Water Monitoring in Rural Areas
Case Study - Moshi District, Tanzania

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Introduction

The 6th Sustainable Development Goal (SDG 6) calls for universal and equitable access to safe and affordable drinking water by 2030. This goal cannot be achieved without Monitoring the quality and accessibility of water collected and consumed by the most needy water consumers - low-income households in developing countries.

To help promote this goal, Tel Aviv University (TAU) together with Amrita University has designed a protocol (AmriTAU) that allows local women to monitor water quality consumed in rural villages. Our goal is to reach a large scale of data monitored by local communities in developing countries. We believe that community-based monitoring holds the power to promote change toward SDG 6, while providing choices in existing water practices by the community that will allow them to consume safer water.

Water sources in rural areas are very diverse, unlike developed countries where the water is, in most cases, supplied by a utility and regulated by a central governmental regulator. People in developing countries, especially in rural areas, are still struggling to secure water supplies to their houses. In these areas the water supply process is much more complex than the water system in developed countries. In a developed country, designing a monitoring system for the water system is trivial. But in developing countries, there are key differences in the water system:

1. The community has to be self-dependent and residents have to get their own water. There is no entity that ensures water supply to homes.
2. There are many fragmented water sources in each area, sometimes in the same village.
3. Fetching water from the water source is usually done by women. Collecting water is done in different ways depending on water source, rather if it's fetching water from a well or from a central faucet. The fetching method, the time when water has been collected, the container material and additional considerations are important factors that may affect water quality.
4. The way that people store water at home, including the container material, the room where the container is kept and other conditions are also important factors to consider when trying to understand water quality.

If properly designed, monitoring can help track progress, ensure accountability and transparency, diagnose and address bottlenecks, and even affect the formation of new goals and targets. Continuous efforts are therefore needed to innovate and adapt monitoring tools to meet the diverse challenges associated with SDG 6 (Khan et al, 2017; Charles et al, 2020).

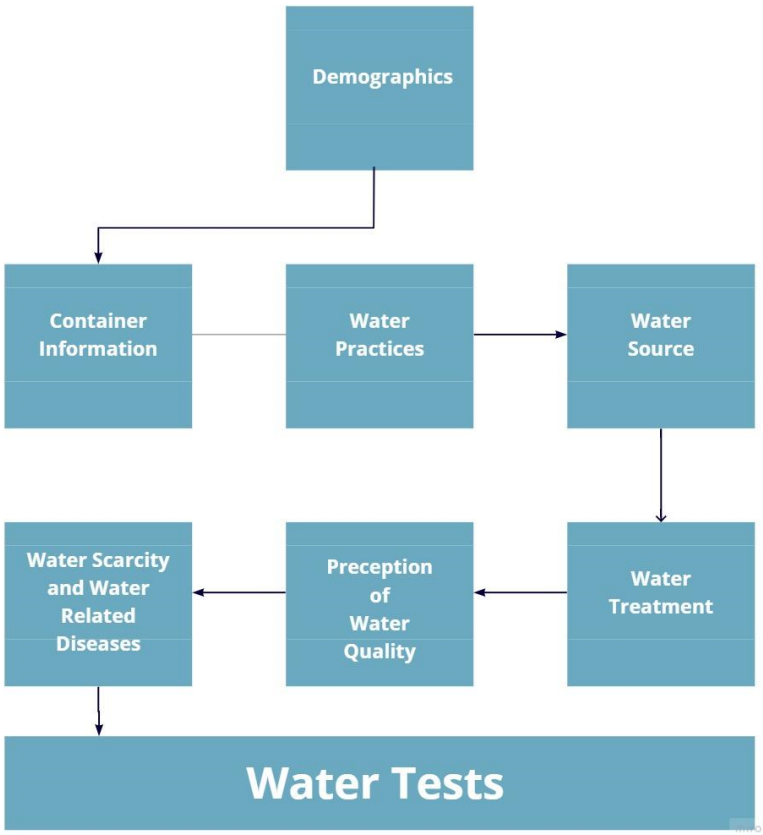
Background

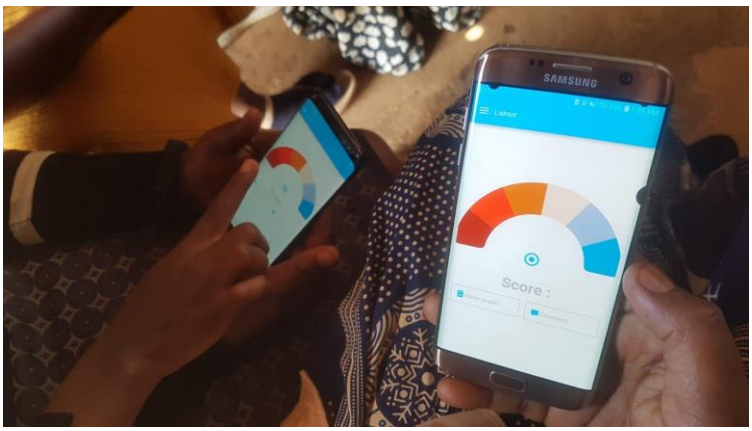
The project goal is to improve off-grid water quality - drip peoples by using technology in order to change undesired practices.

