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Living in the 'hottest room' of hothouse Earth

How a multi-resources-mix can reduce drought risk in Namibia

Robert Luetkemeier, Johanna Kramm, Stefan Liehr

Water scarcity, drought risk, climate change, water supply, Namibia

Water scarcity is an essential threat to the sustainable development pathways of countries in the Global South. In southern Africa for instance, hydro-climatic conditions are already critical but are likely to become worse as climate change projections indicating more severe droughts, uncertain rainfall conditions and a likely temperature increase of up to 6 °C until the end of the century. These 'hothouse Earth' conditions, as recently termed by Steffen et al. [1], are a critical threat to the water and food security conditions of the population. In Namibia and Angola, drought events regularly challenge the local subsistence economy as it is closely linked to water-related ecosystem services.

This report presents research results from the past 14 years that show how a continuous water supply can be ensured in this fragile environment via a multi-resources-mix that comprises centralized and decentralized technologies with appropriate social and institutional settings. If transdisciplinary principles are considered, these interventions can increase local water buffers, decouple people's livelihoods from temporal water availability and trigger sustained agroeconomic growth. Experiences from large scale household surveys, the implementation of water technologies and the setup of adapted institutional frameworks provide a valuable blueprint for other regions in Sub-Saharan Africa to mitigate droughts and contribute to the Sustainable Development Goals.

Drought risk: a regional challenge

Climate change is likely to trigger unprecedented changes in the earth systems with potentially devastating consequences for humanity [2]. Will Steffen and his co-authors recently discussed potential development trajectories for the global society in the Anthropocene and the risk of nearby tipping points that may result in higher global temperatures than projected by recent climate models [1]. They coined the term 'hothouse Earth', depicting the risk of the earth system to switch to a much hotter state due to self-reinforcing feedback mechanisms. These may result in environmental and societal alterations of unknown extent.

This global threat is already perceptible in many regions worldwide, particularly with respect of changes in the hydrological system. Strong, recent drought events were recorded in California [3], Central Europe [4] and on the African continent [5]. Among other regions, southern Africa is at particular risk of drought due to two main reasons: first, climate change projections indicate higher frequencies and severities of droughts in the coming decades [6]. Second, the majority of the population depends on rain-fed subsistence agriculture and traditional water supply systems that are directly connected to local hydro-climatic conditions [7, 8]. Prevailing poverty, limited infrastructures and institutional capacities render the population highly vulnerable to droughts, compared to other regions [9]. Namibia and Angola are two critical examples as their semi-arid environment is commonly considered as the driest area in Sub-Saharan Africa. People regularly struggle with drought events as recently in 2012, 2015 and 2016 [10]. Governmental and international drought relief programs are often required to prevent serious famine situations.

Research for adapted solutions

During the past decade, the ISOE – Institute for Social-Ecological Research carried out several research and development projects with its German and African partners. These transdisciplinary projects investi-

Droughts threaten people and nature: Namibia and Angola are two critical examples as their semi-arid environment is commonly considered as the driest area in Sub-Saharan Africa

gated the local living situation and the environmental conditions in the context of water scarcity and drought in the border region between Namibia and Angola. Under the umbrella of the SASSCAL project (Southern African Science Service Centre for Climate Change and Adaptive Land Management), the ISOE researchers carried out qualitative and quantitative assessments in rural and urban settings of people's water and food consumption patterns as well as their capacities to cope under drought conditions [7, 8]. Furthermore, environmental analyses were carried out to develop an adapted drought indicator that considers precipitation, evapotranspiration, soil moisture and vegetation activity to temporally and spatially identify drought hotspots [11]. ISOE and its partners addressed the drought threat via the research and development project CuveWaters. This transdisciplinary project developed, implemented and evaluated technological and institutional interventions to mitigate the negative impacts of water scarcity in central-northern Namibia. Therein, semi-central and decentralized technologies of rain- and floodwater harvesting (RFWH), groundwater desalination and water-saving sanitation technologies coupled with water reuse were introduced and adapted to local needs [12]. These approaches enable the population to save the limited seasonal water resources and to make them available throughout the dry season for small-scale gardening to enhance nutrition and provide income via market sales [13].

Both projects elaborated on how to enhance local blue and green water buffers to combat the impact of droughts that may become an increasing threat in the near future as precipitation will be more erratic, temperatures will rise and the population grows steadily.

