Rainwater Harvesting in the Informal Settlements of Windhoek, Namibia
-Executive Summary-

S. Baker, E. Grygorcewicz, G. Opperman, V. Ward

Background

> *Around* 1.2 billion people, *or almost one-fifth of the world's population,* live in areas of physical [water] scarcity*, and 500 million people are approaching this situation. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage* (UNFAO, 2007).

In many locations around the world, access to basic human needs, such as water, is not guaranteed. Those living in the poorest of conditions cannot afford sufficient amounts of usable water and must spend a disproportionate amount of their income just to meet their basic needs. The failure of to properly address the global scarcity crisis exacerbates existing social problems, most notably poverty, public health issues, and gender inequality.

Hydrologists define a water scarce nation as one that can only provide 1,000 cubic meters of water per person per year or less, meaning that lack of water becomes a severe constraint on human development (Ohlsson, 1997). Namibia, the driest sub-Saharan country in Africa, can only provide 360 cubic meters per person per year (Heyns, 2005). A variety of social and environmental factors, such as arid climate conditions, government policies, and others contribute to the current scarcity problem in Namibia. One of the biggest problems with this scarcity issue is that some organizations fail to properly engage the community in addressing their needs, which frequently undermines efforts to alleviate the problem. Although Namibian water policy recognizes the right to a base-level of clean water, total cost-recovery policies put the cost of a sufficient amount of water outside the reach of most settlement residents. An alternative means of obtaining water is desperately needed in order to offset the growing demand for water:

> Considering *the acute problems of* water scarcity *that many are likely to face in the near future,* it would seem prudent not to ignore *the direct exploitation of* nature's simplest and most fundamental source of renewable freshwater – rain. (Gould, Nissen-Petersen, 1999).

Harvesting rainwater from rooftops can easily offset the cost of potable water. The primary goal of this project was to use a participatory approach to develop a method for rainwater harvesting within the informal settlements of Windhoek. The rainwater harvesting system was piloted in the settlement of Hakahana, a community that represents a typical settlement in Windhoek. Although there have been numerous case studies and projects focused on rainwater harvesting and participatory research methods, our project was one of the first that successfully integrated both in this particular settlement. Given the extreme limitations of community resources, this project adapted existing rainwater harvesting technologies to use

found or recycled materials, setting up a sustainable supply chain for the continuation of the project beyond the time-frame during which we were able to participate.

Objectives and Methods

In order to develop a method for rainwater harvesting in the informal settlements of Windhoek, Namibia, several objectives were established to ensure the project's success:

- **Determine the amount of water that can be collected:**
  Rainwater harvesting potential was determined by multiplying the average rainfall by the size of the catchment (roof), and multiplying the result by a runoff coefficient. Archival data from the City of Windhoek's Bureau of Meteorological Services was examined to determine the average monthly rainfall. Average roof size was taken from field measurements. Runoff coefficient was found through consultation with experts at the Habitat Research and Development Center.

- **Assess current rainwater harvesting technologies:**
  Several water harvesting case studies were examined to find the most viable technology for the informal settlements. In order to adapt these technologies to minimize cost and utilize readily-available materials, field research was conducted on the local availability and prices of construction materials, as well as an investigation on potential materials that could be salvaged from scrap yards and manufacturers.

- **Engage community interest in order to identify possible harvesting solutions:**
  Informal interviews with residents and community meetings were used to assess the water needs of the residents, including their water consumption and their most common uses for water. The community also expressed several concerns and posed suggestions about possible rainwater harvesting solutions.

- **Implement solutions with the community:**
  To demonstrate the ease and viability of a rainwater harvesting system, we built a pilot system at the Shack Dwellers Federation of Namibia's headquarters, located in the center of Hakahana. By implementing the pilot system at SDFN, a launching pad was established through which the settlement could be empowered to take action in implementing a sustainable, reproducible solution on their own.

