



**Can “Good Practices” be Achieved on Small-Scale, but High Impact Water Distribution Projects?
Examples from an Engineers Without Borders team in Guaimaca, Honduras.**

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Presentation Summary:

We will first discuss the meaning of small-scale, but high-impact projects and the relationship that exists between the human rights approach to water and the UN’s-World Bank’s demand responsiveness approach. There are striking similarities. We will then introduce our project in Honduras, EWB-USA’s approach to water, and describe our communities in terms of a socio-economic context and in terms of the perception that stakeholders have towards the value of water. We also assign scores to our current approach based on the human rights approach to water and based on the World Bank’s demand responsiveness approach. We conclude with steps that need to be taken in order to make this project more sustainable.

Executive Project Summary:

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1. Introduction:

The Engineers Without Borders (EWB-Boston) Professional Chapter is working with the *Dominican Sisters* in Guaimaca (population 15,000), Honduras, to improve the quality and quantity of potable water systems in the region. Our project targets three small towns on the outskirts of Guaimaca called La Calona, Maraquito and Aguacatillo, which have a total combined population of 60 households and 306 individuals. All of these communities are located next to the Jalan river, which flows downstream from Guaimaca, to Calona, Maraquito, and finally to Aguacatillo.



Figure 1. Approximate location of Guaimaca, Calona, Maraquito and Aguacatillo relative to Honduras. (Not to scale)

In the past, Calona and Maraquito have always had better access to water resources than Aguacatillo. For example, in 1986 the government funded a project called “Alas” in which over 20 shallow wells (hand pumps) were built between the outskirts of Guaimaca the end of Aguacatillo. To this date, most of the shallow wells and hand pumps that are functional and uncontaminated are located in Calona and Maraquito. These wells are used frequently by households for all sorts of purposes but do not represent their primary source of water (which comes from the system described in the next paragraph). In addition, although these three communities are located next to the Jalan river, its water is extremely polluted and is only used for agricultural purposes.

In 1994, the government dug a well in a “barrio” in the outskirts of Guiamaca called “Figuroa” but installed its distribution tank 1,271 meters away from the tank, on a hill in Calona. All households in Calona and Maraquito are currently connected to this system. One community member from Calona currently runs this system, distributing water once a week to all the households in Calona and Maraquito. He collects water fees, organizes meetings, and fixes, maintains and operates the distribution system. He is also occasionally greeted with a machete when he approaches a household that has defaulted on water fees for several months.

Because of budgetary constraints, the pipeline never reached the poorest and most isolated households in Aguacatillo. More recently, a government electricity project has also arrived in Calona, and to a lesser extent in Maraquito. To this date Aguacatillo remains without access to electricity or to a reliable source of water.

Since 2008, when the partnership with the *Dominican Sisters* began, EWB-Boston has completed three assessment trips to Honduras. During these visits, we’ve held a variety of meetings with community leaders, learned the region’s politics and demographics, collected water resource and socio-economic data, and more recently performed a Willingness to Pay (WTP) study. We also dug a well in Maraquito.

EWB-Boston is currently working on the design of a water distribution and financial system that will be implemented this summer, and that seeks to reduce tension between the aforementioned villages. By ensuring a more reliable supply of water, increasing communication, and allowing water boards to decide how to manage their old and new distribution system, EWB is hoping to increase the system’s reliability. This project seeks to provide good quality water on a consistent basis to all three communities. At the same time, the scheme strives to be financially viable; thus, a key component of the distribution project has been focused on developing a pricing scheme that is fair and acceptable to the local communities, but also allows for cost recovery.

Figure 2. Community Stakeholders –Calona, Maraquito and Aguacatillo (Credit: EWB – Boston Professional Chapter)



Calona



Maraquito



Aguacatillo

2. Community Characteristics:

Rural poverty in Honduras is among the most severe in Latin America. Approximately 53% of the population is rural, and it is estimated that 75% of the rural population lives below the poverty line, unable to meet basic needs.¹

There are 306 people living in Calona, Maraquito and Aguacatillo. Aguacatillo has the highest population density, with only 14 households but accounting for 20 % of the population (70 individuals). In our communities, 68% percent of the households live above the poverty line². Table 1 depicts some household and community socio- economic characteristics.

