MOHAMMED VI POLYTECHNIC UNIVERSITY

School of Collective Intelligence

Experimental Methods 2

WATER CONNECTIVITY ISSUES IN THE PROVINCE OF SAFI/YOUSSOUFIA/SIDI BENNOUR, MOROCCO

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University Mohammed VI Polytechnic - 2022/2023

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Introduction and Context

Water is essential for all life on Earth. Not only is it necessary to quench our thirst but also vital for the continuity of our ecosystems, agriculture, and industrial activities. More recently, access to clean water has become a basic human right even though many people are still deprived from it to this day. According to the World Health Organization (WHO) , about 2 billion people do not have access to safe drinking water, nearly half of the world's population's sanitation fails to treat human waste, and about 1.4 million people, many of which are children, do not have good sanitation (2023). Additionally, as water distribution alongside the absence of water connections add up to the extensive list of existing region inequalities, other problems arise, causing further disadvantage to the concerned communities.

The absence of reliable water connections means that people, especially women and children, have to travel long distances to fetch water from unsafe sources, making them more vulnerable to health problems. Not only that, but this problem also hinders social and economic progress as seen from the increase in school dropouts and in water induced health issues. In fact, this is the reality of many rural areas such as the rural commune of Al-Ghiath in Morocco where water access is a daily struggle (Hespress, 2022). A video reportage done by the online news channel Hespress reports that since the households of the douars (villages) of Al-Ghiath do not benefit from direct water connections, they tend to fetch water from faraway fountains with the possibility of not finding any water left at the closest fountain, obliging them to cross longer distances in the pursuit of water (2022). Adding up to that, issues with transportation and road quality make it harder to bring enough water from faraway places to their homes (Hespress, 2022). With high poverty rates in the region, many households cannot afford to pay for water services (Hespress, 2022). Furthermore, the lack of reliable water supply affects education as children, especially girls, often have to spend time collecting water instead of going to school, leading to higher dropout rates (Hespress, 2022). These challenges are all interconnected and suggest an urgency to improve the water access conditions for the douars of Al-Ghiath and ensure that all homes have access to safe and affordable water (Hespress, 2022).

In El Amoria, one of the douars in Al-Ghiath, people wait for Baytia (a mobile water tank) which fills up 4,500 liters of water and costs between 200 and 300 dirhams, a relatively high cost for the villagers (Cable News Network, 2016). However, the arrival of water supply trucks to the village is infrequent due to safety concerns on the road (Cable News Network, 2016). As a result, villagers have to rely on animal transportation to bring their own water to their homes or pay those who provide this service 10 dirhams for every 1,000 liters of water (Cable News Network, 2016). Furthermore, the douar's fountains are often empty or overcrowded, forcing villagers to travel several kilometers, typically ranging from 4 to 7

kilometers, to access other fountains for water (Cable News Network, 2016). Obtaining water in these communities is a time-consuming task, requiring people to spend hours fetching it (Safi Now, 2022). The transportation methods used are very basic, involving carts and donkeys (Safi Now, 2022). Unfortunately, digging wells is not a viable alternative for the douar due to the absence of groundwater in this region (Cable News Network, 2016). Additionally, these rural communities experience high poverty and vulnerability rates, further exacerbating the difficulties in securing water (Office National de l'Électricité et de l'Eau Potable - Branche Eau, 2015). Despite attempts to improve the situation through interventions namely the GEP, short for Generalization of Potable Water in english (Office National de l'Électricité et de l'Eau Potable - Branche Eau, 2015), many projects remain incomplete due to some technical reasons not to mention the villagers' resistance to the completion of the project (Hespress, 2022). These factors collectively hinder the community's access to a reliable water supply, making it an ongoing struggle for the residents.

The water connectivity is a common issue not only for the douars of the rural commune of Al-Ghiath, but also for the other 27 rural communes of the Provinces Safi/Youssoufia/Sidi Bennour (Office National de l'Électricité et de l'Eau Potable - Branche Eau, 2015). In response to this issue, we are proposing an intervention to address the water transportation issue faced by these douars.

Proposed Intervention and Research Question

1. Previous Water Connection Related Interventions

Before designing our own intervention, it is helpful to take a look at previous water connection related interventions to gain more insights into how best we can go about solving the problem of water connectivity in our concerned area of study. In Tangier, a program was implemented by Amendis named "Branchements Sociaux Individuals" or BSI to allow low income households to buy a connection to the water and sanitation network at full cost, but on credit (Florencia et. al. , 2011). The intervention was successful in the sense that households showed more willingness to pay for a private connection when credit was an option. This is justified, not by the possibility of improving health outcomes, but by having more leisure time, less inter- and intra-household conflicts on water matters, leading to an improved well-being (Florencia et. al. , 2011). Other interventions namely in some rural areas in Malawi were successful in fighting the water connectivity issue through a transportation-focused intervention that aims to fix the roads and provide transportation means to the water locations (Dingen, 2004).

