Smarter Water

Acknowledgements

1
Executive Summary

Over the past year, five members of the Dow Sustainability Fellows at the University of Michigan have joined together to take a multidisciplinary approach at tackling the problem of resource allocation and information sharing for non-profits that are focused on creating water resources in developing countries.

The team has partnered with Sadagaat, a Sudanese non-profit, to help the organization make smarter sustainability decisions. The first six months of the project were spent researching Sadagaat's institutional capability, narrowing the scope of the project, and conducting on-site interviews with Sadagaat's staff to find the right problem to solve. One of Sadagaat's problems was that as a small non-profit, they often build waters resource where villages can fund construction. This donor-driven model potentially defeats long-term sustainability goals as water resources are often not built in areas that need or provide the most water.

The past year's research has seen the creation of a model that helps Sadagaat weigh Quality, Quantity and Sustainability of the water resource and Need of the surrounding population against projected Cost. This model helps the non-profit move from a donor-based model to a data-based model. The use of this model within Sadagaat's operations will help the organization have greater long-term impact in bringing water to where it is needed most in the region.

In addition to the model, a framework for the Community Water Network (CWN) was created with two goals to extend Sadagaat's impact within the region. CWN will help Sadagaat maintain connections within the community by the creation of a Well Manager that keeps track of health in the village, maintains the water resource and teaches basic hygiene and water cleaning methods to villagers. CWN also posits the creation of a Water Data Analyst that helps Sadagaat build regional relationships with other non-profits, government entities and universities in order to collectively compile water data. The last portion of the project provides recommendations for further research and policy recommendations for next steps towards creating long-term water access in Sudan. This report is intended to provide a framework for Sadagaat's leadership as well as other sustainability leaders in developing countries to incorporate smarter decision-making and information sharing in the development of their own projects.

2
Introduction

DOW Sustainability Fellows

Made possible by The Dow Chemical Company, the Dow Sustainability Fellows Program at the University of Michigan supports full-time graduate students and post-doctoral scholars at the university who are committed to finding interdisciplinary, actionable, and meaningful sustainability solutions on local-to-global scales. The program aspires to prepare future sustainability leaders to make a positive difference in organizations worldwide.

The diverse array of fellows brings together many relevant interests related to water, energy, health, consumption, green chemistry, transportation, built environment, climate change, biodiversity, human behavior, environmental law, and public policy, among others. The program comprises masters/professional degree, doctoral and postdoctoral fellows, who engage with one another within and across cohorts, thrive on collaboration, learn to employ interdisciplinary thinking, experi-

ence diverse stakeholder perspectives, and implement projects with significant potential for impact on local-to-global scales.

Key components of the University of Michigan's Dow Sustainability Fellows Program are as follows:

• Masters & Professional

• Doctoral

• Postdoctoral

• Distinguished Awards for Interdisciplinary Sustainability

DOW FELLOWS MASTERS & PROFESSIONAL FELLOWSHIP

This component of the Dow Sustainability Fellows Program includes a select group of full-time graduate students pursuing terminal masters and other professional degrees at U-M – Ann Arbor (e.g., architecture, arts, business, engineering, environment, health, law, medicine, policy, social work, urban planning, etc). Each year, 40 fellows are selected from a pool of candidates nominated by Schools and Colleges throughout the University. Each cohort begins in January and concludes in December of the same year.

In addition to receiving a $20K stipend ($10K per semester), each masters/professional fellow participates in collaborative engagement activities and a substantial interdisciplinary team project. Co-curricular programming consists of monthly seminars and workshops involving a diverse array of sustainability practitioners in addition to other activities. To meet program requirements and be eligible for funding, fellows must participate in at least 75% of these co-curricular offerings.

For the project requirement, masters/professional degree fellows form interdisciplinary teams (4-6 fellows each) to draft a persuasive white paper (ideally for a client) that develops a comprehensive stance or an analysis of options on a particular sustainability challenge of the team's choosing, or a comparable deliverable approved in advance by the program director.

Schools/Colleges are encouraged to match degree requirements to the interdisciplinary project outcomes, if feasible. For example, a fellow could earn independent study credit in their home unit for project work completed through the program.

http://sustainability.umich.edu/dow

Sadagaat

Sadagaat Charitable Organization is a non-governmental organization (NGO) based in Sudan. Begun in 2002 as a way for Sudanese expatriates to give back to those in need in Sudan, Sadagaat's first projects provided food to the needy during the month of Ramadan.

Over the past 13 years, Sadagaat's charitable mission has expanded to include projects in food, water, health, and education. In 2013, Sadagaat's budget reached almost 2.5 million dollars with its growing network in Sudan and overseas. In 2015, Sadagaat-US became officially registered as a 501c non-profit in the US with representatives in all major states.

