Project Report Part II

Open science to support local water security in Southern Africa (OWASA)

SPONSORED BY THE Federal Ministry of Education and Research

BMBF Funding scheme
WASA_2020-105: 1.1.2022 – 28.02.2023

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unesco Intergovernmental Hydrological Programme

WATERBERG BIOSPHERE RESERVE

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1. Introduction

Hydro-meteorological extremes and water quality deterioration are increasingly challenging Water Security in Southern Africa. As water-related problems vary locally, adaptation strategies need to be designed at the local level.

The OWASA project supports local and regional decision-making towards water security in Southern Africa. To achieve this, we evaluate gridded open access hydro-meteorological data sets, local observations and geospatial data to provide useful information products for the local scale that allow the selection of site-specific adaptation measures, considering in particular nature based solutions. OWASA follows a multi-scale approach to link local, provincial, national and regional stakeholders as well as African universities with the international research community.

Data and approaches are made available to academia and government through an online platform and a capacity development concept. We test them in contrasting pilot regions in Zimbabwe (Chimanimani) and South Africa (Waterberg), in close collaboration with local stakeholders and universities.

The following figure illustrates the OWASA project components:

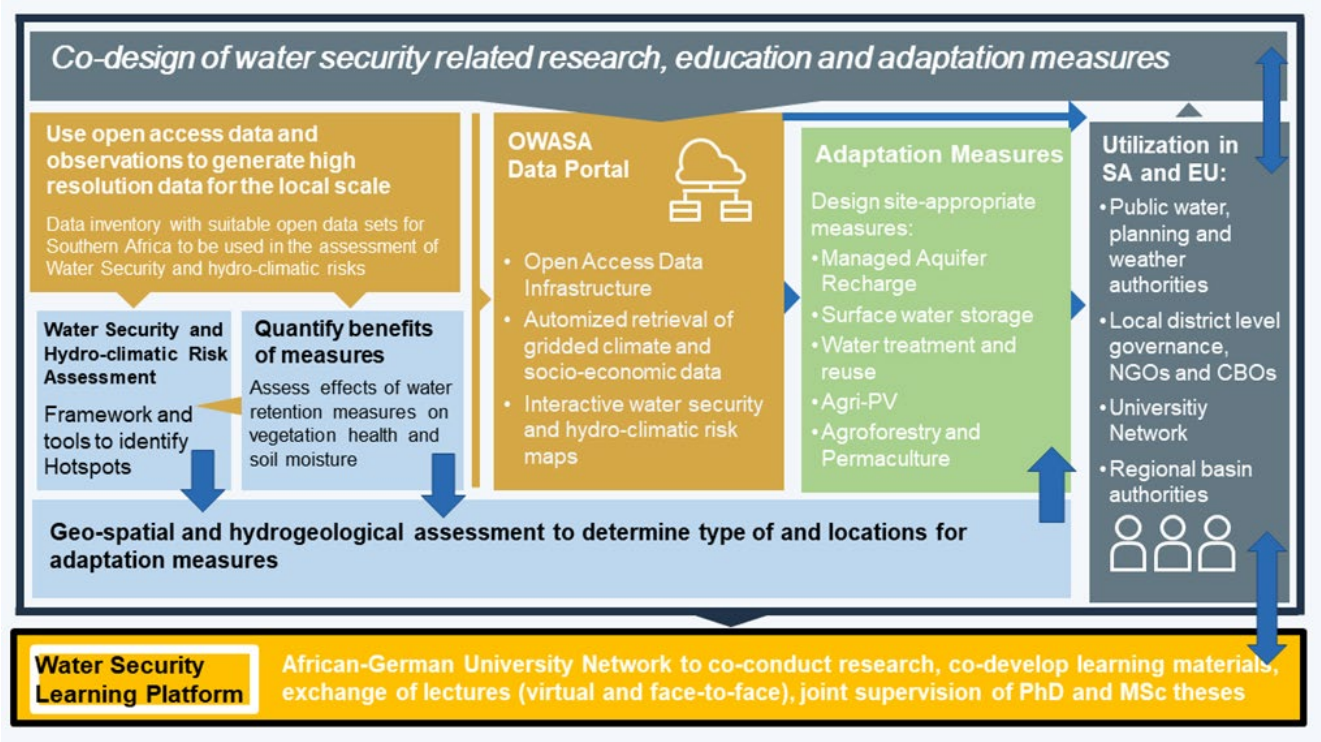

Figure 1: Overall OWASA Project Concept, activities and partners

2. OWASA Objectives

The ***overall objective*** of the OWASA project has been to contribute to decision making processes to improve water security (**WS**) and lower the impacts of hydro-climatic extremes at the local and regional scale. Table 1 gives an overview on the detailed objectives and the corresponding results of the OWASA initial phase.

Table 1: Overview on the detailed objectives and the corresponding results of the OWASA initial phase

	Objective	**Result**
1	To establish a local and regional stakeholder- and university network for the implementation of OWASA.	Network of stakeholders and universities established for Southern Africa and the two study regions, in person and online workshops with Zimbabwean and South African partners; table with partners, stakeholders and their respective role (WP 5, http://www.basin-info.net/owasa/data-platform-owasa/stakeholders-owasa)
2	To understand and document the regional and local demand for WS related knowledge-, information and action => Planning the main phase together with African partners, stakeholders and local universities	- WS related information, action and research demand is documented and incorporated in the main phase planning (Proposal main phase) - Data inventory on suitable open access data for Southern Africa, http://www.basin-info.net/owasa/data-platform-owasa (WP1)
3	To further develop R shiny based South African and Zimbabwean Flood and Drought monitor to openly share novel data, maps, info-graphics for decision makers	Newly developed R Shiny based platform showing complementary information and data sets: OWASA data portal (Prototype/draft – currently only showcase data are shown): WP 1 http://www.basin-info.net/owasa/data-platform-owasa https://obaezvil.shinyapps.io/owasashinyapps/
4	To combine and develop novel data products on hydro-climatic variables, vegetation, land productivity, soil moisture and socio-economy (vulnerability) for two spatial scales - regional (Save/Limpopo basin scale) and local (two or more pilot sites)	- Catalogue of open data sets that are relevant for Southern Africa and useful for the local scale, data used in the OWASA project http://www.basin-info.net/owasa/data-platform-owasa - Geospatial analysis of study regions: thematic maps on several sites of www.Basin-info.net, addressing geospatial features that are relevant for, surface water and groundwater, eg. http://www.basin-info.net/river-basins/limpopo-river-basin-southern-africa - Baez et al (2023) ready to submit: Evaluating the performance of contrasting precipitation products for Southern Africa - Use of high resolution imagery to assess effect of adaptation measures on vegetation health: http://www.basin-info.net/owasa/
5	To deliver a water security and drought risk assessment framework for Southern Africa (indices, maps)	- Relevant indicators/indices for water security were selected that can be representative for the local scale, according to data availability - Drought anomalies observed by Zimbabwe and South African Drought and Flood monitor (Sheffield and Beck,

