Engagement in Practice: Building Community Capacity and Relationships through Rainwater Harvesting Initiatives – Tanzania

Patrick John Sours, The Ohio State University

Patrick is a Lecturer and PhD student in Food, Agricultural and Biological Engineering. Patrick received a B.S. in Civil Engineering from The Ohio State University with a minor in Humanitarian Engineering. Patrick's graduate research focus is international development through engineering. His main research project is Maji Marwa: A Sustainable and Resilient Community Project. Patrick has been involved with Humanitarian Engineering projects at Ohio State for the past seven years. He has worked on project in Guatemala, Honduras, India, Ghana and Tanzania. Patrick is a 2020 Engineering For Change Fellow.

Dr. Michael J Hagenberger, Ohio State University

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BACKGROUND

The World Health Organization (UNICEF and WHO, 2012), estimates that over 750 million people do not have access to simple potable-water service, while over two billion people, a majority of whom live in rural areas, utilize contaminated water. An example of a community like this is Marwa Village located in the Kilimanjaro region of Tanzania.

In Marwa, the Pangani River is the most reliable water source for the community. Most residents travel three to six kilometers to the Pangani River daily to obtain water for domestic use. Even though this river has an abundance of water, human capacity limits the amount of water that can be carried home, in addition the water is unfortunately contaminated with bacteria, pathogens, and pollutants. The inability to access a sufficient quantity of clean water is one of the greatest factors hampering sustainable community and economic development of this region.

Tanzania consist of over 100 different tribes that share common cultural practices and language. The community members of Marwa are predominantly progressive Maasai, but the population also includes people from both the Chagga and Pare tribes. The Maasai have historically been a nomadic, pastoralist society; however, the Tanzanian and Kenyan governments have been applying pressure to their Maasai communities to establish permanent settlements due to concerns with grazing and property rights (McCabe, Leslie, & DeLuca, 2010). In 2015, the population was estimated to be between 3,500 and 4,500. More recent estimates from local NGO Kilimanjaro Hope Organization (KiHO) suggests the village population at approximately 5,000 with the expectation that it will continue to grow.

PROJECT CREATION AND PARTNERSHIP DEVELOPMENT

On January 15th, 2013, the Marwa Village Chairman, Mr. Elifuraha Mason, delivered a letter on behalf of his village to KiHO. Marwa requested KiHO's support on the provision of clean and safe water in Marwa Village. In addition, the letter outlined the long-term problems regarding life without clean and safe water and the potential to open the door to economic and development opportunities for his people. In 2014, through a professional contact, KiHO Executive Director, Kateri Daniels and Michael Hagenberger, a faculty member at The Ohio State University began discussions of initiating a porject. In August 2015, Dr. Hagenberger traveled to Tanzania to meet with KiHO and communities identified with the potential to be a partner in a community development project. During the visit, meetings were held with the community leaders and community members of Marwa Village. The conclusion was that the community had the desire and organizational capacity to be a strong partner for an international water development project. A multi-disciplinary team was assembled, traveled to Marwa in May 2016, and established the foundation that would evolve into a multi-year, multi-phase community development project: Maji Marwa.

The Maji Marwa project was introduced to students as a capstone project option in the undergraduate civil engineering program and has expanded to collaboration amongst two universities, five colleges and participation from over 175 students. The rainwater harvesting initiatives goal was to collaborate with in-country partners to construct three rainwater harvesting (RWH) systems on locations designated by the community. Rainwater harvesting

addressed several priorities identified by the community, specifically 1) access to clean water, 2) improvements to the medical dispensary, and 3) improvements to their primary schools. The decision to install the first RWH system at the Marwa medical dispensary was based on the initial request to KiHO from the Village Chairman and through extensive discussions with the Marwa community, KiHO, UDOM and Same District government officials.

PROJECT DESIGN AND EXECUTION

The basis for the rainwater harvesting initiative was to prepare for the Pangani River System (PRS). The PRS is the proposed long-term solution to alleviate the water needs of the Marwa community. The system will take water from the Panagani River, pump the water to an elevated area of Marwa, and then gravity distribute the water to water storage and distribution points designated by the community. The tanks optimized throughout the RWH initiative will be used at the water storage tanks for the PRS. The women of the community communicated that they did not want water piped into individual living structures as water collection is an integrated part of the women's social identity. The rainwater harvesting initiative was proposed as a small-scale sustainable project to build relationships, educate community partners, evaluate capacity, and learn cultural norms while also addressing specific needs of the community.