Sadagaat currently operates in a donor-driven model; funds come in from expatriates or Sudanese citizens with specific instructions on how those funds should be spent. Sadagaat serves as the intermediary for these earmarked funds. They pro-

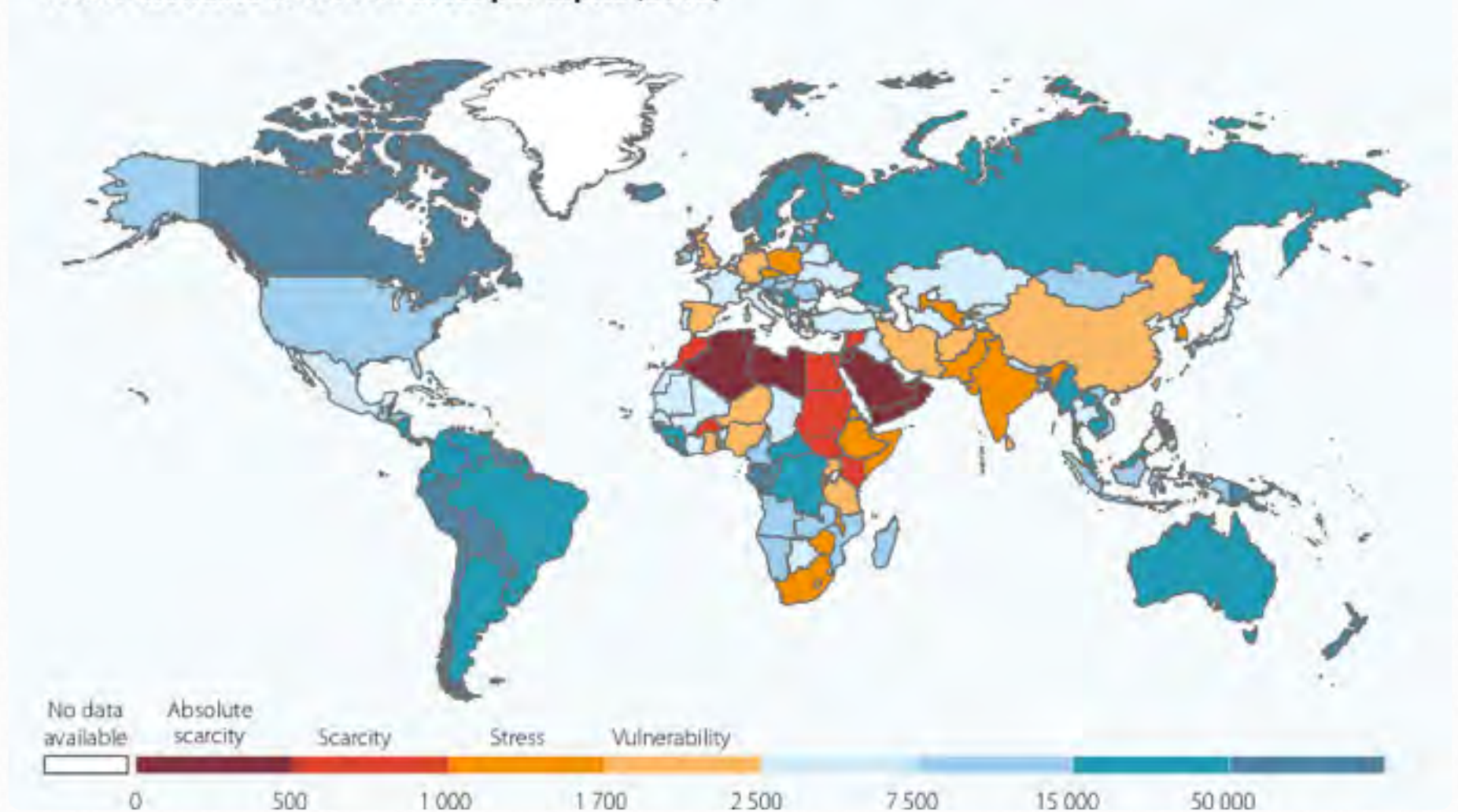**Sadagaat serves _marginalized and vulnerable groups to achieve a lasting impact on the underlying causes of poverty and social justice._**

http://www.sadagaat-usa.org/who-we-are/

cure food for Ramadan care packages, medical equipment for hospitals, and building supplies for construction projects; they contract builders for wells and other works projects; and they handle the accounting.

Water in the World

Total renewable water resources per capita (2013)

No data available | Absolute scarcity | Scarcity | Stress | Vulnerability

0 · 500 · 1 000 · 1 700 · 2 500 · 7 500 · 15 000 · 50 000

Sadagaat wanted to play a bigger role in providing water resources to communities and for good reason. Although oil and coal have competed to be the industrial world's favorite cash crop, water's current and forthcoming roles are blissfully ignored. At any given moment, the World Health Organization approximates that one-half of the developing world suffers from one or more of six primary diseases (diarrhea, ascaris, dracunculiasis, hookworm, schistosomiasis and trachoma) caused by con-

