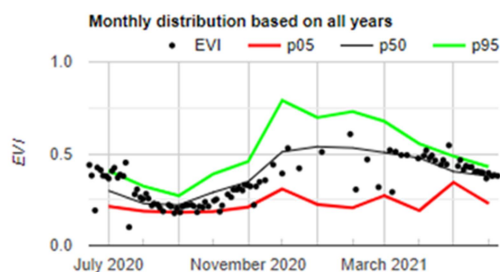


Figure 6: Annual EVI trend over the past year. Dots correspond to individual recordings; red, green and black line correspond to the long-term 5% and 95% percentile and the median, respectively.

Figure 6 shows in detail the corresponding course of the last year, including all available individual images at the selected location. A special feature is the possibility to access the

respective scene by clicking on one of the individual points and to display it as an image for the selected radius.

Both individual plot windows allow the respective enlargement to the full screen and, via this, also the direct data download as a table.

In addition, passing a URL with string elements for the selected observatory, sensor and time period allows generating predefined plots and thus offers another possibility to integrate the functionality of the app directly into the SASSCAL ObservationNet.

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

The monitoring capacity established within the framework of SASSCAL and previous projects (in particular Biota-Africa and The Future Okavango, both funded by BMBF) includes comprehensive documentation of biodiversity and its change at many sites, as well as a growing number of climate stations. Both components are indispensable elements of a long-term monitoring concept for biodiversity and climate change. An accompanying use of the capacities made available by a series of operational Earth observation missions appears indispensable in view of the size of the area under consideration.

So far, however, the necessary analyses are limited to dedicated remote sensing analyses due to the enormous amount of data, processing capacities and data transfer volumes, and not least the necessary expert knowledge in special programming and data analysis. Similarly, users from other groups (e.g. local stakeholders, biodiversity research) could benefit significantly from direct data access based on standardised methods, and are not interested in in-house data processing and analysis.

The tool presented here closes this gap by providing access to two of the most important sensor systems, the derivation of ecologically clearly defined and relevant status quo parameters for ecosystems, and the illustration via comprehensible time series profiles and satellite-based vegetation density maps, which in turn are directly linked to biodiversity. As a result of the continuous, iterative coordination process between technical development and users, the focus of the work was on developing the corresponding interfaces and adapting the functionality in such a way that different users can use it intuitively and interpret it directly.

It should be emphasised that all components are based on freely accessible data archives and platforms.

4 Expected benefit

As already mentioned, the EVI viewer developed here closes a gap between the need of many user groups for easily applicable remote sensing data and the technically highly complex field of evaluating huge data archives between remote sensing and data science. Accordingly, the application can be used by interested researchers in the field of biodiversity research, land management, etc. and by selecting target regions, a wide variety of studies can be supported. Through download options for the different time series, further statistical evaluations are also possible.

At the same time, the presentation of monthly deviations from the long-term average, as well as the integration of data on fire events, allows intuitive use also for non-scientific users, e.g. regional and national administrations, extension officers, etc.

The modular structure of the tool allows it to be expanded to include further sensors and products, as well as the integration of further indices or derived parameters. By transferring the most important control variables via the URL, it is also possible to visualise information directly parameterised for specified targets (e.g. observatories), points in time or sensors and thus enable direct integration into own websites (e.g. SASSCAL ObservationNet).

Last but not least, the scalability via petabyte servers allows the expansion of the module to further countries or regions.

5 Progress made at other agencies/institutions

Currently, there are 2 relevant projects based on Google Earth Engine that deal globally with deforestation (<https://earthenginepartners.appspot.com/science-2013-global-forest>) and the development of open water resources (<https://global-surface-water.appspot.com/>). Both are significant examples of the use of complete sensor archives (here: Landsat) via the Google Earth Engine, but otherwise have no intersection with the tool developed here.

The GEOGLAM RAPP project for "Rangeland and Pasture Productivity" provides globally derived productivity parameters for pasturelands (<http://map.geo-rapp.org/>). However, it is based on a fixed spectral analysis model developed for Australia and is intended for rangelands only and is only available at relatively coarse resolutions (500 x 500 m). Furthermore, there is no direct access to the underlying data, but new data layers are added at regular intervals. Nevertheless, large capacities were invested in the development of a dedicated user interface that can be configured independently of predefined GUI objects as in the Earth Engine.

Thus, it can be stated that no comparable system is yet available for the question of an application for the use of remotely sensed time series for ecosystem monitoring and biodiversity research in the SASSCAL region.

6 Publications

This is a purely technical development of a code for data processing and illustration on the Google Earth Engine. A direct scientific publication is not planned, but with increasing use of the tool there is the possibility that the functionality will enable further analyses and thus ultimately contribute to scientific publications.

Publications based on using this tool:

Gomes, A., Revermann, R., Gonçalves, F., Lages, F., Aidar, M., Sanguino Mostajo, G., **Finckh, M.** (2021) Suffrutex grasslands in south-central Angola: Belowground biomass, root structure, soil characteristics and vegetation dynamics of the ‘underground forests of Africa’. *Journal of Tropical Ecology*, 37(3), 136-146. doi:10.1017/S0266467421000298.

Namibia University of Science and Technology (NUST)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 The achieved results/content

SP1-WP1: Scientific analyses and academic publications of existing time series and regional transects

One Master's thesis was successfully completed by Ms Leena Naftal, entitled '*Assessing the likelihood of vegetation composition shifts under climate change scenarios along a climatic gradient in Namibia.*' This thesis used vegetation data from the Biodiversity Observatories along the main north-south transect in Namibia, as well as gap-filling vegetation survey data, to model the present climatic and environmental niche of present-day vegetation, as well as to model the potential distribution of these vegetation types under climate change scenarios. A paper on this thesis is in an advanced stage of preparation and is to be submitted soon for publication.

An initial dataset of 2136 relevés, selected from the Namibian Phytosociological Database covering the BIOTA transect from Kavango West through to Karas Region (Karios observatory) was cleaned by identifying outliers, specifically relevés from azonal vegetation. This data set was used to model the species distribution along the north-south aridity gradient, and to predict potential shifts in species distribution due to climate change.

To determine dominant plant species distribution along this transect, a classification on the vegetation data was done using a cluster analysis in PC-Ord and a classification of eight (8) groups was developed (Fig.7).

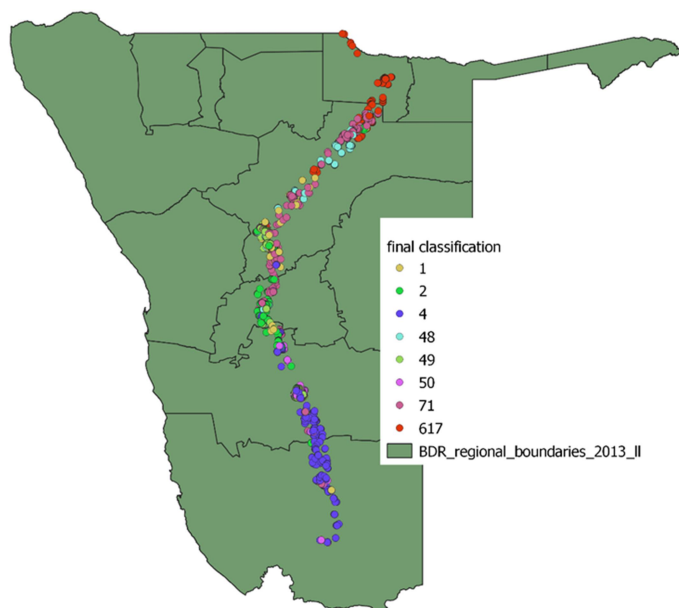


Figure 7: Initial classification results of relevés selected along the original BIOTA transect, representing an aridity transect, in Namibia.

The indicator species and their indicator values, relative abundance and frequency to these groups were recorded. A few selected indicator species within each of these 8 groups were modelled to determine their shift with regards to climate change. This work was undertaken by Ms Leena Naftal as part of her Masters studies.

We presented long-term results of the project at the following international conferences:

- Grassland Society Congress, Uppington, RSA, July 2019
- International Symposium of the Vegetation Scientists, Bremen, July 2019
- 2nd Drone users conference for Agriculture and Nature Conservation, Stellenbosch / online, November 2021
- South African Association of Botanists, Potchefstroom / online, January 2022

SP1-WP4: Sharing research outcomes with land-management stakeholders in arid rangelands

Due to lockdown and social distancing in response to Covid-10 pandemic, the planned stakeholder workshop had to be cancelled. The outreach activities were limited to media like radio or newspaper. In 2020 B. Strohbach gave a short interview on long-term trends in vegetation for the *Landboujournaal* (a farmer's information programme) on a local radio station (*Kanaal 7*).

Ms Nambwandja (working on SP2-WP3) shared her research activities and findings in the Afrikaans *Republikein* newspaper on the 29th of May 2020 (Fig. 8) (Innovative research in the Namib Desert) and explained how she spent her time during this difficult time of the pandemic.



Figure 8: Newspaper clip from the *Republikein*, 29 May 2020.

We presented long-term results of the project at the local farmers' days of the Rietfontein Farmer's Association in March 2022.

SP2-WP1: Continuation and streamlining of the annual vegetation assessment at the Observatories

We managed to resurvey the following Biodiversity Observatories:

- 2019: Erichsfelde, Gellap Ost and Nabaos
- 2020: Mile 46, Mutompo, Sonop, Erichsfelde, Omatako Ranch, Gellap Ost and Nabaos
- 2021: Mile 46, Mutompo, Sonop, Erichsfelde, Omatako Ranch, Gellap Ost and Nabaos
- 2022: Mile 46, Mutompo, Sonop, Erichsfelde and Omatako Ranch

The data has been digitalised, cleaned and shared with the University of Hamburg.

SP2-WP3: Technical innovation: biodiversity monitoring using UAV technology

Throughout the existence of the biodiversity observatory network, large emphasis was placed on the monitoring of floristic diversity on the observatories. Additionally to the ground-based field surveys, we started to do annual high-resolution aerial surveys of biodiversity observatories, in order to get a comparable series of baseline data of the observatories. During the project phase, we were able to do repeat aerial surveys of most of the Biodiversity Observatories as follows:

- 2019: 10 Observatories
- 2020: 14 Observatories
- 2021: 17 Observatories
- 2022: 18 Observatories

Next to supplementing the regular monitoring, we started to develop an individual-based monitoring scheme for larger woody species based on a species map of each observatory. We have undertaken an in-depth survey of tree and shrubs at the Erichsfelde Observatory (Fig.9) and a number of associated study sites on the farm. The aim was to use this data in conjunction with monthly-repeated aerial imagery of the site, to validate an estimation of the woody biomass. This work is undertaken in collaboration with the Pasture Science Division of the MAWLR and the GIZ Bush Utilization Project.

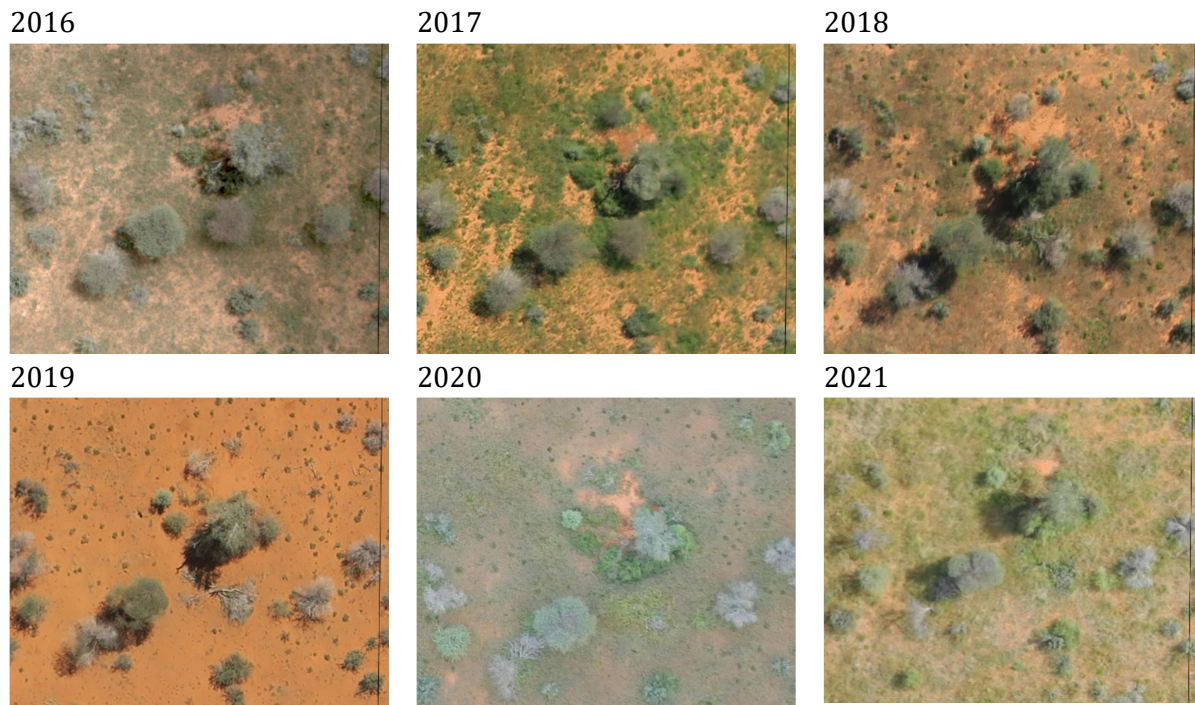


Figure 9: Time series of a portion of Hectare 3 at Erichsfelde Biodiversity Observatory that shows the dynamics of the phanerophytes and grass layer. All images were collected during the growing season (February to April) of the respective year.

A special case for drone monitoring is the coastal lichen fields. Next to being unique in size and composition, these are also under threat by specifically off-road driving as well as potentially by climate change due to retreating fog regimes and changing wind regimes. The coastal observatories of Kleinberg (S34) and Wlotskas Baken (S16) have been established exactly for the purpose of studying the lichen field dynamics. Through the FogNet initiative (SASSCAL 1.0, Task 054), an additional array of weather stations has been established along a coast –inland transect (or decreasing fog –increasing rainfall gradient). With the availability of NIR capability, it is possible to monitor the vigour of the lichens. In this context, several auxiliary observatories associated with the FogNet array in the Central Namib have been resurveyed repeatedly.

We are in the process of establishing a metadatabase of available aerial imagery with the help of the SASSCAL OADC and will in due course share this data with the OADC.

One paper on the status of the endemic *Euryops walterorum* has been published: ‘*Euryops walterorum*, a declining restricted-range endemic of the Greater Gamsberg’ (*Namibian Journal of Environment*, **5** (A), 25–38.). In the Appendix, a detailed monitoring proposal based on the Biodiversity Observatories Model is presented.

One Master’s thesis was successfully completed by Ms Ailly Nambwandja, entitled ‘*The assessment of UAV-based multispectral imagery to monitor lichen-dominated biological soil crusts response to fog and disturbances, Central Namib*’. From this thesis, two manuscripts have been prepared, which are currently being readied for publication: ‘*Optimizing the use of UAV-based multispectral imagery to monitor lichen-dominated biological soil crusts in the hyper-arid central Namib Desert*’ as well as ‘*The application of UAV multispectral imagery*

to assess the coverage, disturbance, and fog response of lichen-dominated Biological Soil Crusts in the Central Namib'. These two papers are also intended to be submitted for publication this year still.

SP3-WP2: Bush encroachment, water distribution and soil erosion at the landscape level

During the course of the project we established a series of ground-water monitoring stations in a river catchment on the farm Erichsfelde, in a landscape very similar to the observatory. Within this catchment, we cleared a portion of a temporary wetland of encroaching shrubs, using the cut branches as a weir to reduce water flow and allow both sedimentation and infiltration of water into the soil profile (Fig.10).



