Stakeholder participation and capacity development during the implementation of rainwater harvesting pilot plants in central northern Namibia
M. Zimmermann, A. Jokisch, J. Deffner, M. Brenda and W. Urban

ABSTRACT
This paper summarises the lessons learned during the planning and construction of four rainwater harvesting (RWH) pilot plants in the village of Epeshona (400 inhabitants) in central northern Namibia. The main problem of the region is that the water demand of its population exceeds the local natural resources. The rainfall in the project region is extremely variable (50–990 mm per year), evaporation rates are high, perennial rivers do not exist, and groundwater aquifers are saline due to low soil permeability and high evaporation. The project’s activities were prepared and accompanied by stakeholder participation and capacity development. The village community chose the techniques and pilot sites in several participatory workshops. Three roof catchment systems with differing tank designs (polyethylene, ferrocement, and concrete bricks) for individual households and a concretelined ground catchment facility for six households were built. The collected water is supposed to be used for horticulture. Hence, gardening plots and drip irrigation systems were created. Selected trainees were trained to build, operate and maintain the RWH systems and gardens. Finally, the pilot plants were monitored and evaluated to examine their social and technological feasibility.

Key words | capacity development, demand-responsive approach, horticulture, northern Namibia, rainwater harvesting, stakeholder participation

INTRODUCTION

Description of the study area

Namibia is located in the south-west of Africa and is the driest country south of the Sahara. The study deals with the four northern regions of the country, namely Oshana, Oshikoto, Ohangwena and Omusati (Figure 1). An estimated 40–50% of the Namibian population lives here (Araki 2005; Kluge et al. 2008). The region is almost exclusively inhabited by the largest ethnic group of Namibia, the Owambo (Niemann 2000). Oshakati is the major city in the region.

In the semi-arid region, up to 96% of the rainfall occurs in the summer months from October to April with a peak in January and February. The winter months are almost completely dry. The rainfall is unpredictable and varies from approximately 50–990 mm per year (Sturm et al. 2009).

The potential evaporation rate is as high as 2,500 mm per year (Kluge et al. 2008). Besides limited rainfall, the area faces another serious water problem due to its shallow topography. The Cuvelai basin stretches from southern Angola to the central north of Namibia and is named after a system of intermittent rivers with a surface area of approximately 100,000 km². Its headwaters are located in southern Angola. Depending on the amount of rainfall in that area, central northern Namibia can experience heavy floodings towards the end of the rainy season. The floodings were exceptionally high between 2009 and 2011.

The water supply system in the region is fed by the Namibian-Angolan border river Kunene and consists of a 150 km long open canal and a pipeline grid with an overall length of about 2,000 km (Zimmermann & Urban 2009). This is due to the fact that perennial rivers are missing and
the groundwater is predominantly saline. The salinity mainly stems from the low water permeability of the soil and high evaporation rates. Further problems can be seen in the population growth of up to 2.8% and migration into the urban centres of the region (Kluge et al. 2012). These factors will probably enhance the demand for water. Since the regional water demand exceeds the local natural resources, new sources for the water supply have to be developed.

Rainwater harvesting pilot plants

One of the water supply techniques which is examined in the CuveWaters research project is rainwater harvesting (RWH). Rainwater is hardly collected in the region by technical means (Zimmermann 2010). It can be harvested from several kinds of surfaces with high runoff coefficients. Gutters and downpipes lead the water into a reservoir (Sturm et al. 2009). When using roof catchments, corrugated iron roofs with high runoff coefficients of 0.8–0.85 are preferred over thatched roofs (Gould & Nissen-Petersen 2003). For the construction of ground catchments, concrete lined surfaces have comparably high runoff coefficients of 0.73–0.76 (Gould & Nissen-Petersen 2003). Regarding the reservoirs, attention has to be paid to the local availability of construction materials and workforce. Selected designs should be cost-effective and robust. The rainwater harvested is expected to be of medium quality and thus not potable, particularly with regard to the ground catchment. This is why it is mainly intended to be used for micro-scale gardening in order to increase self-sufficiency or to generate a small income.

