Water and Quality of Life: A comparative case study analysis between American and Guatemalan Neighborhoods

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Introduction

Water directly and indirectly affects human well-being and happiness. Consider an example scenario where you live with limited water; it’s the tenth year of extreme drought. The government has cracked down on lawn irrigation, communal fountains have run dry, and pools cannot be filled. One day, you turn the tap - water does not flow, which means you cannot cook, clean, or most importantly, drink. In other homes water may flow from the tap, but it’s contaminated and causes sickness. Bottled water becomes a staple, and your cost of living soars. The world as you know will change dramatically. Each scenario may have been prevented if there was a culture acknowledging the true value of water.

Other parts of the world already face water security challenges. For instance the Asif Ounila River (Figure 1) runs through the lush and arid climates of Southern Morocco towards Ouarzazate. Those along the river rely on the flows of the river for their daily lives; therefore when the river turns to a trickle, use of water does too. Due to the lack of infrastructure and drying climatic conditions, residents of Morocco are forced to understand and know the value of water.
In 1776, Adam Smith used Plato’s paradox of value (Euthydemus, 304 BCE) to explain the human relationship with water, “Nothing is more useful than water: but it will purchase scarce any thing...A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it” (pg 121). Maslow’s hierarchy (1943) states that air, food, and water are the most basic needs a human requires for survival. Once those physiological needs are met, an individual can begin to think about safety, then love and belonging, esteem, and finally self-actualization. Yet, even though water is a metabolic resource and a basic need, it is often taken for granted or undervalued. For example, when people consider what makes them happy, responses typically fall in the hierarchies of safety and love and belonging which include family, loved ones, money, or other materialistic items. Most people may not understand their relationship with water nor realize the effects water has on their well-being and happiness. As Fishman (2012) put it, we must recognize water’s role in a person’s happiness, well-being, and quality of life.

“We desperately need a fresh way of thinking about water...Most of us haven’t ever thought about it very much. But we’ll need a foundation for understanding water as water issues become more urgent. We’ll need a framework for thinking about the fate of water, because the fate of water is our fate” -- (Fishman 2012, pp 308).

The terms Quality of Life and Happiness are often used interchangeably. Each term aims to measure positive against negative emotion to seek higher life
satisfaction (HRQOL, 2010; WHOQOL, 1995; Seligman, 2011). In 1995, the World
Health Organization (WHO) acknowledged the need to assess quality of life as a
whole versus just the physical aspects of health. WHO reduced quality of life to six
domains: physical, physiological, level of independence, social relationships,
environment and spirituality (WHOQOL-SRB, 2002). From this, clinicians and health
care personnel adapted Health Related Quality of Life indicators to assess the well-
being of patients to include physical, social, mental and emotional health (HRQOL,
2010). Furthermore, the 2012 World Happiness Report scientifically assessed
international well-being through GDP per capita, social support, healthy life
expectancy, freedom to make life choices, generosity, and perceptions of corruption
(Helliwell et al, 2015). We, as humans, have a relationship with water that is broken
down into 4 distinct areas based on the aforementioned indicators and domains:
physical health, mental and emotional health, spiritual health, and social capital. I
summarize these areas below.

**Physical Health**

As previously stated, water is a metabolic resource, which satisfies our basic
physiological demands - humans need water to drink, cook, bathe and grow food.

Beyond basic needs, water promotes
clean and healthy skin, properly
functioning organs, and prevents
headaches and dizziness. Esrey (1996)
conducted a health study in eight
countries on the relationship between

Figure 2: Jumper, Suzanne. *Water Run*. Qeysar,
Afghanistan. 2010. JPEG
diarrhea and nutritional status and water sanitation conditions. Results showed that improved water sanitation resulted in lower incidences of diarrhea and healthier, taller children (Esrey, 1996).

Water also provides another basic need: food. Certain regions in the world can rely on precipitation to irrigate their land; approximately 80% of the world’s agriculture is rainfed (Wani, 2009). However, precipitation alone is not a sufficient irrigation source in many regions and approximately 70% of worldwide consumptive water use is directed to agricultural irrigation (FAO, 2007). Due to increased technological efficiencies in North America, approximately 40% of our water supply is used for agriculture, yet in developing countries, like Guatemala, 60% of the water supply is diverted for agriculture (FAO, 2007). Phoenix, on the other hand, only receives an average of 8 inches of rain per year, and therefore must divert 33% of its water allocation to agriculture (ADWR, 2013).

Energy and logistical infrastructure may not fall under Maslow’s Physiological Hierarchy, yet socially, in the Western World, we have become dependent on them. Computers, televisions, lights and imported goods from Asia, South America, and Europe have created the life we lead today. Energy and logistical support helps drive the economy and fuels our capitalist lifestyle. Global energy
production uses 15% of the total water withdrawals (OECD/IEA, 2012). Furthermore, trade and transport utilize rivers and oceans to import and export goods - the United States alone constitutes 20% of the world’s ocean trade (Thomas et al., n.d).

