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Water security and climate adaptation through storage and reuse

Rain- and floodwater harvesting (RFWH) technologies and water reuse are ideal and general-purpose technologies to improve water security and to contribute to climate adaptation – in particular for semi-arid regions. These technologies are part of a multi-resources mix within an integrated water resources management (IWRM). They create capacities to buffer water fluctuations and alleviate water scarcity. In this way, they reduce the pressure on existing resources, and can stimulate local economies. However, in order to be sustainable, these technologies need to be adapted to the local context – through suitable design, adapted operation requirements, and a back-up by training users and operators accordingly.

Findings and recommendations

- **Water storage at a small-scale level and water reuse at a municipal level reduce dependence from climate variations and from the effects of climate change, such as higher rainfall variability and longer dry spells. Water storage and reuse thus contribute to regional water security.**
- **Water storage and reuse, together with agricultural production, show cross-sectoral benefits by also improving the food, health and income situation.**
- **Small-scale water storage can be realised by harvesting rain and floodwater at a household-, farm- and community-level as a self-reinforcing bottom-up approach. Nevertheless, this approach needs an enabling environment with regard to policies, legislation, financing, and knowledge transfer (e.g. for operation).**
- **Water reuse has significant economic, technological and institutional requirements and it needs public authorities in order to be implemented. Solutions for reuse require a system perspective which includes sanitation and wastewater treatment. The specific needs of the users (e.g. health and hygiene education, tariffs, security) need to be taken into consideration which can be achieved by a demand-responsive approach.**
- **Institutions are needed that offer solutions adapted to the socio-cultural context. The solutions should address capacity development, financing options, legal security (e.g. of farmer groups) and the creation of market opportunities.**
- **State- or donor-financed training and dissemination centres create a setting that promotes small-scale water harvesting and gardening initiatives and enables them to spread in a self-organised manner.**
- **From the early stages of planning and implementation, women's participation and involvement are indispensable to increase the acceptance for and effectiveness of these technologies, since women are traditionally responsible for small-scale gardening.**

Figure 1: Ephemeral river during the rainy season (Oshana) in central-northern Namibia

Background

The challenges for local populations in semi-arid areas include high rainfall variability over different time scales and extremely limited water availability due to high evaporation rates. Sub-Saharan Africa and other regions of the world are particularly affected. It is expected that increasing demands will be made towards the appropriate management of water resources due to climate change among other factors. In this context three key issues typically exacerbate the situation additionally: (i) existing water resources are often used inefficiently or not at all (e.g. wastewater and rainfall), (ii) there is a focus on one single water source which is broadly exploited (e.g. water transfers) and (iii) there is a lack of knowledge about how to use other resources efficiently. Finally, water insecurity interacts with food security and partly also with energy production, which results in systemic risks in all three areas due to changing climate conditions.

Water storage and reuse

Worldwide, various solutions have been implemented to address water scarcity in semi-arid regions, for example water extraction from rivers, water transfer between river basins, ground-water extraction, and large-scale water reservoirs. We are, however, focusing on two solutions that utilise endogenous resources with a low ecological impact and a low potential for social disturbance (i.e. resettlements). In addition, both approaches help to avoid disputes based on political boundaries. The technological options are part of a solution with different types of approaches. “Bottom-up” approaches stand for initiation and diffusion emanating from users, whereas such activities originating from planning at public authorities indicate a “top-down” approach. While local people can build, operate and maintain the RFWH facilities and the irrigation sites autonomously after intensive training, the complex technology inherent in wastewater collection and treatment for reuse requires significant economic, technological and institutional input.

Characteristics of the approaches can be outlined from the transdisciplinary CuveWaters project, as a reference for research-based implementation of water storage and reuse in semi-arid Namibia. There, local capacities have been built in RFWH (farmers and trainers for construction, maintenance and gardening) and reuse (operators, technicians for maintenance and farmers). And thus, blueprints were developed for Namibia.

Rain- and floodwater harvesting

Rainwater can be harvested on rooftops and impermeable surfaces, while floodwater is pumped out of seasonal water bodies (cp. Figure 1). In both cases, water is collected during the rainy season and stored in tanks or ponds nearby (cp. Figure 2). Model calculations show that, even with a regional spread of RFWH technology, only 1% of the available water would temporarily be removed from the water cycle in the Namibian case. Harvested water has a fairly good quality and is mainly intended for gardening purposes (cp. Figure 3), but can also be used for washing, cooking or watering livestock. The size of a RFWH plant is adapted according to the number of dry months and the number of users in a household or community. Farmers jointly manage the facilities which include gardens, greenhouses and the corre-sponding water-saving irrigation system. Women in particular are interested in this kind of farming. Further details can be found on the respective factsheets about rain- and floodwater harvesting.