		2021) https://hydrology.soton.ac.uk/apps/saf_app/
6	To develop an online catalogue of adaptation measures to improve water resource security and to adapt to climate extremes (NBS and nexus solutions).	Catalogue of open data sets that are relevant for Southern Africa and useful for the local scale, data used in the OWASA project http://www.basin-info.net/owasa/nbs-adaptation-catalogue
7	To expand the regional academic network for water security by offering digital courses and webinars.	- Online lectures offered to MSc IWRM students at UoZ and UL - Participation in defences and graduation ceremonies - Lectures in PhD graduate school SASSCAL, cooperation with NUST, co-supervision of PhD students - Participation of OWASA researchers in Waternet Conference, close collaboration with WATERNET staff
8	Training of young scientists (MSc and PhD level) from South Africa, Germany and Zimbabwe.	- Online lectures attended by MSc IWRM students - OWASA case study research topics addressed by students in Zim, SA and Ge - Co-supervision of 8 UoZ theses related to OWASA in Chimanimani (Zimbabwe) - Lectures in PhD graduate school SASSCAL, co-supervision of PhD students
9	OWASA's public relations (workshops, website, social media).	- OWASA Online: www.Basin-info.net/OWASA - OWASA Flyer - OWASA Data Portal https://obaezvil.shinyapps.io/owasashinyapps/ - WASA stakeholder conference PPT - OWASA Researchgate (projects removed)

3. Detailed Description of results and activities according to Work Packages (WP) in Full Proposal 1st phase

We used different spatial units (basin, subcatchment, administrative boundaries) to address the research objectives raised in the OWASA project. According to the objectives and Work packages suggested in the proposal, during the first phase, the following results have been achieved:

3.1 Work Package 1: Knowledge portal, data- and information products for the regional and the local level

a) Evaluation of suitable information and open access data sets for Southern Africa and the study regions

We reviewed publicly available gridded datasets on hydro-climatic variables, vegetation, soil moisture and socio-economic data. After identifying suitable data products according to specific criteria, we developed a data inventory for open access data (http://www.basin-info.net/owasa/data-inventory) that is available to researchers and stakeholders and highlights key relevant features and usability of these data. Criteria to select data products were performance and representativeness in Southern Africa, temporal and spatial resolution, validation level, time period. Further results:

- An article on the point to pixel evaluation of different gridded precipitation products for Southern Africa (Baez et al., 2023) is going to be submitted to “Atmospheric Research” at the end of June 2023.
- Geospatial analysis of study regions: thematic maps addressing geospatial features that are relevant for, surface water and groundwater, eg. http://www.basin-info.net/river-basins/limpopo-river-basin-southern-africa and http://www.basin-info.net/river-basins/save.
- Geospatial analysis with open access high resolution imagery to identify small water bodies (check dams and smaller reservoirs). A satellite and optical imagery based methodology is being developed to evaluate effects of smaller dams on vegetation health and soil moisture.
- Inventory of observed climate and discharge data in the two study regions indicating observation period, temporal resolution, data gaps, missing years and station locations. Figure 2 shows an example for the precipitation variable in the Odzi basin (Save, Zimbabwe).

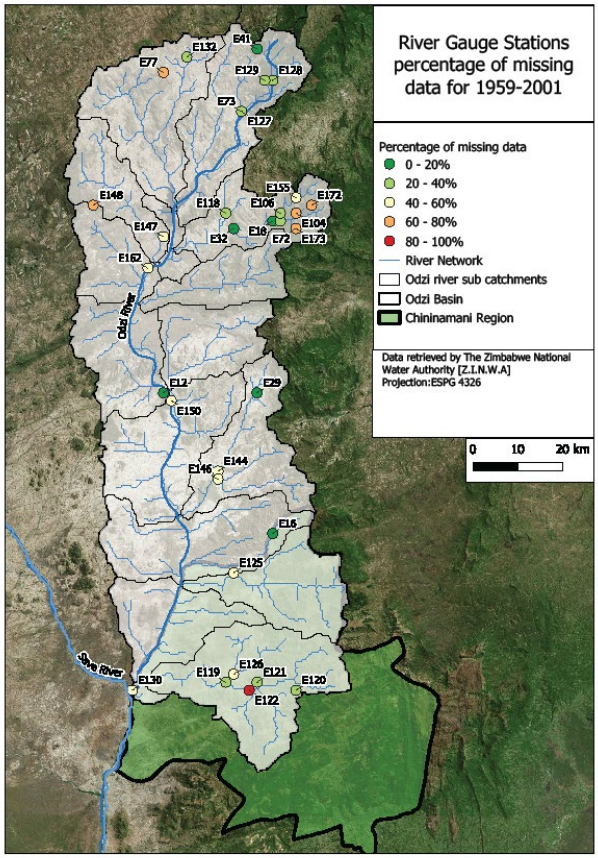

Figure 2 Discharge observation data in the Odzi basin for the period 1959-2001

Picture 1Discharge station in the Odzi basin (Webster Gumindoga)

b) OWASA Data Portal

To showcase some resulting products, we launched the R shiny based OWASA data portal (Prototype); the platform can be accessed following this link (it may need a bit of time to initialise): https://obaezvil.shinyapps.io/owasashinyapps/. This is a preliminary version to be fully implemented during the main phase of OWASA.
The R package for the OWASA platform development is available on GitHub: https://github.com/obaezvil/OWASA.
While we use the Drought and Flood monitor (Sheffield and Beck, 2021; https://hydrology.soton.ac.uk/apps/) to provide information on current hydro-climatic extremes and observations of hydro-climatic variables at different locations, the ***OWASA Data Portal*** *aims at*

- offering an user friendly platform to showcase and share water security related data with partners, stakeholders, academics and the public that are relevant for southern Africa
- highlighting locally useful and open access data relevant for water security
- providing access and retrieval of enhanced gridded climatological datasets that will serve as a basis to develop site-specific water security and drought risk information in Southern Africa and over OWASA sites

- illustrating expected climatic conditions at the annual, seasonal and monthly scale using CORDEX
- presenting spatially distributed water security related socioeconomic data.