**Mental and Emotional Health**

Water not only affects one’s physical well-being, but also mental and emotional well-being. We operate in a stressful world, full of sensory overloads, which can lead to toxic stress, mental fatigue, anxiety, and depression (Nichols, 2014). Studies are more frequently connecting a happier, healthier life to nature.

The biophilia hypothesis states that people have an inherent affinity towards nature and life supporting elements; most notably, water (Han, 2007, Beery, 2015). Simply being around water has been shown to lower stress levels (Benfield, 2015). In Germany, doctors recognize the need for preventative health measures and will prescribe a day at the spa to people who are over stressed from work (Health Care in Germany, N.D). Additionally, a survey conducted through Mappiness, a sustainable happiness app, found that a person’s happiness increased by 5.2% simply by being in a coastal region (Nichols, 2014).

Humans are drawn to include water in our lives; we use waterscapes as backdrops to important life events - such as weddings - and women choose to give
birth in water as it eases pain, is more comfortable and relaxing. Furthermore, numerous programs integrate natural water environments into strategies to help cure depression, PTSD, autism and addiction. Heroes on the Water and Rivers of Recovery take wounded warriors and veterans suffering from PTSD kayak fishing so they can relax, rehabilitate, and reintegrate. The premise is that time on water relaxes us and stimulates positive emotions, which can begin to replace the negative memories (Nichols, 2014). Participants of Surfers for Autism have witnessed the pure joy from autistic children participants as they play in water. In the moment, the children blend in with others and forget about their anxieties. People suspect it is due to the visual stimulation of water and, potentially, womb reminiscence being surrounded and engulfed by water.

Personally, I go to waterscapes to ponder life, relax and sit in awe at how miraculous nature is. Recently, I was able to escape to the beach for a few days and it is hard to describe the joy and emotional uplift it provided me. For the past two years, I have lived in the land-locked, desert oasis of a city, Tempe, Arizona, and I can personally attest to the calm the beach brought me. I stepped out onto the beach and the motion of the waves transfixed me, their sounds captivated me, the salty smell relaxed me, and I was at utter peace with myself.

**Spiritual Health**

From the beginning of time, ancient religions and folklore have revered the power of water and worshipped it: Tefnut was the Egyptian goddess of water, moisture and fertility; Poseidon ruled the Greek waters; Ganga is the Hindu goddess of water and purity and is personified through the Ganges River; Ix Chel is a Mayan
goddess of sexual desire, femininity, rain, medicine and death and is associated with bodies of water; in Chinese mythology, there are too many water deities to count, but there are tales of dragons who carved rivers, brought rains to crops, and looked over each sea (Monteiro-Ferreira, 2009; Manutchehr-Danai, 2009; Ann, 1993; Roberts, 2004, Arvigo, 2012). Today, the Mayan tradition of spiritual bathing is still practiced in order to cure emotional diseases like sadness, envy, or grief. Mayans believe that the physical and spiritual sides of a person are separated by chu’lel, a veil of human emotion (Arvigo, 2012). When the chu’lel is diseased, the spirits cannot interact with the physical actions of a person, thereby leaving them off-balanced. If left untreated, the emotional sickness could cause physical ailments. To be cured of the ailment, medicinal herbs are incorporated with nine prayers and nine healing baths.

Water also holds a special significance in modern religion. In Christianity, baptisms are performed to ensure salvation. When one converts to Judaism, they must immerse themselves fully in water, a rite called tevilah. Finally, in Islam tradition, one must cleanse himself or herself before prayer or entering into the mosque.

**Social Capital**

Quality of life is not just dependent on health, but how people interact within their environment. People are drawn to water, not only because they need it
physically and emotionally, but also because it brings people together and sets the stage for social events. Beaches, lakes, canals, and pools serve recreational purposes; they provide fun and relaxing environments to engage with others. In Morocco, women go to the river to do laundry or to the hammam to bathe; yet it’s more than a mere household chore or maintaining hygiene. The time at the river and hammam is an all day affair and offers women the opportunity to engage with each other without the oversight of men. In Fatima Mernissi’s “Dreams of Trespasses”, she recalls life when she was young and explains the excitement the women in her family had when it was time to go to the river to do dishes; they would joke, sing, picnic, and enjoy life outside of the walls of their home (1995). Moroccan women are not alone - people of all races and religions are captivated by and drawn to water; 44% of the world’s population lives within 100 miles of the coast (Nganvi, 2000).

Initially, in Tempe, Arizona, reservoirs were a necessity to ensure survivability and physical water requirements: consumption, irrigation, and energy. Over time, that need has expanded - reservoirs have recreational purposes and are used by
Valley residents to boat, fish, water-ski, or exercise. As I grew up, a family tradition was to go out on the boat each weekend to fish, ski and picnic. Living in Charleston, South Carolina, I would regularly go to the beach with friends to surf, chill, have bonfires, or cookout.