To determine the potential locations of RWH pilot plants in the project region, essential selection criteria were defined by the project team. Potential sites had to fulfil the following prerequisites:

- Peri urban area to have options for the marketing of horticultural products
- Availability of rainwater
- Availability of tap water
- Availability of suitable roof catchments and potential ground catchment sites
- Local availability of construction materials
- Demand and interest of users for RWH technology
- Willingness of potential users to participate in the construction, operation, maintenance and monitoring of the plants.
The village of Epyeshona (Okatana constituency, Oshana region) fulfilled the selection criteria and was jointly selected as the pilot site by the community, the Department of Rural Water Supply (DRWS) of the Oshana region and the project team. The village is situated approximately 10 km north of Oshakati (Figure 1) and has roughly 400 inhabitants in 80 households (Deffner et al. 2008). The people mainly live from subsistence agriculture and are thus often not employed. Traditionally, pearl millet (Mahangu) is cultivated. The average annual rainfall is around 472 mm (Sturm et al. 2009). The drinking water supply is provided by the regional pipeline system. In the following sections, the lessons learned during the planning and construction of the RWH pilot plants are described. Special attention will be paid to the topics of stakeholder participation and capacity development.

METHODOLOGY

The methodology of this study consists of a demand-responsive approach (Deffner et al. 2010), combining qualitative social research methods on the one hand and participatory planning methods on the other. This allows for the collection of empirical data as well as for the integration of stakeholders. Methods of qualitative social research comprise a large number of approaches and are often applied in development and health studies (Patton 1990; Thomas et al. 1999). Participatory assessment and planning methods (PLA) are widely used (Chambers 1994), e.g. in urban and environmental planning, transport and zone planning, tenant participation or vision development (Davidoff 1965; Arnstein 1969; Bischoff et al. 1995). PLA are being applied in development projects and water resources management as well (Lammerink et al. 1999; Poolman & van de Giesen 2006).

With this approach, the social realities of local community members can be grasped and considered. This is important in terms of the development and implementation of the proposed RWH options. In our case, workshops were conducted with the inhabitants of Epyeshona, including the future users of the pilot plants. Interactions and discussions among the participants as well as with the facilitators were fostered. In doing so, the stakeholders were informed and, thus, enabled to take knowledgeable decisions. This was already one part of capacity development. Additionally, these decisions were taken jointly by the project team as well as the stakeholders in a participatory manner (stakeholder participation).

The demand-responsive approach consists of several stages which can be roughly subdivided on one hand into a planning stage and on the other into an implementation stage (Figure 2). In the planning stage, the local living conditions are examined and assessed to identify and understand the community’s (water supply) problems. Furthermore, the proposed RWH options are introduced and discussed to get an impression of their acceptance as well as to receive feedback in terms of proposals for (technical) modifications. After the incorporation of change requests, the proposed options are once again presented and discussed with the community. This step links the technical decision-making process with the following participatory development of the pilot plant’s institutional setups, as well as the capacity development, monitoring and evaluation processes. These following steps were carried out in a similar manner.

In the implementation stage of the pilot facilities, several threads of the approach were applied, such as monitoring generally the use and acceptance of the facilities, monitoring the technical status but also making interventions for technical capacity development and their monitoring. Several training courses were conducted and can be seen as such an intervention which was then monitored for its effects on the maintenance and management of the pilot plants. Quantitative and qualitative data were collected by researchers as
The methods applied in the steps presented had to be modified to the conditions of the rural area in the developing country. This refers to the language, the participants’ educational level and other socio-cultural issues such as traditional hierarchies. The handling of these aspects was considerably improved by the mixed research team which comprised German and Namibian members of different scientific disciplines, i.e. engineers and social scientists. The workshops took place in the village of Epyeshona and were carried out in the local language, Oshiwambo. Furthermore, all activities were coordinated with formal political and administrational institutions, such as the Ministry of Agriculture, Water and Forestry (MAWF), the Directorate of Rural Water Supply (DRWS), the Regional Council, the Community Development Committee (CDC), and the Local Water Committee (LPC). Care was taken to ensure that the workshop participants were representative in gender and age. Around 20–40 community members took part at each of the five workshops. One half to two thirds of the attendants were women. Both young and elderly people participated at the workshops.

