Participatory design of groundwater retaining structures in Kenya

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Introduction

Participation as the magic key to solve all worlds' problems pops up in every discussion on development issues (references). Defining what participation is, how it can be employed, what it means, etcetera, however, is less frequently made clear. Insights on and new models for design processes, which take these issues on participation and knowledge sharing into account, could be helpful. In Eastern Kenya, in the Kitui region, more than 350 sand dams have been built in the last 10 years within a participatory set-up in which the local Non-Governmental Organisation Sahelian Solutions (SASOL) and local communities co-operate. The small water harvesting structures[1] store sufficient quantities of water for livestock, minor irrigation and domestic use. If properly sited and built, this type of dams can be an effective and efficient water source, providing a possible answer to the high need for soil and water conservation in the drier areas of sub-Saharan Africa. The Kitui dams are in full use, which cannot always be said of other dams constructed in the Kitui area.

Many projects/policies implemented to improve the conditions of land and water would have failed because they did not recognise the location specificity of problems and solutions and the inapplicability of imported methods without adaptation to local conditions and customs. Many contributors to the discussion on participatory approaches stress the power of 'indigenous' knowledge (references). Technological-scientific approaches would be inherently insufficient to deal with the diversity and specificity of local practices, let alone to improve these practices. Much of this apparent fundamental difference, however, has a highly practical dimension and relates to the different spatial and temporal focuses of the different knowledge systems. Usually, scientific theories and laws are valid in abstract and/or idealised situations and are not meant to be applicable to every day situations. Local knowledge on the other side particularly is based on the every day situation, and can be highly successful in coming to terms with them. To be able to link with local practice is not impossible for science, but needs a focus on further translation of scientific knowledge to local situations, to enable scientific approaches and technologies to support improved processes of local practice and learning.

This contribution illustrates these general notions by discussing a key design issue in Kitui's sand dam design process: site selection and location choice of the dam. The decision moment 'location choice' appears to confront three types of knowledge/positions: (1) 'local' (or 'user'), including opinions on (former) water use, myths and relative position to the site; (2) experience from the NGO, including technology choice, construction methods and site criteria; and (3) technical-scientific knowledge, including design calculations and site protection. Before location selection is described and analysed in detail, both the technology itself and the general participatory design and construction process employed are described in the next paragraphs.

Introducing sand dams

The Kitui sand dams[2] are all stone-masonry sand-storage dams and built in non-perennial rivers. The basic principle of the groundwater dam is that instead of storing the water in surface reservoirs, water is stored underground. Evaporation losses are much less for water stored underground. Further, risk of contamination of the stored water from the surface is reduced because as parasites cannot breed in underground water. The problem of submergence of land, which is normally associated with surface dams, is not present with groundwater dams. A sand dam basically functions as a sub-surface dam, but it's crest is raised above bed level (figure 1). A sub-surface dam is constructed below ground level and arrests the flow in a natural aquifer. By the construction of a weir across the riverbed, the sand carried by flow during the rainy season, will settle in front of the dam and gradually the reservoir in front of the dam will fill up with sand. The sand bed is used to store water from the rainy season for use in the dry periods. A single flash flood may fully recharge a reservoir. Upon full saturation of the reservoir, the remaining flash floods will pass over the dam without any more infiltration. The stored volume of a sand-storage dam ranges from 100 m^3 to 50,000 m^3. Typical height of a sand-storage dam is 1-4 m above the surface. An advantage of sub-surface dams over sand-storage dams is that water does not flow over the dam; no spillway is needed. Thus, a sub-surface dam is not exposed to forces of flowing water, a sand-storage dam is. Giving these extra demands on sand dams, the condition of the dams in the Kitui area, all of the sand dam type, is generally fairly good (Beijmers et al, 2001b). If a reason were given for repair works of damaged dams, it always was erosion.

Figure 1. Principles of two types of groundwater dam

Figure 2. Signs of erosion (Beimers et al, 2001a)

Design and construction process of the Kitui sand dams

The participatory design process used by SASOL starts with a meeting with the community, in which the community 'must define its problems, set its priorities, and make the decisions on how to solve them (figure 3). *'Almost invariably, the shortage of water is the first problem identified, and the action plan therefore addresses ways and means of tackling the problem – not only to increase the quantity and availability of water but also to improve its quality.'* (MNU 1999; pXX). Water being the most essential commodity in the entire Kitui district, and consequently its development occupying the number one position in priority ranking of projects in Kitui is also recognized by external agencies (KDDP quoted in KSD 2002). One could argue that it is highly unlikely that in an interaction with a single-issue NGO like SASOL and a community other problem definitions than that particular issue will pop up. This in itself does no have to be problematic: easily agreement can be reached on the importance of a regular water supply.