Water reuse

The concept of water reuse includes sanitation facilities, a vacuum or gravity sewer system and a wastewater treatment plant operated by the town council, and an irrigated agricultural area. A closed vacuum sewer system helps to overcome the health threats posed by a flooding of the evaporation ponds, pit latrines, gravity sewers and open defecation areas during the rainy season. An anaerobic-aerobic treatment process with subsequent filtering and disinfection enables the reuse of the resources water, nutrients, and biomass. After being retained in a storage pond, the nutrient-rich wastewater serves to irrigate an agricultural area by drip irrigation in order to produce crops for human consumption (cp. Figure 3). Biogas from the wastewater sludge is used to produce electricity for the plant. More figures and further details can be found on the factsheet about sanitation and water reuse.

Figure 2: Rainwater harvesting facilities with tank, greenhouse, field and drip irrigation system. The rain is collected from the roof of a house and piped to the tank (village of Epyeshona, central-northern Namibia).

Figure 3: Harvest of green peppers at a rainwater harvesting site (village of Epyeshona, central-northern Namibia).

Water and food security and climate adaptation

According to the IPCC, climate change will lead to even more variable rainfall in many regions of the world, thus increasing the vulnerability of small-scale subsistence farmers. Scenarios also indicate a later onset of the rainy season and longer dry spells during the rainy season, as well as more extreme rainfall events. The consequences would be more floods, droughts, erosion and ongoing desertification, as well as the overexploitation of groundwater resources.

Harvesting rain when its availability is highest, decreases evaporation and generates storage for the productive use of rainwater during dry spells and into the dry season. Water reuse from wastewater from urban settlements enables a continuous flow of treated water for irrigation purposes.

By generating additional local water sources and increasing water use efficiency, both technologies create buffers to mitigate the effects of natural fluctuations in water availability and to take the pressure off available water resources. The technologies enable water demand to be decoupled from adverse climatic trends thus increasing water security (Figure 4).

This subsequently leads to the following cross-sectoral benefits:

- Cultivation of crops, even during the dry season, improves food security.
- Construction of appropriate plants, operation and maintenance as well as farming create jobs and generate income if crops are sold on the market.
- Access to sanitation facilities and a better diet improve the health situation of families living under conditions of extreme poverty without access to markets or adequate sanitary facilities nearby.
- Children in particular benefit from balanced and adequate meals and hygiene.

Both technologies improve water security and the cross-sectoral benefits increase the capacity to adapt to climate change.

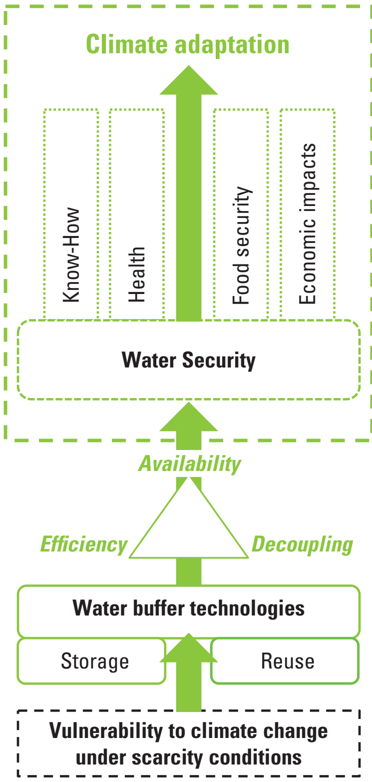

Figure 4: Water storage and reuse as adaptation strategies to reduce climate change vulnerability

Challenges of implementation

The challenge of introducing new water technologies and related irrigation agriculture in the region is: How to successfully guide local organisations and institutions, operators, and farmers through processes of governance and the development of technical and management skills? Intensive training and the development of commitment and responsibility is necessary to ensure working routines and the functioning of the whole system. For RFWH, this involves the construction and operation of the plants, right up to gardening and selling the crops. For reuse, the chain of activities starts with the construction of sanitation facilities accompanied by information campaigns in Community Health Clubs (CHC), continues with the construction and operation of the wastewater treatment plant, including the provision of irrigation water, and ends with tilling the fields and selling the crops on the market. The benefits and feasibility of private and communal activities in the local and regional context need to be demonstrated, as well as the suitable quality of the irrigation water, especially if it originates from treated wastewater. Strong links to technology and training providers are needed for initial (RFWH, reuse) and ongoing (reuse) support and maintenance.

Favourable conditions and requirements

Technological innovations alone are not sufficient to significantly alter the sustainability of natural resources management in the long run. For this reason, technological components have to be supplemented by research on social-ecological conditions, and by various accompanying activities such as governance development, participation of local people and institutions, as well as knowledge transfer. Ideally, a project starts with awareness raising campaigns, definition of milestones, selection of the technological concepts and designs, and continues with planning, implementation, handing-over (in bottom-up approaches accompanied by a legalisation of community approaches) and scaling-up activities.