As presented above there are many factors that could affect the drinking water quality. The objective factors combine with behavioural factors so a new method had to be developed in order to learn which variables are affecting the water quality and how changing even one element in the water supply process can assist improving the water quality.

We contributed to these efforts by presenting an integrated monitoring approach which we call the AmriTAU Water Quality Survey (AmriTAU Protocol) for evaluating rural communities' drinking water quality and its determinants. AmriTAU combined a face-to-face survey with water testing technologies. The AmriTAU tool emphasizes the need to integrate real time water quality testing along with households' perceptions and practices. AmriTAU Protocol has been tested so far both in India and Tanzania. In this paper we will present the work in Tanzania as a case study.

Protocol Flowchart:





Pictures from the 4th training, in Kisangesangeni.
Training water ambassadors on AmriTAU Protocol, Hach dip strips and Lishtot Drop+ Sensor.

Field Work Description

Through 6 weeks of field work in Moshi district, Tanzania we were able to evaluate rural villages' drinking water quality and water practices of the local communities using the AmriTAU Protocol.

We sampled 450 randomly selected households from a cluster of five villages (in each village there are about 1200 residents). The pilot sample is diverse in terms of geography, water source, type of contaminants and the socio-economic characteristics of the communities.

In each house we interviewed the individual who carries the responsibility over water, which was usually the woman. We asked about the process starting from the water source through water consumption. Following this interview, we asked for a cup of water, to be able to see the practices the household does when they want to drink. Then we tested the water and recorded all to the survey.

Water Testing Protocol:

1. Collecting the water from the original container into a cup from which the households usually drink from.
2. Pouring the water to a new disposable cup in order to test with Lishtot's TestDrop.
3. Testing the water with 5-1 Hach test strips.
4. Random testing in few locations for other physical, chemical and microbial components.

Three Main Objectives of the Project:

1. Find the most recommended procedures for water handling in off-grid areas.
2. Mapping water quality in villages in order to predict water quality in similar locations.
3. Training water ambassadors to test drinking water in their own communities

Challenges and methods we had while trying to achieve our objectives

1. The survey
   - Language - we used local translators.
   - Getting honest answers is challenging as it seemed like the women were trying to please us by giving us answers they believed we wanted. Some women changed their answers to answers that made them look better. For example, we believe that more than a few women declared that they boiled the water while it was hard to believe based on the water testing results.
2. Hach 5-1 strips
   - Each strip cost about 0.5 USD - a significant price for local communities in Africa.

- There is no need to test Chlorine in untreated water, all the results were 0.
- The fact that the results scale is limited to only 5 values makes it complex to define water quality.
- The colours on the strips are not unambiguous.
- There is no option to drink the water after testing.

3. Lishtot's TestDrop
   - In order to use the TestDrop we had to teach some of the ambassadors to use smartphones for the first time.
   - It takes a couple of hours of training to teach the local ambassadors how to use it. It is not Considered a long training given the fact that they are struggling using new technologies as mentioned above.
   - We understood that the efficiency of the sensor increases the more it is used
   - In order to avoid human error, we tested each sample 5 times (it takes about 3 seconds per test) and used the average of the tests as the final result.
   - Each test requires a new plastic cup.

Results

After collecting data based on the survey and the water quality results we tested to see correlations between the information gathered from the survey and the water quality results.

The answers we received could vary not only from village to village but also between nearby houses, depending on the water source and socio-economic situation, affecting water practices.