3.2 Work Package 2: Framework for the assessment of water security and drought risk

There are multiple definitions and index frameworks to assess Water Security, each reflecting the perspective and purpose of its application. Given that water is a coupled system (Bogardi et al. 2011), the integration of social and physical indicators is critical for representing and understanding water security: environment, economy, water-related disasters and human needs. For example, Vörösmarty et al. (2010) assessed global water security looking at human water infrastructure and biodiversity related factors. Cook and Bakker (2012) developed a framework using the dimensions availability; water-related hazards and vulnerability to those hazards; human needs and environmental sustainability. In contrast, the ADB (2013) considered five dimensions related to water: economic, household, urban, environmental, resilience, to address Asian megacity related challenges, while Grey et al. (2013) and OECD (2013) focussed on a more risk-based approach.

A different study was published by Gain et al. (2016), they used their own gridded data products to evaluate global water security at National scale, allowing an inter-country comparison. Dickson et al. (2016), in turn, in his review suggested a comprehensive list of water security indicators for rural areas, indicating that data availability was the key constraint.

These varying approaches have only one thing in common: that indicators for different aspects of water security are aggregated to an index; which reflects the diversity of how scholars use the term “Water Security”. How can the term “Water Security” hence be understood by stakeholders?

Besides the ambiguity of the term water security, the key challenge for these evaluation frameworks is data availability and that most of the indicators refer to the National scale using very rough equations to evaluate complex and spatially differing water security indicators. The same constraints can be associated with drought risk index assessment frameworks (Naumann et al., 2014; Carrão et al., 2016; Nauditt et al., 2022); that rely on similar water related and socioeconomic data sets as Water security.

For Zimbabwe and South Africa, during the first phase of the OWASA project, we have identified key data sets that can represent relevant indicators and indices at the local scale (link https://docs.google.com/spreadsheets/d/1TaFlGj8ADEhSK_uc_YDnXjybQsWTjf-bGb98gTLM3X0/edit#gid=664949586 and http://www.basin-info.net/owasa/data-inventory.

During the second phase, the respective vulnerability and socioeconomic information will be collected for the district and community level, also using qualitative interview techniques to obtain representative and solid data. The same applies to hydro-meteorological observed data sets that need to be monitored or reconstructed.

3.3 Work Package 3: Design and implementation of local adaptation measures: Nature based (NBS) and integrated measures for the clean supply of Water, Energy and Food

Based on field visits of the African-German OWASA team, a comprehensive literature review and stakeholder consultations in the project regions, we developed a catalogue of adaptation measures that have been considered adequate to respond to hydro-climatic extremes and water quality problems and to improve water management in the region on http://www.basin-info.net/owasa/nbs-adaptation-catalogue

Figure 2 illustrates the general idea about the NBS catalogue for rural Southern Africa.

NbS	Description	Benefits & addressed climate extremes	Co-benefits
 CONSTRUCTED WETLANDS	Constructed wetlands use natural processes provided by vegetation, soils, and microbiological organisms to treat wastewater and manage runoff.	• **Water Purification** • **Drought**: water retention and supply • **Flood risk** reduction	• Groundwater rehabilitation • Habitat creation
 CHECK DAMS	A check dam is a small dam constructed across a stream often implemented in a system of several dams across an area.	• **Drought**: water storage • **Flood risk** reduction • soil moisture storage • sediment trapping	• Aquifer recharge • Control debris flow • avoiding sedimentation of larger reservoirs
 MANAGED AQUIFER RECHARGE	MAR is a practice that increases the amount of water that enters a groundwater body.	• **Water Purification** • **Drought**: water storage • **Flood risk** reduction • Reduces groundwater salinization	• Reduces losses from evaporation • Productive use of wastewater or runoff
 AGROFORESTRY	Agroforestry combines woody perennials with crops and/or animals to increase agricultural and ecological biodiversity.	• **Drought**: water storage • **Heat stress:** cooling air temperature • Erosion reduction	• Biodiversity • Carbon sequestration • Livelihood opportunities

Figure 3 General overview on potential benefits of NBS measures

The catalogue considers the following criteria:

Criterion 1: Benefits and effectiveness in achieving increased water security at the local scale

The developed catalogue of adaptation measures focuses on solutions that improve capacities to reduce flood and drought hazard impacts, debris flow and erosion, provide water purification and water storage or retention services that can be integrated with agricultural practices in rural areas of Africa. By considering climatic conditions, topography and agricultural land use patterns, the catalogue accounts for the specific characteristics of the project regions, which will be further explored based on geospatial analyses.

Criterion 2: Consideration of Stakeholder Needs

The stakeholder consultation in the project regions guides the meaningful selection of NbS. The local expertise and engagement with stakeholders ensures the acceptance of the jointly identified solutions. The stakeholder preferences and priorities regarding water management and adaptation measures are complemented by choosing measures adequate for the local environmental context.

Criterion 3: Societal Co-benefits for rural areas

NbS that address adaptation challenges can bring additional co-benefits such as biodiversity or job creation. The catalogue provides a holistic perspective on the generated benefits by choosing solutions that offer co-benefits relevant to rural areas.

Criterion 4: Ease of Implementation, Maintenance and economic feasibility

A common challenge when selecting adequate solutions to respond to hydro-climatic extremes and water quality problems is the consideration of available capacities and skills to implement and maintain them. The catalogue considers the planning scale by offering a balanced set of solutions ranging from more technical and engineered solutions (such as Agrivoltaics) to options that require less specialized skills and have a simple design and construction process, such as Check Dams.

Criterion 5: Implementation Scale

Adaptation measures are selected according to their applicability to three different scales. Different scales may be necessary to effectively address water management and adaptation needs, ensuring a holistic approach considering the entire hydrological system and its interconnected components. The three considered scales are the local and farm, watershed, and regional/landscape scales.

Locally suitable measures identified during the first phase:

As locally suitable nature-based and integrated water, energy and food providing solutions we have identified: Sand Dams, Check Dams, Managed Aquifer Recharge (MAR), Terracing, Agricultural managed aquifer recharge (Ag-MAR), Permaculture, Biochar, Agri-Voltaics, Community-based Agroforestry, Conservation agriculture (CA), Constructed Wetlands (CWs), Rainwater Harvesting and Riparian buffers.