Figure 10: Clearing within the Omuramba system at Erichsfelde. Top left – before clearing, 4 August 2020, top right – after clearing, 20 November 2020, and bottom – view of the brush packing to retard water flow in the water flow.

Baseline data was collected, covering soil types, vegetation composition, and, by way of high-resolution aerial imagery, also the topography of the catchment, covering roughly 650 ha. We established a monitoring system on this catchment, which can run for a number of years, to monitor the effect of debushing in such a catchment system, as well as the overall dynamics of both the phanerophytic and graminoid vegetation.

In addition, we collected grass composition data on a number of farms with the arid Thornbush savanna of Namibia to study the effect of bush clearing. For all sites, the bush has been cleared a number of years ago already, and a secondary vegetation state has been established.

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

All work undertaken for this project was necessary and appropriate.

4 Expected benefit

The available data will be further analysed over the next months and years and published as far as possible. In this line a number of proposed papers are listed below (point 6b). This list is not exhaustive; the listed papers are deemed the most important at this stage.

Two PhD studies could not be completed within the timeframe of this project. This is due in part to an over-commitment workwise (in the case of Ms Celeste Espach, who is also Deputy Dean of the Faculty of Engineering and the Built Environment within NUST) or a too short time frame to monitor change, with only two seasons of data available (in the case of Mrs Christa D'Alton, working on work package SP3WP2).

In the case of Ms Espach (working on '*Using UAV technology for tree and shrub species identification for long-term monitoring purposes in the Thornbush savanna of Namibia*'), all required data has been collected. Ms Espach plans to take sabbatical leave within the next two years, to complete her thesis.

A planned Master's thesis by Mr Bernadus Tshelakgosi ('*Determining the comparative accuracy of satellite imagery (Sentinel 2) vs UAV's imagery to measure the bare ground fraction across differing soil types*') is currently on halt due to work commitments of the student at UNAM. In principle, sufficient data is available for this work to be completed without further financial input.

The monitoring work for SP3WP2 is presently continuing, using funds of NUST for the purpose (also with in-kind support by the farm management of Erichsfelde). We hope that through the next season (until July 2023) we have sufficient data available on the soil moisture distribution within the catchment, to come to a meaningful result in order for Mrs D'Alton to complete her thesis and/or publish results.

5 Progress made at other agencies/institutions

None

6 Publications

Completed publications:

- Treichel, C., Strohbach, B.J., Carr, S., Loots, S. & Neckel, A. (2021) *Euryops walterorum*, a declining restricted-range endemic of the Greater Gamsberg. *Namibian Journal of Environment*, 5 (A), 25–38.
- Wildermuth, B., Oldeland, J., Arning, C., Gunter, F., Strohbach, B. & Jürgens, N. (2022) Spatial patterns and life histories of *Macrotermes michaelsoni* termite mounds reflect intraspecific competition: insights of a temporal comparison spanning 12 years. *Ecography*, n/a (n/a), e06306.

Theses:

- Naftal, L. (2022) Assessing the likelihood of vegetation composition shifts under climate change scenarios along a climatic gradient in Namibia. Master of Natural Resources Management. Namibia University of Science and Technology, Windhoek.
- Nambwandja, A.N. (2022) The assessment of UAV-based multispectral imagery to monitor lichen-dominated biological soil crusts response to fog and disturbances, Central Namib. Master of Natural Resources Management. Namibia University of Science and Technology, Windhoek.

Publications in planned or in progress:

- Naftal, L., De Cauwer, V. & Strohbach, B.J., (in prep.) Potential distribution of major plant species under climate change scenarios along an aridity gradient in Namibia. *Vegetation Classification and Survey*.
- Nambwandja, A.N., Knox, N.M., Strohbach, B.J., Marais, E.M. & Maggs-Köling, G. (in prep.) The application of UAV multispectral imagery to assess the coverage, disturbance, and fog response of lichen-dominated Biological Soil Crusts in the Central Namib. *Remote Sensing*.
- Nambwandja, A.N., Knox, N.M., Strohbach, B.J., Marais, E.M. & Maggs-Köling, G. (in prep.) Optimizing the use of UAV-based multispectral imagery to monitor lichen-dominated biological soil crusts in a low vegetated covered hyper-arid Central Namib Desert. *Remote Sensing of Environment*.
- Strohbach, B.J. & D'Alton, C.D. (in prep.) Vegetation changes in an arid Thornbush savanna in Central Namibia over six decades. *Vegetation Classification and Survey*.
- Strohbach, B.J., D'Alton, C.D. & Naftal, L. (in prep.) Are we losing our perennial grasses? Long-term trends in the arid Thornbush savanna of Namibia. *African Journal of Range and Forage Science*.
- Strohbach, B.J., Nambwandja, A.N. & Maggs-Köling, G. (in prep.) Tracks in the Desert: How severe is the problem in the Central Namib? *Namibia Journal of Environment*.

Instituto Superior de Ciências de Educação da Huíla (ISCED-Huíla)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 The achieved results

SP1-WP1: Contributions to publication projects

The Fabaceae data were aggregated with those of the SASSCAL Biodiversity Observatory Network for a transect-wide analysis of Fabaceae diversity and dominance (Fig.11). At the end of the project we were checking the grass IDs, whose data will be used for the same purpose. PhD-student R. Frazão is working on this task.

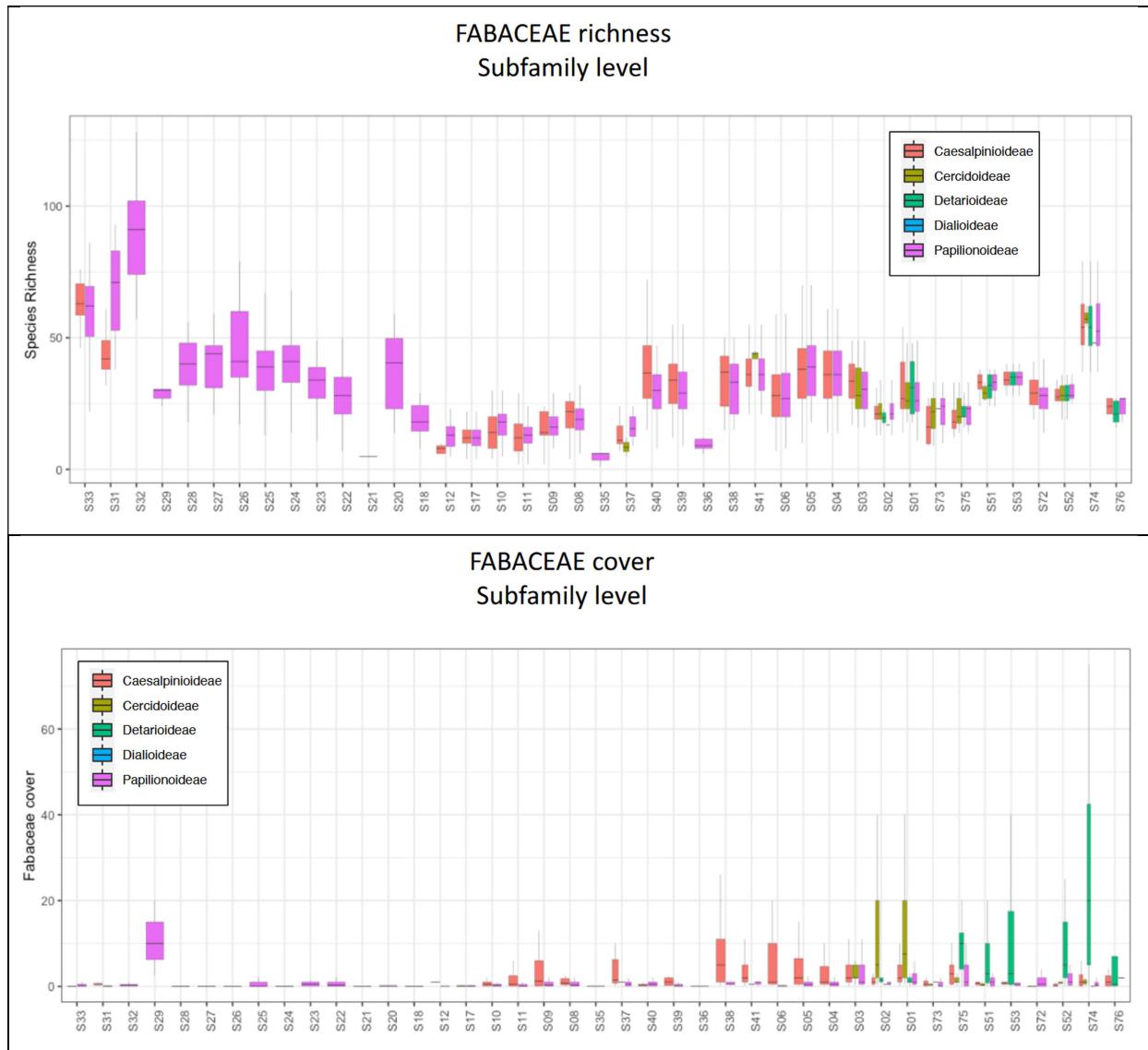


Figure 11: Box-and-whisker plots of species richness and cover of Fabaceae subfamilies along the transect of Biodiversity Observatories from south (left) to north (right). The plots show the dispersion of the respective parameter in the 20 analyzed 1-hectare plots of each observatory.

Results of the Fabaceae analyses done by R. Frazão (Fig.11) show the turnover of subfamilies along the Biodiversity Observatory gradient through southern Africa, with highest species richness and clear predominance of Papilionoideae in the south and increasing subfamily-turnover towards the north, with Caesalpinioideae getting more species rich in the thornbush savannas and then Detarioideae gaining importance in the miombo ecosystems.

Still more relevant in a functional sense is the corresponding analysis of Fabaceae-subfamily dominance in terms of vegetation cover (as a proxy for biomass and ecosystemary importance). The highly diverse Papilionoideae in the southern part of the Observatory transect play only a little role in their respective ecosystems, while Caesalpinioideae dominate the thornbush savannas in the central part of the transect and Detarioideae dominate the miombo ecosystems. This turnover is not only of botanical relevance, but has relevant global biogeochemical implications considering the different N and P capturing strategies of Caesalpinioideae versus Detarioideae.

SP1-WP3: Recommendations on fire management

We supported the fire-awareness film project lead by UHH by field assistance and Portuguese synchronisation (for details see UHH – Angola working group – SP1-WP3).

Although it was not possible to organize the national fire workshop during the project implementation period, it is being prepared for early 2023. The objective is to inform and discuss with stakeholders and resource managers the objectives of fire management and adequate fire prevention strategies.

SP2-WP1: Annual vegetation assessment at the Observatories

Species composition and characterization of the Tundavala Observatory (S72)

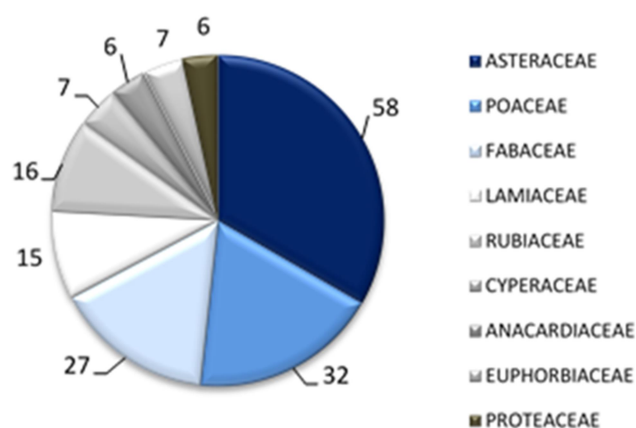


Figure 12: Species numbers of the most frequent plant families at Tundavala Observatory (S72).

So far, 306 species were recorded at the Tundavala Observatory, and 88% of them were identified, belonging to 73 families and 186 genera. The most represented families are shown in Figure 12. Asteraceae, Poaceae, and Fabaceae account for ca. 40% of the total species.

Woody species (trees, shrubs and subshrubs) are predominant, comprising about 57% of the total number of species. Perennial species (woody, bulbous and most graminoid species) account for 79% of the species recorded (Figure 13).

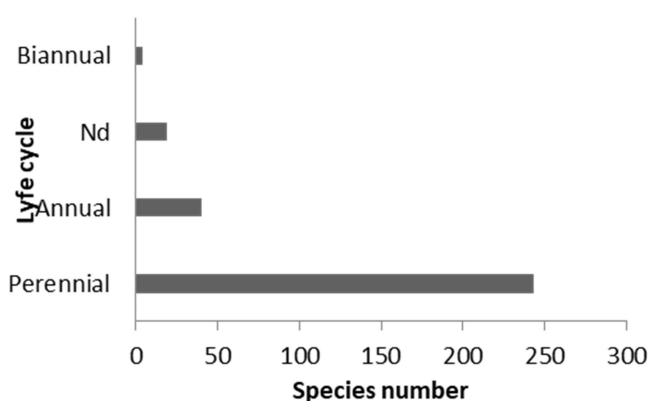


Figure 13: Life cycle of the plant species at Tundavala Observatory (S72). Nd – not determined

In the grassland habitat, a significant number of geoxylic species sensu lato (Fig.14) were found to occur, characterized by a reduced aerial part compared to the well-developed belowground one, with woody roots, rhizomes and tubers serving as storage organs and shoot bank.

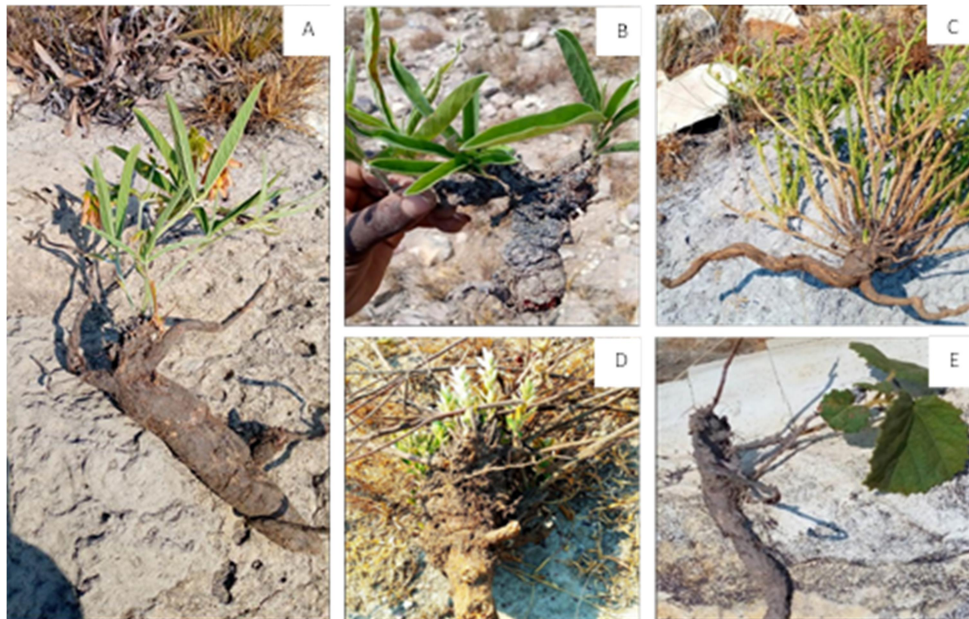


Figure 14: Geoxyles from the Tundavala Observatory. A- *Eriosema gossweillerii* (endemic); B- *Droogmansia megalantha*; C- *Geigeria acicularis* (endemic); D- *Gnidia kraussiana*; E- *Triumphetta geoides*.