Data Analysis Methodology

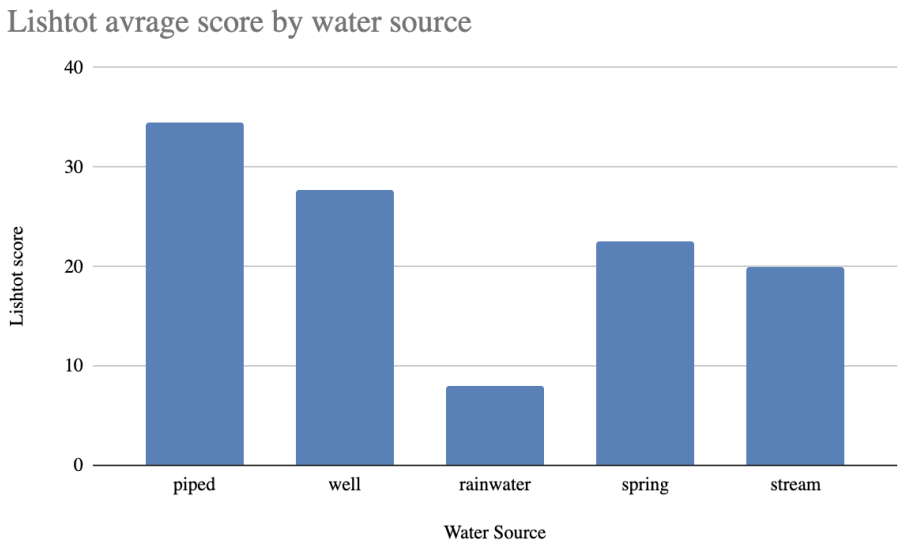
We calculated the average result from the Lishtot TestDrop sensor for each answer in the survey; and found correlation between the survey results and Lishtot's TestDrop results.

This is not surprising as Lishtot's TestDrop is tuned to measure multiple contaminants in water including bacterial and biological contaminants. From our point of view, it is important to know what the water safety level is in total and not what is the exact contamination in water, it is even preferred in situations like these where the users have no advanced filtration option.

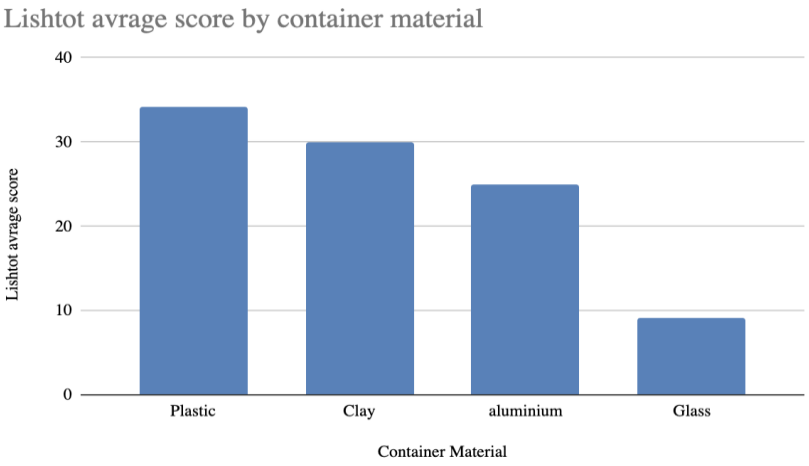
In most cases, especially when people don't have a specific solution for a specific contaminant, giving them too many details about the contaminant could just make them more confused and it could even stop them from taking the right action. In this case, the fact that Lishtot's TestDrop is giving a score that includes the total contaminant load makes it easier for the users to make wiser decisions regarding their water.

Key Findings about Water Practices:

- More than 95% of the households do not have any running water in their houses.

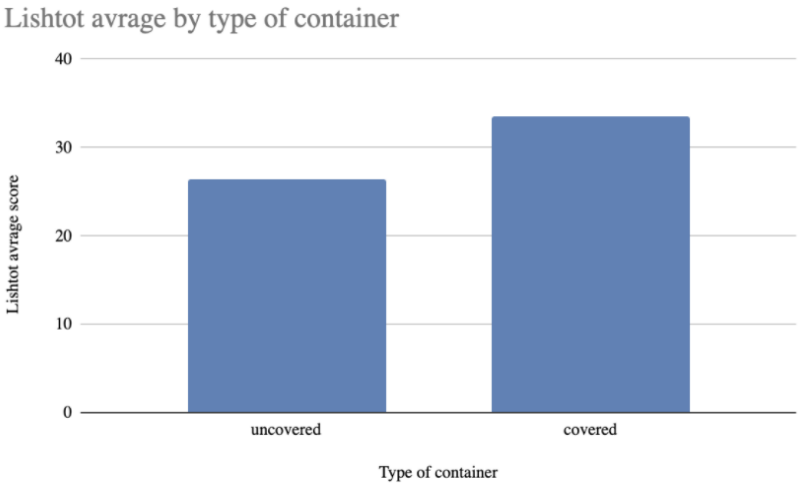


- The best water source is communal tap water from a piping system, it happens to be also the most popular source in the villages tested.
- Storing water in the living room is the option that gives higher TestDrop scores



while storing water in the kitchen gives the lowest scores.