Multi-resources-mix

Most of the population in central-northern Namibia and across the border in Angola lives in rural settings with urbanization processes slowly gaining momentum, today. Traditionally, people live in homesteads of around 5-6 people and practice subsistence agriculture with a focus on millet cultivation, intercropped with a range of vegetables and fruits. In addition, husbandry is an important backbone of each household's livelihood. Cattle and/or goat herds of different sizes provide a valuable protein source for the population and offer the opportunity to gain income [14]. With respect to water consumption, traditional sup-

Source: R. Luetkemeier (2015)

Figure 1: *Traditional wells serve as an important water source, but may fall dry during drought times*

ply systems are still prevalent that mainly fall back on local shallow and deep wells (**Figure 1**), surface water and earth dams. At least in Namibia, these sources are accompanied by an extensive tap water system that provides high-quality water not just in urban environments but also in rural areas [14]. As this water, however, is not free of charge, many people fall back on traditional sources as long as quality and quantity allow its consumption [15]. Both, food and water consumption patterns indicate that people utilize multiple resources to meet their demands. This is a practice carried out to minimize the risk of source failures during drought times. Hence, taking up this traditional practice and developing it further was one key idea of ISOE's research projects in this area. Together with key stakeholders from national and local level authorities, non-governmental organizations (NGO), practitioners from the water and agricultural sector and the local population, technologies were introduced and adapted to local conditions to enhance the availability of water [16]. Two key examples are RFWH techniques and water-saving sanitation systems for rapidly growing urban agglomerations.

Rain- and floodwater harvesting technologies were designed together with the stakeholders for individual households and small cooperatives. The technology makes use of locally available materials to construct either above- or below-ground storage tanks and attaches a small garden or a medium-size greenhouse with drip irrigation techniques (**Figure 2**). High-value vegetables can be produced and traded on local markets. During the rainy season, the storage facilities are filled with rainwater or water from seasonal rivers. Storing this water increases people's options during the dry season to continue their farming activities and hence decouple their activities from primary water availability [13].

The water-saving sanitation technologies again take up the idea of reducing water consumption in this water scarce environment. Designed for rapidly growing urban agglomerations with a flat topography and the risk of being flooded in the rainy season, a vacuum sewage system was constructed in the town of Outapi (see **info box**). This system is semi-centralized and may be extended if new settlement areas are designated. From locally accepted toilet facilities (individual to community facilities), sewage is collected at a treatment plant in the city district. There, the sewage is treated to eliminate major pathogens but conserve valuable nutrients. Together with locally collected

Source: ISOE

Figure 2: *Drip irrigation in a greenhouse using harvested rain and flood water*

rainwater, nutrient dense irrigation water is provided for local gardening facilities. This technology provides sanitation services to the population and enables income generation via agricultural production [17].