Species richness and diversity

A significant difference was found in the species richness of the two habitats (Fig.15) ($t=2.8$, $p<0.05$), habitat 1 ($S=57\pm9$; min=35, max=69), habitat 2 ($S=73\pm18$; min=51, max=95). The biodiversity indices Shannon-Wiener ($H'>3.5$), Simpson ($1-D\approx 0.9$), and Pielou ($J\approx 1$), evidenced a high floristic diversity and uniformity of the species distribution in the Observatory. The similarity analysis showed a clear separation of the two habitats, with a similarity of approx. 30%, with 137 species exclusive of the shrubland habitat and 73 of the grassland habitat.

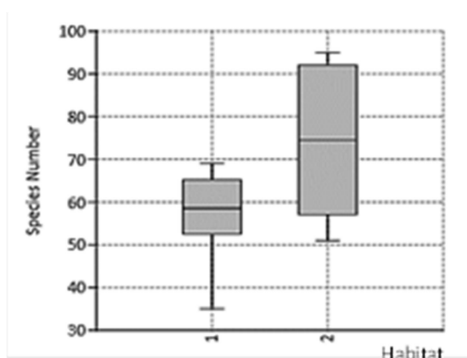


Figure 15: Box-and-whisker plots of total species richness. Habitats: 1: grassland; 2: shrubland

Endemism

Although a significant number of species have not yet been identified (12%), we have confirmed 43 endemic species, i.e., an endemism rate of around 13%. Two of them are new to science – *Barleria crabbeoides* and *Barleria rupicola* (Darbyshire et al., 2019; Darbyshire et al., 2020) – and twelve are only recorded in a small area at the edge of the Lubango escarpment, in the Angolan Afromontane Forest-Grassland Mosaic ecoregion.

The conservation status of these species was not assessed, but their restricted known range, exposure to several anthropogenic stressors and climate change are strong signals that they might be vulnerable. Only two species are on the IUCN red list and none is on Angola's red list nor on the recent publication on Angola's threatened plants (Costa et. al., 2019). Therefore, it is a priority to conduct studies leading to the characterization of the current situation of these species (distribution areas, population size, habitat conditions, anthropic pressures) and do a risk assessment under IUCN criteria.

Vegetation cover

Land cover was also determined for each plot (20 x 50) by visual estimation of vegetation, minerals (gravels, rocks, stones, fine sands) and termite mounds covers. In 2019/2020 we also used aerial images obtained with a Drone, model DJI Phantom 4RTK, at a height of 25 m above the central point of the plot. As shown in Figure 16, the vegetation cover gradually increased over the monitoring period. To assess the significance of the observed differences, a One-way ANOVA was performed which confirmed that the observed differences are statistically significant ($F=26.12$, $p<0.05$). Tukey's test showed that the years 2020 and 2021 are significantly different from the other years, and a significant difference also exists between these two years. Vegetation cover may vary depending on climatic conditions, being affected by seasonal patterns and annual rainfall, as well as by factors such as grazing intensity and the occurrence of fires (Karl et al., 2016). There is also the influence of observer bias, as cover value estimates vary slightly from observer to observer and may show differences between observers and from year to year (Fenner, 1997; Karl et al., 2016).

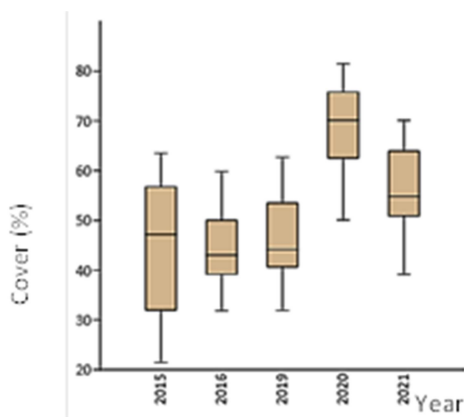


Figure 16: Variation in vegetation cover over the monitoring period.

The observed differences are most likely the result of a combination of the different factors mentioned above. The high cover values recorded in 2020 are probably influenced by the high

precipitation that occurred in that year, reaching 1800 mm, which is 50% above the average of 1200 mm characteristic of the region.

Threats

The level of anthropization in the Tundavala Observatory is high – on the grasslands mainly due to the presence of cattle throughout the year and the fires induced by shepherds in the dry season; on the rocky area due to the felling of trees characteristic of this habitat, such as *Protea gaguedi*, *Faurea rochetiana* and *Dombeya* sp.. The main threats are trees felled for firewood and charcoal, an increase in livestock density, the exploitation of rocks for construction purposes, poaching of small animals, urban waste disposal, regular fires, and the introduction of exotic species (e.g. *Acacia mearnsii* that was recently planted as an ornamental and is invading the grassland habitat). We could not assess the impact of these disturbance factors on biodiversity, so studies are needed to find appropriate measures for their mitigation and ecosystem conservation. A report on conservation issues for the Afromontane archipelago on the Huíla Plateau is in preparation.

References:

- Costa E., Adão T., Pedro M., Catarino S., Romeiras M.M. (2019). Plantas ameaçadas em Angola-estado atual. Revista Internacional em Língua Portuguesa, 35, 31–43. <https://doi.org/10.31492/2184-2043.RILP2018.35/pp.31-43>
- Darbyshire, I., Anderson, S., Asatryan, A. et al. (2017) Important Plant Areas: revised selection criteria for a global approach to plant conservation. Biodivers Conserv, 26, 1767–1800 (2017). <https://doi.org/10.1007/s10531-017-1336-6>
- Darbyshire, I., Tripp, E. A., & Chase, F. M. (2019). A taxonomic revision of Acanthaceae tribe Barlerieae in Angola and Namibia. Part 1. Kew Bulletin, 74(1), 1–85.
- Darbyshire, I., Tripp, E., Crawford, F., & Barker, A. (2020). Barleria crabbeoides. The IUCN Red List of Threatened Species 2020: e.T154071884A154074759. 1–3. <https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T154071884A154074759.en>
- Fenner, M. (1997). Evaluation of methods for estimating vegetation cover in a simulated grassland sward, Journal of Biological Education, 31(1), 49-54, <https://doi.org/10.1080/00219266.1997.965553>
- Hassler, Michael (2004 - 2022). World Plants. Synonymic Checklist and Distribution of the World Flora. Version 14.1. www.worldplants.de.
- Karl, J. W., Karl, M. J. S., McCord, S. E. & Kachergis, E. (2016). Critical Evaluations of Vegetation Cover Measurement Techniques: A Response to Thacker et al. Rangelands 38(5), 297–300. <https://doi.org/10.1016/j.rala.2016.08.005>

SP3-WP1: Fire experiments

We supported our colleagues from UHH M. Finckh and P. Meller in the fire experiments at the Biodiversity Observatories of Cusseque, Tundavala and Bicular. Three students were trained in fire handling, related vegetation measurements and analyses. A publication with results of the fire experiment at Cusseque Observatory was published in the *African Journal of Range & Forage Science* (Meller et al., 2022).

Capacity building

Our team included 3 students who were trained in fieldwork methodologies (botanical surveys, fire experiments), data acquisition, processing and analysis. An undergraduate work has been completed and the PhD study is still in progress.

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

All work undertaken for this project was necessary and appropriate.

4 Expected benefit

The immediate plan is to prepare biodiversity portfolios of the Cusseque and Tundavala Observatories, as a base for proposing the establishment of areas of special protection. The region has great scientific relevance and is the most studied grassland ecosystem in Angola and a world reference for studies on geoxylic grasslands. The same status will be requested for the Tundavala region as it is located in one of tropical Africa's centers of endemism, constituting a distinct floristic bioregion (Droissart et al. 2018), but without any formal protection. We will propose it be designated as a Tropical Important Plant Area (TIPA), based on the criteria by which they are defined: the presence of threatened species, exceptional botanical richness and threatened habitats (Darbyshire et al., 2016).

5 Progress made at other agencies/institutions

The first Biodiversity Observatories in Angola were implemented five years before the Government of Angola launched the National Strategy for Climate Change 2018-2030, which states the establishment of biodiversity monitoring plans on a national scale. We have been invited to be engaged in related government programs, namely: to be part of the technical group created by the National Institute of Biodiversity and Conservation Areas (INBAC) to conduct the assessments for the review and update of the Angolan Red List; integrate the scientific commission of the Government's program for the reforestation of degraded areas.

6 Publications

Gomes, A., Revermann, R., Gonçalves, F., **Lages, F.**, Aidar, M., Sanguino Mostajo, G., Finckh, M. (2021) Suffrutex grasslands in south-central Angola: Belowground biomass, root structure, soil characteristics

- and vegetation dynamics of the ‘underground forests of Africa’. *Journal of Tropical Ecology*, 37(3), 136-146. doi:10.1017/S0266467421000298
- Gomes, A.L., Revermann, R., Meller, P., Gonçalves, F.M.P., Aidar, M.P.M., **Lages, F.**, Finckh, M. (2021) Functional traits and symbiotic associations of geoxyles and trees explain the dominance of detarioid legumes in miombo ecosystems. *New Phytologist*, 230, 510-520. <https://doi.org/10.1111/nph.17168>
- Lautenschläger T, Göhre A, Ditsch B, Baumgärtel C, Monizi M, [...], **Lages F.**, [...], Jürgens N, Finckh M, Meller P (2022) Sixty-seven species newly recorded for the flora of Angola: recent findings from vegetation surveys and herbarium collections. *Check List* 18 (5), 1203–1230. <https://doi.org/10.15560/18.5.1203>
- Meller, P., **Frazão, R.**, **Lages, F.**, Jürgens, N., Finckh, M. (2022) Tipping the scales: How fire controls the balance among functional groups in Angolan grasslands. *African Journal of Range & Forage Science*, 39, 56-69.
- Gomes, A.L., Revermann, R., Gonçalves, F.M.P., **Lages, F.**, Aidar, M.P.M., Finckh, M. & Jürgens, N. (2019). Tree or not a tree: Differences in plant functional traits among geoxyles and closely related tree species. *South African Journal of Botany*, 127, 176-184.
- Zigelski, P., Rudolph, B., Oldeland, J., **Lages, F.**, Jürgens, N., Finckh, M. (2019) The Tough, the Wet and the Hidden: Evolutionary Strategies of a Polyploid Tropical Tree in a Changing Environment. *Perspectives in Plant Ecology, Evolution and Systematics* 38, 1-12. <https://doi.org/10.1016/j.ppees.2019.03.001>

In preparation:

A vascular plants checklist and analysis of diversity and endemism patterns in the Tundavala Observatory

Conservation issues for the Afromontane archipelago on the Huíla Plateau

University of Hamburg (UHH)

Project term: 01.12.2018 - 31.05.2022

Reporting period: 01.12.2018 - 31.05.2022

1 The achieved results

SP1-WP1: Scientific analyses and academic publications of existing time series and regional transects

The time series analyses of the vegetation data from the biodiversity observatories have produced new insights into vegetation dynamics and its controlling factors in the study area. Quantitative time-series analyses for Observatories in the Succulent Karoo and in the Savanna have confirmed that vegetation dynamics are habitat-specific. In the Kalahari, these are the soil-water enriched dune crests or slopes compared to the shallow and drier dune valleys. In the Succulent Karoo, the dynamics of vegetation crest or upper slope sites can be distinguished from those of lower slope and valley sites.

Strong interactions between vegetation, seasonal weather conditions and density of grazing (large antelope) or browsing herbivores (springbok) could be established for the long-term dynamics the South African Kalahari Observatory (Fig.17, Fig.18): Seasonal weather conditions and the density of large game and springbok had the strongest effects on the abundance of the respective life form types. In contrast, the total annual precipitation had no effect. The predominantly grazing large game had positive effects on the abundance of forbs and dwarf shrubs. The predominantly browsing springbok had negative effects on perennial grasses, dwarf shrubs and trees. The trends in abundance of individual life forms over the entire time period (increase in annuals and decrease in perennial grasses and shrubs, increase in large shrubs) and decrease in total annual cover indicate early stages of vegetation degradation and shrub encroachment in response to herbivory and climate (Schmiedel et al. 2021 *JVS*).

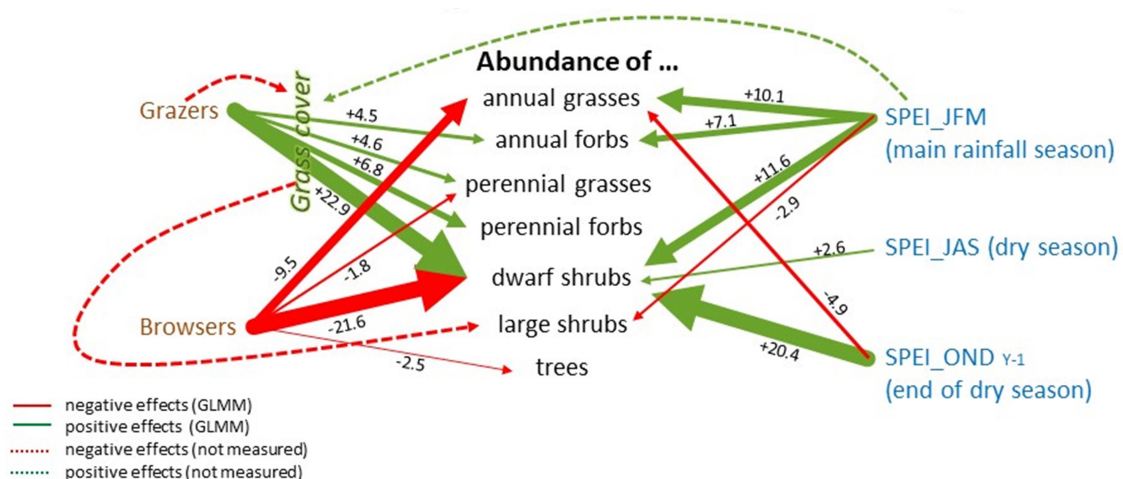


Figure 17: Synoptic summary of the main results from timeseries analyses (Generalised linear mixed models, GLMM) of the plant life forms in response to seasonal climatic conditions and game density (separated into grazers and browsers) and the interaction among them (dotted lines) at the Observatory Alpha S17. (Schmiedel et al. 2021 *JVS*).