- The standard water container is a 10-30 litter bucket, usually made of plastic, some from clay and a small percentage from other materials.



- Covered water containers are higher (by 7 points) than uncovered water tanks. The data show there is a distinct correlation between higher TestDrop scores with covered containers.
- Water is usually stored for a few days and taken out of the tank with designated cups.
- In some cases, water is being fetched from distant taps or wells, depending on water availability in the area.
- The most common water treatment is settling, but boiling water is found to be the treatment method with the highest TestDrop scores.

Key Findings Regarding Water Quality:

- As was already mentioned, water quality changes between houses.
- Each house has different water quality and even though we were able to predict it based on the multiple parameters in our survey, we still had surprises.
- In Kyom and Kisangesangeni villages, households from a lower socio-economic status are not able to afford tap water, and therefore use shallow wells instead. These wells showed high values of salinity and fluoride, exceeding WHO standards.
- Holili village's water comes entirely from large tanks that are being filled once a week. Approaching the end of the week, water turbidity can rise above WHO standards.
- Some water sources have much better water quality than others and it is not trivial to predict which water source has better water without the TestDrop.
- Needless to say, given that water supply is not constant, there is water scarcity in the area which affects people's way of living
- Water is not being properly sanitized in many cases, as most of the randomly taken water samples showed some level of fecal bacteria.

Conclusion

Water supply is a global challenge and is even a bigger challenge in rural areas. Supplying safe drinking water is one of the most important and difficult tasks for women in off-grid areas. During this task the average woman faces multiple decisions that each have an effect on water quality. Some of the decisions could seem minor, for example the choice to cover the water container, but in fact it has a significant effect on the quality of water.

Having a correlation between water storing conditions and Lishtot's TestDrop results could be considered as a validation for the TestDrops' contamination detection also in complex rural areas. Understanding this correlation can also help households in gaining a better understanding about how they should handle their water.

When women were asked how they assess their water quality they usually replied that the water is good or very good, while the objective TestDrop results showed the opposite. Therefore, it seems people don't have the ability to assess their water quality objectively. We believe that it is important to give these households a measurement tool that will assist them to make better decisions in the effort to supply water to their family.

Lishtot's TestDrop was able to detect the total contamination load in various types of water in harsh conditions. Giving Lishtot's TestDrop results to the local women opened their minds regarding the practices they should change in order to have safer drinking water.

From the tests we conducted and the familiarity with the drinking practices of the residents, we understood that the problem is deeper than is commonly thought. The problem starts with the fact that the vast majority of people know very little about the water they drink and about how their choices and practices affect their water quality.

The solution is not only to test the quality of the water and bring technologies that will improve the quality of the water but first of all to help the residents understand more about the water they drink and what they can do to improve the water from the tools they already have.

Water Ambassadors

12 young women from four different villages went through two and a half days training, in order for them to conduct the AmriTAU Protocol and become "Women Ambassadors" Women and girls were chosen as ambassadors as they are the ones who carry the high burden of the water management in the households. The Women Ambassadors are compensated for their time and hold a status of employees. Those women are still testing on their own after we left and their results are recorded by us so we could help them.

Water self-monitoring by the community has inherent value. The fact that for the first time these rural communities have the ability to make wiser decisions regarding their water-related dilemmas could change people's lives. These women will hopefully have the tools to advise their neighbours in questions like "which water source is better today?" or "should I replace my old bucket with a new one?" and by that help avoid water-related diseases.