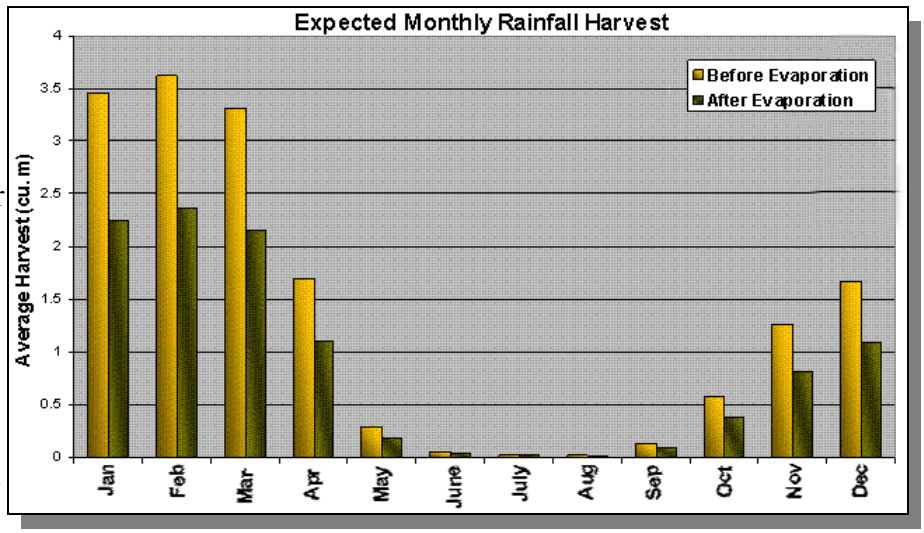
- **Develop a manual for future implementation:**
  Along with physical examples of how to implement water catchment systems, educational resources were developed to address water harvesting. These manuals served as an aid for spreading the project to new communities. The handbooks would be distributed via the Shack Dwellers Federation, Namibia Housing Action Group, or by community members themselves.

Findings

Harvesting Potential

In order to determine the viability of rainwater harvesting in informal settlements, it was vital to know how much water could be harvested, as well as how much this water could benefit a settlement resident.

Even after taking into account the significant runoff coefficient (0.65), during the rainy season of January to March we found that it would be possible to harvest well over 2,000L in a single month. While harvests during the dry season would be negligible, months of moderate rainfall can still produce significant amounts of water (~1,000L). On average, it is possible to harvest approximately 10,500L in a single year.



The amount of water harvested by a rainwater catchment system can significantly offset municipal water usage, given that the harvesting system has enough storage. Through informal interviews with residents, it was found that households in Hakahana pay anywhere from N$50-100 a month for water. Given the City of Windhoek's Bulk Water and Wastewater Division's community rate for water of N$9.57 per cubic meter, it was found that the average household consumes between five and ten cubic meters per month, or 175-350 liters per day. By harvesting rainwater, a settlement resident can save up to N$100 every year on water expenses.

Community Needs

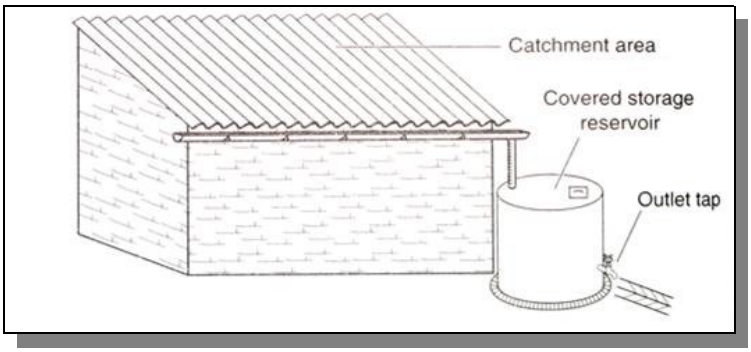
Out of 120 households in the community, 31 expressed interest in collecting rainwater to supplement their water supply. Of the interested residents, 74% were female. The unusually high percentage of interested women represents the community's large number of female-headed households.