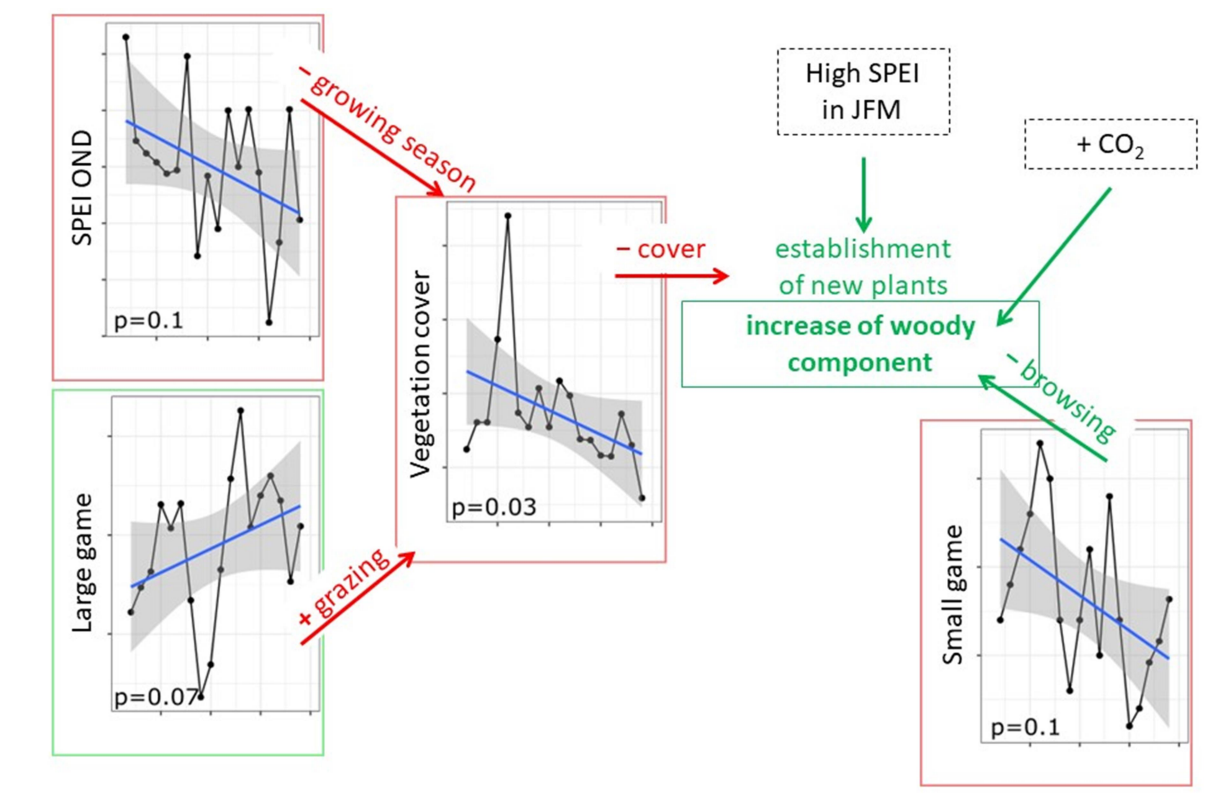


Figure 18: Trends in the main drivers and their projected effect on vegetation change (increase in woody component) as emerged from the timeseries analyses of the Alpha Observatory S17 (Schmiedel et al. 2021 *JVS*).

Results from the fence-line contrast at both the Paulshoek and Remhoogte observatories in the Succulent Karoo also show strong relationships between seasonal weather conditions and vegetation (Fig.19). All life form types responded positively to moist conditions during the main growing season (July - September). Humid conditions towards the end of the dry season were crucial for shrub survival! This has also been shown by timeseries analyses for other observatories (e.g. for the Observatory Soebatsfontein (S22), Schmiedel & Oldeland 2018 *AJRFS* and for the Kalahari (S17), Schmiedel et al. 2021 *JVS*, Schmiedel 2021 *Habilitation thesis*). Analyses of precipitation patterns have also shown that as a consequence of a decreasing trend in the duration of the rainy season over the study period of almost 20 years the plant growing season tended to become shorter. Due to the dependence of plants on relatively wet and cool conditions towards the end of the dry period, this trend of a shortened growing season will foreseeably have a negative impact on vegetation in the study area. The evaluations have also made it clear that spatially specific and temporally highly resolved weather data are a necessary prerequisite for analyses of vegetation time series.

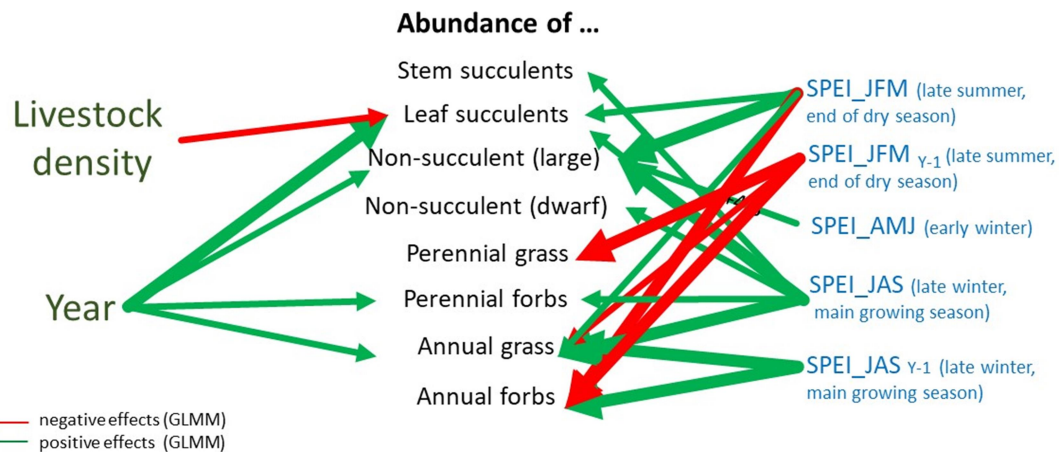


Figure 19: Synoptic summary of the main results from timeseries analyses (Generalised linear mixed models, GLMM) of the plant life forms in response to seasonal climatic conditions, livestock density and time (year) at the Observatories Paulshoek (S24) and Remhoogte (S25). SPEI = Standardised Precipitation Evaporation Index (Schmiedel et al. in prep.).

Analyses of biodiversity parameters for the Soebatsfontein Observatories (S22, S23) over the years 2002-2019 showed decreasing trends for the Shannon and the Evenness index. The biodiversity parameters on the habitat types Plain and Upper Slope /Top of the Soebatsfontein Observatory differed significantly from each other.

The biodiversity parameters for Paulshoek (S24) and Remhoogte (S25) showed increasing trends in species richness (S) and the Shannon index over the observation period. The Shannon index and the equal distribution were significantly higher on the lightly grazed plots of the Remhoogte observatory than on the heavily grazed observation plot of Paulshoek (S24) (Wolanksy 2021 *BSc thesis*).

The permanent observation plots in the South African Richtersveld are among the longest documented vegetation time series on the continent. Twelve of the plots were first surveyed in February 1980 and provide information on the development over a period of 42 years. Currently, 58 plots of 100 m² area each are being revisited regularly; 18 of the plots were established as adjacent contrasts of (a) plots fenced in and (b) plots freely accessible to game and grazing animals. For the international conference on global Mediterranean ecosystems (Medecos) held in South Africa in September 2022, N. Jürgens evaluated some of the plots exemplarily and presented the dramatic collapse of the biotic communities of at the conference. The collapse was the results of 10 consecutive years of severe droughts, i.e., years with total annual rainfall far below the long-term mean of 85 mm (Fig.20). The presented data will now be analysed with the replicates and then published. As far as we know, no such dramatic collapse of such species-rich vegetation (up to 72 species per 100 m²) has been documented anywhere in the world before. Therefore, we will also make the data available to IPCC and IPBES at an early stage. To amend the botanical monitoring, time series data on processes in and around colonies of the termite species *Psammotermes allocerus* and *Microhodotermes viator* at the Observatories Numees (S20), Koeroegabvlakte (S18) and Groot Derm (S21) have been recorded in detail for more than a decade. The data have been analysed and will be published by Jürgens et al. (2022 *Biodiversity & Ecology* 7).

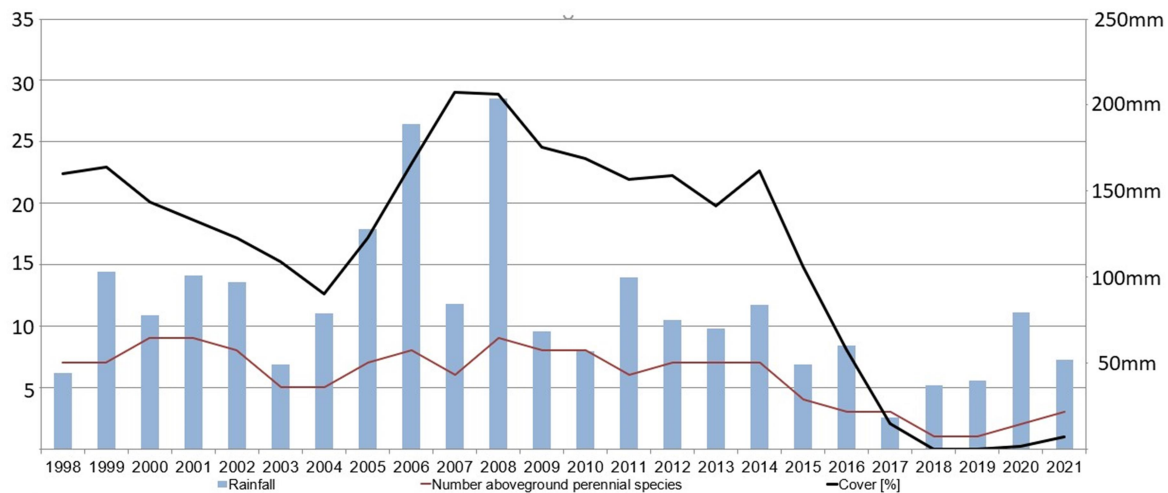


Figure 20: Long-term dynamics of the number of perennial species and cover in relation to total annual rainfall for the plot Numees 3 in the Richtersveld, South Africa, as an example for the dynamics on 15 monitored plots of the *Brownanthus pseudoschlichtianus* vegetation community.

Similar to the Richtersveld, but somewhat less pronounced, the region around the Fish River Canyon and the Karios Observatory (S12) in Namibia have also experienced a very severe drought. Accordingly, only dying plant populations could be recorded over several years. In particular, the populations of the arboreal *Aloidendron dichotomum* (quiver tree) and the stem succulent *Euphorbia gregaria* have declined drastically. The timeseries analyses allow the interpretation of various processes triggered by climate and biological interactions from 2001 to 2022. The Karios Observatory (S12) will continue to be documented by N. Jürgens after the end of the SASSCAL ABC project.

The auxiliary observatories in the drylands of Namibia Dieprivier (A01), Giribesvlakte (A02), Leopard Rock (A03), Featherlion Hill (A04), Marienfluss (A05), Hartmann Plains (A06), Welwitschia Vlake (A09), Rössing Mountain (A10), and Tses have been documented botanically and with regard to termites and ants by Norbert Jürgens in recent years. For Dieprivier (A01), Giribesvlakte (A02), Leopard Rock (A03), Featherlion Hill (A04), Hartmann Plains (A06) and Tses, extensive surveys with game trap cameras and time-lapse cameras were also carried out. The results were published in great detail in Jürgens et al. (2022 *Biodiversity & Ecology* 7).

The Fabaceae data from the Angolan Biodiversity Observatories were aggregated with those of the wider SASSCAL Biodiversity Observatory Network for a transect-wide analysis of Fabaceae diversity and dominance (see above report by ISCED-Huila). At the end of the project we were checking the grass IDs, whose data will be used for the same purpose. PhD-student R. Frazão is working on this task.

However, the planned publications on distribution, plant functional types and dynamics of phanerophytic Fabaceae and grass species along the southern African transect are delayed due to difficult academic support conditions of R.Frazão. Travel conditions during COVID-19 periods inhibited her participation in training courses and summer schools. The research and

support triangle of Angola (research site), Lisbon (place of residence), and Hamburg (University for PhD) turned out to be particularly difficult under these conditions.

In addition, we have contributed vegetation and environmental data from the Angolan Biodiversity Observatories to several international data initiatives such as the Global Index of Vegetation-Plot Databases (GIVD), SEOSAW, sPlot and SoilTemp (Fig.21) and have participated in several prominent publication projects with these data

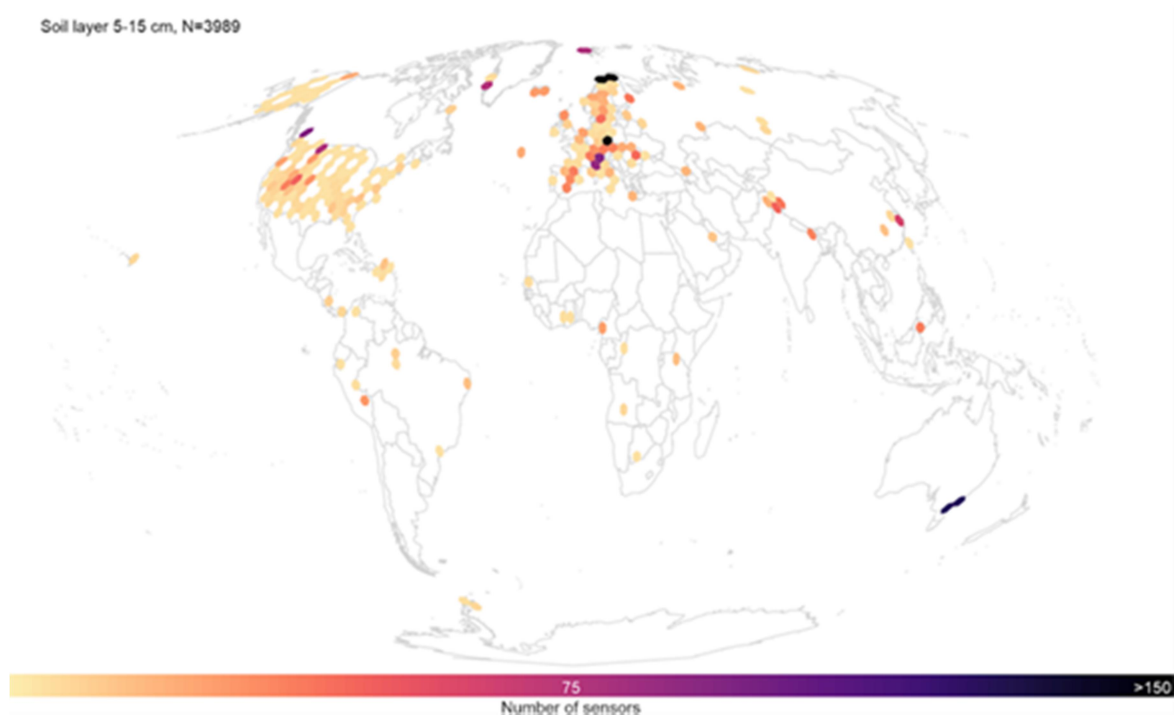


Figure 21: Global distribution of all global soil temperature data series in the soil depth 5–15 cm ($n = 3,989$) (from Lembrechts et al, 2022). The data sets from the Cusque Observatory are the only available data series from the Miombo Biome and show the importance of instrumented permanent monitoring plots for global modelling and earth system science.

SP1-WP3: Recommendations on fire management

We assembled and reviewed most published information on wild fires in Angola and the relevant studies on wild fires in the wider Miombo region (Milestone M1). We also produced the planned awareness film on wild fires in Angola (Milestone M4) (Tool or disaster? Fires in Angola. A film by **Paulina Meller**. University of Hamburg,) in German, English and Portuguese versions (Fig.22, top).

In addition, we also produced a film on forest destruction in Uíge Province (with fire playing an important role) (Conservation or destruction? The future of the Uíge mountain ranges. A film by Paulina Zigelski. University of Hamburg, 2020. (Fig.22, bottom)

English: <https://vimeo.com/405416258>; German: <https://vimeo.com/404927217>; Portuguese: <https://vimeo.com/405444927>



**Ferramenta
ou desastre?**

Incêndios em Angola

Um filme de Paulina Meller



Conservação ou destruição? O futuro das
serras de Uíge

NOCH NICHT BEWERTET

2 years ago | Mehr

 Biodiversity Research Africa [+ Folgen](#)

Figure 22: The Portuguese version of the fire awareness film (top) and the film on forest destruction in Uíge Province (bottom).

Due to travel and meeting restrictions imposed by COVID19, it was so far not possible to realize the planned Angolan fire workshop with Angolan national, provincial and technical authorities (Milestone M2). The Higher Polytechnic Institute of Tundavala (ISPT) agreed to host the workshop in the first semester 2023, taking the opportunity to disseminate the awareness-raising film on wildfires in Angola produced by P. Meller. The planned technical framework for sustainable fire management in central Angola (Milestone M3) was to be developed based on the stakeholder Feedback on the workshop and, thus, has neither been realized so far.