taminated water supplies and within the next decade, nearly two billion people will reside in regions of extreme water scarcity (Ruz, The six natural resources most drained by our 7 billion people). As nations unite against manmade climate change and slow its irreversible effects on water availability, overpopulation will limit these attempts as scarcity and contamination become inevitably prominent. The map, the security nexus diagram and the following statistics in this section can be found in
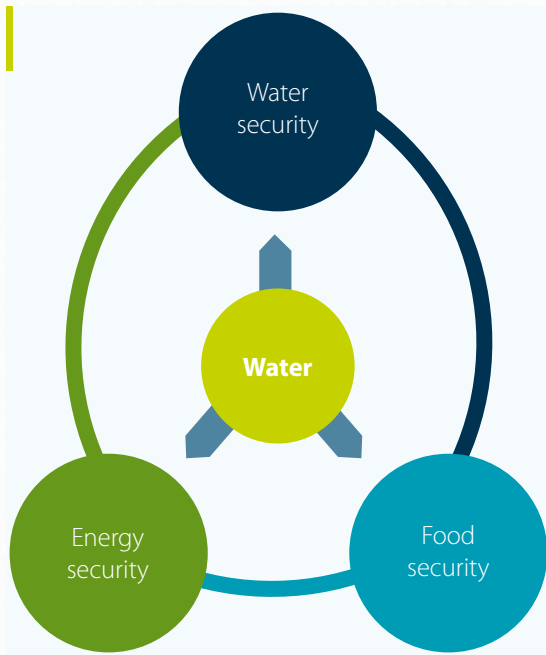
**Water security:
Acceptable quantity
and quality of water
for health,
livelihoods,
ecosystems and
production.**

**Food security:
Access to sufficient,
safe, nutritious food
to maintain a healthy
and active life.**

**Energy security: The
uninterrupted
physical availability
of energy at a price
which is affordable,
while respecting
environment
concerns.**

the 2015 United Nations World Water Development Report: Water for a Sustainable World.

Assuming unchanged global practices, the world is projected to face a 40% global water deficit by 2030 primarily due to population growth. Ultimately, this increase in water use will become unsustainable, especially in places where supplies are scarce or poorly managed. Urbanization and other macroscopic consumption patterns, particularly in the food and energy sectors, also increase water consumption for both production and use. For instance, the energy sector currently accounts for 15% of the world's total freshwater withdrawals and are expected to increase by 20% through 2035. The agricultural sector is the largest user of water resources, accounting for roughly 70% of all freshwater withdrawals globally and over 90% in most of the world's undeveloped countries.

For Africa, the fate and growth of its economies are heavily intertwined with the sustainable development of water re-

sources, which is especially true for Sub-Saharan Africa, the region with the most heterogeneous water distribution in the world. Security of Africa's water-food-energy nexus will ensure sustainable water development but there is plenty of work to do, which is evident in the 36% and 70% of the population who do not have access to improved water resources and sanitation, respectively. Currently, only 5% of Africa's potential water resources are developed and 5% of its cultivated lands are irrigated. Furthermore, less than 10% of hydropower potential is utilized for electricity generation.

Agricultural productivity, which is heavily dependent on groundwater and very variable and unpredictable rainfall, will remain the driving factor behind Africa's socioeconomic development. Improving water infrastructure to meet irrigation needs and other domestic water demands will require greater regional cooperation due to the transboundary nature of Africa's water resources. Monitoring and managing water availability will be a very difficult challenge but must be solved while the rate of unsustainable growth is still reversible. Collecting and sharing surface and groundwater quality and quantity information is key to sustainably extract water and effectively provide for the population.

This issue isn't exclusive to Africa. Two and a half billion people solely satisfy their daily water needs with groundwater, of which are hundreds of millions of farmers who contribute to local food security. Groundwater provides drinking water to at least half of the global population with 43% being used for irrigation. High demand inadvertently lowers supply with approximately 20% of the world's aquifers being over-exploited, which is demonstrated by declining groundwater levels in numerous agricultural areas and cities. Using the hindsight of these developed regions, Africa can efficiently develop to truly improve overall standard of living and achieve political and economic independence.

