Community Perspectives on Drought and Water Management in Madre de Dios, Peru

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Introduction

Across the tropics, the effects of climate change have increased temperature and precipitation anomalies, which lead to drought and potentially irreversible ecological damage (Esquivel-Muelbert et al., 2017; Chavez Michaelsen et al., 2020). Drought frequency and intensity threaten biodiversity, especially in the tropics where an impressive range of species are dependent and evolve based on precipitation patterns (Esquivel-Muelbert et al., 2017; Staal et al., 2020). Unusual seasonal patterns also degrade natural resources which humans and wildlife depend on (Torres-Slimming et al., 2020). Human activity, such as deforestation, contributes to drought, unintentional fire spread, and flooding (Staal et al., 2020; Brown et al., 2006; Torres-Slimming et al., 2020), all of which have been observed in the Peruvian Amazon (Chavez Michaelsen et al., 2020).

In Madre de Dios, Peru, rural communities have reported that extreme climate and high temperatures have impacted their livelihoods on multiple levels (Chavez Michaelsen et al., 2020), including diminished access to water and food, and loss of crops and livestock. In extreme climate events, rural communities believe the Peruvian government is incapable of supporting vulnerable populations (Chavez Michaelsen et al., 2020). Although the Peruvian Ministry of Environment was formed in 2008, the consequences of climate change and unregulated human activity in the Amazon are still a challenge to address and allocate mitigation and adaption budgeting for (Chavez Michaelsen et al., 2020; Gallice et al., 2017).

Lack of clean, potable water has been reported in communities along the Interoceanic Highway that passes through Madre de Dios (Jensen et al., 2018). Of the migrant and non-migrant community respondents surveyed on greatest risks to their well-being, the majority reported that illness was their primary concern (Jensen et al., 2018). Safe water treatment and storage improves water quality, sanitation, and hygiene, which decreases risk of illness (Jensen et al., 2018).

Of 87 survey participants living along the Interoceanic Highway that passes through Madre de Dios in 2014-2015, 84.1% reported that they directly piped water into their homes for general and drinking use (Jensen et al., 2018). Most respondents (69.0%) also reported that they treated their water, with the majority treating by boiling their water and a minority using chlorine or bleach (Jensen et al., 2018). The interviews in this project compile further data on water

usage and governance structures among households along the Interoceanic Highway, with the intention of documenting participant perspectives on drought and sustainable solutions for potential barriers to water security.

There is widespread demand for education and involvement in the governance of health and safety, spanning climate disaster mitigation plans to resource management on a local level (Brown et al., 2006; Jensen et al., 2018). In Madre de Dios, this includes farmers who have expressed a desire to have access to more formal knowledge on climate change policies (Chavez Michaelsen et al., 2020). However, there is a general perception of insufficient communication, technical preparedness, and commitment from the Madre de Dios regional government (Chavez Michaelsen et al., 2020).

Qualitative data on environmental awareness, water quality, and access to informational resources show that increased engagement among local governments and nonprofit organizations may be more effective in developing strong relationships and solutions to community needs (Yard et al., 2012; Chavez Michaelsen et al., 2020; Jensen et al., 2018).

Methodology

To gain an understanding of the quality and level of access to drinking water around a variety of communities and single-family house structures in rural Madre de Dios in 2023, a set of questions was composed for verbal in-person interviewing. These questions focused on basic information about the interviewee and their livelihood, logistics for water usage, perspective on drought, and perspective on water scarcity and governance.

The interview questions were printed on paper and brought to three municipalities established along the Interoceanic Highway outside of Puerto Maldonado. Concessions and farmland were also visited to include more isolated citizens in the population sample. While participants verbally responded, their responses were recorded by hand. See appendix for the complete set of interview questions in Spanish and English.

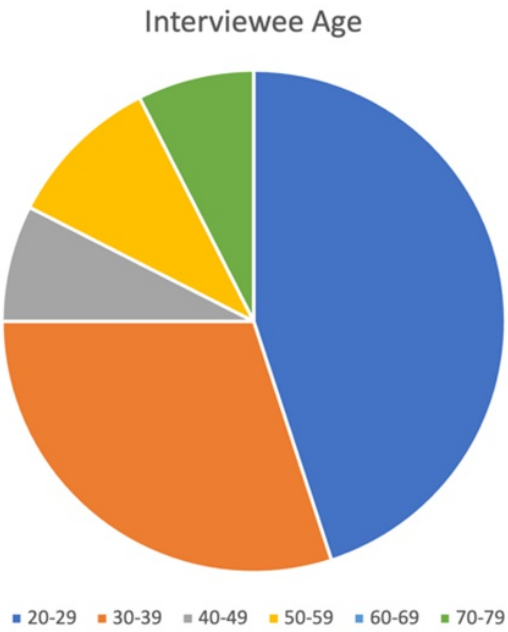
In total, 35 people of varied ages and household sizes were interviewed. Water samples were collected from 9 interviewees across every area visited as well as one sample from the forest around the Alliance for a Sustainable Amazon site to test for dissolved oxygen, nitrate, pH, and phosphate. These tests were donated by a local water treatment facility whose focus is on monitoring environmental hazards. See appendix for water testing procedures.