SP1-WP4: Sharing research outcomes with land-management stakeholders in arid rangelands

Accomplishment:

The planned community workshops for Soebatsfontein (S22/S23) had to be postponed twice and finally cancelled altogether because of the Covid-19 pandemic. In October 2021 and September 2022, Ute Schmiedel was invited by the manager of the Knersvlakte Nature Reserve (Cape Nature) in the Western Cape of South Africa to participate as a Knersvlakte specialist in an Open Day for local land users and officials of the Department of Agriculture in 2021 and 2022. The event was attended by landowners, land users and department officials from the area surrounding the nature reserve. The aim of the event was to discuss ecological restoration measures and the role of geological formations for ecology and land use. During the events, Ute Schmiedel also reported on the SASSCAL research activities and research results from the region, from which important knowledge for ecological restoration can be derived.

In addition, Ute Schmiedel maintained intensive cooperation with the local nature conservation authority. The subject of the cooperation was, among others, the development of a restoration plan for the reserve and the species identification of confiscated, illegally collected plants for the legal prosecution of the perpetrators, but also the further training of the staff of the local nature conservation team, as well as the joint evaluation of the ecological restoration measures carried out in 2020 in the nature reserve.

Due to the problematic pandemic situation and the accompanying contact restrictions, great emphasis was placed on publishing articles in journals for the general public. The most recent article in *Landbouweekblad* (Genis, 2022) summarises the main observations on the consequences of the ongoing drought on the Karoo vegetation of South Africa. The article is based on findings by Schmiedel and colleagues from the Department of Agriculture, Western Cape, South Africa.

To discuss the value and strategies of the involvement of grassroots scientists into transdisciplinary research projects, U.Schmiedel was invited by the Teaching and Learning and the Citizen Science Special Interest Groups of the British Ecological Society for a workshop in July 2022 to talk about her experience with the involvement of paraecologists as citizen scientists into environmental monitoring projects in southern Africa. A report on the meeting has been published on the 1st of September 2022 in the Blog of the British Ecological Society's Teaching and Learning Special Interest Group

(<https://bestteachingandlearning.wordpress.com/2022/09/01/upskilling-citizen-scientists-for-future-professions-a-meeting-report/>).

N. Jürgens shared the timeseries data on population dynamics of species of the genus *Aloe* / *Aloidendron* (see also report on SP2-WP1) with the research community and the Species Survival Commission of the IUCN during a workshop in February 2021.

SP2-WP1: Continuation and streamlining of the annual vegetation assessment at the Observatories

Accomplishment: The South Africa team at UHH continued the annual monitoring of 11 biodiversity observatories as planned, namely on the following observatories: S17 Alpha (South African Kalahari), S18 Koeroegabvlakte, S20 Numees, S21 Groot Derm, S22 Soebatsfontein, S23 Soebatsfontein exclusure, S24 Paulshoek, S25 Remhoogte, S26 Goedehoop, S27 Ratelgat, S28 Moedverloren. Observatories S18-28 are situated in the Succulent Karoo of South Africa. Only for the year 2020 had the monitoring to be interrupted for all South African observatories due to national and international travelling restrictions that were related to Covid-19 pandemic. N. Jürgens also continued to monitoring the observatory S12 Karios in southern Namibia. For the Knersvlakte (Observatories S26-S28) the species dataset of the monitoring data was amended by literature-based functional plant traits (Scheithe 2020 BSc thesis) and for Soebatsfontein observatories (S22, S23) by plant palatability values that have been generated from farmers' interviews and input from various specialists and translated into a grazing value map for the Soebatsfontein commonage (Dannecker 2020 BSc thesis). For the scientific outcomes of the monitoring activities and publications emerged from it, please refer to report on SP1-WP1 Scientific analyses and academic publications of existing time series and regional transects.

Angola: all botanical surveys in Tundavala Observatory as well as data processing and analysis were conducted on time, led by ISCED. The vegetation assessment at the other Angolan biodiversity observatories was done as far as possible under the COVID-19 restrictions in 2020 and 2021. Three of the five other Angolan Observatories have been monitored at least once during the project period.

Data and results from this work package have contributed to a number of high ranking publications. Meller et al (2022b), Finckh, Wendefuer & Meller (2021), Gomes et al. (2021a + b), Baptista et al. (2020), and Gomes et al. (2019) are all directly based on research from the Angolan Biodiversity Observatories. In addition, data from the Angolan Observatories have contributed to the publications by Lautenschläger et al. (2022) (Fig.23), Godlee et al. (2021), and Zigelski, Gomes & Finckh (2019).



Figure 23: New plant species records for Angola: *Crinum binghamii* Nordal & Kwembeya and *Cyperus majestuosus* (P.A.Duvign. & G.Léonard) Bauters (Abb. #6) from Cameia NP Observatory (S76).

SP3-WP1: Fire experiments in Angolan grassland-woodland ecotones

Systematic fire experiments have successfully been established on geoxylic grassland habitats at the Angolan Observatories Tundavala (S72), Cusseque (S74), and Bicular NP (S75). Experimental treatments have been realized in 2019 and 2021, measurements were done in the rainy seasons 2020 and 2022. The field campaigns from mid-2020 to mid-2021 had to be cancelled due to Covid 19. Results from the Cusseque fire experiment have already been analysed and published by Meller et al (2022a) (Fig.24), other data from the sites have contributed to the publications by Lautenschläger et al. (2022) and Meller et al. (2022b). Fieldwork on and results of the experiments (Fig. 25) have also contributed to the fire awareness film (Meller, P., Tool or disaster? Fires in Angola. Hamburg, 2022).

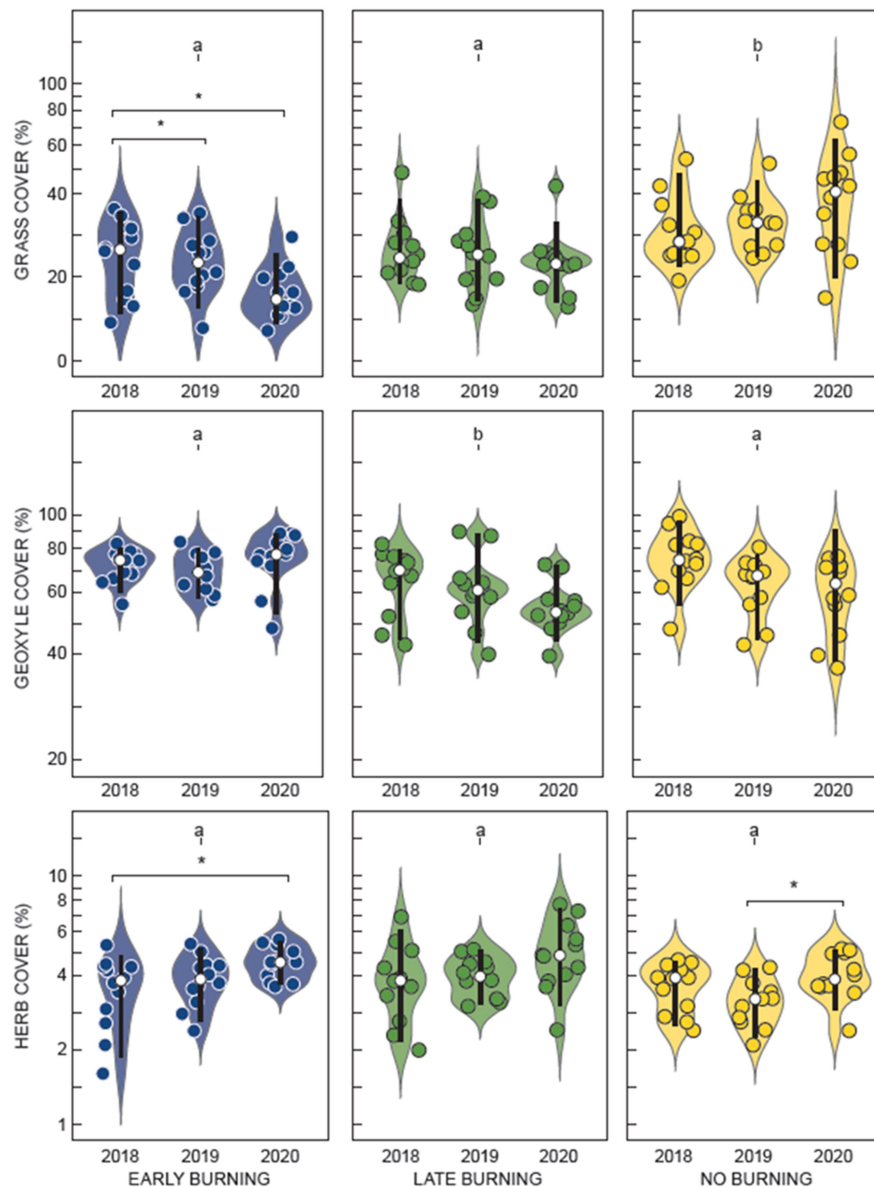


Figure 24: Percentual cover of grasses, geoxyles and herbs over the fire experiment in Cusseque (2018 to 2020). The violin plots show the differences between the experimental treatments per functional group. Die Violin-Plots zeigen die Unterschiede zwischen den Versuchsvarianten und die Entwicklung im Laufe der Zeit für jede funktionelle Gruppe getrennt (top: grasses; medium: geoxyles; bottom: herbs) sowie die statistische Auswertung (Meller et al. 2022a, *African Journal of Range & Forage Science*).



Figure 25: Fire experiments - early dry season fire at Bicuar National Park (left side) and late dry season fire at Tundavala (right side).

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

All work undertaken for this project was necessary and appropriate.

4 Expected benefit

The time series on vegetation, its diversity and its environmental drivers such as weather and land use at the observatories now cover a period of more than 20 years. Time series data of this dimension in time and space are unique in Africa and beyond. The time series and spatial data sets on diversity patterns in the western part of Southern Africa have been used in various analyses of global diversity patterns and their changes, leading to better understanding of global vegetation and biodiversity change. The detailed recording of the collapse of entire biotic communities as a result of the now ten-year extreme drought in the South Africa-Namibia border region will allow unique analyses of tipping points and cascade effects or regeneration processes. The data are therefore invaluable for further science analyses, for decisions on land-use planning and conservation management, for projections of climate change effects and the writing of national reports on the state of biodiversity has already become clear. To assess and project the continued and increasing effects of climate change on vegetation, biodiversity and sustainable land use as well as to assess economic development plans of biodiverse landscapes, the benefit of these datasets will only increase in future.

5 Progress made at other agencies/institutions

Until today, no comparable network of standardised long-term monitoring sites have been implemented in the region. The network therefore represents a unique resource for global change data in southern Africa. The international framework of GEO BON, the Group of Earth Observations - Biodiversity Observation Network, regularly highlight the value of long-term data sets and the important information that can be derived from them.

6 Publications

Scientific publications

2022

- Eibes, P., Schaffrath, F., Oldeland, J., Thormählen, W., **Schmiedel, U.**, Irl, S. (2022) Testing the concept of edaphism for the quartz island flora of the Knersvlakte, *South Africa. South African Journal of Botany*, 151, 555-64.
- Gunter, F.**, Oldeland, J., Picker, M.D., Henschel, J.R., **Jürgens, N.** (2022) Cryptic subterranean diversity: Regional phylogeography of the sand termite *Psammotermes allocerus* Silvestri, 1908 in the wider Namib region, *Organisms Diversity & Evolution*, 1-12.
- Lautenschläger, T., Göhre, A., Ditsch, B., Baumgärtel, C., Monizi, M., [...], Lages, F., [...], **Jürgen,s N.**, **Finckh, M.**, **Meller, P.** (2022) Sixty-seven species newly recorded for the flora of Angola: recent findings from vegetation surveys and herbarium collections. *Check List* 18 (5), 1203–1230. <https://doi.org/10.15560/18.5.1203>
- Lembrechts, J.J., van den Hoogen, J., Aalto, J., Ashcroft, M.B., De Frenne, P., [...], **Finckh, M.**, [...], Lenoir, J. (2022) Global maps of soil temperature. *Global Change Biology*, 28 (9), 3110-3144. <https://doi.org/10.1111/GCB.16060>
- Meller, P.**, Frazão, R., Lages, F., **Jürgens, N.**, **Finckh, M.** (2022a) Tipping the scales: How fire controls the balance among functional groups in Angolan grasslands. *African Journal of Range & Forage Science*, 39, 56-69.
- Meller, P.**, Stellmes, M., Fidelis, A., **Finckh, M.** (2022b) Correlates of geoxyle diversity in Afrotropical grasslands. *Journal of Biogeography*, 49, 339–352. <https://doi.org/10.1111/jbi.14305>
- Oldeland, J., **Gunter, F.**, **Jürgens, N.** (2022) Ecological niche models of *Welwitschia mirabilis* and its subspecies in the Namib desert. *South African Journal of Botany*, 148, 210-217
- Rodríguez-Caballero, E., Reyes, Andrés, Kratz, A., Caesar, J., Guirado, E., **Schmiedel, U.**, Escribano, P., Fiedler, S., Weber, B. (2022) Effects of climate change and land use intensification on regional biological soil crust cover and composition in southern Africa. *Geoderma*, 406, 115508. <https://doi.org/10.1016/j.geoderma.2021.115508>
- Sperandii MG, de Bello F, Valencia E, Götzenberger L, Bazzichetto M, Galland T., [...], **Jürgens, N.**, [...], **Schmiedel, U.**, [...] et al. (2022) LOTVS: A global collection of permanent vegetation plots. *Journal of Vegetation Science*. 33(2): e13115.
- Wildermuth, B.**, Oldeland, J., Arning, C., **Gunter, F.**, Strohbach, B., **Juergens, N.** (2022) Spatial patterns and life histories of *Macrotermes michaelsoni* termite mounds reflect intraspecific competition: insights of a temporal comparison spanning 12 years. *Ecography*, 9, e06306

2021

- Eibes, P.M., Oldeland, J., Irl, S.D.H., Twerski, A., Kühne, N. & **Schmiedel, U.** (2021) Partitioned beta diversity patterns of plants across sharp and distinct boundaries of quartz habitat islands. *Journal of Vegetation Science*, 32. <https://onlinelibrary.wiley.com/doi/abs/10.1111/jvs.13036>