Table 1. Community Population Characteristics

Population Characteristics	Calona avg (sd)	Maraquito avg (sd)	Aguacatillo avg (sd)
Number of Households	21	25	14
People per Household	5 (4)	5 (3)	6 (3)
Household Monthly Income ¹	L 2,566 (1,635)	L 2,426 (1,458)	L 1,251 (1,035)
Monthly Income Per Capita²	L 513 (265)	L 485 (238)	L 209 (197)
Household Monthly Savings	L 135 (173)	L 108 (123)	L 91 (30)
Years of Education per Head of Household	6 (3)	4 (3)	3 (3)
Days Without Water -month/household-	2 (4)	8 (6)	13 (11)
Water Consumption -liters/day/household-	76 (2)	57 (1)	76 (2)
Water Consumption³ -liters/day/capita-	15.2 (0.7)	11.4 (0.3)	13 (0.4)
Household Monthly Food Expenditure	L 1,563 (952)	L 1,713 (1,412)	L 943 (803)

[1] There are 19 Lempiras for every U.S dollar.

[2] The common international poverty line has in the past been roughly \$1 a day. In 2008, the World Bank came out with a revised figure of \$1.25 at 2005 purchasing-power parity (PPP). In our communities, living above the poverty line means living with over L 713 a month per capita.

[3] The *United Nations World Water 2003 Development Report* has estimated that in order to meet basic needs, individuals require a minimum of 20 to 50 liters of safe water each day. All our communities live well below this international standard.

All three communities' incomes are below the international poverty line (\$US 1.85/day; 35 Lempiras/day), and all three communities are below the acceptable water requirements for basic necessities (20 Liters a day). Aguacatillo is the community under most severe water stress as it has the largest population density, is the poorest, and consumes as much water as Calona. At the same time, Aguacatillo obtains its water from much less reliable water sources.

These communities are mainly composed of coffee farmers whose income accrues throughout the harvesting season. When the coffee season is over, income drops dramatically and households have to resort to selling petty goods, working at distant farms, and selling non-cash crops (maize or beans). Individuals in our communities are not land owners, but farmers, whose income depends on the harvesting and the increasingly volatile price of coffee.

¹ The International Fund for Agricultural Development (IFAD). http://www.ifad.org/media/success/honduras_2.htm Accessed: April 1st 2011.

² The common international poverty line has in the past been roughly \$1 a day. In 2008, the World Bank came out with a revised figure of \$1.25 at 2005 purchasing-power parity (PPP). In our communities, living above the poverty line means living with over L 713 a month per capita.

Coffee revenue is often accumulated during one part the year, but household expenditures are spread across the year. In order to meet their needs during ‘deficit’ months households need to have better savings mechanisms and education. With income being accumulated only 6 months during the year, it is difficult to allocate household expenditure during the year. This makes monthly payments of water even more difficult to collect, and to save for.

3. Water Uses, Infrastructure and Finances: Existing and Future Distribution Systems

3.1 Existing System

Calona and Maraquito are currently connected to the system that was installed by the government in 1994. At the time, all three communities collaborated in the development of the distribution system and provided “sweat equity” in exchange for household connections. However, the government only had sufficient resources to connect Calona and Maraquito to the distribution system. Aguacatillo has been left out of the distribution system since 1994, and until EWB-Boston arrived to the region, there had been no serious efforts to incorporate them into the system. Figure 3 depicts the existing distribution system.