**Case Study Neighborhoods**

This paper will specifically focus on water, happiness and improved quality of life in both a neighborhood in Tempe, Arizona and general aspects of three in Guatemala. Arguably, the biggest threat to water and its connection to happiness is the lack of it. Water scarcity results from both physical and economical issues. Aside from simple geography, scarcity is driven by population growth and urbanization, limited investment, a lack of commitment to alleviate poverty, and inadequate government and institution capacity. Furthermore, water may be physically available, but the quality can be a limiting factor and inhibit an individual’s happiness. Therefore, as indicated in Figure 8, the goal of this research is to address water’s value and culture as impacted by 1) general water management policies 2) technology and infrastructure and 3) methods of water education.

![Figure 8: Water and Quality of Life Framework: Improved Quality of Life through policy, technology and education](image-url)
Tempe, Arizona

Tempe, Arizona suffers from physical water scarcity; accessibility and availability of water is naturally limited. Original Arizonian settlers had a difficult time establishing the area due to a general lack of water. The Howell Code of 1864, allocated surface water as “first in time, first in right”, and Theodore Roosevelt signed the National Reclamation Act in 1902 to fund irrigation projects that specifically stored and diverted water. Water security was further established in 1968 through the Central Arizona Project (CAP), which promised Arizona 2.8 million acre-feet of the Colorado River. This water source is dependent on the amount of water in Lake Mead; and if water levels drop too low, Arizona must yield its portion to California, who has senior water rights. CAP water is but a small portion of the total water consumed by Arizona. Between 2001-2005, Arizona as a whole used 6.96 million acre-feet of water for industrial, agricultural, and residential use (ADWR). That is 2.27 trillion gallons of water, which is more than enough water to fill 348,000 football fields to a depth of 20 feet. Policy, engineering and technological advancements have overcome the physical scarcity of water, but unfortunately, the infrastructure that has maintained society and allowed for growth has resulted in high water consumption rates -- Arizona has the fifth highest in the United States -- with a domestic water use per capita of 140 gallons per day (Kenny et. al, 2005).

Guatemala

Guatemala suffers from both physical and economic water scarcity. Guatemala receives 122 cubic inches (2,000 milliliters) annual rainfall (World Bank,
yet major urban areas are located in drier parts of the country, and the rural areas lack the resources to invest in required infrastructure. Current poverty levels are at 53.7% where 87% of rural areas and 94% of urban areas have access to a water distribution system (World Bank, 2015). However, the water is unreliable and unsafe to drink without further treatment. In 2010-2011 Vasquez surveyed 200 villages in rural Guatemala with respect to their water services and found that, on average, water from municipal and community managed systems was treated with chlorine only once a month and that 67% of those communities had not treated their water one month prior to the survey (2013). Unfortunately, it was also found that 58.5% of the sampled tap water was contaminated with E. Coli. Additional water samples were taken from 78 communities without access to tap water and found that E. Coli was present in 80.8% of them. The government recommends residents take additional steps to treat their water by boiling it or adding chlorine to prevent diseases. This is likely due to limited wastewater management and sanitation; 1% of water is treated before returning to the environment (Vásquez, 2011). Due to the lack of infrastructure to provide clean water, diarrhea inflicts 30% of Guatemalan children under the age of 5 and causes 7% of their deaths (Vásquez, 2015). Furthermore, the IPCC stated that extreme weather, such as droughts and floods are likely to increase as well (Jimenez, 2014), which could potentially result in increased El Niño affects and extreme hydrological or agricultural droughts that sweep across Guatemala.
Methods

In order to develop solutions in regions afflicted by physical or economical scarcity, one must understand past, present, and potential future conditions to determine intervention points. My work is a case study analysis of two locations: Tempe, Arizona and Guatemala. For each, I use current and historical normative and descriptive-analytical data to assess the current water situation, which requires field interviews from various stakeholders. In this sense, my definition of a stakeholder is very broad because everybody is dependent on water and everybody uses it. Therefore, I capture the perspectives of community members and non-profit organizations that assist these communities. I use a backcasting framework to determine possible intervention points that will work towards a goal of regional water security thereby ensuring quality of life standards.

Tempe-Specific Methods

In the Tempe community, I was part of a research team that took the first step to establish a sense of value for water within the community through education. We hosted two community tradeshows, where we educated the communities on the value of water and, in turn, sought feedback on their personal relationship with water. The idea was to better understand the local culture around water. In order to create the educational poster, Tempe specific water information was gathered from City of Tempe's Stormwater and Water Conservation teams. To collect data, we approached participants with two strategies: 1) draw the participant’s focus to the educational poster first; and 2) to focus on the
participant’s personal experience with water. We encouraged community members to write their thoughts about water on a Post-It Note to stick to the board.