- Finckh, M.**, Wendefeuer, J., **Meller, P.** (2021) Frost-driven lower treelines in Angola and their implications for tropical forest-grassland mosaics. *Journal of Vegetation Science*, 32 (5). <https://doi.org/10.1111/jvs.13084>.
- Godlee, J., Ryan, C., Bauman, D., Bowers, S., Carreiras, J., [...] **Finckh, M.**, [...], Dexter, K. (2021) Structural diversity and tree density drives variation in the biodiversity-ecosystem function relationship of woodlands and savannas. *New Phytologist*, 232 (2), 579-594. <https://doi.org/10.1111/nph.17639>
- Gomes, A., Revermann, R., Gonçalves, F., Lages, F., Aidar, M., Sanguino Mostajo, G., **Finckh, M.** (2021) Suffrutex grasslands in south-central Angola: Belowground biomass, root structure, soil characteristics and vegetation dynamics of the ‘underground forests of Africa’. *Journal of Tropical Ecology*, 37(3), 136-146. doi:10.1017/S0266467421000298
- Gomes, A.L., Revermann, R., **Meller, P.**, Gonçalves, F.M.P., Aidar, M.P.M., Lages, F., **Finckh, M.** (2021) Functional traits and symbiotic associations of geoxyles and trees explain the dominance of detarioid legumes in miombo ecosystems. *New Phytologist*, 230, 510-520. <https://doi.org/10.1111/nph.17168>
- Gonçalves, F.M.P., Chisingui, A.V., Luís, J.C., Rafael, M.F.F., Tchamba, J.J., [...], **Finckh, M.**, **Meller, P.**, **Jürgens, N.**, Revermann, R. (2021) First Vegetation-Plot Database of Woody Species from Huíla Province, SW Angola. *Vegetation Classification and Survey*, 2, 109-116. <https://doi.org/10.3897/VCS/2021/68916>
- Jürgens, N.**, **Gunter, F.**, Oldeland, J., Gröngroft, A., Henschel, J.R., Oncken, I. & Picker, M.D. (2021b) Largest on earth: Discovery of a new type of fairy circle in Angola supports a termite origin. *Ecological Entomology*, 46, 777-789.
- Jürgens, N.**, Oncken, I., Oldeland, J., Gunter, F. & Rudolph, B. (2021a) *Welwitschia*: Phylogeography of a living fossil, diversified within a desert refuge. *Scientific reports*, 11, 1-14.
- Sabatini, F.M., Lenoir, J., Hattab, T., Arnst, E., Chytry, M., [...], **Finckh, M.**, [...], **Jürgens, N.**, [...], Bruehlheide, H. (2021) sPlotOpen – An environmentally-balanced, open-access, global dataset of vegetation plots. *Global Ecology and Biogeography*, 30, 1740-1764. <https://doi.org/10.1111/geb.1334>
- Schmiedel, U.**, **Siemen, S.-E.**, Dlodlu, M.N., Oldeland, J. (2021) Germination success of habitat specialists from the Succulent Karoo and Renosterveld on different soil types. *South African Journal of Botany*, 137, 320-330. <https://doi.org/10.1016/j.sajb.2020.10.030>
- Schmiedel, U.**, **Jacke, V.**, Hachfeld, B., Oldeland, J. (2021) Response of Kalahari vegetation to seasonal climate and herbivory: Results of 15 years of vegetation monitoring. *Journal of Vegetation Science*; e12927; <https://doi.org/10.1111/jvs.12927>
- Teutloff, N., **Meller, P.**, **Finckh, M.**, Cabalo, A.S., Ramiro, G.J., Neinhuis, C., Lautenschläger, T., (2021) Hunting techniques and their harvest as indicators of mammal diversity and threat in northern Angola. *European Journal of Wildlife Research*, 67, 101. <https://doi.org/10.1007/s10344-021-01541-y>
- Wildermuth, B., Oldeland, J., **Juergens, N.** (2021) A beneficial relationship: associated trees facilitate termite colonies (*Macrotermes michaelseni*) in Namibia. *Ecosphere*, 12, e03671.

2020

- The SEOSAW partnership [...], **Finckh, M.**, ..., Gonçalves, F.M.P., ..., Revermann R., ...] (2020) A network to understand the changing socio-ecology of the southern African woodlands (SEOSAW): Challenges, benefits, and methods. *Plants, People, Planet*, 3, 249-267. <https://doi.org/10.1002/ppp3.10168>
- Aleman, JC, Fayolle, A, Favier, C, Staver, AC, Dexter, KG, Ryan, CM, Azihou, AF, Bauman, D, te Beest, M, Chidumayo, EN, Comiskey, JA, Croomsigt, JPM, Dessard, H, Doucet, J-L, **Finckh, M.**, Gillet, J-F, Gourlet-Fleury, S, Hempson, GP, Holdo, RM, Kirunda, B, Kouame, FN, Mahy, G, Gonçalves, FMP, McNicol, I, Quintano, PN, Plumptre, AJ, Pritchard, RC, Revermann, R, Schmitt, CB, Swemmer, AM, Talila, H, Woollen, E, Swaine, M.D. (2020) Floristic evidence for alternative biome states in tropical Africa. *Proceedings of the National Academy of Sciences*, 202011515. www.pnas.org/cgi/doi/10.1073/pnas.2011515117
- Baptista, N.L., Tolley, K.A., Bluhm, M., **Finckh, M.**, Branch, W.R. (2020) Rediscovery, range extension, habitat and phylogenetic relation of the endemic Scaled Sandveld Lizard *Nucras scalaris* Laurent, 1964 (Sauria: Lacertidae) in the central Angolan plateau. *African Journal of Herpetology* 69(1), 12-28. <https://doi.org/10.1080/21564574.2020.1778108>

- Klak, C., **Schmiedel, U.**, Bruyns, P. V. (2020). The taxonomic status of *Ruschia stricta* var. *turgida* and *R. promontorii* and a new name for *R. vaginata* (Ruschieae, Aizoaceae). *Phytotaxa* 433, 41-54. <https://www.biotaxa.org/Phytotaxa/article/view/phytotaxa.433.1.5>
- Valencia, E., De Bello, F., Galland, T., Adler, P.B., Lepš, J., E-Vojtkó, A., Van Klink, R., [...], **Jürgens, N.**, [...], **Schmiedel, U.**, [...], et al. (2020) Synchrony matters more than species richness in plant community stability at a global scale. **Proceedings of the National Academy of Sciences**, 117, 24345-24351. <https://doi.org/10.1073/pnas.1920405117>
- Valencia, E., De Bello, F., Lepš, J., Galland, T., E-Vojtkó, A., Conti, L., Danihelka, J., [...], **Jürgens, N.**, [...], **Schmiedel, U.**, [...], et al. (2020). Directional trends in species composition over time can lead to a widespread overemphasis of year-to-year asynchrony. *Journal of Vegetation Science*, 31, 792-802. <https://doi.org/10.1111/jvs.12916>

2019

- Bruehlheide, H., Dengler, J., Jiménez-Alfaro, B., [...], **Finckh, M.**, [...], **Jürgens, N.**, [...], Revermann, R., [...], **Schmiedel, U.** [...] & Zverev, A.A. (2019) sPlot – a new tool for global vegetation analyses. *Journal of Vegetation Science*, 30, 161-186. <https://doi.org/10.1111/jvs.12710>
- Fayolle, A., Swaine, M.D., Aleman, J., [...], **Finckh, M.**, Gonçalves, F.M.P., [...], Revermann, R., [...] & Woollen, E. (2019) A sharp floristic discontinuity revealed by the biogeographic regionalization of African savannas. *Journal of Biogeography* 46(2), 454-465. DOI: 10.1111/jbi.13475
- Gomes, A.L., Revermann, R., Gonçalves, F.M.P., Lages, F., Aidar, M.P.M., **Finckh, M.** & **Jürgens, N.** (2019). Tree or not a tree: Differences in plant functional traits among geoxyles and closely related tree species. *South African Journal of Botany*, 127, 176-184.
- Sichone, P., **Schmiedel, U.**, Oldeland, J., **Jürgens, N.** (2019) Impact of land use on woody aboveground biomass in Miombo woodlands of western Zambia – comparison of three allometric equations. *Southern Forests: A Journal of Forest Science*, 0(0), 1–9. doi: 10.2989/20702620.2018.1555943
- Zigelski, P.**, Rudolph, B., Oldeland, J., Lages, F., **Jürgens, N.**, **Finckh, M.** (2019) The Tough, the Wet and the Hidden: Evolutionary Strategies of a Polyploid Tropical Tree in a Changing Environment. *Perspectives in Plant Ecology, Evolution and Systematics* 38, 1-12. <https://doi.org/10.1016/j.ppees.2019.03.001>

Outreach through popular-scientific publications:

2022

- Genis, A. (2022 in prep.). Karooveld herstel stadig. Wetenskaplikes wat die veld in die Karoo en Namakwaland oor die langtermyn moniteer, vind 'n agteruitgang in plantbedekking en ook dat sowat 10% van plante, veral bosse en bome wat baie oud is, gevrek het gedurende die droogte. *Landbouweekblad* (2022 in Vorbereitung)
- Elliott, T. (2022). South Africa – a growing plant poacher's paradise. - With input from Muthama Muasya and Ute Schmiedel. *The Canadian Botanical Association Bulletin*, 55(1), 20-23.

2021

- Meller, P.**, Tavares, É (2021) Pesquisa Científica: As Anharas de Ongote e a sua importância para milhares de angolanos. *O Novo Jornal*. Link: <https://novojournal.co.ao/opinioao/interior/pesquisa-cientifica-as-anharas-de-ongote-e-a-sua-importancia-para-milhares-de-angolans-104334.html>
- Dall, N. (2021) Succulent smuggling: why are South Africa's rare desert plants vanishing? *The Guardian* [Internet]. 2021.

2020

- Genis, A. (2020) Planteprojekt help vir verandering voorberei. *Landbouweekblad*; 2nd July 2020, 58-60.
- Helme N, **Schmiedel, U.** (2020) Namaqualand nightmare. *Veld & Flora*; June 2020, 14-9.

Outreach through films:

2022

Tool or disaster? Fires in Angola. A film by **Paulina Meller**. University of Hamburg, 2022.

2021

How frost and fire shape a tropical landscape in central Angola. Virtual Excursion by **Meller, P., Frazão, R., Lages, F., Jürgens, N., Finckh, M.** for the IAVS 2021 Symposium. Video available at <https://vimeo.com/630553816>. Awarded with „honorary mentioning“.

2020

Conservation or destruction? The future of the Uíge mountain ranges. A film by **Paulina Zigelski**. University of Hamburg, 2020. English: <https://vimeo.com/405416258>; German: <https://vimeo.com/404927217>; Portuguese: <https://vimeo.com/405444927>

Outreach through social media

Finckh, M., Meller, P. & Wendefeuer, J.: Blog related to the Publication in JVS on “Frost-driven lower treelines in Angola and their implications for tropical forest-grassland mosaics”: <https://vegsciblog.org/2021/10/13/frost-driven-lower-treelines-in-angola/>.

Meller, P. (2022) ECR Feature: Paulina Meller on factors shaping diversity in geoxyles. <https://journalofbiogeographynews.org/2022/04/17/ecr-feature-paulina-meller-on-factors-shaping-diversity-in-geoxyles/>

Meller, P.: Twitter-Thread #geoxyleoftheweek by @Undercovertrees, a weekly format to inform about the diversity and ecology of geoxyles.

Theses:

Habilitation theses

Schmiedel, U. (2021) Drivers of spatial patterns and long-term dynamics of arid rangelands in southern Africa. Habilitation thesis, University of Hamburg.

PhD theses

Meller, P. (2022) Diversity, ecology and origin of geoxylic plants in the Western Zambezan Floristic Region. Dissertation, University of Hamburg.

MSc theses

Brendel, M. (2021) Pflanzensoziologische Untersuchungen zu Vegetation verschiedener Quarzflächen-Standorte in der ariden Knersvlakte von Südafrika unter Verwendung von vorhandenen Vegetations- und Bodendaten. Master thesis, University of Hamburg.

Schoreisz, J.J. (2021) The influence of mole-rats (Bathyerigidae) on geoxyle-grasslands in central Angola. Master-thesis, FU Berlin.

Wildermuth, B. (2020) Spatial patterns, life history and biological interactions of termite colonies (*Macrotermes sp.*) in the thorn bush savanna of Central Namibia. Master thesis, University of Hamburg.

Markwart, M. (2019) Comparing land surface phenology metrics with data from Sentinel 2A satellite for predicting plant communities of the Soebatsfontein commonage, South Africa. Master thesis, University of Hamburg.

Bluhm, M. (2019) Herpetofauna diversity and habitat pattern of a savanna-woodland mosaic of Cusseque (Bié Province, Central Angola. Master-thesis, University of Hamburg.

BSc theses

- Dannecker, I.** (2020) Spatial patterns of grazing values of a natural rangeland in the arid Succulent Karoo of South Africa. Bachelor thesis, University of Hamburg.
- Timm, Ch.** (2021) Überleben von Keimlingen unterschiedlicher Altersstadien aus der ariden Sukkulenten Karoo auf anhaltende Dürre unter kontrollierten Bedingungen. Bachelor thesis, University of Hamburg.
- Wolansky, J.** (2021): Trends in der Diversität und den klimatischen Steuerungsfaktoren von drei Biodiversitätsobservatorien in der Sukkulenten Karoo, Südafrika. Bachelor thesis, University of Hamburg.

Module C:

SASSCAL Regional Secretariat

Project term: 01.01.2019 - 31.12.2019

Reporting period: 01.01.2019 - 31.12.2019

1 The achieved results

Operations, administration and institutional development

One of the cores aims of the project was to institutional strengthening by providing support for administrative operations and other institutional activities through budget support of approximately fifty percent of the 2019 operational budget with other outcomes as follows:

a) Human resources

In 2017 the Governing Board approved the new SASSCAL Organogram which resulted in redundancy of some positions and creation of new functional positions. The process to fill the new organisational structure positions was initiated in 2018 and continued into 2019. The availability of budget support ensured that there were sufficient resources in 2019 to employ the required staff to implement SASSCAL activities.

b) Administrative and accounting capacity building

SASSCAL as a growing and young institution is dependent on the capacity of its staff for the provision of its services and operational support functions. In the previous years the SASSCAL nodes received administrative and operational support from the National Executing Agencies (NEA) in their respective countries. The support covered functions such as accounting, reporting and payroll management. In 2019 inhouse capacity development of the administration and finance staff at the Nodes was conducted resulting in Botswana, Angola and Zambia taking over these functions from the NEAs and ultimately reducing the dependency on other institutions for support and a reduction of the administration fees payable to the NEA.

c) Financial sustainability and management

The budget support that was provided through the project ensured SASSCAL sustainability as it transitioned from the initial donor funding to the operational funding from the Member States. By the beginning of 2019 only Namibia, South Africa and Zambia has made the first contributions for the FY2017 invoices. This resulted in a funding gap for operations which was then covered by the project 50 percent budget support, which enabled continuity.

SASSCAL was able to continue with its current office leasehold for the Regional Secretariat and afford operational costs for all offices with the additional budget support.

Though the audits that were carried out during the year 2019 were for the financial year 2018, the process was completed smoothly due to the increase in accounting staff to support the process and increased capacity to manage financial resources. The FY2018 audit for SASSCAL was clean, the only issues noted related to the research portfolio which closed in

April 2018. The noted challenges resulted from the research portfolio contracting mechanisms which excluded SASSCAL in the intricate management of the research funds. The research contracts were directly between the Research Institutions and KfW, though the audit oversight was mandated to SASSCAL. Obtaining of financial reports and supporting documents was a challenge as a result.

d) Asset management

SASSCAL has amassed physical assets from the previous funding mechanisms that are now under its ownership. In 2019 a process was carried out to determine and record all the SASSCAL assets at the Regional Secretariat, Nodes and research partners. The physical verification of SASSCAL assets for the year 2019 started in August at the Regional Secretariat, and the Nodes. Asset verification is a necessary internal control process that safeguards SASSCAL assets by ensuring that all assets are in the reported safe locations. The process also determines the assets to be insured and those to be written off due to loss, theft, redundancy or malfunction. The process will continue in 2020 to establish the actual book value of the assets and record them in the SASSCAL Balance sheet.