The initial catalogue with a comprehensive literature-based evaluation of the adaptation measures – to be completed during the main phase -- is available through the link below: http://www.basin-info.net/owasa/nbs-adaptation-catalogue

The viability of three specific measures was evaluated for Waterberg and Chimanimani (TUD):

The viability of three particular adaptation measures was assessed: Infiltration basins for increasing groundwater levels through the storage of surface water in the aquifers, sand dams for improving the temporal distribution of excess water, and terracing for enhancing irrigation water infiltration through hillsides.

Infiltration basins should be built on relatively flat areas, with high infiltration capacity soils, with proximity to a water source and a high groundwater development potential. On the other hand, sand dams should be built on areas with impermeable soils and gentle slopes. Although proximity to water sources is an advantage for sand dams, it is not exclusively necessary for its implementation, since they can also be used to store rainwater. Finally, the implementation of terracing should be done in areas with high slopes, a good infiltration capacity and a significant size of the contributing watershed. Unfortunately, no places were found that meet these criteria in the study area. The following criteria were assessed in the geospatial analysis: Lithology, Hydrogeology, Watershed area [km^2], Slope [%], groundwater development potential and proximity to water sources. A total of four infiltration basins and five sand dams are proposed for the two project regions. Figure 2 illustrates the identified catchment areas that are suitable for sand dam construction:

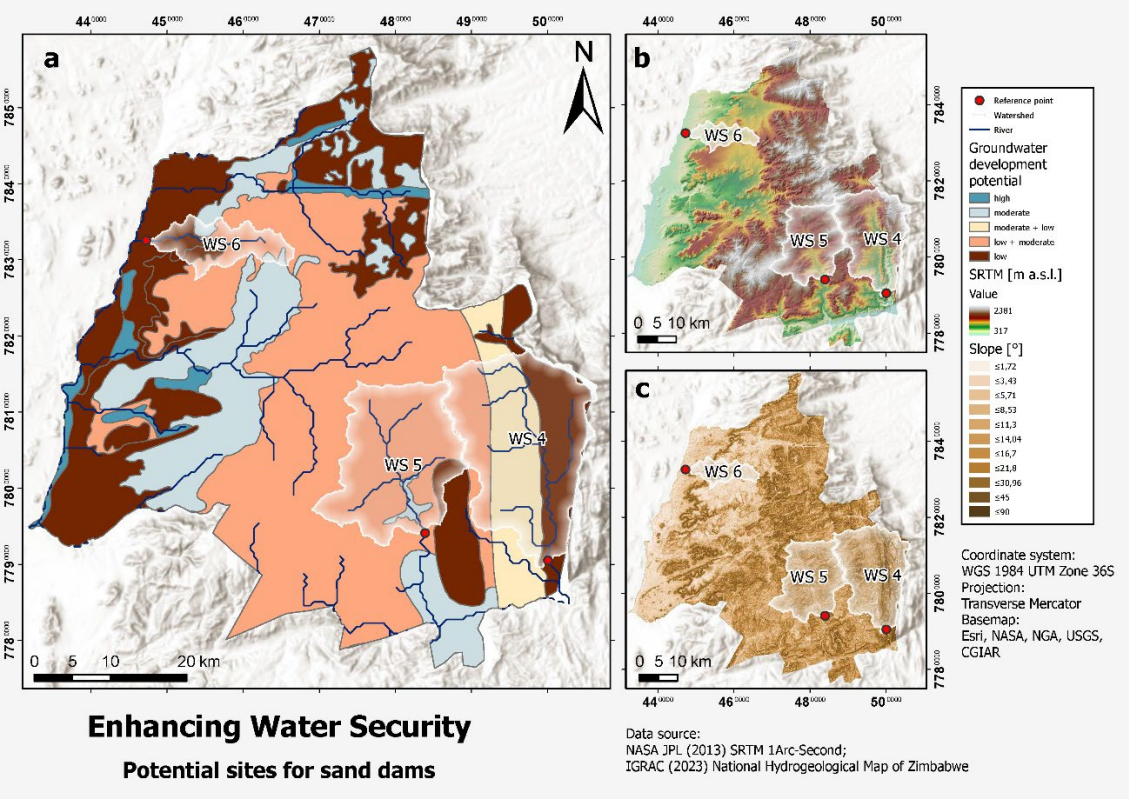

Figure 4: Subcatchments that are suitable for sand dam construction in Chimanimani

Figure 3 shows the catchment area that has been identified to be adequate as infiltration basin:

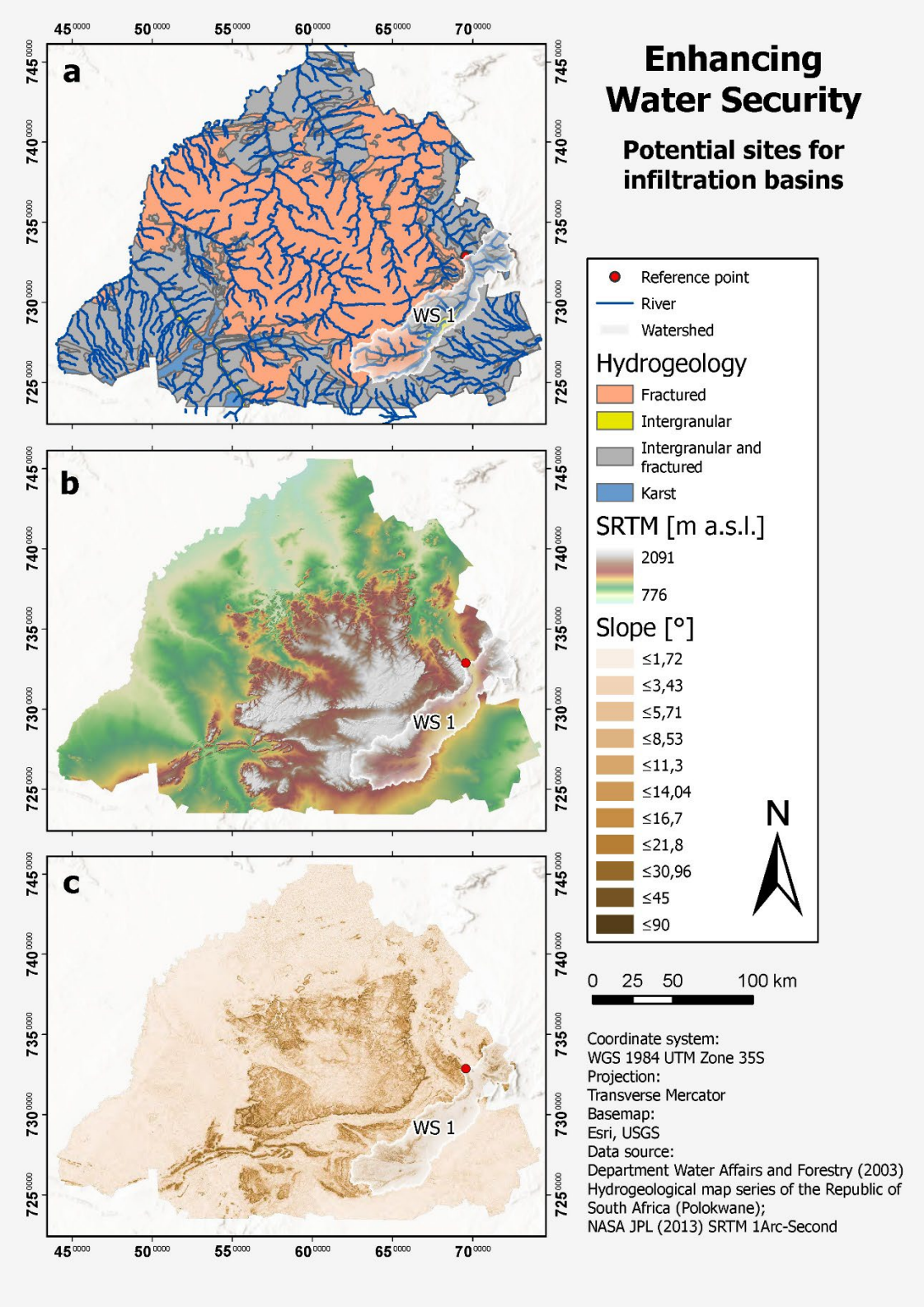

Figure 5: Catchment area (WS 1) suitable as infiltration basin in the Waterberg region

3.4 Work Package 4 OWASA Capacity Building

MSc and PhD education in the field of water resources management is one of the key activities of UoZ, ITT TH Köln and IAG TUD. The three MSc degrees IWRM (Waternet-UoZ), IWRM (www.iwrm-master.info) and Trophee (www.geo.tu-darmstadt.de/trophee/index.en.jsp) each year host DAAD scholarship holders from Africa, Asia and Latinamerica.
Funding for field research in the project regions was provided to the partners at University of Zimbabwe. In the scope of the OWASA project, the following 8 MSc theses have been jointly co-supervised:

Table 2: Master theses co-supervised by lecturers of UoZ, TH Köln and TUD in the scope of the OWASA project

Name	Surname	Project Topic	Study area
More-Grace	Hungwe	Tropical Cyclone Prediction, and Detection: A remote sensing based approach in flood prone areas of Zimbabwe	Chimanimani District
Praise	Kurarama	Assessment of the impacts of plantations/forest conversion on hydrology. A case study of BUPUSA.	Chimanimani District Buzi, Pungue and Save (BUPUSA)
Mike	Mushayi	GIS-based approaches for check dam site selection and evaluation of their suitability for the Chimanimani district of Zimbabwe	Chimanimani District Eastern Highlands
Fidelis	Gasha	Groundwater potential using spatial artificial intelligence machine learning in Chimanimani District with special emphasis on the PORET area	Chimanimani District Hwange
Tawanda	Gijima	Sanitation options for high water table and flood prone areas in Zimbabwe	Chimanimani District BUPUSA
Valentine	Zvomuya	Hydrological Modelling in Eastern Zimbabwe (streamline)	Chimanimani District
Miguiry	Kwenda	Hydrological signature of Cyclone Idai in Chimanimani District of Zimbabwe	Chimanimani District
Kudzai	Tafamba	Hydrological triggers of floods and landslides in Eastern Zimbabwe	Chimanimani District

Further activities have been:

- Contribution to SASSCAL PhD program materials and joint supervision of PhD students
- UoZ, TH Köln and Waternet: Preparation of collaboration and exchange among the three existing Master Program Curricula on IWRM; Proposal to DAAD: SDG University Partnerships
- Online lectures for graduates, MSc and PhD students on article writing and scientific work
- Publication of selected MSc thesis results on OWASA related topics ongoing
- Participation of OWASA researchers in Waternet Conference, close collaboration with WATERNET staff
- TH Köln student Fabian Harder 6 months in Zimbabwe to do field work on thesis “Exploration of Potential Dam Sites in the Nyamusundu Watershed (Chimanimani District,

Zimbabwe, Africa)”

Picture 2 UoZ Students doing field work in Chimanimani

3.5 Work Package 5 Coordination and Network

a) Dialogue and Network activities

To establish our network and co-design the OWASA research in cooperation with the regional and local partners and stakeholders, the following activities were conducted in the first project phase:

- Regular online meetings with the German and African project partners listed in the table 4 to explore the ongoing and upcoming activities relevant for OWASA and knowledge and research needs at local, national and regional scale
- 2-12 April 2022 – Workshops with OWASA project partners and stakeholders in South Africa and Zimbabwe and the Chimanimani and Waterberg study regions

Multiple online workshops and a presentational stakeholder workshop at UNESCO Rosa, Harare, 4.4.2022 and in Chimanimani, 5.-7.4.2022

UNESCO ROSA is implementing several climate change adaptation, water and land management projects in Zimbabwe and northern South Africa and coordinating them with other projects in the region (details are described in the OWASA application). During the meetings and workshops, we presented the OWASA project and the German higher

education institutions to the local and regional stakeholders and universities, asked for the local and regional demand for information, research and capacity building related to water security and obtained an overview on ongoing activities and projects in Zimbabwe and South Africa.

Results:

- UNESCO ROSA /IHP supports OWASA activities in both study regions to achieve strong synergies with the ongoing Be Resilient project and build on the results of the UNOPS Zimbabwe Idai Recovery Project (ZIRP).
- Use the Flood and drought Monitor for Zimbabwe and South Africa as a drought information and forecasting platform and expand it by presenting water security related information.
- Waternet: Collaborate to develop learning materials, student exchange, summer schools and courses on water security.
- University of Zimbabwe, Department of Civil Engineering (MSc IWRM): joint supervision of 8 Masters students, guest lectures, student exchanges. Topics have been exchanged. MOU and subcontract were issued.
- Close collaboration with CBOs in Chimanimani to jointly design adequate measures to climate extremes and to evaluate the effect of implemented adaptation measures and quantify these in Chimanimani.

