Omeya ogo omwenyo – Water is Life

CuveWaters Report

CUVE waters integrated water resources management

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pro|aqua

Solar Institute Jülich (SIJ)

Terrawater

Industry – Sanitation and Water Reuse

Bilfinger Water Technologies

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Ministry of Agriculture, Water & Forestry (MAWF)

Outapi Town Council (OTC)

University of Namibia (UNAM)

Polytechnic of Namibia (PON)

Desert Research Foundation of Namibia (DRFN)

Development Aid People for People (DAPP)

Africa AHEAD, South Africa

One World Consultants, Kenya

Federal Institute for Geosciences and Natural Resources (BGR)

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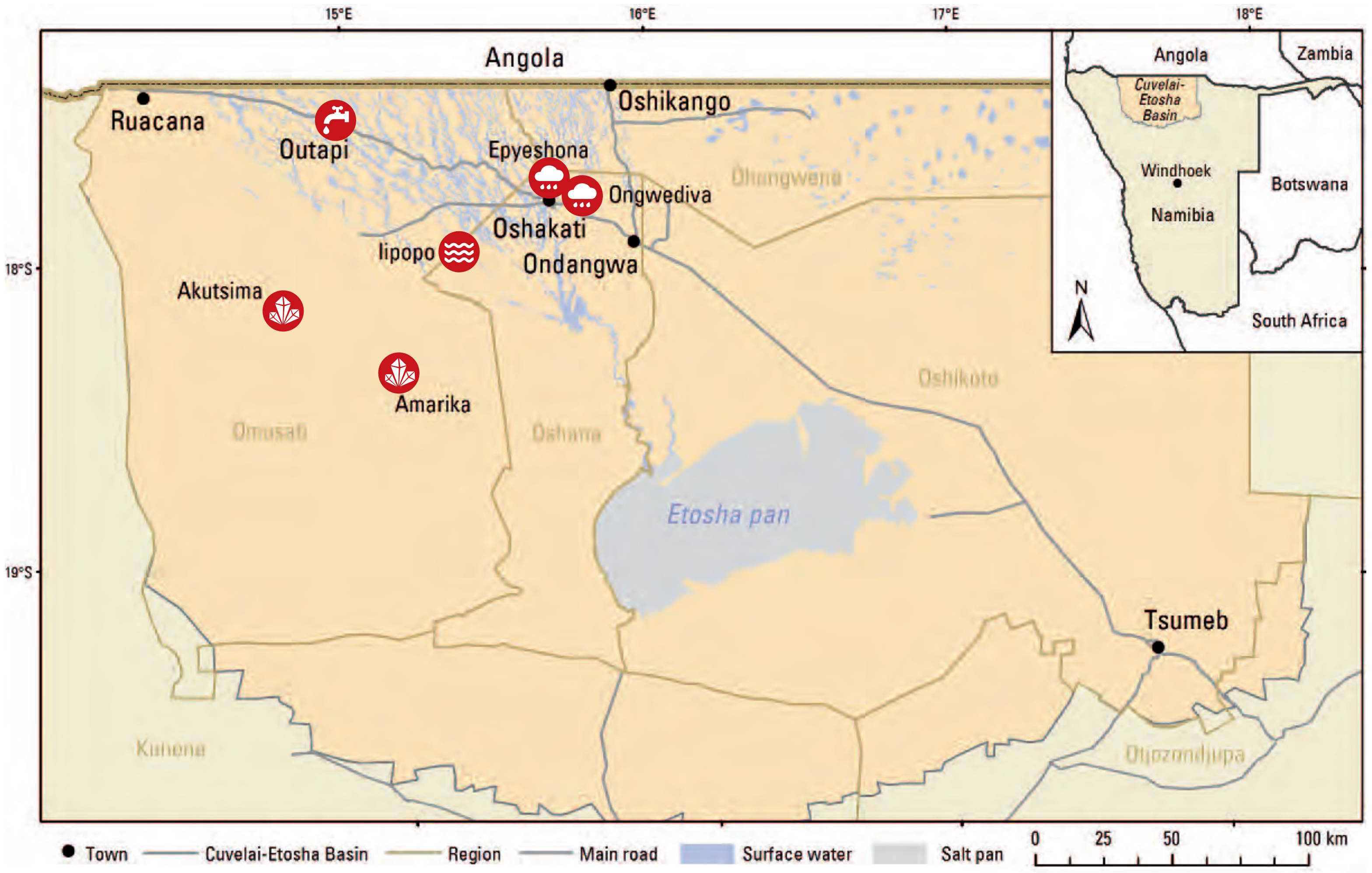
Study area and location of the pilot plants



Rainwater Harvesting

Floodwater Harvesting

Groundwater Desalination

Sanitation and Water Reuse

Foreword

The Cuvelai-Etosha Basin in Namibia is home to approximately 850,000 people – almost half the country's population. They all need good and healthy water for their daily life, for farming and for sanitation purposes. The Namibian Ministry of Agriculture, Water and Forestry, together with the Institute for Social-Ecological Research and the Technical University Darmstadt in Germany, amongst others, launched the CuveWaters project to study and implement new water technologies in the Cuvelai-Etosha Basin. The CuveWaters project is, beyond doubt, a huge success, because it brings more to the region than water: It creates jobs and vocational training and it improves the health situation and food security. Thus, the pilot projects are a blueprint for a better Namibian future and uncover our potential. Water is life. Clean water is better life.