The phasing of the rainwater harvesting initiative followed a three-phase process. The first phase was to provide a student design of a RWH system but to allow the community partners and senior contractor from a nearby city to manage the process. OSU's role was to ensure adequacy of the construction project and focused on the evaluation and insight gathering of the local construction practices. The second implementation was aimed at alleviating selected technical and development challenges through a redesign completed by students and graduate students during the academic year that incorporated feedback from the previous year as well as implementing capacity building process adjustments. This phase centered on the selection of a contractor from Marwa. The final implementation served as a proof of concept that construction difficulties had been reduced through the redesign adjustments and collaboration and that the community was ready to construct the storage tank systems on their own.

MARWA DISPENSARY RAINWATER HARVESTING SYSTEM

A preliminary rainwater harvesting system design was created and shared with our in-country partners for evaluation and feedback. After conversations with in-country partners, the decision was made to allow the contractor, a senior building in the area, to construct a design they were more familiar with, both to address the concerns of the local contractor and to allow the team to evaluate local construction methods. The team did not want to creative a negative and overbearing presence on the first construction project undertaken in the Marwa community. Thus, the first iteration of the rainwater harvesting system served as the baseline comparison for later constructed tanks

DISCUSSION OF IMPLEMENTATION

The implementation of a RWH system took place in May of 2017. Throughout the construction process numerous key observations were identified that included.

- Foundation was thicker than required resulting in excess use of materials

- The support column was structurally unnecessary
- The height and placement of overflow and water inlet pipes decreased the overall volumetric storage capacity of the tank
- There was limited critical thinking with the construction of gutter location as the location resulted in the inability to storage additional water
- Lack of basic equipment increased the difficulty of construction

EVALUATION OF SUCCESS AND OUTCOMES

The first RWH system allowed for the completion of a project within the partnering community and allowed for the collection of information regarding local construction practices. In terms of success, the RWH g system was constructed to a volumetric capacity of 19,000 liters, supplying water to the medical dispensary. In addition, knowledge regarding local construction technique and construction practices was gathered.

The trust or respect of the contractor and the community members working on the construction was not strong during this process. While trust had not completely been established, the foundation for future partnerships and relationships had been laid. The support of the community government was seen when they fixed a settled roof issue.

Recommendations were developed for the future RWH systems based on discussions with the senior contractor, and the construction crew as well as observations gathered during construction of the tank.

LESERWEI PRIMARY SCHOOL RAINWATER HARVESTING SYSTEM

The design for of the Leserwei Primary School RWH system focused on improvement of the construction process, reducing overall construction costs, and increasing communication and building capacity with the new local in-country contractor. Throughout the year conversation with in-country partners allowed for the selection of a contractor that was local to Marwa Village. The aim for working with the unexperience contractor was to seed business capacity with appropriate tools and to aid in the process of improving financial literacy and project management skills.

The redesign focused on key aspects for improvement:

- Increase the size of the tank to ensure collection of all available rainfall
- Redesign of the tank's foundation to reduce concrete used
- Adjust the mix ratio used in the masonry blocks to improve block consistency
- Form the blocks in the community to reduce transportation charges
- Remove the center column and change the top roof slab to maintain structural stability of the roof in the absence of the center column

DISCUSSION OF IMPLEMENTATION

The construction of the system took place in May and June of 2018. Construction difficulties occurred with techniques that the local laborers were unfamiliar with. The tank was completed in June of 2018 at the proposed volume but the as-built differed in the thickness of the foundation. The foundation used in this second RWH tank caused issues in leveling, excavation of soil and placement of rebar structures.

EVALUATION OF SUCCESS AND OUTCOMES

The second rainwater harvesting system allowed for the strengthening of relationships and establishment of trust with in-country partners. The RWH system was constructed with a volumetric capacity of 35,000 liters, supplying water to the Leserwei Primary School. The adjusted mix ratio for blocks resulted in an improved consistency of the blocks. With improved communication flow and collaboration with the new contractor, the technical planning of estimated materials and project management increased.. In addition, the participation of the community increased with community members suppling all the water for construction.