2. Our Proposed Intervention

The intervention involves giving credit to people who will fulfill certain recruitment to buy motor tricycles. We will implement a program that combines Tangier's BSI "Branchements Sociaux Individuals" and the transportation-focused intervention in Malawi where the people will be paying for their purchased motor tricycles using credit and they will be using those motor tricycles to deliver water (as a new way of connecting the douars' villagers to water). We are assuming this means of transportation will lead to an income in return for the service of water transportation. The program anticipates that the credit should not be given to everybody so as not to saturate the market because doing so will lead to higher risks of defaults - given the region's high poverty rates - and the motor tricycle drivers will no longer be getting an income from delivering water to the villagers. Thus, the number of beneficiaries should be controlled for. The figure below summarizes the key characteristics we considered when designing our intervention. The program is open to all but encouragement will be given to a selection of people.

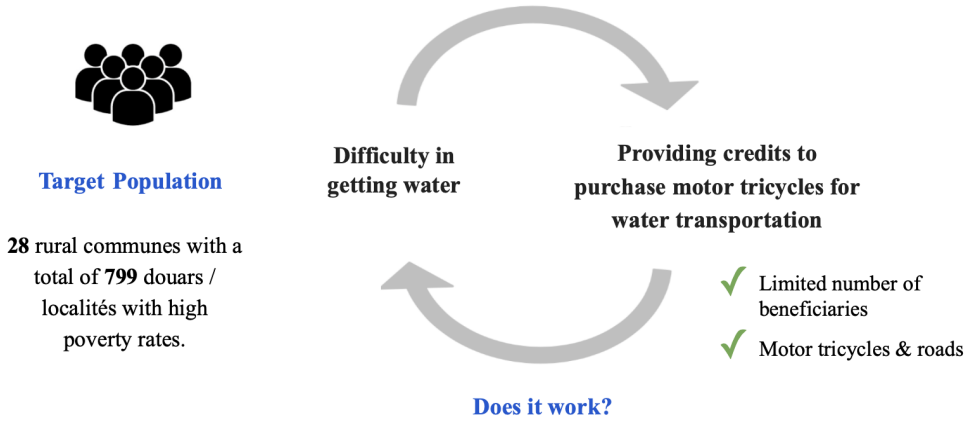

Figure 1: Key characteristics of the planned intervention.

3. Research Question

Our study focuses on assessing water connectivity in the 28 rural communes of the Safi/Youssoufia/Sidi Bennour Provinces of Morocco. Our team has formulated three research questions that aim to investigate and provide answers regarding the state of water connectivity in the region. By addressing these research questions, we aim to gain a comprehensive understanding of the water situation in the area and identify potential areas for improvement. We ask the following questions:

1. To what extent does the implementation of motor tricycle-based water delivery systems effectively address water issues in the studied rural communes?

2. How does the adoption of motor tricycle (water delivery) influence subjective well-being and happiness among households?

3. Does water delivery lead to improvements in health outcomes, such as reduced waterborne diseases for households?

Theory of Change

During our research on the concerned communities, we are able to frame our need assessment around the difficulty in getting water as a key challenge, as seen in the figure below. As previously established, the concerned regions do not satisfy the requirements to dig up wells and easily connect them to water. We also were able to identify that the roads are too unsafe for the Baytia or large tanks to transport water to the concerned rural communities. From this, we decide that a viable alternative to transporting water would be using motor tricycles, which we present as an input in our theory of change (Figure 2) alongside the credit. We expect the output to be that the credits are used to purchase motor tricycles. As intermediate outcomes, the water will be frequently transported and there will be an increase in water supply. Finally, in terms of final outcomes, we expect for the intervention to have created job opportunities to the villagers, for the overall happiness to increase as seen in a the intervention in Tangier, and finally for the school dropouts rates to drop as children, and especially girls, would no longer need to fetch water and could focus on their studies. More details on each of the levels of the theory of change will be discussed in Table 1.