Sudan's Water
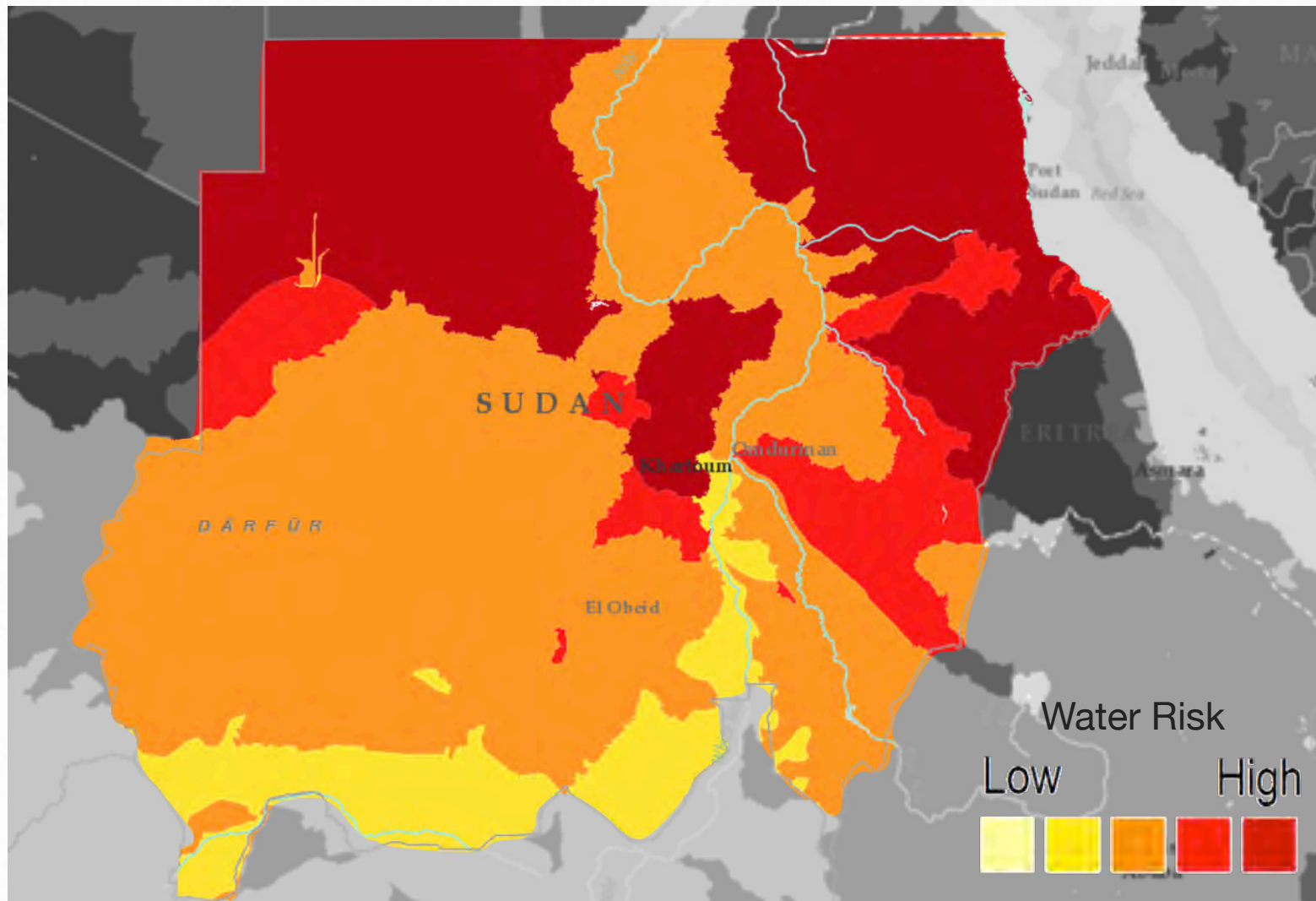
The livelihood of Sudan depends on its excess use of its water resources. Unfortunately, Sudan faces ecological crises, such as water scarcity and desertification, which are exacerbated by nomads due to changing landscapes or a lack of agricultural production. Some statistics include:

-80% of the country works in agriculture

-Agriculture accounts for 97% of its water use

-2% percent of water is available for domestic use, compared to the US at 13%.

-3 out of 5 cases of Guinea Worm Disease come from Sudan

-In 2004, Darfur had 3753 reported cases of hepatitis E within a four month span.

-In 2006, there were 476 deaths caused by diarrhea within a five month span.

Sudan utilizes part of the Nile River Basin, but its use is not regulated or maintained by the government. Most of Sudan's currently accessible groundwater is unrestrictedly shared with neighboring countries, which will ultimately lead to tension.

3

Methodology

The Problem: Which Water Resource to Build and Where?

The specific problem to be worked on with Sadagaat was slowly formed through several interviews, from Mr. Yagoub, the organization's founder, to the Project Manager who is responsible of water related projects. One of the largest desires Sadagaat has was to have a greater long-term positive impact on the areas in which they build their wells. In order to achieve this goal, they needed to make smarter decisions in where they chose to locate the water resources. Their needs evolved into the final problem statement of:

What questions should be asked concerning the quantity, quality, need, and sustainability of a proposed water project to pursue the opportunities that will have the longest-lasting and sustainable impact on villages across Sudan?

Interviews & On-site Visits

To develop the framework, we needed a hydrogeology map of Sudan, population distribution, current water resources information and land topology. After our Sudan visit we realized that other non-profits already started similar initiative and that the government is in the process of building a "water atlas" for Sudan.

One of the key aspects of the project was the visit that our team did to Sudan. During the visit, we met different stakeholders involved in the process. These interviews included:

• Sadagaat reps (top management as well as field staff who are working on the project), to understand their current process on how they determine where to dig the next.

• Community's representatives who contribute to building the well and maintain it after completion.

- Other non-profits which are trying to address the water issue in different areas of Sudan (the top two were Elsugya Charity Organization and International Charity Organization for Water)

- Researchers and professionals working in the water sector (Dr. Muna Mirghani (PhD Hydrology), Mansour Balla (Geologist), Alagib Musa (Geologist and Ph.D. candidate))

- Government officials to understand what they are doing to help address the challenges with supplying water.

- Interviews with community members who are using wells as means of getting water.

Our main findings are summarized as follows:

- Non-profits are trying to address the needs of communities that approach them and are potentially willing to contribute to the cost of construction.

- Most water projects are donor driven and not need driven (while need is there it's not well quantified)

- There is no platform for collaboration between researchers, non-profits, specialists and market players to address the challenges of water on the ground.