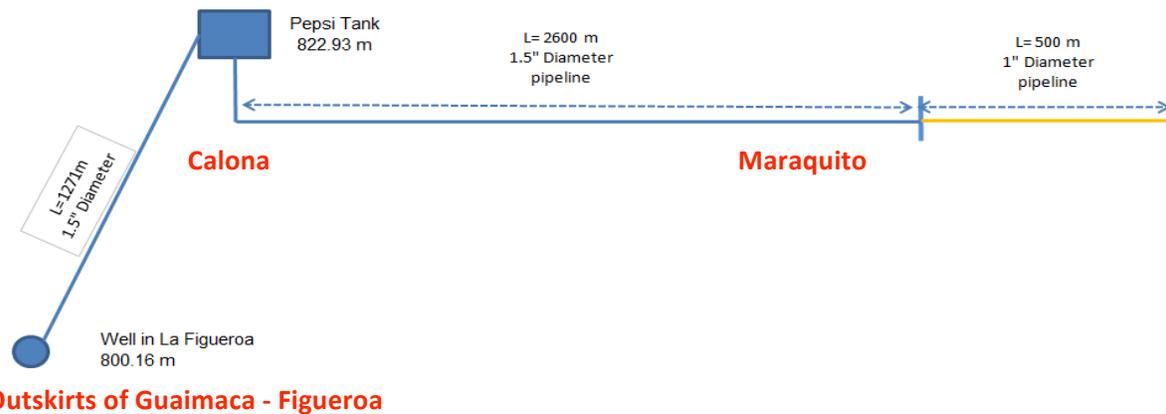


Figure 3. Existing Distribution System. The Pepsi Tank Elevated at 822.93 meters provides water for all the households in Calona and Maraquito. Aguacatillo is not incorporated in this figure or the existing distribution system.³ It is called the “Pepsi” tank because it was also part of a Pepsi advertising campaign. We don’t know if beneficiaries ever received dividends from this advertising.

The current system is composed of a 45 meter deep well (150 feet) with a submersible electric pump that sends water to a 7000 gallon tank in the village of Calona, located more than a kilometer away from the well. Due to constraints on electricity, water is pumped only once every 8 days and the water is gravity-fed from the tank to all households connected to the distribution system. The pipeline system is composed of PVC, but household connections are made out of plastic, or hose like material.

The operator of the system turns on the pump every 8 days and waits for 72 hours until the tank is full. After the tank is full, he announces that he will open the tank and valves and allow for the water to be gravity-fed to the houses. The first houses to get water are those in Calona followed by the ones in Maraquito. Because the system is gravity fed, there are pressure and volume losses as the water flows downstream. Households store water for an entire week, so many of the wealthier households have

³ Engineers Without Borders - Boston Professional Chapter Document 522 Post Assessment Report Trip 3

miniature pools or “pilas” (2x2x1 meters), small tanks, and many of them have buckets where they store water for the following 7 days to avoid running out of water.

Water from the distribution system in Calona and Maraquito is used for drinking, cooking, and cleaning and a few of the houses use water for small gardens and subsistence farming. However, the water is not allowed to be used for intensive farming purposes. Since these communities are situated next to a river, most of the farms in the region use electric pumps to send water from the river to the nearby farms. However, Aguacatillo’s residents get most of their water from streams or shallow wells, often times polluted and shared with animals from nearby farms. Figure 4 outlines different sources of water for household consumption in Calona, Maraquito and Aguacatillo