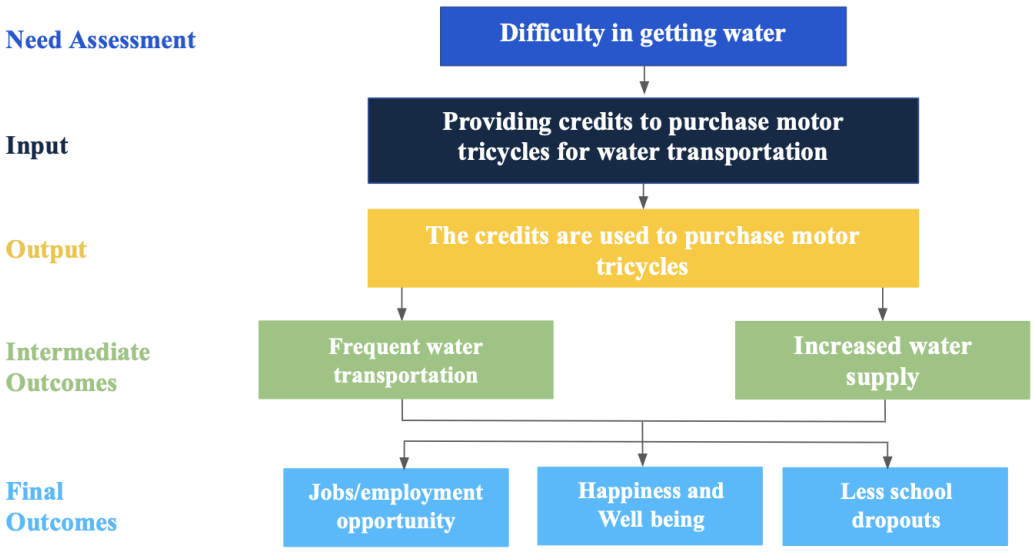

Figure 2: Theory of change for the water connectivity intervention.

Outcomes, Indicators and Data

As seen from the table below, the logical framework for the intervention can be split into four parts which we also see in Figure 2 on the theory of change. For the input, we are providing credits to purchase motor tricycles for water transportation and to measure this construct, we will be using "people's willingness to buy motor tricycles using credits to deliver water" as an indicator. Similarly, we consider the possible outputs, intermediate outcomes, and final outcomes that were indicated in Figure 2 of the theory of change. For each category, we list the objectives, the indicators, data collection method, and the assumptions linked to those as seen in Table 1 below.

Table 1: Logical framework for the intervention

Inputs / Outputs	Objectives	Indicators	Data & Assumptions
Inputs	Providing credits to purchase motor tricycles for water transportation	- People's willingness to buy motor tricycles using credits to deliver water.	**Assumptions:** - Households are willing to pay for water delivery. - Youths are interested in getting a credit to buy a motor tricycle for water transportation. **Data:** Surveys/ Interviews/ Focus group interviews/door to door.
Outputs	The credits are used to purchase motor tricycles	- Number of people who purchased the motor tricycle using the credit. - People's willingness to buy water from the motor tricycle driver.	**Assumptions:** - People who purchased the motor tricycle are engaged in water delivery. - People are tired from traveling long distances to get water. **Data:** Surveys

Intermediate Outcomes	Increased water supply. Frequent water transportation	- Evolution of the water quantity taken per household per month. - Frequency of water transportation per month. - Quantity of water transported per day.	**Assumptions**: - People they don't have anymore the problem of water **Data:** Survey - There is going to be a change in the frequency of water usage per day. **Data:** Survey
Final Outcomes	Jobs and employment opportunities especially for young men. Happiness, well being. Less school dropout.	- Number of self employed motor tricycle drivers at end of program (Compared with before). - How many people are satisfied with/ complaining about water transportation? - How many protests in front of the Caïdat's office? - How many times they visit the doctor - School attendance rates.	**Assumptions**: - Motor tricycle Water delivery provides stable income for young men. **Data:** Survey - People are no longer complaining about the water situation. **Data:** survey - People in the douars are less exposed to rare diseases. **Data:** from local hospital - Children go to school more. **Data:** From school.

Evaluation Design

Initially, we intended to conduct randomization at the douars (villages) level for our program. However, we recognized the potential issue of spillovers since douars within the same commune share the same public fountains. To mitigate this concern and maintain the integrity of our study design, we have decided to randomize at the commune level instead. To measure the effect of our program, we will establish a treatment group and a control group. Randomizing at the household level was a possible option, but due to the risk of spillovers between neighboring households, we have chosen to randomize at the commune level to ensure a clearer distinction between treatment and control areas.