Furthermore, we surveyed residents at the tradeshow event and canvassed houses in the neighborhood to determine potential areas to improve happiness through water projects. We met with SRP’s Canal Multiple Use (CMU) program manager to discuss possible improvements to the canal alongside the Tempe neighborhood. The City of Tempe has already implemented a multi-use path along the canal, thus our surveys sought to determine specific changes desired by the neighborhood residents. We presented these ideas to the CMU project manager to determine their feasibility. Additionally, we determined a green infrastructure (GI) project would be a sustainable, innovative solution to both flooding and transportation issues in the neighborhood. We canvassed several houses in the neighborhood to determine where flooding and transportation issues existed. Finally, we researched grants, specifically the Surdna Grant -- a funding source to upgrade urban water management systems and infrastructure -- to help fund a project on behalf of the community.

Guatemala-Specific Methods

In Guatemala, the research team participated in three community meetings in the municipalities of Santa Lucia Utatlán, Santa Lucia Milpa, and Santo Domingo Xenacoj to understand the current standards and values of water in their neighborhoods. The community leaders were asked to take thirty minutes to internally discuss their village’s greatest needs and present them to the researchers. Each community leader stood up and described their greatest needs. Furthermore,
each community leader was asked about their community’s strengths so researchers could assess both the positive along with the negative. The intent was to identify areas in the community as a whole that could improve quality of life. While questions did not directly focus on water, it was discussed at length.

Results & Discussion:

This research aims to address water’s value and culture in both Tempe, Arizona and Guatemala as impacted by 1) general water management policies, 2) technology and infrastructure and 3) methods of water education.

Tempe, Arizona

Water Management Policy

Arizona has been overly reliant on their groundwater supply. By the 1970s, Arizona was on target to deplete its groundwater sources in less than 100 years (Larson, 2009). In response, Arizona passed the Groundwater Management Act which established groundwater rights and permits, mandated management plans for five geographic territories called Active Management Areas (AMA), required developers to prove a 100-year water source to allow for growth, and required that wells be monitored and reported. However, the 100-year rule is currently being challenged and could possibly be repealed by some cities’ desires to control their own water use (Stone, 2016).

The Phoenix AMA created the First Management Plan, effective 1980-1990, which focused on ways to conserve water and adopted reduction targets for municipalities to maintain the safe-yield of 140 gallons per capita per day (GCPD).
The Second Management Plan, effective 1990-2000, started to implement aspects of the First Management Plan. However, cities argued that obtaining safe yield was not realistic; the lush landscape of Arizona State University in Tempe and large plot sizes and numerous pools in Scottsdale made safe-yield unattainable (Larson, 2009). The Third Management Plan, currently in effect, formed an effective water management strategy (Phoenix AMA), which seems to emphasize water conservation programs instead of meeting specific target reductions. The Fourth Management Plan was supposed to be effective by 2010; however, it still has not been implemented seemingly due to lack of agreement.

The greater Phoenix metro area anticipates that by 2050 the population will increase by 2-4 million people (ADOA-EPS). Water consumption will increase because there will be more demand, but the supply of water will remain as it is today and arguably may even decrease in the next 50 years. The International Panel on Climate Change (IPCC) stated that as climate change progresses, temperature shifts will result in negative effects on the world’s freshwater sources. Surface and groundwater levels will decrease in arid regions such as Tempe, and droughts will increase in frequency and severity (Jimenez, 2014). Water availability and accessibility may be further reduced and impact the general well-being of desert dwellers.

The state of Arizona has been in a declared Drought Emergency since 1999 and, in response, a Drought Task Force and Drought Plan were implemented in 2004. A review of the Drought Plans, shows that only 51% of the communities provided feedback on their emergency water sources: 60 had no back-up plan for
water, 41 would drill new wells, 99 would provide bottled water, 179 would haul water, and 131 would use a back-up well (ADWR, 2014). It appears that, in the state of Arizona, there is a lack of appreciation for water. The response to drought is to find more water; however, this does not reflect a resilient system. Arguably, if the value of water were recognized, the Active Management Plans and Drought Plans would be taken seriously and adaptation measures would be integrated. It is possible the residents of Tempe and Arizona may have a false sense of abundance.

Water quality may also be a concern when it comes to an individual’s well being. The United States has some of the safest drinking water in the world, yet recent crises in Flint, Michigan and Charleston, West Virginia have highlighted the fact that our drinking water can quickly become contaminated, generating a general lack of trust in the system, government officials and the water we receive. Tempe residents generally prefer filtered over tap water because of the taste and corrosion of faucets and pipes. The Tempe Water Quality Report shows that small traces of copper and lead have been found in the water supply, which is largely due to degraded and corroded household plumbing systems (2014). Furthermore, traces of uranium, arsenic, fluoride and nitrate were found in the water, which is due to water run off and soil erosion. However, overall, the Tempe 2014 Water Quality Report reveals that water provided by the city of Tempe meets and exceeds all national and state water quality standards.