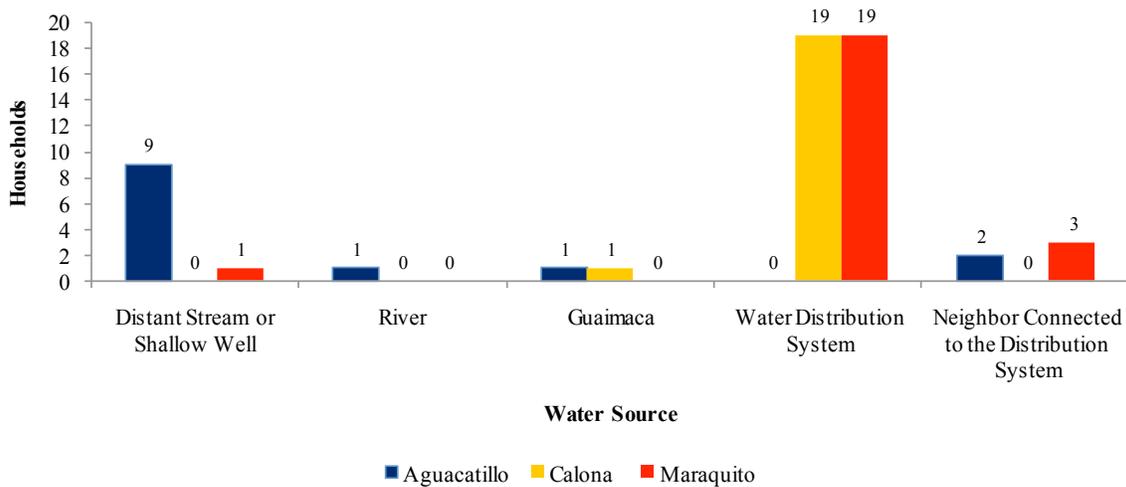


Figure 4. Water Source by Community (Data was not available for all households because they refused to respond to the survey)

Currently, households pay 35 Lempiras a month for receiving water every 8 days. There is also a preferential rate of 25 Lempiras for households that cannot afford the water fee. A 35 Lempira water fee is not sufficient to cover electricity costs and the system currently operates a loss. *A majority of the households are late on payments, and many of them refuse to pay the water fees; at the moment, stakeholders do not take any responsibility for the distribution system.* Better water service and reliability depends on increasing revenues to the system, which would require a higher water fee and a lower default rate.

Although the system seems to work for the communities of Calona and Maraquito there are five main problems: 1) households only receive water every 8 days, 2) there is no system reliability in case the pump brakes (this has happened at least three times in the past), 3) the system works at a loss (no revenue to maintain the system), 4) households take no responsibility or ownership over the system, and 5) Aguacatillo is permanently out of the system.

3.2 Future System

The system proposed by EWB-Boston, in agreement with the water boards of Aguacatillo, Calona, and Maraquito, outlines a dual distribution system with increased reliability. Calona will be serviced by the existing distribution system, and Maraquito and Aguacatillo will be serviced by a new distribution system. This decision was reached by a consensus on all water boards and EWB-Boston in January 2011. The decision was also made after considering the results of a Willingness to Pay study conducted by EWB-Boston, which is discussed below in Section 5. Figure 5 outlines the future distribution system.

In January 2011 EWB-Boston installed a 76 meter well (250 feet) that can produce 20 gallons per minute (76 liters per minute). Because the hydrogeology of the area is not well known, we chose the location based on the following factors:

- The anticipated subsurface geology based on a geologic map
- A centralized location with respect to the three villages
- Drilling contractor's preference (likely due to proximity to the river and site accessibility)
- Where donated land was available for the well (the land where the well is located is now owned, by the communities' water boards)
- Where donated land was available for the tank (the land where the tank will be located is now owned by the communities' water boards)⁴

In this dual system Calona will only receive water from the existing system and will only pump for 36 hours. Although they will only be using water from the existing system, the dual system is connected by a valve that can be opened, and water shared by all three communities in case one of the two systems breaks down. Currently, EWB-Boston does not know where the system will be split as we need more knowledge regarding pressure differences and losses along the pipeline. Calona will be in charge of operating and administering their own distribution system. The following are water demand assumptions based on a hydraulic model simulation, surveys, and anecdotal evidence from EWB-Boston's trip to Honduras (for Maraquito and Aguacatillo):

- Conservatively provide 25 gpcd (gallons per capita per day). About 95 lpcd (liters per capita per day)
- System will be able to provide 95 lpcd to 301 residents, based on a population growth factor of 2% and 20- year design life
- Store over 10,000 gallons (37,800 liters) in a circular ferro-concrete tank
- EWB-Boston has paid for installing the well and will continue to fundraise for construction materials for the distribution system.
- EWB-Boston will work as a contractor and engineering firm in this project. The communities will provide all the labor (unskilled and skilled when available and EWB-Boston will supervise the project. Guaimaca's municipality will provide construction materials when available. All stakeholders will be required to invest in the project either with labor, materials or money and will sign a contract before construction resumes.