RESULTS AND DISCUSSION

The results of the study are presented and discussed in three sections, namely according to the planning, the construction, and the operation, monitoring and evaluation phases.

Planning phase

During several community workshops and social-empirical inquiries in 2007 and 2009, the local water supply situation and water usage were recorded and assessed in Epyeshona (Figure 3). The participants consisted of males and females who actively took part in the workshop processes and gave valuable inputs (CuveWaters 2009). RWH techniques were introduced to the participants using drawings and models of the plants. Advantages and disadvantages were extensively discussed by and with the community. Generally, the people gave a positive response on the concept of RWH. On the one hand, the participants valued advantages such as saving money for the public water points or private taps, using less water, and having water available in the proximity of their own houses as well as for different

![Figure 3](https://iwaponline.com/ws/article-pdf/12/4/540/416932/540.pdf)
purposes (CuveWaters 2007). On the other hand, they worried that mosquitos could breed in the tanks or children might fall into them, both of which are unfounded fears. During the discussions, some participants mentioned that they wanted to store the total amount of the rainwater harvested in the rainy season in order to use it only in the dry season. This kind of usage pattern, however, would require a reservoir which would be three times as large as that implemented later on. This was why the suggestion was rejected and the reservoirs were sized according to a usage pattern with withdrawals during the dry as well as the rainy season. This was one of the few cases when recommendations by the participants were finally overruled for technical or economic reasons.

After the workshop attendees agreed to build four RWH pilot plants (three roof catchment facilities and one ground catchment system), the community selected three households for the installation of private roof catchment facilities. The criteria which served as a guideline for choosing the beneficiaries were jointly selected and comprised, among others, the availability of corrugated iron roofs of sufficient size and the willingness of the future users to contribute to the construction of the facilities. Three different tank types which had been preselected by the project team were installed at the three pilot plants (Table 1). The criteria for the preselection were that the designs of the facilities should be reproducible and materials or prefabricated parts should be locally available. Among the beneficiaries were the headman’s household as well as the vice headman’s household. Both families are highly respected in the local community. The whole participatory process would not have been possible at all without the contributions of the traditional authorities and their family members. Apart from that, the community also selected the site for the ground catchment system from a number of identified potential sites. The six households which would jointly use the ground catchment facility were chosen by the participants as well. In this regard, the main criterion for the selection was the immediate vicinity to the pilot plant. The institutional setup of the ground catchment system was solely developed by the community members, which is why it can be regarded as one of the main outcomes of the participatory workshops.

Most participants expressed their willingness to help with the construction of infrastructure by volunteering. The community discussed potential members who would have to be trained in the skills required for the construction (Deffner et al. 2008). The main criteria for the selection were: potential trainees should be willing to stay in the village for a longer period of time so that they might apply their skills even when the project was over. They also had to be able to speak and write English (CuveWaters 2009). The language barrier might be seen as a constraint but the trainees are supposed to train others in their local language Oshiwambo in the future. Eventually, six trainees were identified by the community to be trained in the construction phase. The trainees were local young men and women who were unemployed at that time and who were not members of the traditional authority’s family. During the construction phase, further labour was needed and additional trainees were chosen by the community.