Establishing and further implementing the SASSCAL Open Access Data Centre

a) SASSCAL conducted an ICT Infrastructure assessment to determine infrastructure needs and procured a server to serve as a development and backup server for OADC services. In addition, SASSCAL procured workstations for new staff. SASSCAL also upgraded its internal network infrastructure including the Wireless LAN and the Internet service (bandwidth) and renewed all required software licences to support the operations of the organisation.

b) Furthermore, SASSCAL conducted an options analysis of possible data centre hosting solutions, including own server co-location with an internet service provider (ISP) versus developing and building a data centre versus renting server space in the cloud or considering a hybrid model for hosting of infrastructure. Hence, SASSCAL adopted a hybrid model with benefits of cloud services and of a local IT infrastructure.

c) As part of the activities under the InTeCRes project to procure, install and commission an automatic weather station at the Zambia – German Agriculture Knowledge Training Centre (AKTC) within the Golden Valley Agricultural Research Trust's Chaloshi Farm, a team from the Zambia Meteorological Department installed a complete Automatic Weather Station and three separate soil moisture sensors within the project fields in October. The data is available to the public via the SASSCAL WeatherNet, Zambia Meteorological Department portal and is also disseminated by AKTC to their network of farmers and stakeholders.

d) The SASSCAL Data and Information Portal was upgraded with new features such as plotting of time series data associated with a station, additional precipitation indicators including standardized precipitation index (SPI) and discharge indicators. This upgrade was carried out with support from SASSCAL partners from the University of Jena in Germany.

e) SASSCAL continued to maintain, update and ensure quality assurance of the data portal. SASSCAL added and published new data sets to the portal including the "Vegetation

classification along a hydrological gradient: The Gomoti tributary of the Okavango Delta” and “The vegetation and wildlife habitats of the Savuti-Mababe-Linyanti ecosystem, Northern Botswana” and various thesis documents and publications.

f) SASSCAL made several updates to the website content to keep it current and improved the design of the website. The home page was updated to reflect the latest event about the Ministerial meeting of 26 September 2019 and a new page on the Innovative Technologies to Improve Climate Resilience in the Zambian Agricultural Sector (InTeCRes) project was added under the Projects menu. Additional website pages redesigned to better reflect the latest developments include the Capacity Development and OADC landing pages, SASSCAL Graduate Programmes and the Alumni Network page and online registration form. Related to this is the Capacity Development poster and flyer which were also designed.

g) SASSCAL is the lead of the project WeMAST (Wetland Monitoring and Assessment Tool and Service which is funded through the GMES and Africa programme implemented by the African Union. Here, the OADC supports the development, implementation and operation of the software platform and provides the IT environment for hosting the data and the online tool.

h) In support of the EU-funded SEACRIFOG project which aims to develop a roadmap for an enhanced observation of climate forcing in Africa, OADC provided the required IT infrastructure for operating the developed inventory tool.

Support for the WeatherNet system

a) In order to ensure a smooth transition of the WeatherNet system to SASSCAL, two SASSCAL staff were trained at the University of Hamburg (UHH), Germany, on data management, operations and maintenance support of the system. By the end of the reporting period, the two SASSCAL staff had taken up full responsibility to manage the system daily with continuous support from the UHH WeatherNet team, indicating a full ownership of the system by SASSCAL.

b) To keep the tool on par with latest technologies and to get it ready for future enhancements, SASSCAL, in collaboration with UHH, upgraded the WeatherNet software to the latest version of the PHP programming language (PHP v7) and achieved a key milestone of deploying and live hosting of the WeatherNet within SASSCAL's data centre.

c) Following the active participation of SASSCAL at the WeatherNet System Operations and Maintenance Technical Workshop held on 30 October 2019, in Windhoek, Namibia, SASSCAL developed and introduced an online inventory tool allowing all relevant partners to provide meta information such as the type of data being collected by each weather station, functionality of stations and type of stations for all Automatic Weather Stations (AWS) operated by the respective institution.

d) SASSCAL facilitated and worked with MAWF Namibia and consultants from Central Technical Supplies (Pty) Ltd in Namibia to install three AWS which were procured through SASSCAL task 014 project. These AWS were installed in the Cuvelai Basin at Okalongo,

Omafo Agricultural Centre and Dudukave Agricultural Centre near Lake Liambezi in the Zambezi Basin.

Service development for integration in the SASSCAL Climate Service Centre

a) To streamline the process for service development, SASSCAL developed a guide (process flow) for implementation of services and products from concept development through relevant SASSCAL structures of approval, to development, testing and deployment of products and services. Following the guide, two concept notes were developed and eventually endorsed for further development, including the use of the CHIRPS 2.0 precipitation data product for producing SASSCAL products and services, and the creation of a SASSCAL Dam and Reservoir Atlas for southern Africa.

b) Using the CHIRPS 2.0 data product, SASSCAL has compiled a factsheet on the recent (2018/19) drought in southern Africa, showcasing the rainfall data, and the drought indicator, the Standardised Precipitation Index (SPI), a WMO recommended way to assess drought. This factsheet is the first to a series of climate related fact sheets for southern Africa to be produced. A first SASSCAL Fact Sheet addressing the 2018/2019 Drought in SADC was finalised.

Support of implementation of new SASSCAL Graduate Schools and HCD

a) SASSCAL Graduate Studies Programmes (SGSPs) Framework for Implementation

SASSCAL developed a framework to guide the implementation of the SASSCAL Graduate Studies Programmes (SGSPs) in the region in June 2019. The draft document was presented to SASSCAL Governing Board during its 11th Ordinary meeting held on the 29 and 30 August, 2019, in Leipzig, Germany. The Board approved the SGSP IWRM framework with minor comments for consideration.

b) SASSCAL Graduate Studies Programme in Integrated Water Resources Management (SGSP – IWRM)

The draft SGSP – IWRM proposal was developed in May 2019 and the document was presented at the Stakeholder Briefing workshop hosted by SASSCAL and the Namibia University of Science and Development (NUST) on 21 May 2019 in Windhoek. The workshop was attended by representatives of BMBF, NUST, national and regional players in the Water sector and SASSCAL. Participants provided invaluable feedback to the draft proposal, identified institutions' technical capacity in order to harmonise regional priorities and needs, discussed models of implementation of the programme, its expansion and sustainability, and provided a provisional timeline from submission to finalization of the grant/start of implementation. A workshop report was shared in June 2019.

The revised draft proposal was presented to SASSCAL Governing Board during its 11th Ordinary Meeting held on 29 – 30 August, 2019 in Leipzig, Germany. The Board approved the draft proposal with minor comments for consideration during the same meeting after which further revisions were made to the draft proposal in September. Based on the outcomes of a technical meeting with SASSCAL, NUST, PT-DLR and BMBF convened on 4

November 2019 in Bonn, it was agreed to develop a short version of the proposals followed by the hosting of a technical expert meeting to finalise the outstanding documents and appendices. Draft summary proposal was developed in December 2019.

c) Alumni Network building

Information on the current status SASSCAL alumni was obtained through the Nodes from programme coordinators, some principal investigators and students in February – March 2019. This exercise provided SASSCAL with a basis for developing and motivating effective alumni programmes and initiatives. A detailed report was shared in June 2019.

Since June 2019, SASSCAL collaborates with DAAD on the CLAP Africa programme for postdocs and alumni of all German funded programmes. The first call for applications was launched in September 2019 and SASSCAL promoted the programme and disseminated the necessary information about the call in the region. In addition, SASSCAL participated as an observer at the selection committee meeting on 9 December 2019 in Bonn. Although none of the SASSCAL alumni applied, 8 of the successful postdocs will be hosted at institutions in South Africa.

An alumni database concept, webpage and online registration form were developed and approved in November 2019.

d) Short courses

- Training on R programming and R studio: To strengthen internal human capacities, SASSCAL held a knowledge transfer session on R programming and R studio on 10 October 2019 for 5 technical staff members of the OADC. Drawing on experiences gained from the SEACRIFOG project, the session focused on introduction, sample applications, and possibilities offered by R in statistical computing as well as R Studio in the development of statistical programs in the context of SASSCAL.
- InTeCRes project training: The Zambia node in collaboration with Stellenbosch University and the Zambia Meteorological Department conducted two trainings on Application of electromagnetic induction in Agriculture and operation of the Dualem-1 geophysical survey instrument and Weather data products and services, retrieval and weather equipment and maintenance at the AKTC in Chisamba from 5 to 8 November. Participants were introduced to practical operation of the Dualem-1 geophysical survey instruments, electromagnetic induction data collection, processing and analysis and its application in agriculture, weather data retrieval and access from the SASSCAL WeatherNet and ZMD portal, existing crop specific weather products and services and day to day maintenance of the weather instruments.

e) HCD Communication Material:

Outreach material for capacity development were developed and approved in November 2019 after which the webpage was finalised and uploaded on the SASSCAL website.

Coordination of all further research activities:

a) SASSCAL 2.0 Research Call

Based on the preparatory work in 2018, the SASSCAL 2.0 Research Call was published in April 2019. In support of the call, SASSCAL staff were trained in various meetings. The

trainings were aimed at proving the staff with capacity to articulate the technicalities and formalities of the procedures of the call implementation. In addition, awareness and information platforms with a wide stakeholder representation were successfully held in Angola (11 June), Botswana (25 June), Zambia (21 June), Namibia (17 June) and Germany (3 July). Potential applicants received in-depth information on the aims and particularities of the call and also had question and answer segments. The events were also used to facilitate consortia building by assisting stakeholders in the partner countries to identify potential partners in other SASSCAL countries.

In preparation of proposal submission, all national nodes provided research assistance, review and improvement of pre-proposals through suggestions and recommendations to researchers. Management Committee nominated a Technical Committee (TC) which was responsible for the implementation of the call. The TC consisting of representatives of the Management Committee, is guided by Terms of References which were drafted in June 2019 and approved by the Board in August 2019. The committee is also responsible for providing the required procedures and supporting documents for the submission phase, the review and decision process, the contracting phase as well as the implementation phase (inclusive of Monitoring and Evaluation).

During the phase launching the call and submission deadline, the SASSCAL 2.0 Research Call Technical Committee drafted all relevant documents guiding the implementation of the call, including the terms of references for the eligibility evaluation, the review process, the reviewer's selection criteria and a roadmap. With the deadline for proposal submission on 16 August 2019, the TC, together with DLR-PT started to process the proposals in order to identify the number of eligible proposals considered for the review.

A TC meeting was held in Windhoek from 25 to 27 September 2019 at Regional Secretariat to finalise the inventory and ensure a first administrative and formal evaluations of the submissions of the Call. The TC conducted preliminary review processes on the Research Proposals submitted under the SASSCAL 2.0 Research Call. This is an ongoing process which will be concluded when proposals are submitted to the reviewers for evaluation in early 2020. The major activities of the TC included inventory of hardcopy submissions, consolidation of submitted proposals, formal screening of proposals, eligibility criteria and preliminary eligibility assessment. Based on this exercise, an overview of the proposals submitted through the different submission channels was summarised in terms of number per category and budgetary needs. The TC and DLR-PT considers this as the final list of submissions.

Eventually, the TC compiled a list of experts suitable for serving as independent reviewers in the external review of the proposals. The list was revised various times and submitted to the Scientific Advisory Committee and the Governing Board.

For all activities of the TC, detailed reports were drafted and are available.

b) Other research activities

SASSCAL is coordinating and collaborating in various research projects, for which following main achievements can be concluded:

- WeMAST (Coordinator, AU GMES): All subcontracts with the partners were finalised and signed. A revised work and training plan was finalised and agreed upon with the

consortium. A prototype platform was developed and presented to the AU Technical Team.

- SEACRIFOG (Partner, EU H2020): All deliverables were submitted in time and accepted by the European Commission. The project will be concluded in February 2020.
- InTeCRes (Partner BMEL, GFA, AKTC) which aims to introduce new technologies to the agricultural sector in Zambia in support of better climate resilience was successfully concluded in January 2020. A detail report is available.
- ECI Visualiser (Partner, ARC): The project was successfully concluded.
- Miombo Network (Partner, World Bank): The project was successfully concluded.

For all activities, reports detailing the outcomes and the contribution of SASSCAL staff were drafted and are available.

c) Resource Mobilisation

SASSCAL continued to intensify its resource mobilisation efforts with a view to diversify sources of funding for regional integration. The Resource Mobilisation Technical Committee which was constituted in July 2019 highlighted the need for a more selective and alternative approach to resource mobilisation for the sustainability of the organization at its inception meeting in August 2019. It was resolved that there is need to match current efforts with the global trend in fundraising therefore a draft structure on proposal approach and accessing funds is being developed. The Resource Mobilisation Technical Committee also met in October 2019 and resolved that the compilation of documents to support the organisation's accreditation with the Adaptation Fund should commence.

In response to a call by the German Federal Ministry for Food Security and Agriculture, SASSCAL applied for funds to conduct a knowledge transfer and capacity development project (InTeCRes) which was granted in May 2019. At national level, a funding proposal was submitted through Okongo Conservancy in attempt to access funding from the Environmental Investment Fund of Namibia.

After the successful submission of a project concept and its acceptance by the EU, the Turning Climate Risks into Opportunities through Climate Services for Africa (TRIO) full proposal was submitted on 4 September 2019. The proposal was submitted under the Horizon 2020 programme and will in case of funding allow SASSCAL to participate and focus on regional integration for climate action by co-developing climate services in 2 case study areas (Luanda and KAZA). The full proposal was positively evaluated but put on a reserve list due to the oversubscription within the programme.

d) Strategic partnerships

- SASSCAL is an implementing partner of the EU-funded project 'Supporting EU-African Cooperation on Research Infrastructures for Food Security and Greenhouse Gas Observations' (SEACRIFOG). SEACRIFOG is implemented over a three-year

period (February 2017 to February 2020) by a consortium of 16 African and European partner organizations. The project aims to design a fully interoperable integrated observation network for climate forcing and underlying environmental dynamics on the African continent.

- SASSCAL is the lead consortium member for the implementation of the GMES and Africa Wetland Monitoring and Assessment Service for Transboundary Basins in Southern Africa (WeMAST). WeMAST aims to develop an online decision-support platform, which will provide wetland stakeholders in SADC with EO (earth observation) based wetland monitoring and assessment services, tools, and information. The WeMAST project focuses on four southern African basins: the Cuvelai, the Limpopo, the Okavango and the Zambezi basin.
- SASSCAL is the coordinating partner in the implementation of the *Innovative Technologies to Improve Climate Resilience in the Zambian Agricultural Sector (InTeCRes)* project. The project is part of the German Bilateral Cooperation Programme funded by the German Federal Ministry of Food and Agriculture (BMEL). The project objectives are:
 - To strengthen Zambia's vulnerable agricultural sector by building scientific and technical capacities in the application of innovative technologies for improved crop production and farm management under climate change conditions.
 - To build the capacity of emergent farmers to use precise soil scanning equipment and drone technology for crop and drought monitoring and efficient farm management under climate change conditions.
 - To build the capacity for climate and weather information-based farm decision making and planning in response to changing rainfall patterns and other weather conditions.

The project is implemented in collaboration with the Zambian – German Agricultural Knowledge and Training Centre (AKTC), Golden Valley Agricultural Research Trust (GART), National Remote Sensing Centre (NRSC), Stellenbosch University (SUN), Zambia Agricultural Research Institute (ZARI), Zambia Air Services Training Institute (ZASTI) and the Zambia Meteorological Department (ZMD).

- Namibian Node, through SASSCAL Regional Secretariat, entered into agreement with the University of Namibia (UNAM), effective from October 2019 until 30th September 2020. The purpose of this agreement is to strengthen regional (sub-national) climate governance through integration of gender responsive climate action into regional development plans and projects. The University of Namibia (UNAM) in collaboration with the Desert Research Foundation of Namibia (DRFN), the Ministry of Urban and Rural Development (MURD) and Ministry of Gender Equality and Child Welfare through the Climate and Development Knowledge Network (CDKN) held an inception meeting in October to launch the project.
- SASSCAL committed to the Namibia National Rural Development Strategy review in order to mainstream gender responsive climate action into the updated strategy. The

Namibia Node will implement this activity underpinned by an Agreement between SASSCAL and the University of Namibia.