Under the new system water will be provided daily, on demand, to Maraquito and Aguacatillo. The storage tank will have low and high level floats to ensure that it will not overflow or run dry. Connections in Maraquito will be at the household level, as they are under the existing system.

⁴ Engineers Without Borders - Boston Professional Chapter Document 522 Post Assessment Report Trip 3

Aguacatillo will be connected to the system via “house clusters” where there will be one tap stand per 3 or 4 households. However, the system will be designed in a way that Aguacatillo’s households can connect to the distribution system in the future.

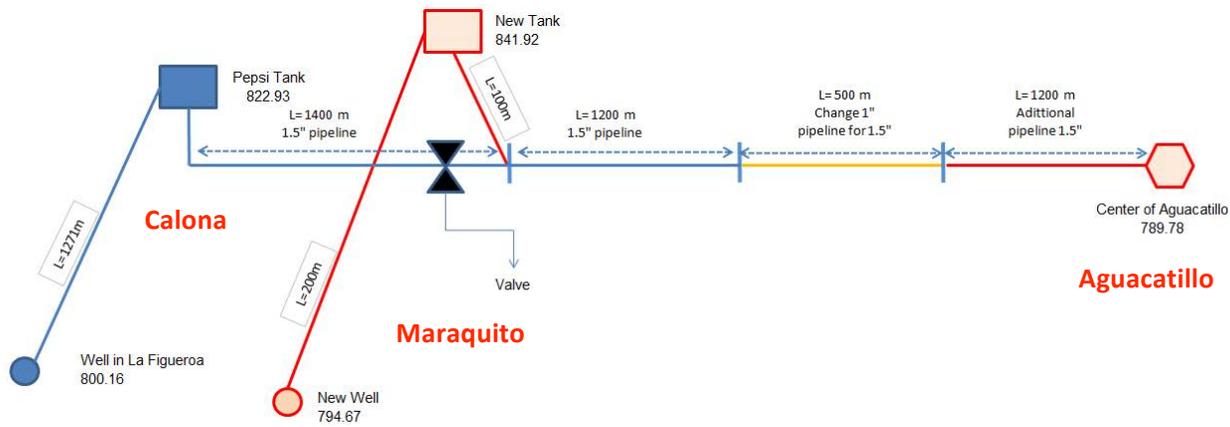


Figure 5. Future Distribution System. Calona will be split from the system by a valve and Maraquito and Aguacatillo will be serviced by the new system.⁵

Meters will be installed at the community level to measure and control water demand. In the future, EWB-Boston hopes to introduce house meters and charge using a volumetric rate. Because water-fees have never been collected this way, we are hoping to introduce this idea progressively.

Although the rate structure is yet to be determined, EWB-Boston will suggest a rate structure that incorporates:

- operations and maintenance, administrative, and watershed protection costs (5% of subtotal),
- a revolving fund to help families that cannot afford the water tariff,
- the idea that our population accumulates most of its income during the coffee harvesting season; EWB-Boston will suggest and discuss a rate structure that:
 - charges a one-time fixed payment to cover staff salary, tools, small and large replacements, water shed protection and revolving fund costs at the end of the harvesting season, and
 - a variable rate (paid throughout the year) that takes into account water treatment (chlorine), and electricity costs (variable costs).

EWB-Boston hopes to increase service reliability by allowing the existing and future system to be shared if one of the system brakes. In addition, water will be provided on demand, every day. Increased ownership and responsibility towards the system is expected to increase by using community-level water meters and financing the system using a fixed and variable- rate structure.