By implementing this approach, we aim to minimize potential contamination and accurately assess the impact of our program on water connectivity outcomes in the region. Randomizing at the commune level will provide a robust framework for evaluating the effectiveness of our intervention. To ensure a rigorous evaluation of our intervention program, we employed a randomized assignment of treatment and control groups using a treatment lottery. The experiment design also utilized an encouragement design for the treatment group, as the program was made available to all participants in the treatment group but since the intervention has to do with giving credit, we had to utilize the encouragement design for participants in the treatment group to encourage them to take our credit to get motor tricycles for the water transportation.

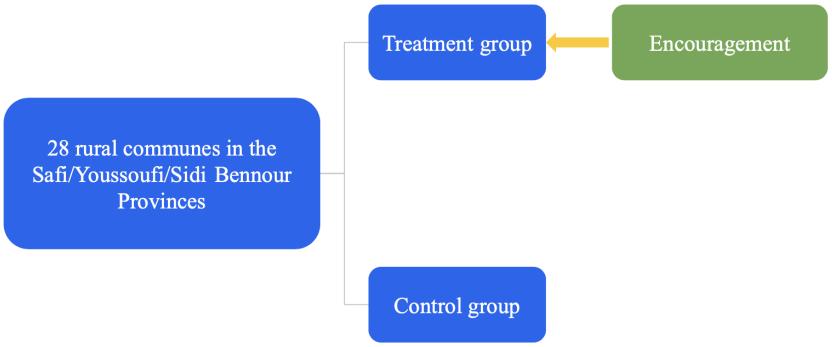

Figure 3: Evaluation design of the proposed intervention.

Random assignment took place at the level of rural communes, with some communes being assigned to the treatment group and others to the control group. This randomization process helped establish comparable groups and minimize selection bias. The treatment group received targeted information and participated in a comprehensive marketing campaign aimed at promoting awareness of the intervention program. Additionally, they received assistance throughout the application process to facilitate their engagement with the program.

By employing this randomized assignment approach and providing differentiated support to the treatment group, we aim to accurately measure the impact of the intervention on water connectivity outcomes in the region. This rigorous experimental design allows for a more robust evaluation of the effectiveness of our program.

Clustering and randomization are crucial components of our research design. In our study, the communes are defined as clusters, and we have a total of 28 clusters in our sample. To ensure a fair and unbiased evaluation of the intervention, the research team performed random assignment of these clusters into treatment and control groups. The random assignment process involved allocating a specific number of clusters as the treatment group (N clusters), while the remaining clusters were assigned to the control group (n clusters). This randomized allocation ensures that each cluster has an equal opportunity to be assigned to either group, minimizing selection bias and enhancing the validity of our findings.

Sample Size

1. Power Analysis

In our study, we are focusing on 28 poor rural communes in the Provinces of Safi/Youssoufia/Sidi Bennour, comprising a total of 799 douars or “localités” and a total population of 262,043 individuals (Office National de l’Électricité et de l’Eau Potable - Branche Eau, 2015). To determine the appropriate number of participants in each cluster, we are making certain assumptions based on previous studies.

Typically, studies aim for a statistical power of 80%, and we will adhere to that standard for this study as well. The inter cluster correlation (*ICC*) is assumed to be 0.1, indicating a low correlation between the clusters. Considering an effect size of 0.4, which yielded the optimal value of N in previous analyses, we are maintaining 28 clusters in total. This aligns with the number of communes in our study. Furthermore, we are following the widely accepted convention for the significance level, which is set at 0.05. By employing these assumptions and considerations, we aim to design a study that will yield statistically valid results while accounting for the specific characteristics and parameters of our research context. As seen in Figure 4, the number of subjects per cluster is found to be around 28.

```
> wp.crt2arm( J = 28, icc = 0.1, f = 0.4, alpha = 0.05, power= 0.8)
Cluster randomized trials with 2 arms

     J        n   f icc power alpha
    28 27.93983 0.4 0.1   0.8  0.05

NOTE: n is the number of subjects per cluster.
```

Figure 4: Power analysis.

From our statistical power calculations, we found out that to get a statistical power of 0.8 we have to set the following values as follows :

- Clusters $J = 28$
- Effect size $f = 0.4$
- Power $p = 0.8$
- Significance level $alpha = 0.05$

Potential Risks

In this study, there are several potential risks that need to be considered. One such risk is attrition, which occurs when researchers are unable to collect data on some or all of the outcome indicators for certain individuals. This can happen when study participants abandon the study, are still involved but not measured, or refuse to answer certain questions. This creates a missing data problem and can lead to misinterpretations of the true impact of the intervention. To manage attrition bias, we can improve data collection through pilot testing, follow-up, and tracking data. It is also important to allocate resources to track participants even after they leave the program and provide incentives for their cooperation. Additionally, changing the randomization level can help mitigate this risk, which we have already accounted for by randomizing over the rural communes.