The Next Stage

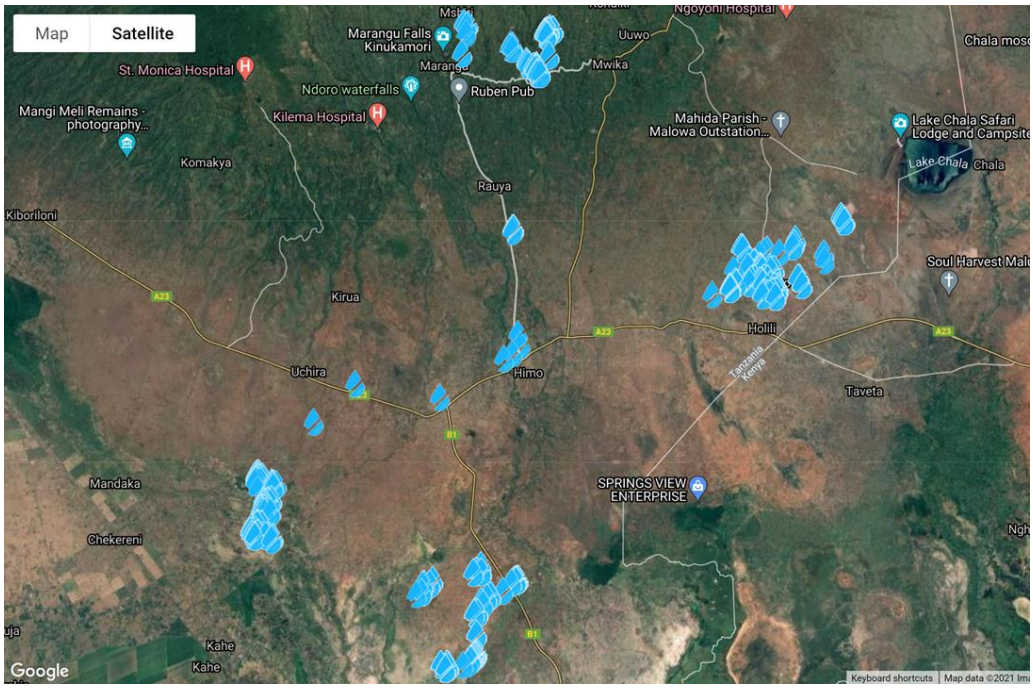
Helping 6000 people in Tanzania to get better water is important but we do believe that in order to accomplish the 6th SDG we should work on a much larger scale.

We have found that the combined approach of a survey and the TestDrop could lead to promising results that can assist people to make better decisions regarding their water practices.

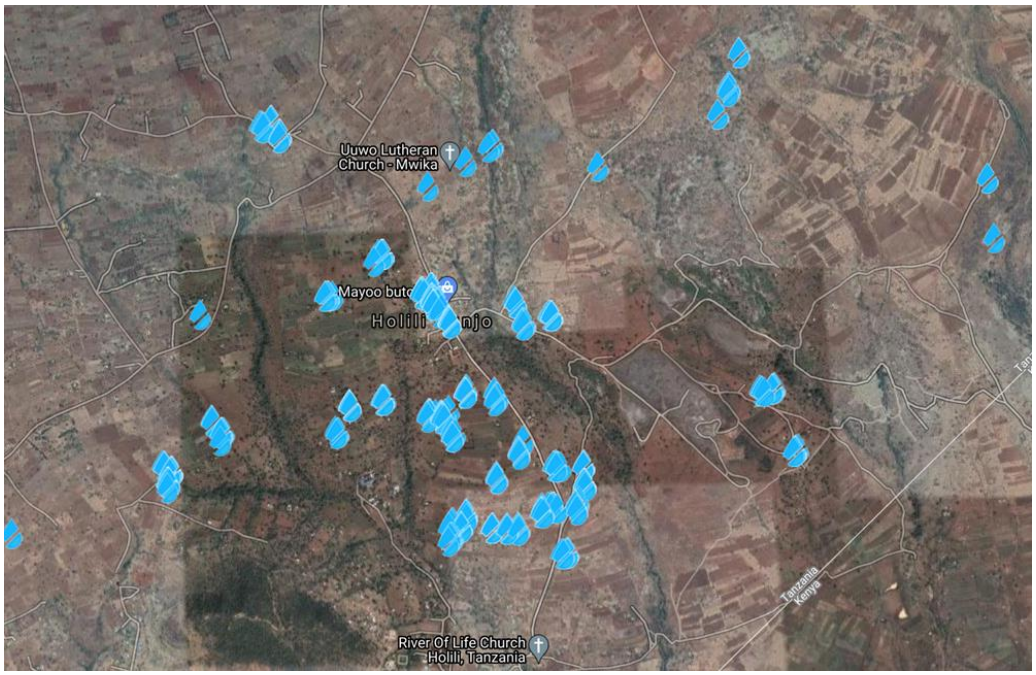
We believe that combining the AmriTAU Protocol which proved to be very relevant to water quality with Lishtot's TestDrop results in one app has the potential to save people's lives.

We hope that in the next stage we will not only validate the concept, but we will be able to use similar methods for improving millions of people's lives in Tanzania, India and other developing countries in need of safe drinking water.

Appendices



Layout of data points collected with Lishtot TestDrop, which is spread over five villages in Moshi district, Tanzania.



Zoom in on tests done in Holili village. The symbol of the drop reflects a concentration of several tests performed in the area.