Abraham Nehemia
Acting Permanent Secretary of the
Ministry of Agriculture, Water and Forestry

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The Cuvelai-Etosha Basin

Namibia is the driest country in southern Africa. The Cuvelai-Etosha Basin (CEB) in central-northern Namibia is particularly affected. It covers four regions, namely Ohangwena, Omusati, Oshana and Oshikoto. The climate is characterised by the highly variable nature of its water supply. People normally have abundant water during one half of the year while there can be drought during the other half, making them dependent on a water supply. The rainy season lasts from October to March, with an average annual rainfall of 470 millimetres. However, annual rainfall varies up to 60 per cent due to natural variations. This means that annual rainfall can be as low as 200 millimetres in some years, or up to 770 millimetres in others. This makes the availability of water even more unpredictable for the populace.

Most of the water in the CEB originates from the Cuvelai, the border river to Angola. During the rainy season an interconnected system of shallow water courses, called Oshanas, channels the water southwards, where it finally effaces in the specific geological formation of the Basin. Due to the seasonal changes between flooding and drought, surface water is only available in sufficient quantities during the rainy season.

The difficult water supply situation has an enormous impact on the inhabitants. With about 850,000 people, almost half the Namibian population is concentrated in the CEB. Most residents live in rural areas and form household communities. The water supply system – sometimes just consisting of an open canal – provides most of the communities with drinking water. But where this supply network ends, people depend on water from hand-dug wells in some areas. The water serves both for individual use as well as for drinking water for animals such as cattle. At lower layers, this groundwater is extremely salty, putting the population's health at risk. Another challenging situation is found in Outapi. The regional capital is growing fast, with corresponding sanitation problems. Access to sanitation and sewerage facilities are the main challeges in Outapi.

The Research Project CuveWaters

The research project CuveWaters implemented an Integrated Water Resources Management (IWRM) in the CEB between 2004 and 2015. The central goal of the project was to strengthen the potential of the region's water resources by developing and adapting innovative technologies for water supply and sanitation as pilot and demonstration plants. The implemented technologies are made up of pilot plants for rain- and floodwater harvesting, groundwater desalination, as well as sanitation and water reuse. Depending on its quality, the water is used as drinking water or to irrigate vegetable gardens.

The development and implementation of all this infrastructure was carried out in a participatory manner. In fact, participation was the key to involving stakeholders, such as the residents and the Namibian Ministry, so that they can develop ownership and goals to improve their living conditions. That is why a demand-responsive approach was developed.

This Namibian-German joint transdisciplinary research project was led by the ISOE – Institute for Social-Ecological Research, together with the Technische Universität Darmstadt in Germany. The Namibian partners were the Ministry of Agriculture, Water and Forestry (MAWF), the Outapi Town Council (OTC), the Desert Research Foundation of Namibia (DRFN), the University of Namibia (UNAM), the Polytechnic of Namibia (PON) as well as the local communities of lipopo, Epyeshona, Akutsima and Amarika.

"In order to lead a project properly, communication is essential: you have to speak to people. Whether they are old or young, you have to show them respect. You do not only demand respect, you show it yourself. You have to be friendly with everyone. Who will work with you if you are not willing to really cooperate?"

Emerita Iipinge
Acting village head of Epyeshona

PROJECT PHASES

The project CuveWaters began in 2006 and consisted of three phases.

During **Phase I** (2006–2009) the concepts were developed, potential technologies and sites were identified and weighed up in close collaboration with the local decision-makers and stakeholders. The demand-responsive approach was established.

During **Phase II** (2009–2013), the pilot phase, four different technology options were implemented: rainwater harvesting, floodwater harvesting, small-scale groundwater desalination, and sanitation and water reuse. The implementation covered technical facts and assessments on environmental impact. One aspect during this phase was to offer assistance in finding the most suitable technology for a given site and highlight its advantages and disadvantages. Capacity development by training the local populace was essential.

During **Phase III** (2013–2015) the handover to Namibian institutions as well as funding and management issues of the pilot installations was addressed. Future replication possibilities were elaborated.

Phase I
2006–2009
Concept phase

Phase II
2009–2013
Pilot phase

Phase III
2013–2015
Handover

Scientific & Societal Approach

Technologically sophisticated concepts can easily clash with users' socio-cultural needs and everyday behaviour. Therefore, the project used a transdisciplinary approach based on the integration of science, technology and society. This approach is reflected in the project's structure: the scientific components, concept development and empirical studies are closely interlocked with the integrative societal components. These processes constitute the basis for adaptive problem-solving. They promote the social embedding of technologies and the active involvement of institutional players and the local population. A new participatory method (demand-responsive approach) has thus been jointly developed with Namibian partners. It was applied in the project to develop and implement the new technologies based on informed choices. Additionally, knowledge management provided tools to support decision-making and planning processes.

Transdisciplinary Research

The project was carried out in a transdisciplinary manner. That means the social and the natural sciences interdisciplinarily contributed to the research results, and the practical experience and knowledge of stakeholders was included. This kind of research and work is necessary because the problems facing our world today are becoming ever more complex. Societal actions and ecological effects are so tightly intertwined that the boundaries between society and nature become more and more blurred. In dealing with complex societal problems, transdisciplinary research transcends the boundaries separating disciplines and scientific fields, as well as the boundaries between scientific knowledge and relevant practical knowledge. Furthermore, the practical experience and expertise of partners from society, politics and the economy are integrated from the onset.