Figure 3. Kitui design/construction process

Concerning solutions to the problem, every solution can be selected as long as it is a sand dam. Appropriate as the technology may be, pre-definition of the technical solution again limits community decision making in the participatory process. The Kitui sand dam project is not an exception, as participatory planning appears to be least common in the choice of technology and/or service level. (Van Wijk 2001). Perhaps this reflects an accepted and practical 'division of responsibilities' between communities and NGO's or other agencies, with communities setting the problems and agencies offering solutions for these problems. With the sand dam option as single offer, the participatory process in practice starts with the local community has to take the initiative to ask for a dam, indicate the stretch of river where storage would be most useful, and agree to provide the labor needed (MNU 1999). Stone, sand, ballast, water for mixing concrete and labor are all provided by the community. The NGO provides technical assistance (trained masons) and financial help for cement and reinforcing that would be beyond the resources of the local community. In such a way, water is provided to communities at relatively low cost (SASOL/MNU 1999).

People's participation is apparently limited to providing physical contributions, within the context of a supply-driven project, with the aim to construct a new, already defined facility. A standardized package is offered to communities. Such a simple statement, however, made from a relative distance, would not do justice to both the activities of stakeholders and the approach used in the Kitui region. The participatory approach, although it might be limited, should stimulate community abilities to develop own resources (MNU 1999). Strengthening communities through sand dam development would work because the technology is simple and thus suitable for participatory development methodologies (KSD 2002). Van Wijk (2001) points out comparable connections between 'simplicity level' of a technology and potential for participation. Apparently, mainly gravity systems (relatively easy to maintain and repair, low recurrent costs) aimed at organizing communities to manage their own domestic water supply. One study found that people's participation was strongly associated with the use of more simple technologies (Finsterbusch and Van Wicklin, quoted in Van Wijk (2001)).

To stimulate local development, with sand dams as catalyst, existing structures (in conformation with the governmental District Focus for Rural Development) are employed when working in a community starts, to strengthen existing institutions such as village development committees. It is also encouraged that communities organize themselves, in their own way, as village development committees are often weak (MNU 1999). In the formation of dam committees, the NGO offers guidelines on the characteristics of the composition of the committee (related to age groups, sexes, education levels, religious beliefs and political party affiliations). It is the community that decides. Apparently, this process does not result in clear procedures. Many community members seem not to know how processes of recruiting dam committee members are done (KSD 2002). Generally, users seem to be uncertain of differences between nomination, election and selection. Furthermore, low frequency of the dam committee meetings was reported. Indefinite tenure in office was reported too (KSD 2002). The functioning of the dam committees seems to have ended when the construction has (REAL-field research has confirmed this). A related issue is the perceived ownership of dams. Apparently, a vast majority of the water users in the region, whether they use sand dams or not, perceive water sources as community property. When ownership of sand dams is concerned, quite some users seem to consider SASOL as owner. Although this issue needs further study, a provisionary hypothesis can be that the participatory approach has not resulted in clear ownership.

A factor probably influencing this is the relative short period, in which SASOL and communities are working together. In the literature suggestions are sometimes made to build the dam in stages, to allow the reservoir to gradually fill up with coarse sediment due to higher flowing velocities. Fine particles will just flow across the dam. The coarse sediments increase the storage possibility of the dam because coarse sediment has a higher porosity. Furthermore the abstraction of water from the reservoir is easier in case of coarse material. SASOL has chosen not to build the dam in stages, as SASOL considers it to be difficult to mobilize communities for three consecutive years. Furthermore, a sand dam built in stages will only be fully effective after three years, time, which at least SASOL claims cannot be spared anymore; a solution is needed immediately. Most dams appear to have no serious problems concerning the sediment behind the dam, but this should be verified. Keeping activities limited to just one construction season could have its negative influence on the possibilities for a community to find a suitable organization. Organizing takes time. Van Wijk (2001) describes the Swajal project, with a total community project cycle lasting 33 months: 7 months pre-planning, 12 months of planning, and 14 months of construction.

Location choice

One of the most important decisions to be taken is the location of the dam. Topographical, geological and soil conditions of the area influence possibilities for and dimensions of the future underground reservoir and the dimensions of the dam. Presence of impervious layers in the subsoil prevents seepage of the water laterally and into the deeper layers. A sandy soil layer with sufficient water returning capacity in case of a sub surface dam is needed, or the possibility to build up such a layer in case of a sand-storage dam; the sand provides the storage space within the pores. At the same time, the dam should be approachable by community members; after all, the basic idea is to provide people with water closer to home. A certain dam location could favor users closer to it than others. As dams generally back up water for a few kilometers, their effect is not as local as one perhaps would expect. Nevertheless, access to and control over the dam itself and the water-enriched banks is a key issue. When locations for dams are discussed, SASOL staff and community members have to balance the two aspects.