### Construction phase

The RWH plants were constructed right after the participatory planning process during two phases. The first one started in October 2009 and ended in February 2010, whereby all four mentioned RWH facilities were

<table>
<thead>
<tr>
<th>Catchment type</th>
<th>Catchment size (m²)</th>
<th>Reservoir material</th>
<th>Reservoir size (m³)</th>
<th>Expected yield (m³ per year)</th>
<th>No. user households</th>
<th>Construction days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof catchment</td>
<td>100</td>
<td>Polyethylene</td>
<td>30 (6*5)</td>
<td>28–40</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Roof catchment</td>
<td>100</td>
<td>Ferrocement</td>
<td>30</td>
<td>28–40</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Roof catchment</td>
<td>87</td>
<td>Concrete bricks</td>
<td>30</td>
<td>24–35</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Ground catchment</td>
<td>480</td>
<td>Concrete bricks and ferrocement</td>
<td>120</td>
<td>118–170</td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>
constructed, including accompanying infrastructures (Figure 4). The main features of the four RWH systems are shown in Table 1. The building sites were supervised and managed by project team members, but the plants were constructed by the selected trainees under the guidance of Namibian and Kenyan consultants. The second construction phase lasted from February to March 2011 and mainly comprised irrigation facilities.

As part of the technical capacity development, appropriate training was intended to enable the trainees to construct, operate and maintain the RWH facilities (Figure 5). The technical instructors taught the trainees in all areas of guttering and piping, including soldering, ferrocement and brick tank construction, concrete brick making, and also in the organisation of construction sites, e.g. building material supply, calculations, etc. At the beginning, only the six selected trainees were trained at the first construction site (which was the roof catchment system with polyethylene tanks at the headman’s homestead). But the team of trainees increased to 25 people during the simultaneous works at the underground reservoir for the ground catchment and the ferrocement cistern. Mainly volunteers, such as local inhabitants from the surrounding households or students who were visiting their families, joined the team. This not only shows the interest that arose from the activities but also the motivation of the community. The trainees’ skills and educational backgrounds were very diverse, ranging from people without any handicraft experience to good skilled masons. Nevertheless, the trainees’ work assignment, commitment and attitude to work were very good to excellent.

During the first weeks of construction, the trainees were not paid but received food and drink as well as workwear. However, for the construction of the last RWH system, which was the concrete brick tank, and during the second construction phase, they received a payment according to local salaries. This is due to the fact that the trainees had already acquired some skills at that point. These trainees were primarily those who were originally selected by the
community. After the completion of the pilot plants, certificates of attendance were handed over to all trainees.

Other community members were also involved in the construction process, particularly members of the headman’s family. They gave organisational support, for instance by providing food and drink for the whole team. In doing so, it could be promoted that as many inhabitants of the village as possible felt part of the project. This is expected to lead in general to a better acceptance of the RWH systems but particularly also to better operation and maintenance by the users. Furthermore, a sense of ownership for the facilities can be created and fostered.

During the second construction phase in February and March 2011, small-scale irrigation systems and gardens were installed at the RWH pilot sites, since the harvested water is mainly supposed to be used for horticulture. Interestingly, the rural population did not apply any kind of artificial irrigation at all until then. All four sites were provided with lo-tech drip irrigation systems. Additionally, a greenhouse was built at the ground catchment. Therefore, the trainees received training in the installation of drip irrigation systems and in the construction of greenhouses as well as ponds for additional water storage. Furthermore, the user households and some of the trainees were trained in the preparation of gardens and received intensive gardening training.

Operation, maintenance and monitoring phase

Right after the end of the construction works, the responsibility for the operation of the RWH pilot plants including the gardens was handed over to the users. The roof catchment systems are operated by the respective household members. In most cases, there is one responsible person within each user household who was elected by the family or by the community. In terms of the ground catchment, the six selected households operate the plant jointly. Each one of them has the same right to use the harvested rainwater as well as one of six gardening plots of the same size.

The user households had already received training in the basic operation and maintenance of the pilot plants during the construction phase. Generally, RWH systems are comparably easy to operate and require relatively low maintenance (One World Consultants 2011). Operational activities consist of, for instance, diverting the first flush and checking the catchment surface for dirt. Maintenance comprises the annual cleaning of the catchment surface, the guttering and the reservoir. Apart from that, the trainees were instructed to carry out minor repairs such as fixing gutters and pipes or sealing tank leakages with cement if necessary. All described capacity development measures are supposed to ensure the reliable operation of the RWH systems as well as the fertility of the gardens in the long term. This is of particular importance when the project has ended and the responsibilities for the facilities will be completely handed over to the user households.