Blueprint for Handling Climate Extremes

Water is not just in short supply in Namibia. Climate change, population growth and urbanisation are generally increasing the pressure on this resource. Dr. Thomas Kluge, leader of the research project CuveWaters – Integrated Water Resources Management in Central-Northern Namibia, explains how sustainable water supply and water disposal might be achieved under these conditions.

The CuveWaters project is about Integrated Water Resources Management (IWRM). Why did you choose the Cuvelai-Etosha Basin (CEB) in northern Namibia for your project?

During most years, the rainy season causes extreme precipitation accompanied by flooding. This gives rise to extensively flooded landscapes, the so-called Oshanas. The rainy season is followed by an 8-month dry season, in the early stages of which the water of the Oshanas evaporates very quickly. Salt deposits then develop on the surface of the Oshanas and the groundwater also becomes highly saline over time, which means it is hardly suitable as drinking water anymore. But this is just one of the problems the region is facing. Climate change causes strong variations in the amount of rainfall and also with regard to the onset of the rainy season. This in turn complicates the sowing of millet (the main staple food), and bad harvests become more frequent. These increasingly difficult living conditions the populace of northern Namibia is confronted with prompted us to launch the CuveWaters research project: we wanted to learn more about the effects of the climate extremes on the lives of the people in semi-arid regions and use the research results as a basis from which to develop sustainable solutions for the future.

Using rain- and floodwater harvesting, desalination and sanitation facilities means that you focus on a huge variety of instruments. Was your intention to test what works best or is this kind of technological mix a solution for semi-arid regions like northern Namibia?

In retrospect, 'resource mix' seems to be the right answer here. We began by asking ourselves how to make better use of the water available, whether it be rainwater, floodwater or even the highly saline groundwater. We then built rain- and floodwater collection systems that made it possible for rainwater to be utilised as a resource in this region for the first time. And this led us to the next question: for what purposes can the local people utilise the water? Until then, the people from the village had lived from animal husbandry, and water was only of interest for watering the livestock. We therefore combined the collection of rainwater and floodwater with the introduction of gardening, an activity not practised in this region at the time. This enabled us to make a vital contribution towards food security and poverty reduction.

The second approach involves groundwater desalination. Here we adapted both very low-tech and high-tech systems. Our primary aim in this respect was to promote health, because when people drink salt water over an extended period, it causes ailments such as softening of the bones, impaired vision and skin irritation.

Our third starting point was the construction of sanitary installations in the informal settlements. Together with the local populace, we tested a variety of models from a washhouse to small decentralised sanitation clusters with toilets, washing and shower facilities. The aim was to develop an appropriate sanitation concept and the use of wastewater as a resource.

Water is a huge cost factor for people in the CEB. Does the CuveWaters project make water cheaper or was the focus rather on access and availability of fresh water?

The focus was on water supply, which currently depends very much on the supply from the Kunene river, a border river between Namibia and Angola. The new installations are designed to promote self-sufficiency and reduce dependency on river water. The investment costs for the construction of these facilities, even for very basic low-tech models of rainwater collection, go beyond what the local people can invest. The expenses must therefore be covered by taxes and transfers (international funds). Here, the state is under the obligation to invest in the infrastructure. The idea is that the users themselves finance the maintenance and operation of the installations (and if need be also spare parts) via a system of water utility charges.

'Knowledge transfer' as the cue: How much of what you did can be transferred to other regions?

We are always aiming to convey knowledge in such a way that it actually reaches people and can be used by them. Thus, the experience gained by the local populace plays a vital role: certain engineering techniques are required to solve specific problems, but above all we need people who are capable of implementing and maintaining such solutions. Therefore, (continuing) training is important. The project is all about imparting basic skills and knowledge in the field of market gardening or the management/maintenance of the installations. It turned out that capacity development in the form of training in skilled trade is perhaps more important than a degree from a university.

The CuveWaters project has been running for almost a decade. During this time you have visited the people and places many times. Which experiences and moments did you personally find most moving?

The most moving aspect is that the people I have met over the past ten years live their everyday lives with an unbelievable degree of optimism despite their depressing and in some cases degrading living conditions: they live in houses made of tin sheets that become unbearably hot in summer and very cold in winter. Sanitation facilities fit for human beings are a rarity. Every dry season represents an existential threat to these people, who seldom have a steady income to rely on. I take my hat off to those who exist under these kinds of conditions without despairing or becoming fatalistic.

Rain- and Floodwater Harvesting

Rainfall over central-northern Namibia is restricted to a rainy season lasting from October to April. While during this rainy season, the region experiences on average 470 millimetres per year, the rest of the year is almost completely dry. Surface water is thus only available during certain times of the year. This is one reason why the landscape of central-northern Namibia is shaped by a system of so called Oshanas, fed during the rainy season by local rainfalls, as well as by water coming from southern Angola. Oshanas are very shallow ephemeral river streams which branch far out into the countryside and reach the Etosha salt pan during flood events. Only during the rainy season is the water quality in the Oshanas fairly good. It decreases rapidly during the dry season, due to evaporation as well as pollution from humans and animals. To lay out new gardens and irrigate them during the dry season with rain- or Oshana floodwater of appropriate quality, harvesting and storage techniques had to be introduced. This makes local water sources also available during the dry season.

Starting point was the local demand for additional water for small-scale irrigation farming. This met sustained interest within local communities to build and run these facilities, as well as gardens and small farms. It allowed year-round horticulture techniques to be introduced for the first time.