Social and institutional innovations

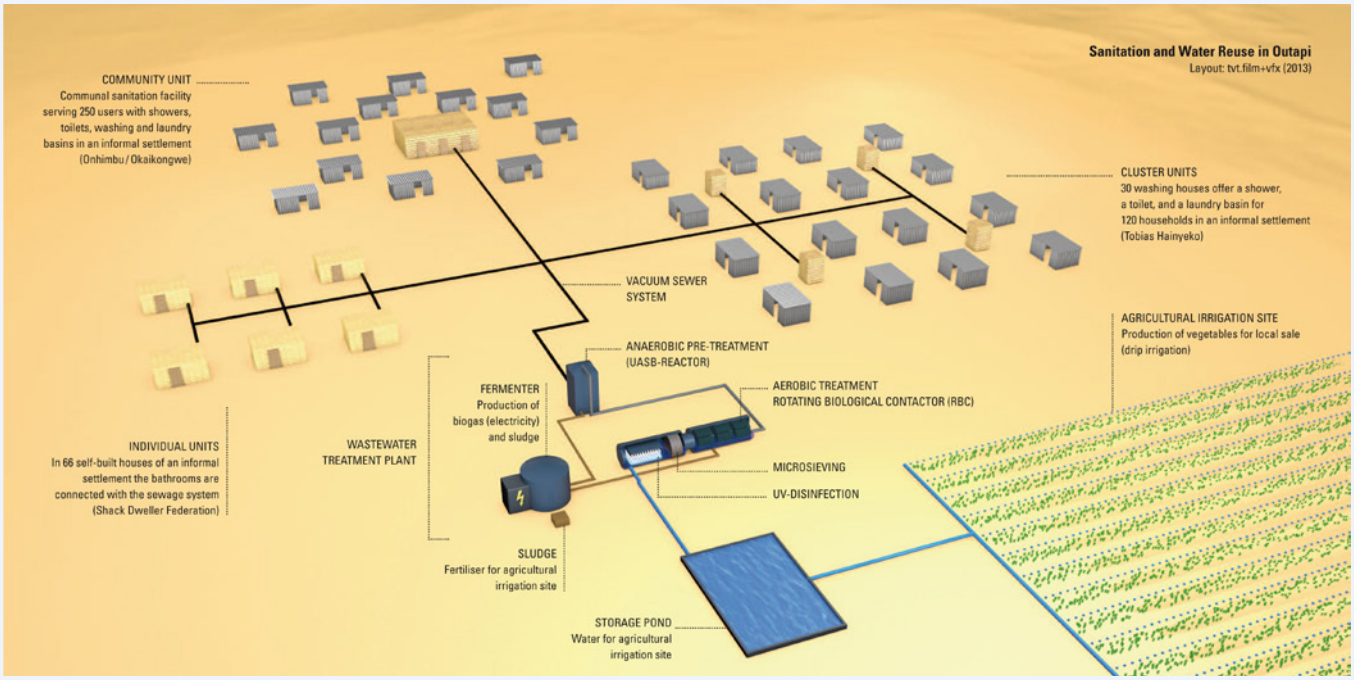
While these technologies provide the opportunity to enhance local water buffers, their institutional embeddedness and acceptance by the local people is a critical necessity. For this reason, the entire research process involved key stakeholders with a particular interest in the local population to participate in the design of the integrated (technological) solutions and during the construction and operating period. In this regard, ISOE researchers developed the so-called demand-responsive approach that combines qualitative socio-empirical research with participatory planning and hence facilitates mutual learning processes among researches, practitioners and local communities [18]. Besides, capacity development activities played a vital role during the entire project period. Trainings were provided on multiple topics from building/construction techniques via agricultural cultivation and the application of irrigation systems to basic accounting skills. Furthermore, voluntary community health clubs served as forums to discuss health issues and water-related hygiene practices. Overall, the empowerment of women was a focal point of the project activities as they stood out as the most interested group, in particular with respect to the setup of local cooperatives to produce and sell the agricultural products produced from RFWH technologies.

Conclusion

Droughts are already a critical threat for the society in Namibia and Angola and are likely to increase in severity and frequency in the near and mid-term future. Paired with a growing population, degraded ecosystems and changing lifestyles due to urbanization, this will challenge the population to provide adequate levels of food and water security.

Building upon people's traditional way of utilizing local food and water resources in the sense of a multi-resources-mix for risk mitigation, the ISOE research activities are targeted towards the implementation of adapted technologies to enhance local water buffers. Making use of seasonally available rain- and floodwater to provide irrigation water during the dry season (**Figure 2**) as well as water-saving sanitation and water reuse techniques, local communities are empowered to decouple their livelihoods from the precarious hydro-meteorological conditions. Semi-central and decentralized technologies, embedded in suitable institutions and socially accepted by the people who use them are a key adaptation strategy for northern Namibia and southern Angola. These technologies are required to accompany the governmental plans to expand the centralized tap water system in both countries.

Overall, the threat of drought is critical in many regions worldwide. Semi-central and decentralized so-



Source: ISOE

Sanitation and water reuse in Outapi/Namibia

A waterborne vacuum sewer system with poor-flush toilets was chosen for sewage conveyance from the settlements to a wastewater treatment plant. This 'closed system' helps to overcome the threat of seasonal floods in the area. After the wastewater has been transported from the sanitation facilities to a vacuum station, first it is pre-treated and then further purified with rotating biological contactors. Organic compounds are oxidised and nutrients largely remain in the water for fertigation purposes. Finally, solids and pathogens are removed by a microsieve and UV radiation before the water is stored in a pond for reuse in irrigation. Rainwater is also collected in this pond to gain additional irrigation water. The biogas produced from the sludge and biomass of the agricultural irrigation site is used to generate electricity, and the processed sludge itself is utilised as fertiliser.

lutions are one important cornerstone of future sustainable pathways, especially in developing societies, where no large-scale centralized infrastructures are available and flexible solutions are necessary in response to highly dynamic and uncertain developments. Transdisciplinary science that integrates decision-makers, practitioners and the local population as important knowledge-holders can design adapted technological and institutional solutions. As southern Africa and in particular Namibia and Angola may be regarded as the 'hottest room' in 'hothouse Earth', these interventions will support the population to adapt to future conditions.

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