Another risk is partial compliance and sample selection bias. This can occur when factors other than random assignment influence the treatment status of individuals. For example, some participants may not adhere to their assigned group or treatment. To address this, we can compute the intention-to-treat (ITT) and local average treatment effect (LATE).

The Hawthorne Effect is another potential risk where the behavior of subjects may change due to their awareness of being observed. This can influence the outcomes of the study and should be taken into account during the analysis.

Other risks to consider include the possibility of other programs being launched concurrently, the resistance from the population to receive the intervention, the refusal to cooperate with the study, the

indirect encouragements or help from individuals in the treatment group to those in the control group, and the misuse of the motor tricycles for purposes excluding their intended goal. These risks have the potential to either underestimate or overestimate the impact of the program and should be carefully considered in our analysis. We do however realize that the motor tricycles may be used for extra benefits in addition to their intended goal, which further expands the interventions' intended outcomes.

Analysis Plan

In the previous section, we have seen the potential risks for this study. We will see what will happen after the data collection. Before we start any analysis, we need to prepare, i.e. clean our data and make sure we have a good understanding of their properties. This usually involves taking the following steps:

Define the analysis population: The analysis will include all participants from the 28 communes in the region that were initially randomized into the treatment and control groups.

Assess the baseline characteristics: In this step, we will compare the baseline characteristics of the treatment and control groups, including demographic information, socioeconomic status, and water accessibility indicators, to ensure randomization was successful and there are no significant differences between the groups that could bias the results.

Conduct descriptive analysis: Using descriptive statistics, we will summarize the data, calculate means, medians, standard deviations, and other relevant summary measures for outcome variables (e.g., water consumption, waterborne diseases) and covariates (e.g., household income, distance to water source).

Examine treatment receipt: Analyze the extent of treatment receipt in the treatment group by calculating the proportion of participants who used the credits to purchase motor tricycles for water transportation.

Perform the ITT analysis: Conduct the primary analysis using the ITT approach, comparing outcomes between the treatment and control groups based on their original assignment. This analysis provides an unbiased estimation of the intervention's effect on water connectivity in the rural communes.

Choose appropriate statistical tests: Select the appropriate statistical tests to compare outcomes between the treatment and control groups. For continuous outcomes like water consumption, we will use t-tests or non-parametric tests. For categorical outcomes such as waterborne diseases, we need to use chi-square tests or logistic regression.

Adjust for covariates (if applicable): If there are pre-specified covariates that may influence the outcome, consider adjusting for them using regression models. Potential covariates could include household income, education level, and distance to the nearest water source. Adjusting for covariates helps control for confounding variables and improves the precision of the estimated treatment effect.

Assess sensitivity to attrition and missing data: Address potential attrition and missing data issues through sensitivity analyses. Explore the impact of missing data using different imputation methods or conducting analyses under different assumptions about the missing data mechanism. This helps ensure the validity of the results.

Report the results: Present the results of the ITT analysis, including estimated treatment effects, confidence intervals, and p-values. Describe the findings in a clear and concise manner, highlighting the impact of the intervention on water connectivity outcomes in the said rural communes.

Interpret the results: Interpret the estimated treatment effects in the context of the water connectivity intervention in the region. Discuss the implications of the findings for improving access to water, reducing waterborne diseases, and enhancing overall well-being. Address any limitations of the study, such as potential spillover effects or external factors that may influence the outcomes.

Results and Conclusion

After conducting the Theory of Change and reviewing similar studies, we are expecting that connecting houses to the water grid using moto tricycles will have positive outcomes. Firstly, it will increase the quantity of water consumed by families. Secondly, motor tricycle water transportations will save families significant time, leading to more leisure activities and potentially reducing school dropouts. Families are likely to highly value the convenience of motor tricycles to existing methods, resulting in reduced complaints and increased overall satisfaction with their quality of life. The introduction of motor tricycles for water delivery is not expected to affect the quality drinking water or household health. Moreover, facilitating access to credit could enable households to want to invest in solutions like motor tricycles for water transportations. When comparison groups will see their neighbors benefitting from credits to purchase motor tricycles for water transportation, they were more likely to want to sign up for the program. Overall, this approach has the potential to increase water accessibility, improve time management, and positively impact the well-being of families.

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