After the SASOL committee training, representatives of the community walk with two SASOL representatives (mostly the technical manager and a mason, sometimes the field manager) along the river and show them what they think is the best place to build a dam. Before this walk the community has already discussed what they think is the best location for the dam. Both women and men are involved in site selection. Women play a major role as water managers and drawers in the household. As the project is mainly on water, they play a major role in it. They know which areas are most convenient to obtain water from and the distribution of these points for maximum coverage. In the community meetings the women's voice is heard loud and clear. The community has picked out the sites in accordance to user suitability and their knowledge of the area. The presence of a road appears to be important from a legal point of view. When there is a road the community does not need permission of the landowners to build the dam, otherwise she does. The SASOL representatives look from a technical point of view whether there is a location to build the dam. If so, SASOL’s technical manager will try to convince the community this is the best location. Criteria of the technical manager for a good dam location are given in Box I. Sometimes water may be needed at a location where the favourable conditions are absent. In such cases, risk of failure is high. When the community agrees with the proposed location for the dam, the technical manager discusses his findings with SASOL’s general manager. Each approved site elects a site committee (see section 4.2), which will supervise the implementation, operation and maintenance of the site.

1. Enough local materials must be present. Water, needed for the construction must be available in a maximum radius of 1 km.
2. At least 30 households must be participating for 2 reasons:
- There is more labour power available.
- More people benefit one dam. This enlarges cost-effectiveness. Cement makes the largest expenses.
3. The site must be easily accessible. Mostly a dam downstream, close to a road is best.
4. Riverbanks must be suitable:
- Banks must be high enough: at least 1.5 meters to prevent the construction from being too large.
- Soil must be firm enough. Soft soil needs large wings to stabilize the construction. Based on experience, SASOL uses 7 meter wings for soft soils (only if there are no other possible locations) and 5 meter for firm soils.
5. Scoop holes provide an indication of present natural barriers. Scoop holes that dry up during the dry season are considered good locations for a dam. 'Wet' scoop holes already provide water all through the year. This information is obtained from users.
6. Reservoir volume: Gradient and recharge possibilities are used as an indication of the volume of a reservoir. A smaller gradient makes a larger reservoir, also more recharge will increase the volume of the reservoir.
7. Risks of bypass: A dam can't be built in a bend since this will cause bypasses.
8. A possible natural barrier can be used as foundation for a dam. Note: there are risks of seepage when the rock is not impermeable. Scoop holes upstream that dry up very fast after the rainy season are suspicious.
9. There must be enough inflow (in mainstreams, this is never a problem).
10. Soil in banks: Kunkar limestone and Black Cotton Soil (BCS) have the habit to cause piping very easily because the soil flushes out or dissolves (kunkar limestone).
11. The location should be at least 3 km away from an earlier built dam because of social aspects:
- Certain communities might get more water then needed when dams are too close to each other.
- Water sources will be too far away for certain communities when no attention is paid to the allocation.
12. The river must flow from time to time:
- To provide water for storage

Box I. Design demands for sand dams in Kitui

In some cases, it happens that the community interests are in conflict with the required geological conditions for a sand dam. For example, the community members may settle for a site, which is central and thus convenient for most households, a site with fertile flood plains (a necessary condition for agriculture), or a site, which is good for watering animals (*Isyuko*). On the other hand, SASOL's technical staff may disagree with the site owing to its geological structure. For example some chosen sites may lack the necessary conditions for a strong foundation for the dam. At other times, the community identified sites may be too steep to allow the river to deposit sand, too steep to allow the river to back-up or too fast flowing for the safety of the dam. SASOL staff has to explain to the community members the site they have identified for the dam is not the best. Care has to be taken to avoid misunderstanding between the two parties.

Although detailed procedures for design and construction of the sand-storage dams in the Kitui area show some variability, as each site is different and the design has to be modified accordingly, designs are made on the basis of some rules of thumb. One source of knowledge is the fact that SASOL's technical manager has worked together with Erik Nissen-Petersen (one of the main promoters of water storage techniques) from 1980 until 1991. Together they have built several dams in Kenya. Another source of knowledge for SASOL has been cooperation with Delft University of Technology. Teams of students have worked in the area, evaluating dams, suggesting slight modifications based on general technical criteria and investigating hydrological issues. The University at its turn has gained from this cooperation, as its students[3] could experience new situations and enlarge their own knowledge base. SASOL knowledge and community knowledge is connected during a field trip, a very simple and cheap investigation method. As dam technology is low-tech, low budget and the location choice depends on community preconditions, the field trip seems to be more suitable than systematic studies that are expensive and time-consuming. More

User involvement in design and management

For an irrigation engineer, a first personal experience with users involvement occurred in an irrigation system in Argentina. On his first day, he walked through the system, and spotted a very subtle, but nevertheless clear adaptation of an irrigator to the regular infrastructure. Irrigation canals are usually fitted with emergency outlets, to divert surplus water to the drainage canal. In the Argentinean case, a lower canal bank in certain reaches of the canal system provided emergency outlets. The adaptation of the irrigator was simple: he or she had filled the low part of the bank with earth, thus blocking the outflow to the drain and increasing the inflow into the irrigation canal.