⁵ Engineers Without Borders - Boston Professional Chapter Document 522 Post Assessment Report Trip 3

4. Governance in Honduras: Colona, Maraquito and Aguacatillo

There are 4 main governmental agencies that should be providing services to our communities: 1) CONASA (national council of clean water and sanitation), the 2) Ministry of Health, 3) ERSAPS (regulatory agency of water distribution and sanitation services), and 4) SAANA (national agency for the development of water distribution and sewers). In Honduras, ERSAPS has developed a detailed guideline of good practices to be closely followed by the key players in rural and peri-urban water distribution: ERSAPS, municipalities, and local water boards.

ERSAPS (Ente Regulador de los Servicios Agua Potable y Saneamiento) is a governmental agency in charge of outlining good practices and guidelines to be followed by rural and peri-urban community water boards. It outlines infrastructure requirements, tariff requirements, and many other obligations and responsibilities that water boards and municipalities have in providing clean water and sanitation to their population. It is the main regulatory agency that handles disputes between municipalities and their community water boards.

Municipalities are in charge of providing material and financial resources for their immediate and surrounding communities. They work together with ERSAPS in the development of a sustainable relationship between local water boards. Finally, water boards (elected by the communities) are in charge of the administration, and operations and management of their water distribution systems.

Until EWB-Boston arrived in the Guaimaca area, Aguacatillo had been neglected by the state agencies. Calona and Maraquito have had a government sponsored distribution system since 1994, and more recently an electricity project is under way in both communities. Aguacatillo has been left out of both projects. However, Guaimaca's municipality has recently shown strong interest in the success of the project and has vowed to contribute to the project with construction materials and possibly, funding for the project.

All of our communities have a water board except for Aguacatillo. But, despite the fact that these communities have elected officials to their water boards, there is only one man who manages the entire system. This issue stems from the fact there is no community ownership or responsibility over the project, and the fact that water boards lack training in terms of engineering and financial management as the system currently operates only once a week, and at a loss.

The presence of both the municipality and ERSAPS in ensuring clean water and sanitation for these three communities is lacking due to scarce resources. A strong partnership between the three local water boards, the municipality and ERSAPS are key to ensuring the long-term sustainability of the project. A good relationship between EWB-Boston and the municipality (including the mayor and vice mayor) is a promising and essential factor in ensuring this projects sustainability. Before the project implementation, all stakeholders will sign a contract in which responsibilities and expectations will be agreed on by everyone. Failure to reach an agreement on a contract could lead to project termination.

5. Willingness to Pay and Perceptions of Water: Calona, Maraquito and Aguacatillo

During a site visit to Honduras in January 2011 EWB-Boston performed a contingent valuation willingness to pay (WTP) survey on the value of water across *all* households in Calona, Maraquito, and Aguacatillo. Two EWB-Boston team members conducted the surveys at the household levels throughout 10 days, conversing and discussing the questions and surveys with every household.

Preliminary results of the WTP survey suggest that Calona and Maraquito are content with their current water situation despite living below the international poverty line and receiving less than 20 liters of water a day, the minimum amount determined by the UN for an individual to meet basic necessities. Aguacatillo on the other hand is completely dissatisfied with their current situation.

These preliminary results make us question the approach towards small-scale development type projects. Do Maraquito and Calona need to be helped? Do they want to be helped? Do they think their water is clean? Are they happy and satisfied with their current distribution system? Do available water sources satisfy people's daily needs? Where should our engineering and financial resources be focused? Are our engineering and financial resources being optimally used?

Table 2. Perceptions on Water

	Calona avg (sd)	Maraquito avg (sd)	Aguacatillo avg (sd)
Perception on the Quality of Water Source ¹	5 (0.59)	5 (1.49)	3 (1.75)
Satisfaction with current Water Situation ¹	4 (1.66)	3 (1.72)	2 (1.16)
Perception Regarding the Quality of Water and Disease ²	4 (0.67)	4 (0.73)	3 (0.93)
<i>Individuals Connected to the Distribution System</i>			
Does the system help you meet your families daily needs? (Yes/No)- N, (%)	15 (71%)	14 (56%)	-
Quality of the Distribution System ³	5 (1.17)	4 (1.07)	-

[1] Perception and satisfaction were rated on a 1-7 scale where 7 is "Perfect Quality" or "Perfectly Satisfied". A score of 0 means the quality of water is regarded as "Deplorable" or "Complete Dissatisfaction" with the current water situation.