Floodwater harvesting stores water from Oshanas in artificial closed ponds and tanks constructed next to the Oshanas. To this end, the Oshana water is pumped into the storage reservoirs with a motor pump at the height of the rainy season, when the water quality is at its best. The stored water can then be used by the local populace for the irrigation of gardens and inside a greenhouse, both of which were equipped with a water-saving drip irrigation system. CuveWaters introduced the floodwater harvesting technology in a community-based approach in the village of Iipopo, 40 kilometres south-west of Oshakati. The gardens can improve the dietary situation and income potential of the local populace.

Rainwater harvesting on the other hand is a technology that is very well known all over the world as a means of providing water on a small scale, especially in developing countries. In CuveWaters, different technical and operational options for rainwater harvesting have been piloted in the village of Epyeshona, near Oshakati. During the rainy season, rainwater is harvested on roof tops or concrete surfaces and stored in tanks made of different materials such as bricks, polyethylene or ferrocement. The harvested water is of fairly good quality and gardens with water-saving drip irrigation were established next to the tanks. People cultivate tomatoes and other vegetables with the harvested water. Such newly introduced cropping systems generate additional income for the families.

During the implementation of rain- and floodwater harvesting projects, scientists, together with the local populace compared technical and organisational options. In the household approach, water is harvested from the roof of single households. The communal approach to rainwater harvesting comprises five different households that work together, while in the case of floodwater harvesting, ten households work together and share both the work and the revenue. In both cases a water-saving drip irrigation system pipes the stored water to a greenhouse and an open garden area. Furthermore, all farmers involved also have their own plot which can be used for self-consumption or market production of fruits and vegetables.

"The water we use is rainwater and river water. Before, we did not know how to harvest water from the Oshana. We used to let the water flow away along the Oshana. But now we have learned this good method to harvest water from the Oshana. We use a kind of bicycle and pump the water into the tanks. So we can use it during the dry season."

Rauna Nakahambo
Deputy Chairperson of the Green Village in Iipopo

RAINWATER HARVESTING FINDINGS

- Existing infrastructure in central-northern Namibia offers good possibilities for harvesting rainwater, e. g. roofs of public and private buildings.
- Nearly all materials for construction can be obtained from regional hardware shops.
- Tank, greenhouse and irrigation systems can be constructed by local staff under supervision of the trained technicians.
- Cost-benefit and sustainability analyses showed that on the household level, ferrocement tanks, and on the communal level, greenhouses with ponds are the most appropriate options.
- Cultivated vegetables improve the local food supply, thus helping to increase the health status of families.

Type of costs	Household approach		Communal approach	
	Material costs for pilot plant	Calculated costs for roll-out	Material costs for pilot plant	Calculated costs for roll-out
Investments for construction				
Infrastructure (tank 30 m³, gutters, downpipes)	N$ 12,000-18,000	N$ 9,000		
Infrastructure (ground catchment, underground tank 120 m³, shade net covered pond 80 m³, gutters, downpipes)			N$ 110,000	N$ 82,000
Garden (90 m²), drip irrigation system	N$ 2,700	N$ 2,000		
Garden (750 m²), greenhouse (160 m²), drip irrigation system			N$ 40,000	N$ 30,000
Operation and minor maintenance (per year)				
Infrastructure (e. g. tanks, fences)	N$ 100	N$ 75	N$ 1,000	N$ 750
Garden (drip irrigation system, seeds, fertilisers, pesticides)	N$ 500	N$ 375	N$ 2,000	N$ 1,500

N$ 1,000 ≈ € 65 (October 2015)

FLOODWATER HARVESTING FINDINGS

- Floodwater harvesting is restricted to places close to the main Oshanas, since water availability during the rainy season is more regular here than in the distributaries.
- Nearly all materials for construction can be obtained from regional hardware shops.
- Ponds, greenhouses and irrigation systems can be constructed by local staff under supervision of trained technicians.
- Cost-benefit and sustainability analyses showed that water ponds made of dam liner with roofs made of shade net are recommended materials for water storage.

Type of costs	Material costs for the pilot plant	Calculated costs for roll-out (per plant)
Investments for construction		
Underground tank (130 m^3)	N$ 42,000	N$ 32,000
Shade net covered pond (135 m^3)	N$ 23,000	N$ 20,800
Corrugated iron covered pond (135 m^3)	N$ 31,000	N$ 24,500
Garden (1,000 m^3), including drip irrigation	N$ 47,000	N$ 35,250
Greenhouse (176 m^2), including drip irrigation	N$ 43,000	N$ 30,000
Operation and minor maintenance (per year)		
Infrastructure (e.g. tanks, ponds, fences)	N$ 1,500	N$ 1,125
Garden (drip irrigation system, seeds, fertilisers, pesticides)	N$ 2,500	N$ 1,875

N$ 1,000 ≈ € 65 (October 2015)

Success factors

Social and organisational aspects were an important part of the project and the key to success. This included training in group management to adopt rules for common tasks, working times, how to market the products as well as maintenance. For diversity reasons, different age groups of women and men were combined to ensure continuity. Women in particular were offered support in seizing the opportunity to earn their own money, expand their skills and assume full responsibility for the project. Communication with the local group members was in the native language. The regional staff of the MAWF and its extension services also offered assistance in accounting and bookkeeping as well as in marketing the products. Training included farming step-by-step over at least one growing period, fertilisation, pest control, fencing and daily maintenance issues, as well as long-term maintenance of tools and other facilities to avoid extensive repairs. Technical problems that cropped up were addressed with the help of outside support from the engineering and extension services of the MAWF – for future replication, this must include long-term guidance of the groups in their activities for at least five years. Simultaneously, the extension services mentioned above received training and teaching material to help existing groups of farmers as well as to support replication of the technologies. Success factors for the household approach were a demand for additional water, a sustained interest in gardening, and continuity with regard to the people responsible for the tanks and gardens.