Technology and Infrastructure

Arguably, Phoenix and Tempe exist because of the progressive technological measures taken to capture, store, and divert water. Yet, due to population growth,
agriculture and industrial development, both areas have exceeded their safe-yield. Water is limited and more stringent measures and technological advancements are needed to preserve it for future use. In order to alleviate the pressures of drought, Arizona began recharging its aquifers by storing unused water and has since expanded that program to include Central Arizona Project (CAP) water. Furthermore, engineers designed ways to turn wastewater into recycled water to irrigate agriculture lands, golf courses, and public landscapes. As of 2006, 6% of Phoenix’s water supply came from reclaimed water. For example, Tres Rios, a constructed wetland located in Phoenix, Arizona is a tertiary, polishing pond, designed to improve the quality of water discharged from the 91st Wastewater Treatment Plant to irrigate agriculture in Buckeye. Historically, groundwater or surface water would have been used to irrigate the fields of Buckeye, but now that water comes from the Wastewater Treatment Plant and has the added benefit of creating an ecosystem.

Furthermore, specific to the Tempe neighborhood, it was found that some streets flood during rain events. In general, the neighborhood has poor stormwater management and, in one case, water drained into the local church. Additionally, it was found that the path adjacent to the canal could be improved. The City of Tempe has already implemented a multi-use path along the canal, which is part of the Salt River Project and carries water throughout the valley. The residents we spoke with showed an interest in the following improvements along the canal: more lighting along the path; benches that only allow sitting, not lying down; a fence along the water’s edge; and hosting community events around the canal.
In order to create a sustainable water system, one must include ‘soft’ technologies as well as the ‘hard’ engineered technologies. Tempe utilizes other methods to promote water conservation in the area. They provide incentives and rebates for low flow toilets and xeriscaping and offer free water audits to encourage increased efficiencies at home.

**Education**

The educational poster was utilized at two events: a workshop on September 28th, 2015 in Gilbert, Arizona, and a trade show on October 26th, 2015 in our neighborhood in Tempe, Arizona. The results from the September Workshop are presented in Table 1 and the results from the October Workshop are presented in Table 2.

**Table 1: Comments from September Tradeshow**

<table>
<thead>
<tr>
<th>GOOD</th>
<th>BAD</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find balance between green infrastructure in the neighborhood</td>
<td>SRP does not pay for maintenance of flood system, so community must fix</td>
<td>What is the value of using grey water other than an economic value?</td>
</tr>
<tr>
<td>Life x 3</td>
<td>Poor infrastructure/flooding</td>
<td>What's reclaimed water?</td>
</tr>
<tr>
<td>Emotional well-being</td>
<td>Poor water damage</td>
<td></td>
</tr>
<tr>
<td>SRP flood irrigation-fruit trees</td>
<td>High Calcium in water</td>
<td></td>
</tr>
<tr>
<td>Relaxing to be around</td>
<td>Dirty water outside of the US</td>
<td></td>
</tr>
<tr>
<td>Fruit trees</td>
<td>Germicide of weeds pollutes water</td>
<td></td>
</tr>
<tr>
<td>Life support &amp; aesthetics</td>
<td>Wasting water</td>
<td></td>
</tr>
<tr>
<td>Maintain neighborhood</td>
<td>Mosquitos</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Use grey water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Comments from October Tradeshow**

<table>
<thead>
<tr>
<th>GOOD</th>
<th>BAD</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility to tap</td>
<td>Population in the Valley and amount of water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funny Tasting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water Fountains get gunk on them</td>
<td></td>
</tr>
</tbody>
</table>

The majority of individuals attending the workshops gave positive feedback about water (Tables 1 and 2). However, not all were positive; some stated that water brings mosquitos, it floods their neighborhoods, and there is a high level of calcium in the water. The ‘Other’ column indicates that several people were interested to learn more about water in their neighborhood. Both strategies we used to approach residents at the tradeshow worked well. The advantage of the first strategy, to bring the resident’s focus to the board first, was that they were willing to write down thoughts on their own. The benefit of the second strategy, to bring the focus to the resident’s perspective, is that it created a personal connection and portrayed our true interest in what they had to say. It is important to continue educational outreach efforts that stimulate further discussion and a sense of value of water. Overall, comments from the tradeshow covered many facets of water, both good and bad. It seemed people understood the value of water and were able to point out issues with the water system. However, it was unclear whether their
behavior towards water reflected their beliefs. It was also nice to see that people wanted to learn more about ways to conserve water.