Of those interviewed, nearly two-thirds indicated that they would use harvested water in order to offset or decrease their municipal water usage. When asked about specific water activities, community members indicated a wide variety of potential uses, among them sanitation, drinking, cleaning, gardening, and use in construction. Of these, human consumption of the water and small-scale gardening were most popular.

Community members voiced a number of concerns regarding the project. Nearly all of the participants surveyed voiced cost as a major deciding factor in their desire to build a rainwater harvesting system. Most residents also preferred individual storage to communal water resources. Some participants cited portability as another concern, as a few homes were being torn down and rebuilt due to pending infrastructure improvements in the settlement.

Implementation

The most viable solution for harvesting water in an urban environment is by harvesting water from a rooftop. A basic rooftop rainwater harvesting system consists of a catchment surface (the roof), a gutter, a down pipe or spout attached to the gutter, and a storage tank. As rain falls onto the roof, the water flows in the direction of roof slope and into the gutter. The gutter, which is also sloped, carries the rain to one end of the house where it passes either through a down pipe or spout that directs the water downwards. The water flows through the down pipe or free-falls into a funnel and reaches a storage tank that is placed beside the house at ground level. If the storage tank has enough capacity, only one may be needed. If storage tanks are of a lower capacity, multiple tanks can be used so that overflow from one tank passes into the next. The City of Windhoek requires that all water storage tanks to have a black lining to prevent the growth of algae. The tank must also be sealed in a manner that prevents the breeding of mosquitoes. A rooftop rainwater harvesting system that meets these requirements can be easily constructed out of a variety of conventional and non-conventional materials



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Available Materials

Available materials consisted of bought materials, those from hardware and building supply stores, and found materials, those materials that could be obtained from scrap yards. Below is an analysis of the most appropriate materials that are available in the Windhoek area.

Conventional Gutters

- Easily accessible from most building stores;
- Highly effective;
- Slightly complex to construct;
- Approximate cost of 7.2m gutter and hardware: N$300

Sheet Metal Gutters

- Metal can be bought at most building stores or recycled from scrap;
- Bent in a V-shape and then hung from roof edge with cable ties or wire;
- Simple to construct; almost no hardware needed;
- Approximate cost of bought 7.2m gutter: N$140

Conventional Down Pipes

- Available at any building supply store;
- Effective and easy to construct;
- Approximate cost for 2.7m length: N$90;

Discarded Down Pipes

- Obtained from local scrap yards;

- Assembling an appropriate length can be time consuming;
- Simple connection to storage tank can be made with 5L plastic container;
- Approximate cost: free

Polyethylene Tanks

- Highly effective at safely storing water;
- Approximate cost for 1000L tank: N$1,400

200L Drums with plastic lining

- Obtained from scrap yards and various manufactures who dispose of the drums;
- Black plastic lining needed to prevent against algae growth and leakage;
- **Multiple drums can be configured to increase storage capacity**

Various System Configurations

Taking into account the availability of building materials, we can compare the cost of a rainwater harvesting system against its benefits. The cost of storage clearly puts the affordability of a new system outside of the average informal settlement resident's reach. By replacing the storage tank with a found container lined with black plastic, such as a 200L oil drum, and by using bought sheet metal for gutters, the system becomes much more affordable. This system, classified as a bought and found materials system, is the simplest and quickest to construct. For these reasons, it was chosen as to be the pilot system for this rainwater harvesting project. However, the cost of a system can be decreased by using almost all found materials, i.e., using found sheet metal for gutters, discarded down pipes, and multiple 200L drums for storage. Although construction of this system is slightly more time consuming than others, it only costs N$80 and pays for itself in approximately six months during a year with normal rainfall. Due to the low cost and short payoff period, the system comprising of all found materials may be the most feasible for informal settlements.