MARWA PRIMARY SCHOOL RAINWATER HARVESTING SYSTEM

For the third iteration of the rainwater harvesting initiative focus was placed on improving ease of construction, reducing overall costs, and improving work agreements with the Marwa Contractor. Adjustments from the previous design were implemented and additional focus was given to the logistics and planning aspects of the project.
The redesign focused on the following aspects:

- Redesign of the tank foundation. The new foundation design attempted to reduce concrete mix used and improve the constructability of the foundation
- Improvement of the water access tap point. The previous water access pit was not installed as designed
- Adjustment and refinement of the top slab to improve constructability
- Improved written communication and agreements between collaborators

DISCUSSION OF IMPLEMENTATION

The Marwa Primary School RWH System was treated as an assessment of the relationships and capacity built since the beginning of the Maji Marwa project. The goal was that the tank would be constructed without much guidance from outside partners. The construction of the system took place in May and June of 2019. The Marwa Primary School RWH System was constructed closely to the proposed design and overall construction of the system ran more smoothly than in the previous two years. The system construction was finished by the local contractor without outside involvement.

EVALUATION OF SUCCESS AND OUTCOMES

The system was constructed to a volumetric capacity of 37,000 liters. The relationships that had been grow over the two previous years allowed for open and honest communication between partners. The system was constructed more efficiently and a direct improvement in project management was demonstrated by the local contractor as he was able to construct the system with limited involvement from outside partners. The community took an increased involvement in this iteration and provided sand, water and part of the required stone. The community took ownerships and self-organized themselves to aid in problem solving and contributions.

The technical innovations that were adopted by the third tank construction included adjustments to mix ratios, improved block consistency, use of smaller aggregate, improvement to water to cement ratios, improvement in consistency of concrete batches, improved foundations, and more consistency of mortar joints. These technical changes were more readily adapted when it was made clear to the labor crews that it would allow for a decrease in the effort required to construct the tank.

There were a few technical changes that were attempted to be introduced that were a challenge or rejected. These included a first flush system (a system design to divert the first few minutes of rainfall to remove debris), the placement of more than three courses of block in a day, and the coating of the outside of the tanks in cement and then the drawing of block outlines. These technical innovations mainly failed due to the underlying cultural differences and preconceived technical notions. Knowing when to adjust priorities and focus attention on a different aspect of the process was important.

SUMMARY OF KEY RESULTS

The results are as followed,

- Costs of the RWH system construction was reduced by $700
- Size of RWH storage tanks increased from 19,000 to 37,000
- Trust and relationships were built between the local community, local contractors, the NGO KiHO, and participating Ohio State faculty and students
- Local construction techniques were observed to stem from a desire to reduce the physical labor required, allowing for the process to be adjusted accordingly
- Pre-conceived notions were difficult to overcome
- Those processed and changes that would have the most impact were prioritized
- In-country partners are now able to construct storage tanks with limited oversight

Table 1 Summary of Rainwater Harvesting Results

Tank Cost	Cost in US Dollars	Value of Community Contribution	Volume Liters	Cost per Liter
2017	$5,984	0%	19,000	$0.31
2018	$6,240	3%	35,000	$0.18
2019	$5,280	10%	37,000	$0.14

As seen in Table 1, from 2017 to 2019 there was an increase in community involvement and contributions, an increase in volumetric storage and a reduction in cost. With the installation of three rainwater harvesting systems, the community of Marwa has access to over 350,000 liters of water and can store over 91,000 liters. In terms of the Pangani River System design, the desired tank size of 32,000 liters can now be constructed at an estimated cost of approximately $4000 USD.

CONCLUSIONS AND NEXT STEPS

The aim was to engage the Marwa community in the construction and build aspects of the Rainwater Harvesting initiative. The conclusions from this initiative are;

- By respecting and incorporating indigenous practices and integrating decision making based on engineering knowledge, the cost of the project can be reduced and will be replicated in the future
- Developing relationships and establishing trust within the community proved crucial to the capacity building process

The process of establishing meaningful relationships and partnership takes an immense amount of time, patience and effort. Through a planned phasing of projects, the team was able to take time to meet with the community and allow for their input into the project. By listening to the wants and needs of the community throughout the RWH initiative more engagement was fulfilled. The community has taken ownership in the projects and has demonstrated their willingness and ability to contribute. Through these relationships a more thoughtful approach can be made to the way that technical innovations are presented. Working with the community instead of for the community allowed for their ideas and experiences to be incorporated into the design and construction process. This initiative has shown that through thoughtful planning and collaboration a meaningful and beneficial impact can be made on the community.

Through the construction of the RWH systems relationships were formed and trust was established with the community. The Maji Marwa project presented a proposed project, worked together with multiple partners and completed that project in a timely fashion. The next steps of the project are to continue collaborating with the community to transition to the implementation of the Pangani River system

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