**Guatemala**

**Water Management Policies**

Guatemala's economy is dependent on resource extraction, from bananas and sugar cane to water. The agricultural sector makes up a mere 13.7% of their $125.6 Billion GDP (CIA, 2015) yet is the largest consumer of water; 60% of Guatemala's water is used to grow crops. Agriculture is extremely water intensive, which makes water an extracted resource. For instance, a 5-pound bag of sugar at the grocery store in the United States has an approximate water footprint of 138 gallons (209 m³/ton) (Gerbens-Leenes, 2011). This is called virtual water, and many countries have invested in foreign lands that are water rich, like Guatemala, to establish both food and water security. Furthermore, regulations and laws are lax to encourage this investment, which is unfortunately at the expense of not only the environment and virgin resources, but people as well.

The informal economy, the portion of the economy that is not taxed or regulated, accounts for 73.6% of Guatemala's employed population (Gonzalez, 2015). Agriculture contributes to 39.5% (Vulletin, 2008) of the informal economic sector. Furthermore, 88.6% of agricultural workers are informal with 18% of those being women (Linares, 2013), meaning they do not receive social security or have health care, and make less than minimum wage ($211.35 USD per month). The result is that only 25% of those in the informal agriculture sector live above the poverty line. Furthermore, almost all irrigated systems that exist were developed by
the private sector, which means smallholder farmers likely rely on precipitation or have direct access to contaminated ground or surface water. This makes smallholder farmers more vulnerable to weather and unable to cultivate large tracts of land due to inefficient watering practices, which thereby results in low crop yields.

As recently as 2000, Guatemala had no comprehensive water policy, no wastewater treatment laws and minimal water resource management. However, the country has started to make progress, likely due to their Millennium Development Goal commitment in 2000 to increase access to potable water and proper sanitation and to decrease health risks associated to water born diseases (i.e. chronic malnutrition, diarrhea, stunted growth, cholera) (MDG, 2015). Today, the National Constitution, the Municipal Code and the Health Code, and municipal governments are responsible for providing drinking water. The Ministry of Public Health and Social Assistance is responsible for regulating and supervising drinking water systems. However there is no central water law, weak regulation, inefficient public administration, and lack of enforcement (United Nations, 2015).

Technology and Infrastructure

As alluded to earlier, the rural impoverished have the most to gain by investing in improved water technology and infrastructure; many have no water source or means to irrigate their crops and most are afflicted by poor water quality. Amongst the three communities visited in Guatemala (Santa Lucia Utatlán, Santa Lucia Milpa, and Santo Domingo Xenacoj), all had water concerns, whether based on physical scarcity or issues regarding sanitation and drainage. In many locations,
community members had insufficient access to water; their water treatment system was inoperable, they lacked rights to the nearby stream, or they received water only 1-5 hours a day. Furthermore many recognized the need to separate wastewater from potable water, but lacked the infrastructure or human capacity to do so.

In order to address water quality issues, residents already boil water, add chlorine tablets or simply do not address it at all. Chlorine costs money, as does the electricity needed to boil water. While firewood can be acquired in the forest to boil water, it is not a clean energy source, which ultimately causes indoor air pollution and early death. Life is valuable and should not be cut short because one is unable to keep water clean. Local organizations are invested in bringing clean drinking water to residents of Guatemala. For instance, EcoFiltro is an organization committed to clean water for 1 million ruralites by 2020 (EcoFiltro, 2016). EcoFiltro builds a household filtration system, made from layers of clay, sawdust and colloidal silver to remove organics and bacteria from water. Through their program, clean water is offered for life with one filter purchase at an affordable price and tailored payment plan. It seems to be a very popular and viable program based on the number of organizations they are partnered with. However, the filters have a 2-year life span under optimal conditions. The life span could potentially be cut down to 6-months if the water source is extremely poor quality, which is likely considering the minimal regulations to control run-off and discharge. Finally, the filters do not address other potential contaminants in the water supply, such as pesticides, herbicides or other chemicals.

Wastewater management is spotty in rural communities, which results in
heavily contaminated water sources. For instance, Lake Atitlán, arguably one of the world’s most beautiful lakes, is heavily polluted and in danger of turning eutrophic in the near future. When a lake becomes eutrophic, it essentially dies; an abundance of nitrogen, phosphorus, and other organic nutrients create an ecosystem where algae and plants thrive, soaking up all the oxygen in the water and killing the fish. The algae in the water creates a toxic environment and results in a source that can no longer be used for human consumption. In Lake Atitlán’s case, 100,000 people are threatened with losing their water source because the waste of more than 300,000 people is discharged directly into the water (USAID, 2013).