Achievements

Construction and operation of rainwater and floodwater harvesting facilities has been successfully implemented in northern Namibia: Good quality water from both technologies has been available during the dry season for gardening and other domestic purposes. The lower water quality of floodwater compared to rainwater harvesting does not seem to have a negative long-term effect on the crops.

Nevertheless, availability of water during the dry season varied, because climate and rainfall variability over several seasons proved to be very high. Therefore, during the course of the project all communal facilities were connected to the central pipeline system in order to supply the gardens with water when there is no rain. Greenhouses with ponds seem to be the most sustainable solution. Drip irrigation in the greenhouses achieved a relatively high level of acceptance from the farmers, as did the advantages of water saving and efficient work. Additionally, training enhanced knowledge about agriculture and irrigation. Three further communal plants have already been built in the region by people trained in the project, and several others have recently applied for funds to construct more plants.

Challenges

Farmers of the green village faced difficult processes of self-organisation and learning. The drought in 2013 was a challenge for the populace. The learning and training process was intensive and of course not always easy. However, when it became clear that training paved the way to improved living conditions, more people asked for admission. The demand was that 'everybody from the village get a piece of the cake' as inhabitants said in interviews. But rotating the farmers' group in this way caused new problems, because all the farming experience and training had to be obtained anew. Though this was clear from the project's onset, one recommendation for the future is to substitute only two of the group, so that know-how is continuously passed on to new members.

Local trainees preparing a roof for rainwater harvesting

Ladies from the village with their first harvest

Small-Scale Groundwater Desalination

How can people who live in remote areas without connection to a water supply system get better access to drinking water? This is the key question for people in the Northern Namibian Cuvelai-Etosha Basin (CEB). Currently, most inhabitants in rural areas without a piped water supply depend on groundwater from hand-dug wells. These wells fill up during the rainy season, while the water quality degrades rapidly due to evaporation and uncontrolled use by humans and animals during the dry season. The contamination with algae, faeces and parasites can be quite high. In addition, the groundwater is mainly salty. In some places the salt content of the groundwater can be three times higher than seawater. Drinking this water makes people sick, especially children.

To provide remote areas with clean and healthy drinking water, small-scale groundwater desalination technologies were piloted to supply the villages of Akutsima and Amarika with drinking water by request of the Ministry for Agriculture, Water and Forestry (MAWF). Four different technologies were piloted. The plants run on solar energy and without any chemicals added. They minimise adverse impacts on the environment, while at the same time securing the self-sufficiency of the villages. Due to the availability of land and the impermeable clay layer found at both sites, which serves as a natural lining, the disposal of the concentrate to evaporation ponds has been the most favourable solution both in environmental and financial terms.

Community involvement

In October 2010, the plants were officially inaugurated by the former Honorable Deputy Minister of the MAWF, Petrus Iilonga. The selection of the installation site

Amarika was a focus of the MAWF at an early stage, because the people in Amarika requested clean drinking water. The Akutsima site was chosen later by the project partners. They identified both a demand for such installations as well as spending capacities in the village. Populations in Amarika and Akutsima are quite similar, with 370 inhabitants and about 380 inhabitants, respectively. People in the two villages usually practice livestock farming and cultivate mahangu, a local millet seed. The main source of monetary income is the pension paid by the Namibian government, followed by selling items. Planning and implementation of the plants has been accompanied by community participation in the two villages to ensure that the offer of fresh water meets the needs of the local population. Throughout the process, exchanging information with the community was ongoing in order to create ownership of the plants. People from the villages were trained to look after the plants and are responsible for protecting them.

With success: In Akutsima, the demand for water has been much higher than expected. One reason seems to be that people in that village have a higher income level than in Amarika and therefore can afford to use the purified water for daily purposes, including, for instance, soaking beans which are the principal local food source. In contrast, in Amarika the desalted and purified water is not completely distributed, possibly because of the low income of the residents.

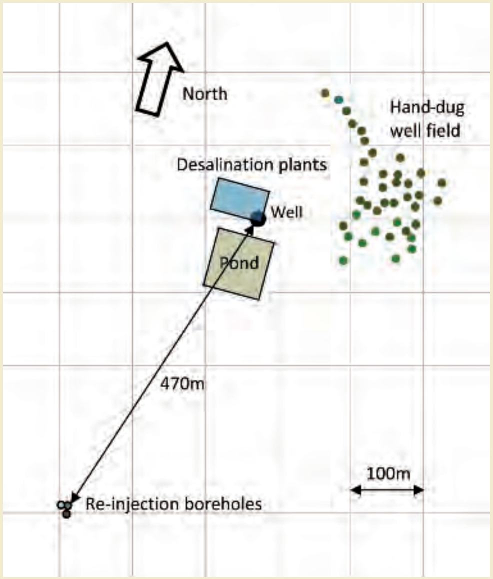
Today, the MAWF has ownership of the plants and a clear structure of responsibilities was implemented: Local caretakers are in charge of the everyday operation of the plants and of minor maintenance work. Maintenance skills depend on the capacity of the persons in charge and can fail without redundancy.