- There is a need for a framework to determine the need of the community and assess the benefits that the community would gain from providing a water resource.

- The government is working on a project to develop a water atlas which would have the topology of land, different types of water resources (under and over ground).

As part the trip to Sudan, the team was able to visit some of the remote areas which had challenges with the water resources. The two main challenges were lack of wells to extract water from aquifers and where wells are available the high levels of salinity in the water. We interviewed some of the community members who expressed their interest in more resources and that salinity is not their highest priority because of the fact that water is scarce and that they don't have any other options. They also mentioned that they can use it for other purposes like bathing and cleaning.

4

The Model

$$\frac{\text{(people)} \times \text{(water drop)} \times \text{(recycle)} \times \text{(bacteria)}}{\$}$$

Need is the average time to a water resource currently & number of people that a new resource could serve

Quantity is the amount of water the new resource will be able to produce per person per day

Sustainability is how long the water resource infrastructure will last & the water recharge rate

Quality is the adjusted concentration of physical, chemical, & biological contaminants in the water

Cost is how expensive it would be to build & maintain the new water resource

While non-profits in Sudan had a general view on how to prioritize which well to build and that's primarily based on donors' preferences, there isn't a formal framework that non-profits go through to determine which resource would have the highest impact.

Our recommendation to Sadagaat on how to tackle "where to build the next well" is to take holistic view to the different factors contributing to the decision. We recommend a 3-step process that involves

1. Qualify the potential resources that could be reasonably built and maintained in a particular area.

2. Quantify the benefits and compare them to cost associated with building and maintaining that resource.

3. Compare the outcome of the different options and build or start fundraising for the resource that provides the highest benefits-to-cost ratio.

Step 1: Qualify

The first step is Sadagaat should assess the potential types of resources that would provide water to the location population and qualify only those that are feasible.

The potential resources are:

- Deep well

- Shallow well

- Hafeer

- Local water tanks

The main factors that would determine which resource to be shortlisted are:

- Rainfall

- Aqua-geology of aquifer (if any)

- Nature of soil

- Land topography

In certain areas of Sudan, the seasonal rain falls between the months of July and October. Water can be harvested during these months using a hafeer (an artificial reservoir) or a local water tank.

Local water tank is a low-cost tanks built in the ground of a personal property, normally a house, and is used by a family to store water for a few months until the end of the dry season. It is constructed using bricks and cement and is covered to prevent evaporation and contamination.

Hafeer is an artificial reservoir that is built to store large amounts of water for a com-

munity. A large hole is dug in the ground and if the soil is highly permeable, a concrete layer is built to prevent the water from soaking into the soil. The hafeer is normally protected by a fence to prevent cattle and other animals from drinking from it directly but there is no easy way to prevent birds from drinking from a hafeer. Another challenge with the hafeer is the loss of water due to evaporation because it is directly exposed to sunlight.

If there is rainfall in that area exceeds a certain threshold then a hafeer or a local water tank are potential options but if the area doesn't get rainfall on regular basis then hafeer or water tanks are not shortlisted.

On the other hand, if there is an aquifer which is not over utilized by other villages and the location of building the well is reasonably good to extract water from the aquifer then a shallow or deep well are options, otherwise they are not. To determine whether a location for building the well is good then an aqua-geology map of the aquifer is required to ensure

that this location is on the deeper side and not close to the shallow end where salinity levels are higher.

Step 2: Quantify

The second step after resources are shortlisted for a certain area, is to compare the benefits to the cost of building that resource in the specific area using our proposed model. The main factors that contribute to the model are: cost, need, water quantity, water quality and sustainability of resource.

Our proposed model to measure the benefits-to-cost ratio is defined by the equation:

$$Ratio = \frac{Need * Quanity * Sustainability * Quality}{Cost}$$

Below is a high level description of the five factors:

- *Need:* measured by population served and time saved by building this resource

- *Quality:* measured by salinity, contamination, gamma rays, etc. levels

- *Quantity:* measured by gallons provided per period (without over consumption)

- *Sustainability:* measured by how long would that water resource last

- *Cost:* measured by how much would it cost to build and maintain a resource

Step 3: Compare

Once we compute the ratios for different resource/area combinations, the last step is to compare these ratios and build the one that provides that highest benefits-to-cost ratio.

Need

The Global Water Supply and Sanitation Assessment 2000 Report (GWSSAR) defines "reasonable access" to water as at least 20 liters per person per day from a source within one kilometer of the user's home. Inline with this statement, we define the need factor to comprise of two individual factors as detailed below.

Population Size

The demand for water in a community depends on the demographic information, such as number of households, composition, and age structure. Considering drinking water and sanitation only, the absolute minimum amount of water required to maintain human health is 2 liters per capita per day (Water International, 1996). The recommended amount of water intake for proper hydration increases in places with above-average temperatures, like Sudan. Considering to what extent this need can be met is important while deciding to select a location for a new water source.

In our model, population size refers to the number of people that can be served by the new water source. It is a key piece of information to prioritize which locations to build a water source. It will also help to identify which type of water source is best suited for a community. This value of this factor is obtained by dividing the population size by 6000, which is the average size of 16 different cities with ongoing or completed well construction projects. If a population is less than 6000, it will have a value of 1. If greater than 30000, its value will be 5.