[2] On a grade from 1-5, this question measured a household's perception regarding the relationship between the quality of water and disease. 5 was a perfect relationship or "Dirty Water is the direct cause of stomach related disease". A score of 0 would mean that the individual thinks that there is no relationship between the two.

[3] Quality is a score given by every individual depending on their perception regarding the pressure, structural design, cost, color, smell and taste of water from the existing distribution system. 6 is the highest possible score.

Table 2 results suggests that Calona and Maraquito have a good perception of the quality of their water for drinking and cooking, and are more or less satisfied with their distribution system. Both of these communities understand that the quality of water can have a direct impact on their health. This is likely due to health campaigns organized by the municipality, and the *Dominican Sisters* to educate households on boiling water for consumption. Aguacatillo on the other hand has a poor perception of water quality and residents are more dissatisfied with their current water situation.

Furthermore, 71% and 56% of Calona's and Maraquito's residents respectively feel that the current distribution system fulfills their basic necessities. Both communities also think the quality of the distribution system is very good.

What do these results suggest? Calona and Maraquito are generally happy with their current situation (despite the fact they receive less than 20 liters a day) but Aguacatillo is very dissatisfied with their situation and water supply. Should Calona's and Maraquito's water distribution issues be addressed despite of their positive perceptions on water? Should resources and investment be more focused on Aguacatillo than on the other two communities? How should the investments be made and at what level? Should our approach to the communities have been different?

5.1 Willingness to Pay

One of the most challenging aspects of a water distribution system is the sustainable financing of the system. Currently, households pay 35 lempiras a month to receive water once a day every 8 days. There is also a preferential rate of 25 lempiras for families who cannot afford the service. However, these two – low priced- water rates, and the fact that they are infrequently paid, have the existing system working at a loss.

In the past, the tariff was chosen by a vote amongst the individuals connected to the system. Although a vote has the potential to elucidate willingness to pay, individuals can be easily skewed into a value by the more dominant and outspoken individuals in a community.

A dichotomous contingent valuation survey allows development workers to estimate the WTP for water, *contingent* on a specific scenario being described and presented to them during an interview. EWB-Boston performed such a survey in January 2011. Calona and Maraquito were presented with an improved distribution system that would provide clean water, 7 days a week, every month, at a reasonable and fair price. Aguacatillo's scenario depicted access to clean water 7 days a week, every month, at a reasonable and fair price.

WTP is then determined by presenting each interviewee with a *randomly selected* water tariff from a previously calculated array of water tariffs. The interviewee is asked whether or not he/she is willing to pay for water – at a randomly selected value - and WTP is determined after a bidding game where the tariff may go up or down depending on an interviewee's response. For example, if the interviewee is asked whether she would be willing to pay 35 L for a monthly water fee (contingent on the scenario presented to her) and answers yes, we would ask her if she'd be willing to pay 45 L (a higher price, depending on the starting bid). If yes, we would ask her for the max WTP above 45, if no we would also ask her what the max WTP would be above 35 L. There were 7 initial values ranging from 34 lempiras to 100 lempiras.

In addition, because it is difficult for these communities to estimate savings we asked them questions regarding their Coca-Cola consumption. We chose Coca-Cola because it is drink that is generally regarded as a substitute for water in the region because of the scarcity of clean, cheap and reliable sources of water.

The analysis can then be controlled for confounding factors, and through the use of regression analysis one can estimate the true WTP for water in a community. Table 3 presents a summary of our findings (results have yet to be adjusted for confounding factors).