" The project brought many changes in our house. In drinking and cooking, washing and bathing. We are really fit now and our bodies are healthier. I can say that in our house we are better off now. Also when I look at the people in Akutsima now."

Lavinia Nekongo
Inhabitant of Akutsima

TECHNOLOGICAL EXPERIENCES

In 2010, four small-scale desalination plants were installed in two villages: In Amarika, the plant works with reverse osmosis. In Akutsima, the technologies used are humidification-dehumidification (or multi-effect humidification) and multi-stage desalination. Raw water is provided through 50 metre deep wells and pumped with solar pumps, while brine is disposed of in evaporation ponds and, in the case of Amarika, also in re-infiltration wells. Three plants have been adapted to the local conditions and have proved to work reliably when properly maintained, while the fourth plant, working with membrane distillation and installed in Amarika, was dismantled in 2013, since it could not be adapted to the local conditions.



Map of Amarika, showing wells, re-injection boreholes and hand-dug wells

Costs

The costs for desalination are highly dependent on site conditions, especially on the prevailing salt content and the preferred freshwater quality. Investment and operation and maintenance costs for the plants are within the same range of full-cost estimates for supplying the project sites with alternative options, e.g. water brought by tanks, extension of the pipeline supply or rainwater harvesting with disinfection.

Achievements

Groundwater desalination enables safe drinking water provision all year round for the local population. It helps reduce the health risks related to the consumption of salty or contaminated water. It also creates jobs in the villages and enhances skills and capacities at the local, regional and national level. The implemented small-scale desalination technologies are chemical-free and solar-coupled, making them an innovative method under challenging conditions.

Success factors

Successful operation and maintenance needs a multi-level responsibility structure which is embedded into the existing governance structures, processes and routines. A strong sense of ownership of the plants has to be developed from an early stage at the operating institution in order to avoid a feeling that the plants are too high-tech or too “alien”. Early and continuous on-the-job training of the in-house personnel is also essential in this regard. The maintenance of the plants (both identifying faults and reacting) needs to be addressed in a timely manner, which can prove to be very challenging given the remoteness of the plants and the fact that spare parts are often not stocked by local providers. The technical implementation has to be accompanied by awareness-raising within the communities on the benefits of the desalinated water for supporting the demand of purified water. Finally, a clear plan for the utilisation of the revenue from the sale of water needs to be developed, clearly communicated and monitored, in order to keep non-revenue water at low levels.

Local caretakers are in charge of everyday operations

Children enjoying the water from the desalination plant

Sanitation, Water Reuse and Irrigation

Approximately 40 per cent of the urban population in Namibia does not have access to improved sanitation facilities like toilets. That impacts mainly fast-growing cities such as Outapi in northern Namibia. In 2008, the municipality had barely 4,600 inhabitants, in 2015 it was already more than 6,600 inhabitants. This rapid growth has a tremendous impact on the urban water supply and effluents. Therefore, Outapi was ideal for implementing a sanitation and water reuse infrastructure.

CuveWaters combined wastewater management with water reuse, fertiliser recovery, energy generation, and a community-based approach. It was clear from the beginning that one single type of sanitation facility could not serve the needs of all residents. The Outapi Town Council (OTC) and CuveWaters implemented three different types of sanitation facilities in the following settlements: Individual connections to private facilities in the Shack Dweller Federation, small cluster washhouses in Tobias Hainyeko, and a communal washhouse in Onhimbu/Okayekongwe. Today, about 1,560 inhabitants benefit from the project's achievements.

The communal washhouse began operations in April 2013 in a very young informal area, today serving 900 inhabitants. Residents of the settlements as well as people from a nearby market place can use the toilets, showers, hand wash basins, laundry basins and kitchen basins. Security and maintenance staff is provided by the Town Council. 30 small cluster washhouses are shared by four to five families each. They are equipped with an indoor shower, toilet with hand wash basin and an outdoor laundry wash basin. The facilities are managed by the allocated households. 55 households in a self-built neighbourhood (with brick houses) are connected to water pipes and sewers.

Special attention was paid to altering hygiene behaviour to prevent waterborne diseases. The concept included almost a dozen Community Health Clubs (CHC) to improve household health and hygiene. The adaptation of the CHC approach was developed together with local NGOs and partners to meet the communities' needs. The wastewater collected from the sanitation facilities is conveyed through a vacuum sewer system to the water treatment and reuse plant, where it is treated in different stages. The reclaimed water is then stored in a pond for reuse on the irrigation site. There is also the option of producing biogas from the excess sludge and the biomass of the agricultural irrigation site, which can be used to generate electricity and heat. The processed sludge itself is utilised as fertiliser and to improve the structure of the soil.