Picture 3 Visit of the OWASA team by the CBO CELUCT, Chikukwa, Chimanimani District, 5.4.2022

Picture 4: Permaculture Training Centre of the CBO Celuct in Chikukwa

Multiple online meetings and a stakeholder workshop with Waterberg Biosphere Reserve (WBR) on 8.4.2022.

WBR is an NGO that implements biodiversity and water conservation, environmental education and climate change adaptation projects in the Waterberg District. WBR coordinates a variety of local activities, projects and research with the aim of promoting synergies in the above-mentioned areas. The region is affected by droughts, groundwater over-exploitation, mining pollution, urban flooding and landslides. During the meetings and workshops, we presented the OWASA project and the German higher education institutions to the local and regional stakeholders, representatives of the University of Limpopo, asked for the local and regional demand for information, research and capacity building related to water security and obtained an overview on ongoing activities and projects in Lhe Limpopo Province in South Africa. An overview of the Waterberg region, ongoing activities and projects in Waterberg was presented.

Results:

- Waterberg Biosphere Reserve, together with UNESCO ROSA /IHP, is supporting OWASA activities in Waterberg to achieve strong synergies with the ongoing Be esilient project and other local activities: Waterberg Governance Project, hydro-climatic monitoring, Internet of Things, IWRM Limpopo (water level measurements). Cooperation agreement and subcontract have been issued and signed.
- Main problems in the Waterberg region: water quality problems due to mining activities and illegal settlements. Groundwater overexploitation, water scarcity. Agricultural activities in the Waterberg district are sparse due to low soil fertility. Few job opportunities, food insecurity, water scarcity, poverty, informal shelters.
- Research: three Limpopo sub-catchments (Mogalakwena, Tambotie and Laphalala) draining into the Limpopo River have been identified as pilot regions for OWASA research and adaptation activities such as: hydro-climatic assessment and modelling, monitoring, water quality assessment and potential management, water source protection implementation (e.g. high altitude wetland in Marakele National Park), water security and drought risk assessment, surface and groundwater management (quality), identification of potential MAR implementation sites.
- University of Limpopo, Department of Biodiversity: main topic is water quality and monitoring, joint supervision of PhD and Masters theses in Waterberg, guest lectures, student exchange and joint supervision of Masters theses. A cooperation agreement was signed with the Waterberg Biosphere Reserve (WBR) and the University of Limpopo.

Picture 5 Workshop in Waterberg

b) Stakeholder analysis and network development in the first project phase

Stakeholder analysis

The OWASA project is a transdisciplinary research project that aims both to develop new scientific knowledge based on societal knowledge demand and to make this knowledge accessible to the society. There is a broad consensus in the literature that a systematic strategy for stakeholder analysis and collaboration since the first step of the project constitutes the groundwork for the demand-oriented research design and for the development of evidence-based and applied solutions (Freeman 1984, Jahn et al. 2012, Colvin et al. 2016). Hence, a comprehensive stakeholder analysis and dialogue with the actors in the study regions to co-design the research demand for the main phase of the project have formed an essential part of the OWASA initial phase. The stakeholder analysis has aimed at:

- Mapping stakeholders relevant for water security and the adaptation to climate extremes in Zimbabwe, South Africa and the SADC region considering the linkages of water resources with other sectors such as agriculture or energy;
- Mapping current projects and initiatives the OWASA project could connect with to create synergies considering both projects implemented by the national and local institutions as well as the sector of international cooperation;
- Assessing the relationship of the stakeholders with the OWASA project;
- Document the structure of water management intuitions in the case study countries to know the actors involved and understand how they are institutionally linked.

To identify and list the stakeholders and partners, we have combined three stakeholder analysis methods: literature review, building up on existing networks and snowball sampling - a method to collect information on relevant stakeholders by asking the involved actors to

provide further contacts (Phillipson et al. 2012, Bendtsen at al. 2021). In detail, the fallowing activities were carried out:

- In the first step, we fell back on networks and contacts established in the context of previous work of the ITT with the UNESCO Regional Office for Southern Africa ROSA
- UNESCO ROSA is implementing several projects on climate change adaptation, water and land management in Zimbabwe and South Africa and coordinates their activities with other projects in the region.
- Based on it the further actors were identified. In February and March 2022 online workshops were carried with the water-related UNESCO ROSA team to prepare a field visit in April 2022 of the OWASA team in Harare and Chimanimani District in Zimbabwe and to Waterberg, South Africa.
- 2-12 April 2022 - Stakeholder visits to Zimbabwe and South Africa, and visit to the Chimanimani and Waterberg study sites by the OWASA team.
- Review of scientific and grey literature on topics related to water security in South Africa and Zimbabwe published in the last three years to map current institutions involved in water management and ongoing projects/ government programmes in the study region in order to create synergies and avoid overlapping of activities with the OWASA project.
    a) Review of regional development plans in the case study region to identify stakeholders involved and create synergies with the development plans.
    b) Review of the federal funding catalogue (Förderkatalog des Bundes: LINK) and KfW project database (LINK) to create synergies with the projects in the study region funded by the German institutions
    c) Analysis of the institutional structure of water resources management in Zimbabwe and South Africa to understand the institutional environment in which the local water management institutions interact and how they are interconnected. (Results available here: LINK)

Results of the stakeholder analysis

STAKEHOLDER MAPPING

Based on the stakeholder analysis we have mapped 50 institutions and developed a table with almost 100 individual contacts relevant for the OWASA activities. The stakeholder table aims both to support the network building and co-design of research in the initial phase of the OWASA project and to provide a general overview of local and international institutions working on water security in Zimbabwe, South Africa and the SADC region helpful for further transdisciplinary MSc and PhD research either in the context of OWASA or other activities. The table is attached as annex to this report. The identified stakeholders were classified into eight groups according to their institutional linkage: Education and Research, Government institutions, NGOs or Community based Organizations, River Basin Organizations, User Associations (water, land), Development cooperation, Private sector, Projects: Defined as a separate category to avoid overlapping with existing activities

OWASA NETWORK

Based on the results of stakeholder mapping and of the dialogue with our partners and their interest in the OWASA activities, we jointly established the regional OWASA network consisting of:

- **Project partners** who have co-designed the objectives of the second phase of the OWASA project and are members of the project consortium
- **Further regional and international stakeholders** who may become relevant for the OWASA depending of individual research questions and will be contacted in individual implementation phases.