Travel Time

In many developing countries, millions of women spend several hours a day collecting water from distant, often polluted sources (Episcopal Relief & Development, 2015).It is primarily deemed the responsibility of the females in the household to fetch water. When access to water demands travelling up to 8 hours a day to a remote site, other important activities like attending school become neglected. Lack of girls' education not only affects individual lives, it results in a socioeconomic impact at a national level (King and Hill, "Women's education in developing countries barriers, benefits, and policies", 1998).

Water collection travel time also negatively correlates with water consumption. The farther people have to trek to access water, the more restricted their consumption. This can lead to compromised health due to insufficient hygiene and dehydration.

These impacts reveal that long travel time to water source is a large indicator of need. Hence, our model includes a factor that measures the average travel time saved by building a water source. Average travel time refers to self-reported time taken to reach a water source, averaged over the number of households. The amount of time saved is computed as the difference between the average time currently taken to gain access to the clean water and the time it would take if a water source were built in that village. We obtain the value of travel time in our equation by converting the units of time save to hours. Time less than an hour will be given a value of 1. Time greater than 5 hours will have a value of 5.

Water Quantity

Water quantity is a measure of the volume of water the resource will be able to produce for the people of that location. WHO recommends a [minimum of 7.5 liters of water per person per day to meet basic needs](). Therefore, we assign the value for water quantity on the following scale:

• ≥ 15 L/person/day, value of 10

• 8 L/person/day, value of 5

• < 2 L/person/day, value of 1

Values between 1-10 can be assigned accordingly.

In order to fully evaluate the quantity of water available, it will be necessary to conduct hydrogeological surveys to estimate the total water available in, for example, an aquifer. Water quantity will also be a function of the water pressure in that location, which will influence how much water can be extracted from a given area.

Sustainability

Sustainability is the third factor the model takes into account. It represents (1) how long the water resource infrastructure itself will last as well as (2) the rate at which the water resource can be replenished (the water recharge rate). We include sustainability in the model because the longevity of the water resource and its location matter; water resources that will last for a long time without having to be rebuilt due to infrastructure deterioration or overuse of the

water supply are advantageous from both a cost and an environmental perspective.

The water resource infrastructure depends on the building materials used in constructing the resource. Materials commonly used now include concrete (what else?) and materials last a range of 10 to 50 years. Each resource type should be assigned a value from 1 to 5 based on the longevity of the construction materials. Our general recom-

Resource Type	Infrastructure Score
Deep Well	5
Shallow Well	1
Hafeer	3
Water Tank	2

mendations for values based on resource type are shown in the table on the left.

The water recharge rate is the amount of water per unit of time needed to replenish the available water. For deep wells, for example, the recharge rate is the rate at which the aquifer is replenished, accounting for water withdrawn. For a hafeer, the recharge rate is a function of the rainfall over the acreage covered by the hafeer. The water recharge rate should be assigned a value from 1 to 5 based on how quickly the water resource recharges, with 5 being the fastest. This value, combined with the longevity of the resource infrastructure, comprises the complete value for sustainability.

Water Quality

Routine water analysis for Sudan's Ministry of Water Resources and Electricity divides water quality into three categories: physical properties, aesthetic quality and inorganic constituents of health concern. Relative to other countries in the region, Sudan has a large number of constituents in its contaminant database, which generally complies with WHO guidelines and can be found in A compendium of drinking-water quality standards in the Eastern Mediterranean Region (2006). Other than odor & taste, physical parameters can be quantified and have recommended values. Chemical contaminants and metals are measured in parts per million (1 ppm=1 mg/L). With the latest research (2014) out of Khartoum putting an upper limit on fluoride at 0.35 ppm, almost all of the chemical constituents recorded by the Ministry of Water Resources and Electricity have corresponding maximum contaminant levels (MCLs). When it comes to microorganisms, E. Coli, pathogenic intestinal proto-

Category	Score
Microbiological Contaminants	3, Zero detection in 100mL samples
Chemical Constituents	2, Total dissolved solids (TDS)/conductivity and alkalinity/hardness 2, Metals, halogens and nitrogen species
Physical Properties	1, Turbidity and total suspended solids (TSS) 1, pH and dissolved oxygen (DO) 1, Taste, odor and color

Physical: **Color (Pt Co), Turbidity (FTU), Conductivity (μs/cm), DO (ppm), Odor & Taste, pH and TSS (ppm).**

Aesthetic (ppm): **TDS, Total H, Alkalinity (Total, HCO_3 and CO_3), Cl, SO_4, Ca, Mg, Na, K, SiO_2 and Fe.**

Inorganic Constituents of Health Significance (ppm): **F, NO_3, NO_2, NH_3, Mn, As, Cu and Pb.**

zoa and total coliform must not be detectable in any 100 mL water sample.

Listed in the left column are parameters and contaminants which are routinely tested for in Sudan. An analyst from the General Directorate of Groundwater and Wadis in Khartoum takes the results and deems the water potable or not. Collectively using this information, water quality for a given site is scored based on physical, chemical and microbiological categories. An example scorecard is outlined in the above table. The Water Quality Index will ideally evolve to include weighing areas with more water information and geographically-specific contaminants more favorably.