Small-scale water storage through RFWH needs

- legalisation of production units on communal land
- financing options for construction and renovation
- Capacity Development for construction teams and farmers
- advice on demand by agricultural and technical extension services

Reuse of communal wastewater needs

- liability of political decisions and local planning (urban development plan, programme budgeting)
- financial feasibility
- technological robustness
- commitment of population
- health and hygiene education (Community Health Clubs, CHC)
- Capacity Development for institutions, operators and farmers
- advice on demand by agricultural and technical extension services

Special attention should be paid to the external funding required in both approaches (for the example of Namibia, cp. Table). These technologies are crucial infrastructure and can only be implemented with a mix of taxes, transfers (donors, subsidies) and tariffs. Expenses for operation, maintenance and spare parts can be balanced or lowered depending on the technology. In RFWH, the profits from selling crops exceed running costs.

With regard to water reuse, water tariffs can cover the operational expenditures as long as the sanitation system is optimally utilised (maximum number of users according to the capacity of the treatment plant). Additionally, there are benefits through the self-supply with energy from the fermentation of wastewater sludge and biomass. Compared to conventional wastewater treatment through evaporation ponds, capital expenditures of the CuveWaters sanitation and reuse system might be higher but this is more than compensated by its social, environmental, and technical advantages (e.g. hygiene improvement, water and nutrient recovery, robustness against flooding). All in all, the embedding in national policies and programmes is a prerequisite for successful implementation and a significant contribution of the technologies to climate adaptation.

Table: Financing options for water storage and reuse (with Namibian, and German examples). Possible forms of financing are budget allocation, (micro-)credits, subsidies or grants. Particularly for international institutions, the chances for financing strongly depend on the strategic fit regarding target country, technology and recipient.

	Water storage (RFWH)	Sanitation and water reuse
National	• Private/Households • Regional Councils • Ministries (e.g. MAWF-DAPEES) • National (Development) Banks (e.g. DBN) • Government Investment Programmes (e.g. EIF)	• Municipalities • Ministries (e.g. MRLGHRD, MAWF-DWSSC) • National Development Banks (e.g. DBN)
International	• Development Cooperation (e.g. GIZ) • Development Banks (e.g. AfDB, KfW) • European Union (EU), European Development Fund (EDF) • Green Climate Fund (GEF) • New Partnership for Africa's Development (NEPAD) • Seed Initiative (funded 2002 by UNDP, UNEP, IUCN)	

Abbreviations: MAWF = Ministry of Agriculture, Water and Forestry; DAPEES = Directorate of Agricultural Production, Extension and Engineering Services; MRLGHRD = Ministry of Regional and Local Government, Housing and Rural Development; DWSSC = Directorate of Water Supply and Sanitation Coordination; DBN = Development Bank Namibia; EIF = Environmental Investment Fund; GIZ = German Development Cooperation; AfDB = African Development Bank; KfW = German Development Bank

References

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For further information please have a look at the following publications:

- Deffner, Jutta/Thomas Kluge (2013): Participatory implementation of sanitation infrastructure in urban areas of north-central Namibia. WHOCC Newsletter No. 21, pp. 1–6 http://www.ihph.de/dokumente/whocc-news/Water_and_Risk_Vol_21_print.pdf
- Liehr, Stefan/Marian Brenda/Peter Cornel/Jutta Deffner/Jörg Felmeden/Alexander Jokisch/Julia Röhrig/Vanessa Stibitz/Wilhelm Urban (2015, in press): CuveWaters: From the Concept to the Tap – Integrated Water Resources Management in Northern Namibia. In: Dietrich Borchardt/Janos Bogardi/Ralf Ibisch (eds.): Integrated Water Resources Management: Concept, Research and Implementation. Springer
- Woltersdorf, Laura/Alexander Jokisch/Thomas Kluge (2014): Benefits of rainwater harvesting for gardening and implications for future policy in Namibia. In: Water Policy, Vol. 16, No 1, pp 124–143. http://dx.doi.org/10.2166/wp.2013.061
- Woltersdorf, Laura/Stefan Liehr/Ruth Scheidegger/Petra Döll (2014): Small-scale water reuse for urban agriculture in Namibia: Modeling water flows and productivity. Urban Water Journal, Vol. 12, Issue 5 http://dx.doi.org/10.1080/1573062x.2014.938295

Detailed information on rain- and floodwater harvesting as well as on sanitation and reuse in central-northern Namibia is provided by the respective factsheets which can be downloaded at http://www.cuvewaters.net.

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