The following figure illustrates our OWASA network (1st phase):

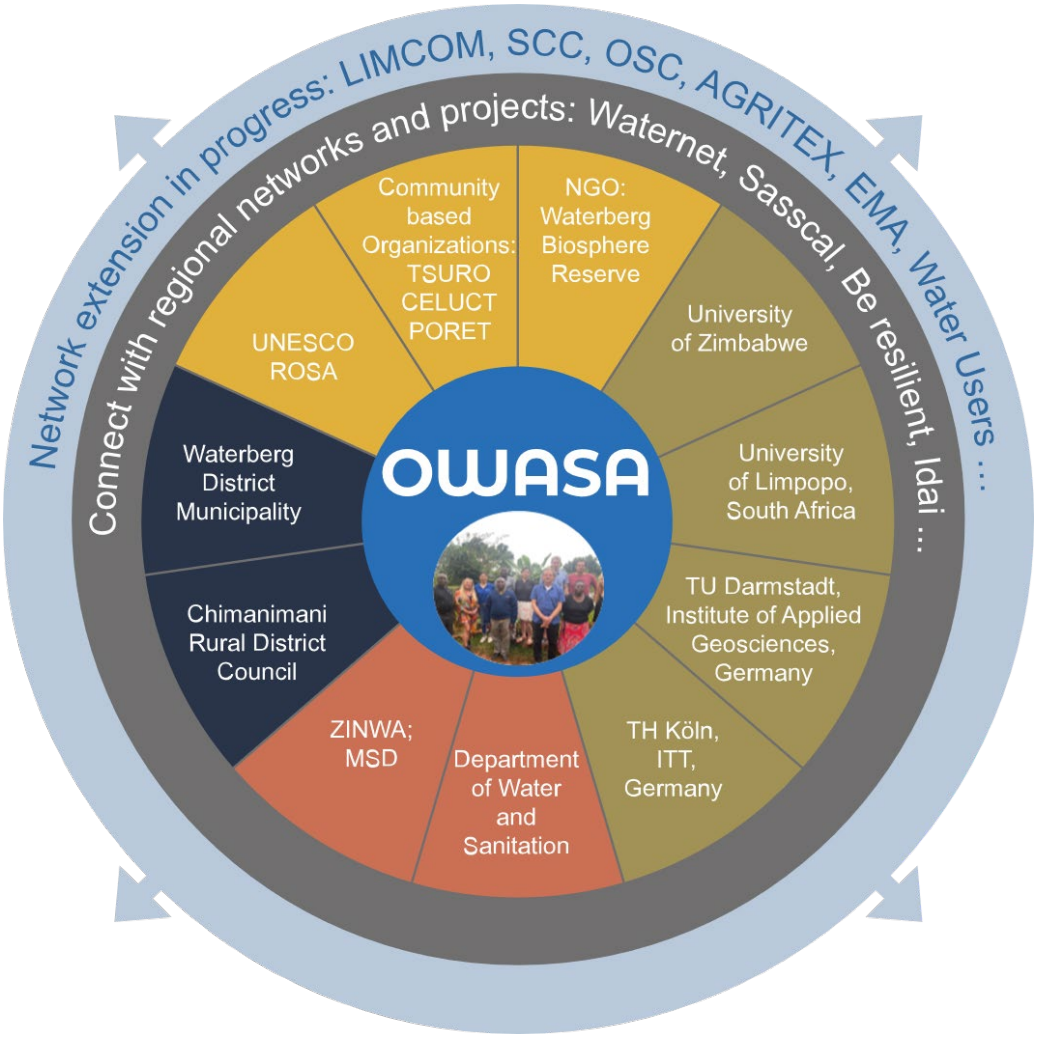

Figure 6*: OWASA Network: selected local partners and stakeholders*; **ZINWA:** Zimbabwe National Water Authority, **MSD:** Meteorological Service Department (Zimbabwe), **SCC:** Save Catchment Council (Zimbabwe), **OSC:** Odzi Subcatchment Council (Zimbabwe), **AGRITEX:** Department of Agricultural, Technical and Extension Services (Zimbabwe), **EMA:** Environment Management Agency (Zimbabwe), **TSURO:** Towards Sustainable Use of Resources Organisation (Zimbabwe), **CELUCT**: Chikukwa Ecological Land Use Community (Zimbabwe), **PORET:** Participatory Organic Research Extension and Training (Zimbabwe), **Idai** Idai Recovery Project (Zimbabwe) **LIMCOM:** The Limpopo Watercourse Commission (South Africa and Zimbabwe), **SASSCAL:** the Southern African Service Centre for Climate Change and Adaptation (South Africa and Zimbabwe), **Be Resilient:** Comprehensive Resilience Building project in South Africa (Waterberg) and Zimbabwe (Chimanimani).

Table 3 provides an overview on the key OWASA project partners and their role:

Table 3 OWASA project partners and stakeholders and their role and interests within the OWASA project

Group	Name	Connection to OWASA
Research	University of Zimbabwe, Department of Construction & Civil Engineering,	- Joint research and scientific publications of results in peer-reviewed journals (open access), - Joint supervision of MSc and PhD students, - Joint Hybrid lectures - Lecturer and student exchange - Capacity development (organization of summer schools, trainings for professionals) - Joint development of learning materials on water security, open source tools and open access data developed within the OWASA project.
	University of Limpopo, Department Water and Sanitation, South Africa	
NGOs and CBOs	UNESCO ROSA, South Africa and Zimbabwe	UNESCO ROSA supports OWASA to connect with ongoing projects related to water and land management in the study regions (e.g. Be-resilient; Idai)
	Waterberg Biosphere Reserve (WBR), South Africa, Local NGO	The WBR implements projects related to biodiversity and water conservation, environmental education and climate change adaptation in Waterberg. It supports OWASA to achieve strong synergies with local activities such as Waterberg Governance project, hydro-climatic monitoring, Internet of things, IWRM Limpopo (water level measurements).
	Tsuro Trust, Zimbabwe, Chimanimani District	Three community-based organizations (CBO) and training centers towards the sustainable water management, sustainable agriculture and climate change adaptation; OWASA connects with the CBOs to co-design site-adequate and cost-effective adaptation measures such as small reservoirs (check and sand dams), smart irrigation concepts or photovoltaic driven irrigation.
	Celuct Trust, Zimbabwe, Chimanimani District	
	Poret Trust, Zimbabwe, Chimanimani District	
Government institutions	Department Water and Sanitation (DWS), South Africa	DWS is the custodian of South Africa's water resources primarily responsible for the formulation and implementation of policy governing this sector. The OWASA project connects with DWS to co-develop data and information products on hydro-climatic, geospatial and socioeconomic variables; to exchange data and information and to co-design further research demand.
	ZINWA: Zimbabwe National Water Authority	The ZINWA is a state-owned company tasked with managing the water resources in Zimbabwe. OWASA connects with the ZINWA to co-develop data and information products on hydro-climatic, geospatial and socioeconomic variables; to exchange data and information and to co-design further research demand.
	Chimanimani rural District Council	Local governments are in charge of regional development plans including water, agriculture, energy and adaptation to climate change