Table 3. Willingness to Pay for Water Distribution

	Calona avg (sd)	Maraquito avg (sd)	Aguacatillo avg (sd)
WTP1 (Lempiras/month) ¹	41 (15)	49 (13)	40 (12)
WTP2 (Lempiras/month) ²	35 (12)	34 (11)	36 (9)
MAX WTP (Lempiras/month)³	61 (22)	59 (19)	58 (17)
Monthly Coca-Cola Consumption (Lempiras/Month)⁴	228 (198)	148 (126)	177 (161)

[1] Average response of all yes and no random values presented to interviewees.

[2] Average response of all yes and no random values presented to interviewees. The WTP is lower because many interviewees responded no (a value of 0) to the second question.

[3] The Maximum WTP at the end of the bidding game.

[4] Number of days of Coca Cola Consumption * 19 Lempiras (cost of a 2 liter bottle of coke)

The max WTP for all three communities is strikingly similar. Although this value could be the result of meetings and discussions that the communities have had in the past, a random array of prices and a bidding game are a reliable way to elucidate an individual's true willingness to pay.

As we can see from figure 6, an equation used by ERSAPS (Honduras's government agency in charge of regulating small water boards) suggests that by taking into account our communities characteristics and water demand, the cost of a distribution system for 60 and 40 families should be 54 and 81 lempiras respectively. The costs of the actual system, together with a revolving fund and a watershed initiative will likely be higher than that. However, we can see that the current tariff and the average WTP of our population is much less than that. Our monthly savings and coke-consumption values also suggest that our population can afford a higher monthly tariff.

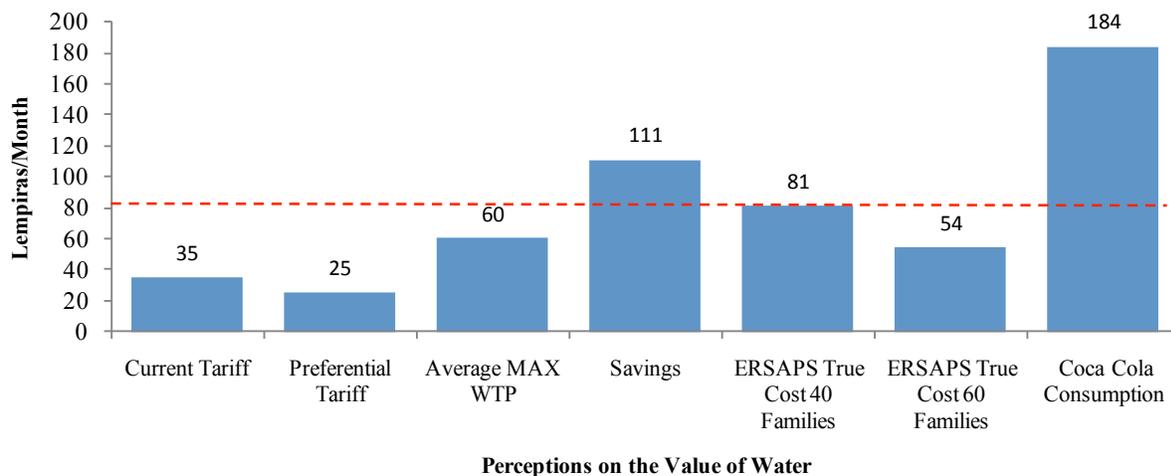


Figure 6. Perceptions on the value of Water. The system's finances will be limited by the O&M costs of the system represented by the red dotted line.

If these are our communities true savings and true coca-cola consumption values, why is that families are constantly defaulting on monthly payments? What could be a good strategy in ensuring the system's financial viability and sustainability? What factors would convince families to prioritize paying their water tariff? Is there a relationship between a consumer's satisfaction with the current services and their willingness to pay for water?

6. Conclusions

In the summer of 2011 EWB-Boston will work with Guaimaca's municipality, and the water boards and members of the communities of Aguacatillo, Calona and Maraquito in the implementation of a more reliable water distribution system. All the information in this document will be taken into account to make this system a success many years after EWB-Boston has left the region of Guaimaca.