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be analysed as social learning. Scheer (1996) introduces a model, in which the design process is conceptualized as an interactive learning process of actors involved (adapted version in figure 4). In the model, several stages of the learning process are made explicit. The separate learning cycles of designers and users (in the simplest version only these two parties will be present) are linked to and confronted with each other. During the confrontation, learning experiences of actors are shared, providing a basis for the joint knowledge that is required for quality design. In interactive design processes (future) users of the artifact or other product to be designed are involved explicitly in the decision making process. Organizing an interactive design process is not necessarily an additional burden for projects and agencies. It is recognition of actual processes, with users manipulating structures or otherwise behaving differently than designers had expected. Therefore, interactive design processes brings problems and possible conflicts forward that probably would have come to the front later.

Figure 4. Interactive design process [adapted from Scheer 1996]

Return to the Kitui situation using this perspective. Describe interactions again, in particular the location and design issues using these learning cycles. Focus on the interaction between SASOL and water users. Interaction DUT and SASOL (and partly DUT-communities, as students interact with communities too) needs description. It might be nice to include Kolb-like elements, to show learning cycles a bit more in detail.

Conclusive remarks

Put the Kitui situation in perspective. SASOL takes the initiative, thus is the stimulus for development and perhaps learning. Social learning may require extensive inputs in time, probably more than provided at this moment. Nevertheless, promising results. Discuss division of responsibilities: participation should not suggest that the end-user could do everything. There is a definite need for technical input. This input, however, should be given in a social learning context, not in a top-down thing. Making the context as concrete as possible would probably help.

Interaction between users and designers (and not participation in agencies' projects!) in relation to the physical design is possible and necessary, and leads to adaptations of concepts used. Attention should be paid to broadening the designer's frame of reference as well as the users' in order to develop effective interaction. In the interactive design process, more than in any traditional design approach, participants search for an optimum match between the physical system and the social environment. There is not one optimal, technical solution anymore. Instead, a range of options for matching technical and societal factors is available or will be developed. The options imply design dilemmas, which cannot be solved on objective, technical grounds. The choices may refer to social aspects (changes in the household), to the interplay between technical system and societal environment (organizational demands), and to technical options available to achieve goals.

Designers have a different role in interactive processes than in standard design processes: instead of making the final decisions alone, they should stimulate and facilitate discussions and decision making by the group of people involved. This new role does not change the technical responsibility of designers. Designers are responsible for the quality of the design, and should take that responsibility. An approach like interactive design asks for a setting in which the different actors can learn from each other. People should be willing to discuss their inputs in the process, and people should be open and have a spirit of partnership. For many agencies this requires a complete change of culture or style, which may take years. The REAL design manual might trigger them to start the process of change.

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Notes

[1] Water harvesting technologies, which concentrate precipitation through runoff and storage for beneficial use, have probably been in use since 9,000 BC (Oweis et al 2001). Water retaining structures of the sand dam type intercept or obstruct the natural flow of water and provide storage. Damming groundwater itself is not a new concept either: groundwater dams were constructed on the island of Sardinia in Roman times and by old civilizations in North Africa (Nilsson 1988). More recent efforts include small-scale projects in many parts of the world, notably India, Africa and Brazil.

[2] The sand dam technology is probably best classified as a 'macro-catchment' method or 'medium-scale' level technique (Oweis et al 2001, Gould and Nissen-Petersen 2002). In relative terms, the percentage of total runoff captured by techniques at these levels is lower than for smaller-scale techniques. Furthermore, as the boundaries of the catchments extend beyond the boundaries of individual users' properties, issues of water rights in relation to water distribution for different use(r)s become highly important (Oweis et al 2001; 15. See also Barrow 1999 and Reijntjes et al 1992). Typically, as already indicated, the structures involved can be divided into in-stream structures, with the aim to catch/slow down/manipulate the (ground)water flows in river beds; and off-stream structures, which catch/slow down/manipulate overland flow from slopes. Groundwater dams are examples of in-stream structures. The advantage with sand river storage is that it normally represents an upgrading of a traditional and hence socially acceptable water source (Gould and Nissen-Petersen 2002; 37) (like scoop holes or hand-dug wells).

[3] And staff members for that matter.