Monitoring measures have been divided into the monitoring carried out by the users, further technical monitoring and socio-cultural research. Many technical monitoring activities are being undertaken by the users of the RWH systems themselves. Parameters such as water quantity and quality as well as technical functionality of the tanks and adjoining infrastructures are monitored. Additionally, socio-cultural inquiries are being made every year in which the users of the RWH pilot plants are interviewed to determine the role of this additional source of water in their everyday lives. The same applies to the monitoring of the gardens watered with harvested rainwater. Here, the users are responsible for keeping records of ploughing, seeding, harvesting and manure application. The users are also asked to document the garden products they consume, share or sell at local markets. In doing so, the RWH systems’ contribution to income generation and livelihood improvement can be measured and assessed.

CONCLUSIONS

The project CuveWaters aims to develop endogenous water resources in central northern Namibia. With groundwater desalination, subsurface water storage, and sanitation and water re-use, RWH is one of four technological options which is implemented and tested in the project region as part of CuveWaters’ multi-resource mix. The regional hydrological situation is a major constraint for irrigated agriculture and gardening. Hence, the additional water resource provided by RWH is a considerable improvement. With it, local subsistence farmers are enabled to cope with
the dry season and to achieve higher yields. The horticultural harvest can either be used for self-consumption or to generate income by selling it at local markets. This can be seen as a crucial contribution to improving the livelihoods of rural communities. Apart from that, the harvested rainwater has already proven to be an essential water source. During the floods in 2011, several households in Epyeshona were cut off from the public water supply. However, they could be supplied with harvested rainwater by one of the pilot plant users during these times of need.

All activities in the research project include stakeholder participation and capacity development measures. The project's understanding of participation not only relates to the decision-making process, but also to the processes of planning, construction, operation, maintenance and monitoring. This high degree of participation is supposed to guarantee the acceptance of the proposed techniques. The experiences of many development projects have shown that users often are not satisfied with the measures provided if, for instance, the technique does not meet their expectations. The consequences are that the pilot plants might be operated improperly and maintained poorly. Without the users’ acceptance and sense of responsibility, even well designed and constructed systems are neither useful for the community nor the researchers. Another important aspect of participation is the adaptation of the proposed technique and its embedding into local conditions. To achieve this, an understanding of not only the physical but also the social living conditions is necessary. This comprises the water usage patterns of the users as well as their attitudes, needs and preferences regarding the proposed technique. Hence, stakeholder involvement and participation was encouraged from the beginning of the project.

Stakeholder participation and capacity development are interdependent. The one cannot be carried out without the other. Without explaining the techniques to the community and discussing advantages and disadvantages with them, the users would not be able to participate in the activities and to take informed decisions. Apart from that, the selected trainees received technical training. In doing so, not only could job opportunities be created by capacity development but access to the regional labour market could also be improved for those who participated in the training. This is of particular importance in a region where unemployment and emigration of young and educated people is a serious problem. Even though only a limited number of participants can be trained by the project, it is expected that those who received training are able to spread the knowledge they gained.

The whole community of Epyeshona participated in the planning process and more than 30 inhabitants were directly involved in the construction process. Another 10 people are now responsible for the operation of the facilities, mainly as farmers of the gardens irrigated with harvested rainwater. The work commitment of all participants was outstanding and the trainees have already successfully proved their skills in reservoir construction by building another ferrocement tank for an external client. During a 2 year monitoring process until 2012, the RWH pilot plants are currently being evaluated in terms of their general operability, cost-benefit ratio and viability. In the third phase of CuveWaters, it is planned to spread those techniques in the region which have proven to be sustainable in the pilot phase.

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