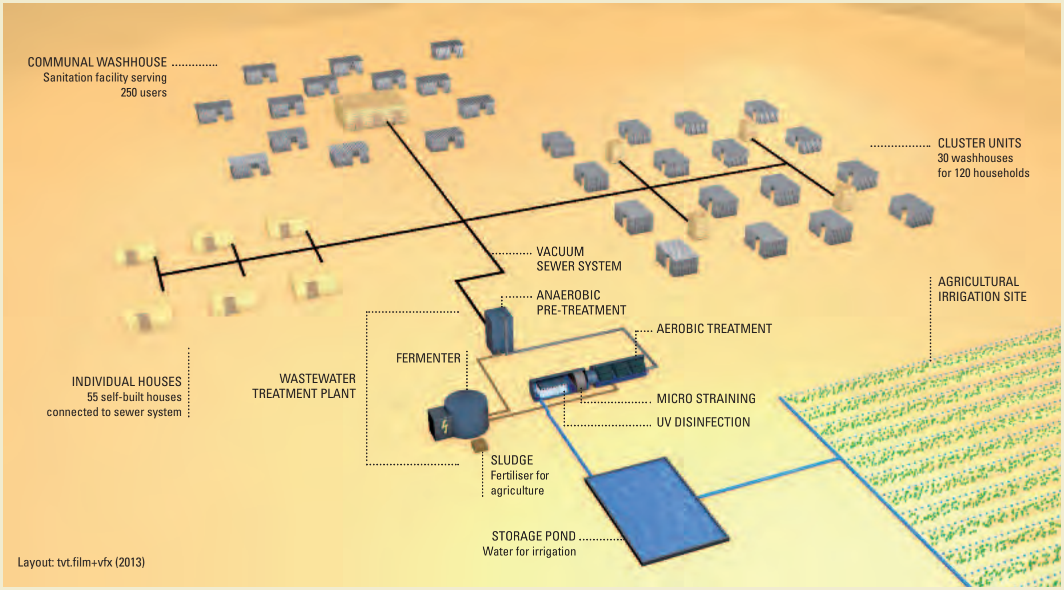
Health Aspects

When the sewage from the sanitation facilities enters the wastewater treatment plant it contains many microorganisms like bacteria and viruses, some of which can cause diseases. To ensure that the reclaimed water provided for irrigation is safe and "fit for purpose", a multi-barrier approach is implemented: Firstly, the number of pathogens is substantially reduced during each water treatment step in a gradual manner. Most of them die during disinfection with UV radiation, and their number is further reduced in the storage pond due to the extended storage times. The drip irrigation lines prevent the direct contact of the irrigation water (and thus of any remaining microorganisms) with the crops. The use of protective clothing by the farmers, as well as washing and possibly cooking the harvested vegetables provide the final barrier between the microorganisms and the users. The project site is prone to flooding. As a result, evaporation ponds, pit latrines and conventional sewers pose a risk of waterborne diseases spreading during the rainy season. The sanitation system in Outapi includes a tight vacuum sewer network and no open storage tanks for untreated wastewater, preventing rain- and floodwater mixing with sewage.

"Before the introduction of the communal washhouse, life was very difficult for our people. Right now we have a site where people can go and clean their clothes and blankets on a daily basis. That's why I can see that the living standard of our people has really improved."

Ananias Nashilongo
Chief Executive Officer (CEO) in the Outapi Town Council (OTC)

SANITATION AND WATER REUSE IN OUTAPI



1,560 inhabitants in pre-formal neighbourhoods in Outapi benefit from the sanitation and water reuse infrastructure. The concept includes the individual connection of houses, small, and communal washhouses. The municipality and the end users committed themselves to managing the facilities.

Achievements

Specifically, around 900 inhabitants of Okayekongwe and Onhimbu, where only a few public pit latrines were installed, now have access to a communal wash-house. 360 residents at Tobias Hainyeko Settlement benefit from shared facilities, but within a small group of users, which increases comfort and safety. Finally, in the Shack Dwellers Federation, 55 private households benefit from the highest comfort and privacy standards of private bathrooms.

Other benefits of the sanitation facilities were improved living and health standards. The rate of open defecation in the area addressed dropped from 58 per cent in 2012 to 12 per cent in 2015. Technical improvements include the relief of the overburdened stabilisation ponds used till now, and the avoidance of overflowing sewers during floods in the rainy season thanks to the waterproof vacuum sewer system. In total, sanitation and water reuse in Outapi created 11 full-time and 15 part-time jobs. Meanwhile, vegetable production was introduced with irrigation water from the treatment and reuse plant.

Agricultural irrigation site

Beside sanitation and health aspects, the reuse of the water in the surrounding agriculture is a key benefit of the Outapi project: Today about three hectares are being cultivated. The reclaimed nutrient-rich water is used for farming with drip irrigation. This type of agricultural food production has a low environmental impact. It generates income for the populace by selling crops grown on the irrigation site. Crops produced include tomatoes, green peppers, maize, water melons and pumpkins, among others. Because residents refuse crops that come in direct contact with the wastewater from the sanitation facilities, farmers only plant vegetables that grow above the soil. For irrigation, they use a pond with a water storage capacity of 3,700 cubic metres.

Strengthening the Governance of the State

A ready supply of drinking water is not only important for people's health, but also for social cohesion. Dr. Thomas Kluge explains the correlations between water and governance.

Projects such as CuveWaters depend very much on ownership by local communities in order to consolidate and carry forward what has been achieved. For this reason, was the societal approach every bit as vital for CuveWaters as the scientific perspective?

The first task was to carry out an exhaustive analysis of local needs together with the individuals concerned, as well as with policy makers and administrators. The success of such projects crucially depends on a common understanding of the problem at stake, from which feasible solutions can then be developed. This is why the sanitation area in our research project included larger washhouses as well as small clusters with four or five households sharing the use of and responsibility for a sanitation facility. And we found out that both models work well! The important thing is to listen very carefully to what the residents want while ensuring that the infrastructure remains in good working order, even given the changes that become inevitable over the course of time.

The same applies to the collection systems for flood- and rainwater that we designed and tested: with the water from these installations, people are growing vegetables for the first time in their lives and now need to learn all about plant health, soil improvement, and irrigation techniques such as drip irrigation. It became apparent once again that there is little point in setting up technical equipment and expecting people to use it. Instead, one needs to involve future users in the development of facilities and then develop good working practices during a process of mutual learning.