- A Memorandum of Understanding (MoU) between SASSCAL and UNESCO Country Office over the provision of training of trainers on environmental change and other thematic areas such as biology conservation, participation of SASSCAL at UNESCO Symposiums as well as fund raising for capacity building is being developed.
- SASSCAL signed a Memorandum of Understanding with the Environmental Investment Fund. The MoU charted joint obligations for research and educational activities for the purpose of enhancing awareness and mutual understanding. The MOU will also enable SASSCAL to access relevant EIF-funded projects
- A Memorandum of Understanding was signed with Helmholtz-Zentrum Geesthacht Climate Service Centre (GERICS), this agreement will provide ground for SASSCAL to receive training from GERICS on publication of Policy Briefs and the development of Fact sheets.

Stakeholder Engagement and other activities

Over the duration of the project SASSCAL co-operated with other agencies and partners such as Future Earth, World Bank, GERICS, Germany Research Institutions, Commonwealth Group of Windhoek and SADC in line with SASSCALs Mandate to support and engage other regional co-operations and programmes on climate change issues for the purposes of sharing best practices and incorporating them in SASSCAL activities.

a) SASSCAL served in the Interim Steering Committee of Future Earth Regional Office for Southern Africa; providing support, guidance and oversight in operationalizing the Southern Africa Future Earth Office. <https://www.nrf.ac.za/tags/ferosa>. SASSCAL assumed the lead authorship of the guiding document in the formation and operational framework of the FEROSA.

b) SASSCAL also participated in the tour of Germany's leading research centres focusing on renewable energy from 20 to 26 March 2019. The tour was held under the theme "Building Bridges – a tour of Germany's leading research. This tour and subsequent discussions have ignited the Green Hydrogen Energy Project funded by BMBF to be implemented by SASSCAL and WASCAL.

c) SASSCAL participated at a panel discussion at the "SDGs Implementation in Africa - Reflections on A Three-Year Journey" conference held from 11 to 13 June 2019 in Kigali, Rwanda. SDGs are global goals in which all countries have signed to implement. Furthermore, BMBF also has a programme focus on SDGs. As a key climate service centre in the region, SASSCAL has a role to play in supporting and sharing information on the status of achieving SDG 13- Climate Action among other SDGs that are highly related to the climate action SDG.

d) SASSCAL participated at 'The Expert Workshop on Future African-German Cooperation in Education, Science and Research' held in Berlin from 18 to 19 June 2019. The workshop

identified and discussed major aspects of advancing inter-ministerial synergy projects from African viewpoints. Nurturing ministerial synergies is important for advancing the SASSCAL mandate. Links to existing African-German science structures (i.e. DAAD Centres of Excellence) and the development of further capacities in the areas of academic training, research, and vocational training were also discussed. Such links enhance technology and knowledge transfer which are key for capacity development under SASSCAL 2.0.

e) SASSCAL attended GERICS Scientific Symposium in Hamburg, Germany to strengthen the long-term partnership. The symposium reviewed the work carried out at GERICS over the last ten years, and highlighted the strong partnership between GERICS and SASSCAL. The anniversary event focused on the main results of IPCC's Special Report on the impacts of global warming, its implications for tailor-made climate services, and the transformational processes required for comprehensive climate resilience worldwide. SASSCAL as a regional science service centre plays a key role in supporting and providing information for climate action.

f) The Commonwealth Group of Windhoek based High Commissioners and Ambassadors invited SASSCAL to present on, "current challenges and trends of Global warming with special emphasis on Namibia." in Windhoek, Namibia. The presentation was an informative session to sensitise the high-level delegation on challenges of climate change and mitigation with specific focus on climate issues surrounding Africa and the SADC region at large. Represented at this gathering were High Commissioners and representatives of UK, Botswana, Kenya, Malaysia, South Africa, Zambia, and Ghana missions. Such platforms enable SASSCAL to share science-based information with policy makers thus advancing the SASSCAL Mission.

g) As a lead in managing and co-ordinating research in Southern Africa, SASSCAL participated in a panel discussion on "The state of climate research for development in Africa." at the African Climate Risks Conference from 5 to 10 October 2019 in Ethiopia. The aim of the conference was to ensure greater impact and legacy of completed and on-going research programmes by promoting the uptake of new data, tools and knowledge; and brokering new research collaborations. The conference was convened under the auspices of key global, regional and national institutions such as the WMO-GFCS, WMO-AMCOMET, UNECA-ACPC, WCRP, IPCC, CR4D, WASCAL, SSN and FCFA partner organizations.

h) SASSCAL participated in the Innovation Bridge Technology Showcasing and Matchmaking Event and Science Forum South Africa (IBSFSA) in Pretoria from 4 to 6 December 2019. During the same event SASSCAL attended the Future Earth panel discussion on 4 December titled Towards the Future Earth Regional Office for Southern Africa (FEROSA): Harmonising the sustainability research landscape. The session facilitated discussions about climate change, biodiversity and technological innovation for economic development closer to society. By bringing the people at the forefront of policy formulation and implementation and academia to discuss the issues affecting society to date the event served as a platform that stimulated and encouraged an informative discussion with participants that is envisaged to input into the FEROSA strategic vision. SASSCAL also held a Panel Discussion side event entitled, "International Partnerships for Climate Change Action" on 6 December during then IBSFSA. This discussion highlighted the importance of

building regional and international partnerships in support of the Paris Climate Agreements and SDGs. There was a consensus that without these partnerships progress in responding to Climate Change will be challenging and slow to bring meaningful strides to catch up with the “runaway climate change”. This session also highlighted the critical role that gender consideration plays in responding to climate change as more and more women are exposed to these impacts and yet remain an untapped source of information as a result of their daily experiences. Participants had an insight on how the partnership between SADC Member States and Germany through SASSCAL has produced excellent products in Research, Capacity Building and Service provision for the region.

i) SASSCAL participated in the 25th Conference of Parties (COP 25) from 12 to 14 December 2019 in Madrid, Spain. Together with the Potsdam Institute for Climate Impact Research (PIK), Germany and WASCAL, SASSCAL hosted a joint EU side event titled ‘Challenges and solutions for agricultural adaptation planning in Sub-Saharan Africa’ on 13 December at COP 25 which was attended by various stakeholders from various countries and organisations. Participation as such platforms allows SASSCAL to grow its global footprint and ensures its continued alignment with both the regional and international research agendas.

j) GMES & Africa and SASSCAL consortium are collaborating in the monitoring and assessment of wetlands in Southern Africa on the WeMAST projects since 2018. In 2019 the focus was on the development of the monitoring and assessment platform and data collection. The SASSCAL led consortium participated and engaged with water sector practitioners at the WaterNet symposium from 30 October to 1 November 2019 under the theme Integrated Water Resources Development and Management: Leaving No One Behind for Sustainable Water Security in Eastern and Southern Africa.: Such engagements strengthen regional cooperation and enhances visibility of not only the SASSCAL brand but its global partnerships while informing the development of the WeMAST platform.

k) SASSCAL collaborated with GFA on the Innovative Technologies to Improve Climate Resilience (InTeCRes) in the Zambian Agricultural Sector. Implementation of the InTeCRes project furthered SASSCAL attainment of its Capacity Building pillar in the region.

l) SASSCAL, the Namibia Meteorological Services, relevant ministries and other partners organised and conducted a WeatherNet System Operations and Maintenance Technical Workshop on 30 October 2019, in Windhoek, Namibia. The meeting brought together key Namibian stakeholders in line ministries and relevant institutions dealing with weather observation and data provision. The aim of the meeting was to share information highlighting the importance and value of the weather observation and to motivate for a country-wide inventory of weather observations efforts. The meeting also provided a good platform to discuss the current operational status of the WeatherNet system in Namibia and elaborate on shared responsibilities and commitment for collaboration amongst institutions in order to improve the data situation in Namibia.

2 Main items of the numerical evidence

For this purpose, the administration of the University of Hamburg will prepare a numerical proof of use. The amount of planned and approved finances was sufficient for carrying out the planned work.

3 Necessity and appropriateness of the project work carried out

The relevance of the project results from the description under 1.

4 Expected Benefit

As a result of the project, SASSCAL's organisational and technical structures were notably strengthened. This resulted in a number of activities and achievements, ensuring the further development and strengthening of SASSCAL towards a highly acknowledged regional key institution in the area of climate science and related decision support to the various actors dealing with climate change.

- With the successfully conducted Ministerial Conference in September 2019, SASSCAL laid the fundament for its transformation in an international organisation which will be finalised in 2020.
- With the strengthened administrative structures, a credible finance management, compliant Human resources policies, SASSCAL can be entrusted by international donor institutions and other potential partners with the implementation of education and research programmes and projects at regional and national level, e.g. through the Green Climate Fund or the Adaptation Fund.
- With the recruitment and training of qualified staff, SASSCAL is enabled to fulfil its mandate to influencing decision making at policy and practitioner level in order to contribute to societal efforts in coping with the challenges resulting from climate and global change.
- With the successful start of the implementation of the SASSCAL 2.0 Research Call, i.e. the call launch, the handling of submitted proposals, the setup of a Technical Committee, the start of the review process, SASSCAL is prepared for its full implementation and has all necessary administrative and technical structures in place to ensure a transparent and compliant programme implementation following highest international standards.
- With the enhancement of the technical infrastructure and the respective technical support staff, SASSCAL OADC is enabled to offer climate-related science services and data products to a variety of stakeholders.
- With the finalisation and approval of the SASSCAL Graduate Studies Programmes framework document, SASSCAL has a strategy to develop and deploy innovative, excellent and collaborative education and research at PhD degree level complemented by selected tailor-made training programmes for decision makers and industry. The programmes will be designed to increase the number of highly qualified experts and

knowledge in the region and promote innovation in interdisciplinary education and research. The establishment of the first SGSP IWRM, with NUST as host and implementing Higher Education Institute, has already started and will be officially launched in 2020.

- With an active Alumni Network established, SASSCAL is enabled to inform its alumni on both regional and national capacity and skills development programmes and initiatives, job opportunities and latest research outcomes in the field of climate change and, in turn, may benefit from Alumnis when strong partnerships with their new work environments can be developed.

5 Progress made at other agencies/institutions

Given the objectives of the project to provide support for the organisational strengthening of SASSCAL, no direct impact on partner institutions was expected.

However, SASSCAL was able to demonstrate its capacities to partner institutions and supported in technical and IT infrastructure support. The SASSCAL service portfolio, in particular the SASSCAL WeatherNet as well as the Data and Information Portal, are essential for many users from various sectors (e.g. research, media, governmental agencies) for their daily operations.

With a strong collaboration with NUST aimed on establishing the SASSCAL Graduate Studies programme 'IWRM', NUST, supported by SASSCAL, will increase its academic portfolio by offering a novel, innovative and excellent education and research programme at PHD level which is unique in the region.

The successful implementation of the SASSCAL 2.0 Research Call will notably affect granted research and Higher Education Institutions in their efforts to conduct excellent and demand-driven research in the region.

6 Publications

The following publications and other support documents were finalized and published.

Scientific publications

2019

- Beck, J. López-Ballesteros, A., Hugo, W., Scholes, R., Saunders, M., Helmschrot, J. (2019) Development of a Climate Forcing Observation System for Africa: Data-Related Considerations. *Data Science Journal*, 18:42, 1–11. <https://doi.org/10.5334/dsj-2019-042>
- Branch, W. R., Baptista, N., Keates, C. W., Edwards, S. (2019) Rediscovery, taxonomic status, and phylogenetic relationships of two rare and endemic snakes (Serpentes: Psammophinae) from the Angolan Escarpment. *Zootaxa*, 4590 (3).

Serrano, A. R., Capela, R. A., Santos, C. (2019) Biodiversity of tiger beetles from Angola with the description of a new species of the genus *Neochila* Basilewsky, 1953 (Coleoptera: Cicindelidae). *Zootaxa* 4567, zootaxa. 4567.1. 4.

Tlhalerwa, K., Mulalu, M. (2019) Assessment of the concentrated solar power potential in Botswana. *Renewable and Sustainable Energy Reviews*, 109, 294-306.

Internal Publications

i) Management Reports to the Board

Combined Q1 and Q2

Combined Q3 and Q4

ii) AOP 2019

Outreach Publications

i) Annual reports

2019 Annual Report

ii) 2019 Newsletters

Q1 Newsletter

Q2 Newsletter

Q3 Newsletter

Q4 Newsletter – In progress

iii) Selected 2019 website articles and press releases

18 March 2019 - EIF and SASSCAL signal data driven response to climate change by signing MOU on technical cooperation - <http://www.sasscal.org/eif-and-sasscal-signal-data-driven-response-to-climate-change-by-signing-mou-on-technical-cooperation/>

3 June 2019 -Launch of SASSCAL 2.0 Press Conference - <http://www.sasscal.org/launch-of-sasscal-ii-press-conference/>

24 June 2019 - SASSCAL at the “SDGs Implementation in Africa – Reflections on A Three-Year Journey” Conference - <http://www.sasscal.org/sasscal-at-the-sdgs-implementation-in-africa-reflections-on-a-three-year-journey-conference/>

1 October 2019 - SASSCAL Treaty and Joint Declaration signed consolidating International Partnership for Climate Action - <http://www.sasscal.org/sasscal-treaty-and-joint-declaration-signed-consolidating-international-partnership-for-climate-action/>

23 October 2019 - Press release: International Partnerships for Climate Action through the SASSCAL Treaty and Joint Declaration - <http://www.sasscal.org/press-release-international-partnerships-for-climate-action-through-the-sasscal-treaty-and-joint-declaration/>

11 November 2019 - Future Earth: A knowledge action network for sustainable development - <http://www.sasscal.org/future-earth-a-knowledge-action-network-for-sustainable-development/>

19 December 2019 - SASSCAL at the innovation bridge technology showcasing and matchmaking event and science forum south africa (IBSFSA) - <http://www.sasscal.org/sasscal-at-the-innovation-bridge-technology-showcasing-and-matchmaking-event-and-science-forum-south-africa-ibsfsa/>

19 December 2019 -SASSCAL at COP25 - <http://www.sasscal.org/sasscal-at-cop-25/>

Document Control Sheet

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18. abstract SASSCAL Module A WeatherNet: The SASSCAL WeatherNet was established to complement the existing national weather networks in the SASSCAL countries of Southern Africa and to provide an open online weather data source for research and decision-making processes. The project built the necessary capacity to operate the WeatherNet system (http://sasscalweather.net.org) at the SASSCAL Open Access Data Centre (OADC). The system was successfully transferred from the University of Hamburg to SASSCAL OADC and full responsibility for its operation now lies with SASSCAL Regional Secretariat OADC. In addition, several enhancements have been developed to allow optimised access to and use of the WeatherNet data SASSCAL Module B ObservationNet: The project addresses the impacts of climate change and land use on biodiversity and ecosystems. For this purpose, biodiversity changes were documented in an established network of standardised long-term study plots in Angola, Namibia and South Africa using modern recording methods. Accompanying experimental approaches evaluate biodiversity-controlling management measures. The findings are made available to the scientific community, local decision-makers and the interested public. The project has contributed to the education and training of young African and German scientists and local decision-makers. SASSCAL Module C Support for organisational strengthening of SASSCAL: The project aims to take all necessary steps and arrangements to strengthen SASSCAL in terms of systems and human capital to enable it to achieve its goals as a regional science service centre. Main outcomes are: Support to administrative operations, establishment and implementation of the SASSCAL OADC at the Regional Secretariat, transfer and operating of the SASSCAL WeatherNet, development of new products and services, launch of a new SASSCAL Graduate School, coordination and support of other research activities (including implementation of the SASSCAL 2.0 Research Call) and expansion of strategic partnerships.	
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