	Waterberg District Municipality	(e.g. in Chimanimani District Climate Change and Watershed Management Steering Committee was established under umbrella of the district council); OWASA connects with the local governments to co-design the research demand; co-develop regional adaptation measures
Ongoing Projects	SASSCAL	The OWASA project cooperates with SASSCAL to create synergies with the SASSCAL doctoral programme in IWRM (co-design of PhD research topics on water security and joint supervision of PhD students); to connect with the SASSCAL data portal, to develop learning materials on water security, open source tools and data developed within the OWASA project.
	WATERNET	OWASA collaborates with Waternet in offering hybrid teaching, developing learning materials, organizing summer schools and short courses related to water security
	Idai ZRP – Word Bank	Idai ZRP – a project of the World Bank and the UN (2019-2023) to address the early and medium-term resilient disaster recovery needs of Cyclone Idai-affected communities in Zimbabwe OWASA builds up upon the results of the Idai ZRP project by referring to their identified check dam sites and adaptation strategies
	Be-Resilient Project UNESCO ROSA	- The Be-Resilient program is funded by the Flanders UNESCO Science Trust Fund aims at addressing climate risk and building adaptive capacity in Southern Africans Biosphere Reserves - OWASA creates synergies in the field of climate extremes vulnerability assessment for identification of ecosystem-based adaptation strategies

4. Additional Information

4.1 Main expenses during the first phase

- Personnel expenses: WMA (0.5) Oscar Manuel Baez Villanueva: 31000 €
- Administrative Personnel Celine Caspar: 6500 €
- 2 Scientific Assistants (WHK): ca 25000 €
- Travelling expenses (Ribbe, Nauditt, Sycz, Baez-Villanueva): 11300 €
- Subcontracts UoZ und WRB: ca 15000 €

4.2 Necessity of the grant for the implemented work

The first phase of the OWASA project could not have been carried out without the requested funding. No other third-party funding is available to implement the project. The planning and coordination of the project as well as the research on local water security and the development of adequate data sets + geospatial analysis are very personnel-intensive and thus not feasible without support from third-party funds.

4.3 Exploitation of results (1st phase) and future prospects

a) General OWASA exploitation potential (beyond outcomes Table 1)

- Our OWASA information and knowledge products are open access and can be used by the partner universities and stakeholders mentioned above.

- The catalogue of measures is a valuable source of information and also of interest for the international scientific and adaptation community with relevant guidance for decision makers, future applied research projects and capacity building. Many regions in Europe have been affected by hydro-meteorological extremes, especially droughts, during the past years. There is a strong need for adaptation strategies heading for water security and a transformation in agriculture. Many best practices can be adopted from African experiences. A proposal for Horizon Europe on Nature Based Solutions together with African partners is under preparation.
- The partners in the OWASA Consortium gain expertise in the field of development cooperation in the water security and adaptation sector and can subsequently act as a consultant to both governmental and scientific actors.
- The transferability of the project results (novel methods for assessing water security at the local scale as well as the catalogue of adaptation measures) to other regions offers exploitation potential for the development of economic products in the form of decision support systems for public and private actors.
- This includes potential for the establishment of consulting companies that support public and international institutions or planning authorities in the selection of suitable adaptation measures for the respective context (development of a marketing strategy in connection with the teaching module "Intrapreneurship" taught in the network).
- The OWASA Data Portal will be further fed with relevant data sets – especially when relying on funding for manpower and server capacity, adequate data infrastructures will be established that can further be harmonized with European and international standards like Geonode.
- Further providing open-access teaching and learning materials and fully designed courses for postgraduate research and teaching on the scientific methods used in the OWASA team and preparation of interactive exercises with data from the two local case studies;
- Guidance on assessing the hydro(geo)logical water balance as a decision support tool for adaptation measures (Managed Aquifer Recharge, geospatial analysis for water retention measures) for future applied research projects and capacity building;
- Strengthening scientific and economic cooperation between Germany and Southern Africa by involving a large number of doctoral and Master's students in activities during the initial phase of the OWASA project.

b) Future prospects

During the initial phase of the OWASA project, we have formed an engaged and competent water security related network of universities, public institutions as well as local and international NGOs. These fruitful ties will be expanded by further connecting to ongoing activities like by GIZ (South Africa, Project Inspired), World Bank (Reservoir Rehabilitation in Zimbabwe), UNOPS (Check Dams), new project of UNESCO ROSA funded by UNDP on Climate Change Adaptation in the BUPUSA), several WRC funded projects related to Water Security in the Limpopo Basin with University of Limpopo, among others.
In a joint effort with these local initiatives, we will identify further hotspots that are strongly exposed to hydro-climatic extremes and water insecurity and design site-adequate adaptation strategies.

The project region will be adapted to the above mentioned initiatives, using the Zimbabwean part of the BUPUSA region together with the Limpopo basin as pilot regions.

The OWASA Data Portal is currently only displaying example data sets. During the main project phase, it will be showcasing interactive climate information and projections, as well as deliver other information and data sets for the analysis of regional and local water security challenges. Its data infrastructure will be upgraded and harmonized with European and international standards like Geonode. The company 52 North will be involved to support this process.

A comprehensive catalogue of open data sets and one for adaptation measures relevant for rural Southern Africa (http://www.basin-info.net/owasa/nbs-adaptation-catalogue) has been elaborated and will be further developed, by describing and evaluating the effects of eg. Managed Aquifer Recharge (MAR), smaller reservoirs like check and Sand dams, Permaculture, Agroforestry and Constructed Wetlands.

In a joint effort with the high resolution imagery of the company UP42 and other partners, we will quantify the water security related benefits of the suggested nature based solutions at existing sites. Besides nature based solutions, we will evaluate the impacts and potential of Agri-Photovoltaics to support the sustainable supply of water, electricity and food.

Based on the analyses described above, we will design adequate adaptation strategies for the identified climate risk and water insecurity hotspots in the Zimbabwean Save and the South African part of the Limpopo basin.

As for the initial project phase, key pillar of the OWASA network will be university collaboration and capacity building on water security for the German-Southern African research community and stakeholders.

5. References

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