To ultimately place water quality responsibilities in the hands of local communities, mobile laboratory instruments make it possible to detect and measure a large number of these contaminants and parameters. Hopefully, more and more communities will have access to such technology in order to create a series of data points and provide insight into the overall quality of aquifers and other shared water resources. Even though the technology needed for water analysis can be provided, the financial and organizational capabilities of local communities may not support water quality oversight. Thus, non-profits should help establish local water analysts and well managers.

Cost

The type of the resource (hafeer, local tank, deep well or shallow well) is a strong predictor of the cost to build it. Local water tanks and shallow wells cost a lot less than hafeers and deep wells. Local water tanks are built in houses while shallow wells normally serve small communities.

Below is a list of the main factors that would determine the cost:

• Land topology.

• The static and dynamic water levels of a well.

• Capacity of a hafeer or water tank.

• Uncertainty and instability associated with building in conflict areas.

Sadagaat sends a Request for Quotation to different contractors for different resources. Once Sadagaat receives each contractor's bid, the price of each resource (in SP) is converted to US dollars to avoid volatile exchange rates and the dollar amount is divided by a thousand to get the cost factor.

$$Cost = \frac{SP\left(\frac{\$}{SP}\right)}{1000}$$

5
Recommendations

It should be noted that this model is likely to need adaptations after it has been tested in the field. For other non-profits that may choose to use this framework, it is important to note that the algorithms and factors used were chosen specifically for Sadagaat's circumstances. The factors placed within the model should be altered for each non-profit's individual circumstance and geographic region.

Framework for Smart Cities in Developing Countries

The tools in the first part of the paper enable Sadagaat to understand how to assess the environmental sustainability of the wells, and in the second section tools were developed to understand the water quality in the wells. This section of the essay will turn from specific recommendations to the larger strategy of how Sadagaat collects, analyzes, and strategically uses information and information technology to make sure accurate information is received and integrated into their overall business strat-

egy. By better strengthening the network of how Sadagaat utilizes information, it might be possible for the organization to better understand whether its water projects meet its stated goals and whether there are long-term pathways for the organization to complete their goals more fully. As well, as greater technology is introduced into the region, the non-profit will likely have greater and greater access to more technology. It is important for the organization to be forward thinking in terms

of how it will utilize future tech in the attainment of its goals.

Sadagaat's goals in its water initiative might be summed up as: delivering high-quality water through the creation of wells that are both culturally and environmentally sustainable. At the current moment Sadagaat's achieves its goals through creating partnerships with potential villages, raising funds through donations of expats from Europe and the United States, and then moving onto the next village/well after the completion. The current way villages are selected is through informal friendship networks. Although this helps in the long term in entering a community with fewer barriers towards building consensus and volunteer numbers, in the end it can mean that long-term sustainable community development is not a high-priority consideration.

Although it is harder at the outset to form ties in communities outside of the organization's friend networks enables wells to be situated in areas of greatest need and long-term community viability. The ability to give a community long-term dependability to build on their former developments can help them increase their standard of living. Much of this dependability comes from the ability to have consistent, long-term access to water. By orienting their

strategy towards the goal of long-term sustainable water provision, Sadagaat can begin the process of more proactively developing the social connections that can provide wells that better achieve these goals.

As well, after the completion of wells, little evaluation is done on the health, wellness, and agricultural increases in the area. This means that Sadagaat has little knowledge of whether the water provided to the communities continues to be of a high-enough quality to drink. This knowledge would better help them raise money from both individual donors and international aid organizations. This knowledge would also help them to understand where their organization should make strategic investments in teaching the community members how to clean their water if it is found that certain pollutants are at higher levels in certain wells. This accumulation of data helps the organization move from simply the creation

of wells to the wider goal of the provision of clean water.

By making data accumulation and analysis a key component of their mission, Sadagaat also becomes a strategic connector between communities, governments, other aid organizations, and universities. Sadagaat is in a key position to become a regional actor in the water provision space, and what's more, to be the foundation for further health and planning initiatives. A key component towards becoming a regional actor is in collecting the data. A key part of this is in creating a network of data collectors with continued incentives to provide consistent and accurate data. Within the appendix this system is expounded in greater detail, but the overall idea is pivotal to understand in terms of how Sadagaat can move forward in integrating the sustainability model into its operations.

Sadagaat, instead of ending its formal relationships with the community after the completion of the wells, they should build on these ties. Currently, in our interviews we discovered that often villages have a role of "Well Manager", a man who stands by the well and collects amounts of money for villagers utilizing the well can be utilized to collect data on the health and wellness of the villagers. The large investment from

Sadagaat would be in needing to have a person go around every few weeks to collect the pamphlets in which the data is collected. This person would then need to analyze the results of this data.

This "Well Analyst" would add value to the organization by allowing them to collect better data on the efficacy of their own operations, as well as to sell this data to local universities and non-profits.