Confidence in democracy relies amongst other things on good governance. Has CuveWaters improved this aspect in the region?

CuveWaters has improved the living situation of the local populace. This path was not always free from conflict, but the basic message is that a functioning water infrastructure is feasible. Clean running water, a toilet and the regulated disposal of wastewater are fundamental things that strengthen confidence in the state and in democracy. It is, however, vital to include the population in this journey and to develop solutions jointly with them. This is not just a question of human dignity, but it also opens up prospects for new goals such as being able to work, learn, or attend a school instead of having to carry water for hours on end. Generally speaking, the project aims to enable people to be in a better position to cope with everyday life, to have a better stepping stone for job opportunities, and thus be able to regain control over their own life.

Mapping of the village with the community

Technician at the wastewater treatment plant

Sharing Knowledge

Sharing the knowledge gained is a key to long-term sustainability. CuveWaters used several methods to transfer the findings to society and science. The CuveWaters project developed a total of 14 tools, among them the Interactive Digital Atlas of the Cuvelai-Etosha Basin (see next page), the Integrated Water Resources Management (IWRM) Toolkit and the Technology Toolkit for Rain- and Floodwater Harvesting (RFWH Toolkit). This last tool supports decision-making, from the initial planning steps to the implementation of sustainable rain- and floodwater harvesting facilities, including micro-scale gardens. Developed by a cooperation of scientific and practice partners from Germany, Namibia and Kenya, the toolkit was applied and approved in several workshops in Namibia.

Capacity development within the CuveWaters project includes academic education and non-academic training. Training enables local residents to autonomously maintain and operate the facilities even beyond the project's duration. It fosters the sharing of knowledge and ownership as well as the spread of the technologies in the region. A good example is the train-the-trainer programme for the RWH teams: The local participants learned to build tanks and to organise the processes. Furthermore, all farmers were trained in how to prepare the soil and how to use the water efficiently. Challenges included: to establish a new culture of crop production, to educate farmers on the benefits and feasibility of private gardening and horticulture, to find construction materials that are available locally, and to implement the new system with local organisational and institutional structures. In order to establish the new technologies as well as the irrigation agriculture, programmes were conducted in which the extension staff of different local organisations was trained to be able to assist farmers.

INFOBOX

INTERACTIVE DIGITAL ATLAS OF THE CUVELAI-ETOSHA BASIN

The digital multimedia atlas integrates existing information about the Cuvelai-Etosha Basin and project results with the help of easy-to-understand maps, texts, photos and graphs. Basic analysis tools, overlay functionalities and cartographic multilayer display make it easier to grasp complex facts and processes. The ultimate goal is to allow everyone who is interested access to this wealth of information. The atlas is a joint project developed by Namibian and German partners and is available in a bilingual English-German version.

www.cuvewaters.net/Digital-Atlas.113.0.html

Highlights

- Fact sheets, implementation concepts and a policy brief were published to provide all the necessary (technical and organisational) information for decision makers, planners and local partners.
- Interdisciplinary and disciplinary publications were written by social scientists, engineers, natural scientists and economists.
- Many degrees and internships by young Namibian and German researchers were conducted to foster the international exchange right from the beginning.
- A field laboratory on RWH was implemented at the University of Namibia for long-term research.
- Vocational training for water operators and academic lectures on IWRM were given and will be included in the Namibian curriculum.
- CuveWaters was nominated for the „Sustainable Developments" research award of the German Federal Ministry of Education and Research (BMBF) in 2012.
- Local newspapers and radio stations showed a high degree of interest during the entire project.
- Various films documented the research progress over 10 years.
- Groundwater desalination was introduced and three technologies were successfully adapted to local demands.
- Altogether, more than 2,500 Namibians benefit from the technologies and their direct surroundings.

"I had an opportunity to come and work in Namibia through CuveWaters. The purpose of my coming is to train the people here in clean water harvesting. The impression that I have is that the water is there, the land is there, the soil is there. What was lacking was information."

Isaac Kariuki
Gardening consultant from Kenya

Outlook

Many towns in Namibia are growing fast and facing challenges like providing water, sanitation and a clean environment to all their inhabitants. The semi-central approach of CuveWaters for sanitation and water reuse is especially suited for towns with drastic population growth. This has great potential in Namibia, but also in other countries of the global south. The sanitation facilities in Outapi developed by the CuveWaters project can serve as a blueprint. To enable replication, the project partners, together with the OTC, invited mayors from 30 municipalities to Outapi to share knowledge about sanitation, wastewater and irrigation solutions, as well as about implementation and financing conditions.

Desalination has a nationwide relevance for semiarid regions with salty groundwater, but also for wells at the coastline. Their decentralised use is especially suited for rural areas which can be affected by poverty. However, in order to be sustainable, these technologies need to be adapted to the local context – through suitable design, adapted operation requirements, and by training users and operators accordingly. Technology roundtables were organised to provide information about the most important results of the implemented approaches. These roundtables addressed technical planners in order to enable them to execute the demands of decision makers in Namibia.

Recapitulating the CuveWaters project, there are various goals that will outlive the programme: In the case of rainwater harvesting, the spread of the technologies began at the onset of the project. From private people to schools, many local inhabitants ordered tanks and laid out garden plots. RFWH is well-suited for regions that are affected by climate change and have a high variation between floods and long dry spells.

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