**Education**

Interestingly, a survey conducted in communities near Lake Atitlan, found that a third of those surveyed had negative associations with chlorine in their water (Nagata, 2011). Local communities associated high levels of chlorine with death. During the civil war, there was a cholera outbreak and officials increased chlorination levels in the water. However, there were rumors that the military dumped massacred bodies into Lake Atitlan. Additionally, people thought the bitter taste and cloudy color of the chlorine was the Guatemalan government poisoning the water supply. Later, in 2005, similar sentiments arose during Hurricane Stan when officials increased chlorine levels again. Residents knew mudslides had swept people and animals into the lake and saw their corpses emerge after a period of time. Therefore, they once again distrusted their water source and changed their drinking habits to include bottled water or self-treatment (Nagata, 2011).
Regardless of the fact many believe their water is dirty, almost half prefer drinking water without chlorine because they believe chlorine either tastes bad, has no real function, or causes illness. 77% self-treat their tap water and it was found that those who had more education (3.92 years vs 0.92 years) and those who were literate were more likely to treat their water (Nagata, 2011). Field research demonstrated that the community leaders were aware of basic sanitation and hygiene methods. They understood one cause of diarrhea was from poor quality drinking water – they recognized the need to separate their wastewater from their water source. Many community members specifically noted the need for latrines, water filters, water treatment facilities and dams to separate wastewater.

**Recommendations**

Given the results and the policy, technology and education focus of this applied study; I recommend three strategies to promote water sustainability:

1. **Policy:** Water management practices and policies should **protect water to ensure there is an appropriate quality of adequate quantity for all purposes to include ecosystems and future demand.**

2. **Technology and Infrastructure:** More **efficient and out of the box water systems,** to include wastewater and sanitation, should be incorporated into municipal, industrial, and agricultural sectors.

3. **Education:** The population should be **educated on the value of water** and health to respect this finite resource, decrease consumption, and protect our sources.
While the recommendations above are general, they do apply to most communities on the planet. However, I offer Tempe, Arizona and Guatemala specific recommendations below.

**Tempe, Arizona**

In Tempe, both water and sanitation systems are centrally managed and in relatively good condition. Therefore, there appears to be less responsibility on individuals to control or influence the system. The surveyed community revealed that they were educated on the values of water to some degree, but some comments revealed a desire to know more about water conservation projects.

1. Policy: The community should **create an informal governance system to support and coordinate water projects** in the neighborhood.

   The community already gathers informally for potlucks and other events. Therefore, through these avenues, it would be an excellent way to address water issues at a local level. Furthermore, they would be able to organize action committees who could 1) reach out to the city to conduct workshops, or 2) submit grants to install green infrastructure throughout the neighborhood.

2. Technology and Infrastructure: The community should **implement green infrastructure within their neighborhood** and turn the canal into a community space.

   With respect to the neighborhood, a green infrastructure (GI) project would be a sustainable, innovative solution to flooding in the neighborhood. Since green infrastructure is typically costly, we
recommend applying for and obtaining a grant - specifically the Surdna Grant - to upgrade urban water management systems and infrastructure. Additionally, further design, cost estimates, and schedules of work will be needed for the system before a letter of inquiry is submitted.

Based on discussions with SRP's Canal Multiple Use project manner, the installation of lights and benches and hosting community events are plausible; however, a fence is not because it would interfere with maintenance. I recommend the Sustainable Neighborhoods for Happiness class pursue a license agreement between SRP and the City of Tempe and/or Mesa. Furthermore, they should ensure that the voices of the residents are heard and considered as the number one priority throughout the process.

3. Education: Assistance should be provided to help individuals learn about household water conservation projects.

   In order to educate people about the value of water, they should be involved in their water systems. The City of Tempe offers workshops on how to harvest rainwater or greywater, how to landscape with low water use and how to design and install drip irrigation at home. Furthermore, the city offers rebates and grants for these programs, which would benefit low-income neighborhoods.
Guatemala

The surveyed communities highlighted their main concerns around health and water. In order to improve quality of life with water, water security must be established. One way to do this is to focus attention on the security of the water source. Historically, water solutions have centered on treating water at the point of consumption. However, that does not solve underlying sanitation problems. Currently, no infrastructure or institutional capacity to separate wastewater from potable water exists, which therefore pollutes the water source and requires further energy to treat water at the point of consumption.

1. Policy: Support should be offered for **communities to create decentralized water treatment systems**.

   Municipal sanitation systems have failed the rural regions in Guatemala. Therefore, sanitation will have to be accomplished at decentralized levels within communities. Establishing and maintaining a decentralized sanitation system can be very challenging because everyone must be involved at every level, transparency throughout the process needs to be upheld, and knowledge and education must be shared. Furthermore, communities must identify that they are ready to tackle complexities, establish the goal and value structure, assign roles and responsibilities of key players, and ensure rules are fair with equal responsibility and benefit to the members (Olstrom, 2010). In rural Guatemala, decentralized sanitation could
improve equity, warrant accountability of local officials, expand knowledge, and build capacity.