A cohesive data collection and sharing strategy has the power to improve Sadagaat's individual organizational efficiency. Access to better data on well depth and quality can help Sadagaat choose better locations for future wells and could potentially allow them to create larger impact for lower cost.

Better data also has the ability to empower communities. Data in a community leader's hands can allow individual villages to better plan for the future investments, such as roads, houses, and agriculture of their community. At the other end, by selling this data to universities, governments, and non-profits it allows more informed policies, and quicker actions to be taken. This network of information flows can help to make the entire water efforts stronger throughout the region.

Future Technological Investments

In speaking with leaders at Sadagaat and researching the technological capacity of aid groups in the region, there has also been an acknowledgement that technology will be an increasing component of operations and they desire to embrace technology. However, few look at the strategies that can enable technology to give exponential increases in organizational efficiency and sustainability.

1.   Increased Accountability

Social networks such as Twitter and Facebook play a very important role in government by helping news and problems on the ground gain traction and a far wider audience. Especially in developing countries where there are often fewer mechanisms by which to correct incorrect decisions or unchecked authority, technologies that give greater amounts of information to the largest amount of people should be prioritized.

2.   More coherent and responsive decision-making

Technology allows a smaller time between when measurements of a phenomenon are taken in the field (whether water quantity soil nutrients, etc.) and when decision-makers (whether those are local authorities or regional legislators) have access to this information. This shortening of response times allows decisions to be made more nimbly and better targeted. This increases the likelihood of a more desirable outcome for a city, village, or region.

Technology has the power to exponentially shift the scales of communication. City and sustainability leaders should keep in mind the different kinds of ways in which technology can shift organizational dynamics within and between organizations.

Technology gives leaders increased abilities:

a.   To plan rather than to react

b.   To understand how individual organizations fit into a larger network

c.   To have different departments work together enough to foster trust

d.   Quicker scaling of both solutions and problems

e.   Horizontal collaboration amongst different sectors of government, academia, and the private market, creating greater idea movement and innovation

f.   Breaking down of silos between different sections within an organization, leading to faster idea development

g.   Greater agility in responding to emergency situations

h.   Smarter resource allocation for long-term planning

3. Greater Collaboration

The increasing advent of the smartphone has allowed community members to gain access to more information from governments, whether via apps or text-based communication. There are attempts to create further engagement between

communities and governments past information giving, or "tokenism" which trivially allows people into the governing process. Within developing contexts, often the problem is not that a trivial response from government occurs, but there is simply no government entity to turn to in order to solve a problem. Within this context the collaborative ability of technology is immense to allow people to create flexible solutions from the ground up, and to interact with each other in productive ways without the intermediary of government structures. A lot of these different collaborative models that technology enables have yet to be explored, but offer immense potential for new patterns of interaction.

Questions that people within Sadagaat's organization should ask before investing in technology for the organization include:

Is the system in which the technology will be used technologically sustainable for the environment?

Technology that depends on limited access to electricity and intermittent mobile networks for use should be prioritized above those that demand large amounts of energy and continuous network access. As well, systems that depend on air conditioning, or specialized expertise that is not

available in this area should have low priority in terms of what the organization should invest in.

Does this technology fit into existing organizational models?

It often takes organizations a long time to acclimate to a new technology, which often demands a different process of relating to people within the organization. No technology should be given to a community without care taken to understand how it will fit into organizational norms and processes.

Is this technology individually sustainable?

It takes people a long time to acclimate to new technologies. The further the technology is from existing paradigms, the harder it will be for individuals to acclimate to it, and the likelier that there will be backlash at an individual level against this tech. Data should be displayed in ways that are easily understandable to decrease the need for and the power of small groups of experts.

Before technology is brought into a system, these questions should be asked and the opportunity costs for more accurate data should outweigh the potential for longer or varying uptake of the technology.

6
Conclusion

Information regarding *need, water quantity, sustainability, water quality and cost* can be collectively used to help Sadagaat and other non-profits determine which water resource to build and where. First, the possible water resources (*shallow well, deep well, hafeer and water tank*) are narrowed down for a given area, which takes into consideration precipitation, hydrogeology and topography. Then, the potential benefits and capital and operational costs for each suggested water resource are quantified. Finally, the different scenarios are compared to one another and the region with the water resource that provides the highest benefits-to-cost ratio will be prioritized. Ultimately, this model will help non-profits transition from donor-driven decisions to data-driven decisions.

To further promote data-driven decisions among collaborating organizations, a *Framework for Smart Cities in Developing Countries* is proposed. The framework outlines good practices for better data, increased accountability, more coherent and responsive decision-making, greater collaboration and physical planning. The framework suggests to establish well managers, water data analysts and water boards in order to effectively gather and spread regional water information. The framework fuses policy, data and collaboration together to provide a water-based, community-centric platform.

Team Members:

Mohamed Elamin Abbadi

Dow Sustainability Fellow, Ford School of Public Policy

Helen Arefayne Hagos

Dow Sustainability Fellow, College of Engineering

Ashley Marie Hill

Dow Sustainability Fellow, School of Public Health

Rachel Aliana Jaffe

Dow Sustainability Fellow, School of Information

Selman Mujovic

Dow Sustainability Fellow, Ford School of Public Policy