Average Water Use: 175-300L/day
Average Water Cost: N$50-100/month
Potential Water Harvest: 10,480L/yr
Water Savings: approximately N$100

All Bought Materials
Gutter: new
Down Pipe: new
Storage Tank: 1000L polyethylene tank
Hardware: various connectors
Payoff Period: 16 years
Approximate Cost: N$1,800

Bought and Found Materials
Gutter: bought sheet metal
Down Pipe: found/recycled down pipes
Storage Tank: 200L drums, lined with black plastic
Hardware: wire or cable ties
Payoff Period: 2 years
Approximate Cost: N$220

All Found Materials
Gutter: found/recycled sheet metal
Down Pipe: found/recycled down pipes
Storage Tank: 200L drums, lined with black plastic
Hardware: wire or cable ties
Payoff Period: 6 months
Approximate Cost: N$80

An Appropriate Harvesting System

Based on the various configurations that can be used to construct a rainwater harvesting system, it can be concluded that the most appropriate system is one that consists of all found materials (see above table). At a cost of N$80 and a payoff period of six months, these found materials provide the most affordable, effective, and simplistic rooftop rainwater harvesting system. This rooftop rainwater harvesting system consists of the following components:

- **Gutter:** found/recycled sheet metal gutters
- **Down Pipe:** found/recycled down pipes
- **Storage Tank:** 200L drums lined with black plastic
- **Hardware:** wire or cable ties

Recommendations

In order to facilitate the spread of rainwater harvesting practices, we created several recommendations for community members and non-governmental organizations. If followed, these recommendations are designed to provide a sustainable framework through which rainwater harvesting systems can be easily implemented:

- **Establish a program to educate and train community members:**
  Community organizations such as NHAG, SDFN, and students from the Polytechnic of Namibia should work together to conduct regular instructional workshops to interested communities. The workshops would provide key community leaders with the training and assistance necessary to implement a rainwater harvesting system, as well as encourage those leaders to further spread this knowledge to others.
- **Community organizations should provide logistical support and assistance to settlement residents:**
  Local NGOs are advised to actively maintain a sustainable supply chain for constructing rainwater harvesting systems, including the implementation of a tool library and inexpensive transportation for the procurement of materials.
- **Include rainwater harvesting in designs for future settlement homes:**
  When building new homes, a small portion of the home's funding should be allotted for the construction of a rainwater harvesting system, and incorporated into the standard informal settlement dwelling design.
- **Incorporate rainwater harvesting into urban agriculture projects:**
  Rainwater harvesting techniques can be used improve local community projects such as the UNFAO's Urban and Peri-Urban Agriculture program.

Summary

Water scarcity is a global problem that affects many of the world's most impoverished people. Namibia is currently experiencing the effects of water scarcity, as arid climate and other social factors exacerbate growing demand and short supply. Although the Namibian government recognizes that access to water is an inalienable right, the cost of providing such water is high. As a result, many impoverished people living in informal settlements cannot afford to meet their water needs. In order to alleviate these problems, harvesting rainwater from rooftops can greatly offset municipal water usage.

With the assistance of the community of Hakahana, we were able to design and implement a rainwater harvesting system that took into account the settlement's needs. The system, which harvests rainfall from rooftops into a recycled storage container, can potentially provide settlement residents with over 10,000 liters of water a year, providing a significant, renewable water resource to offset municipal water usage. By using recycled or found materials, the cost of the system can be minimized to as little as N$80, an amount that can be recovered through water savings from a single rainy season.

References

Gould, J. & Nissen-Petersen, E. (1999). *Rainwater Catchment Systems for Domestic Supply*. Rugby, UK: ITDG Publishing.

Heyns, P. (2005). *Water Institutional Reforms in Namibia.* Water Policy, 7, 89-106.

Ohlsson, L. (1997). *Water Scarcity and Conflicts*. Paper presented at “New Faces Conference” dealing with “Security Challenges of the 21st Century”.

United Nations Food and Agriculture Organization. (2007). *Coping With Global Water Scarcity*.