2. Technology and Infrastructure: Communities should **install low cost /low maintenance wastewater treatment options.**

There are many types of low costs wastewater treatment options that don’t have intensive maintenance regiments. One way to achieve sanitation on a broad spectrum is to use a waste stabilization pond - an engineered system that uses nature to separate solids and kill pathogens. It requires minimal maintenance and has low operation costs. The system is constituted of three different ponds, which perform anaerobic, facultative, and aerobic functions. In the most basic terms, organic matter separates out of the water in the anaerobic pond and settles at the bottom to create a nutrient rich sludge. After about 7 days, the filtered water flows into the facultative pond where a secondary cleaning takes place. In the lower levels of the pond, further sedimentation occurs and in the upper level, the wind and sun help aerobic functions take place to further dissolve organic matter. At this point, approximately 90% for the Biochemical Oxygen Demand (BOD) is removed and water can be used for non-consumable agriculture and aquaculture (Goad, n.d). For a tertiary cleaning, the third aerobic pond is where UV radiation, oxygenation and photosynthesis kill remaining pathogens.
3. **Education:** Communities should be **taught how to operate and maintain the system.**

Based on the survey and conversations with the communities in Guatemala, it appears, they are already knowledgeable on basic hygiene and sanitation. Therefore the next step is to build capacity. A decentralized sanitation system offers the opportunity to expand knowledge within a community, provide an avenue for new jobs. Once sanitation is achieved, diarrhea rates decrease, less time and money spent going to the doctor; therefore individuals will be able to spend more time on other ventures.

A decentralized sanitation system can also offer communities opportunity for economic development and job security in conjunction with improved health. Van Dijk (2012) suggests developing countries consider sanitation as a value chain where fecal matter is the ultimate end product. Fecal matter is high in the nutrients nitrogen and phosphorus, which are the key ingredients in fertilizer. Therefore, if treated properly to eliminate pathogens, it can be turned into fertilizer for crops or converted into biogas as an alternate energy source. Paris realized the importance of separating human waste from their water source back in the 1800s and thereby sold that waste as agricultural fertilizer (Sedlak, 2014). Furthermore, by separating human waste out of the wastewater and discharging it downstream of the withdrawal point, they ultimately were able to improve the cleanliness of their water source.
Today, in the United States, sludge from wastewater treatment facilities is already used as fuel in industrial boilers and kilns, as an add-in for concrete, and as fertilizer in the agriculture sector (Satinder, 2009). Furthermore, the process of anaerobic digestion can be used to capture the biogas release and transferred into energy. It has also been found that dried fecal sludge could also be used as a renewable biofuel. A study in Uganda, Ghana, and Senegal found that dried fecal sludge had similar calorific values, amount of energy released when burned, as other locally used resources. Fecal matter had a calorific value between 16-20 MJ/kg, where coal was 28 MJ/kg, coffee husks were 20 MJ/kg, and rice husks were 15 MJ/kg (Muspratt et al. 2014).

**Conclusion**

Water security is a growing sustainability challenge both locally and globally. This report provided case study assessments of water challenges in Tempe, Arizona and Guatemala. Recommended solutions were determined based on the needs established by each community and from research based on existing water management policies, infrastructure, and education of water values. Furthermore, key indicators were used to relate our relationship to water and how truly valuable it is to our happiness. The path toward water security looks considerably different in Tempe, Arizona and Guatemala, yet both move toward improved quality of life. Tempe already has access to water. However, the challenge is how to maintain water security amidst a future of climatic uncertainty. On the other hand, Guatemala largely lacks water security and citizen’s health is severely impacted. Regardless,
both can strive for water security by taking an alternative approach to sustainable water management, technology and education to promote greater opportunities for happiness and overall quality of life.

The key to any solutions-oriented approach is sensitivity of and adaptation to cultural norms. Furthermore, the projects and potential solutions presented within this report only represent a stepping-stone towards happiness. In both case studies, the solutions need to be expanded, both inwardly and outwardly. For instance, Tempe’s green infrastructure projects should include the whole neighborhood and build on efficiencies and technology to improve the overarching system. In Guatemala, the path towards water sanitation must start small so that the community can be educated on the processes and technology involved. Once the community sees improved health, it will encourage further action and leadership to build capacity and improve values. While there is no universal solution to water security or happiness, iterative steps and actions can be taken to make improvements regardless of how small.

If an individual considers how water affects happiness, he or she has to think outside of selfish desires to include cultural and community needs, thus contributing to communal happiness. If water security is achieved, there could be accessible and adequate water for all purposes. Clean and sufficient water sources can promote physical happiness, while potentially improving access to nature that would enhance mental, spiritual, and social happiness. When happiness is enhanced through improved water quality and accessibility, the values surrounding water will improve as well. Ultimately, when water is respected as an invaluable resource,
policy, technology, and education will reflect sustainable cultural values and promote a healthier and happier culture.
Sources