Results and Discussion

Over a 1-week period, 35 people were interviewed. 65% of interviewees had lived in the area for the duration of their lives. All interviewees from elsewhere had moved from within Peru, with a range of habitation length in their current home from 1 year to 45 years. Across every community, concession, and farm, people were very willing to communicate and share personal thoughts.

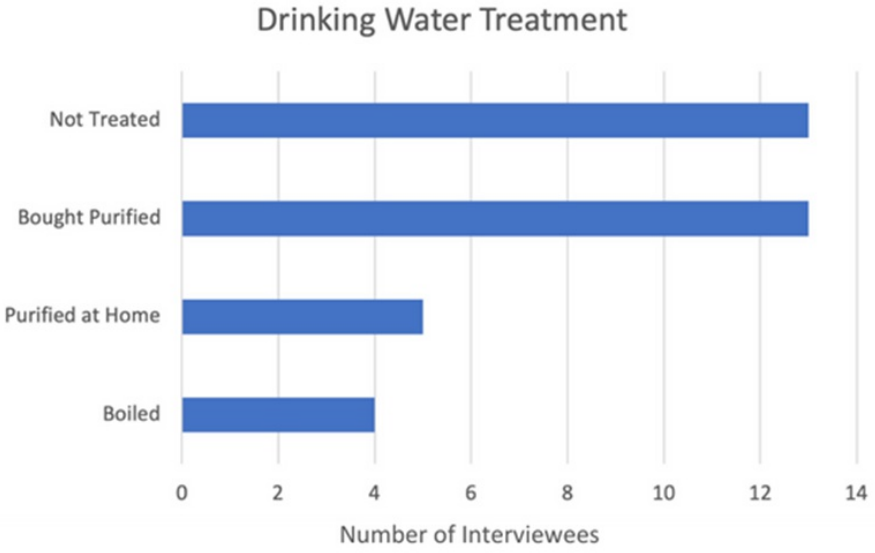
Logistics

In total, 74% of interviewees expressed concern for their access to water. 29% of people carried water home from a nearby stream or had installed their own wells. Every person who had installed their own well shared that this was a result of consistent and prolonged water shortages and poor water quality. One respondent

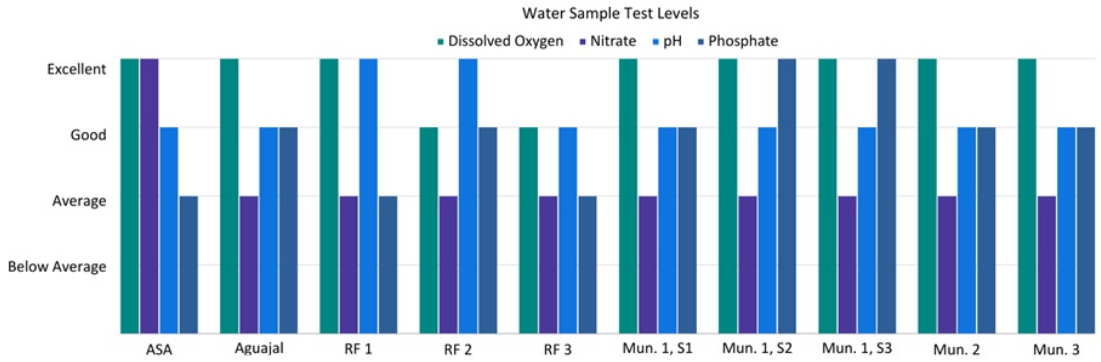


shared that when they had previously depended on water from the community water tank, they always stored water in buckets because there were frequent and unexpected pipe bursts or other issues and energy blackouts, which also cut off the water pumps. They explained that consistent water shortages became very expensive for families who had to resort to buying all of their water in plastic bottles or 10-gallon tanks for unforeseeable lengths of time. Many interviewees shared that the water shortages often lasted for multiple days.

Many interviewees who were buying purified water in bottles or tanks also shared that this was a last resort for them or their neighbors as water shortages increased over the most recent drought. While the data show an equal frequency in buying purified water and drinking untreated water, it is likely that there is a greater majority of people living in rural Madre de Dios who do not treat their water. This may also explain the shift between the most common methods of water treatment in this survey and Jensen et al.'s 2018 survey in a similar



Graph 1 (above): Water "Bought Purified" refers to bottled water or water delivered in the regionally common 10-gallon tank which is purchased and refilled by private water companies such as Rijka and Coca-Cola.



Graph 2 (above): Levels of dissolved oxygen, nitrate, pH, and phosphate. The bottom row abbreviates sample names as: ASA; Alliance for a Sustainable Amazon tap water, Aguajal: trail name near ASA with a stream, RF; Rural of Farm, Mun.; Municipality. See appendix for full results.

region of Madre de Dios along the Interoceanic Highway. In 2018, 56.5% of survey respondents who treated their water reported use of the boiling method (Jensen et al., 2018). In 2023, of the interviewees for this study who reported to treat their water, only 18% used the boiling method while 59% bought their water already purified.

A local who had worked across larger rural areas in Madre de Dios and with more individuals than the sample population size shared that drinking water is typically untreated, including on gold mining sites. According to this interviewee who had worked and lived around mining sites around Tambopata National Reserve, water for drinking and cooking is often stored in buckets that were previously used or used in tandem with mercury and other elements for gold filtration. They also shared that these used barrels are often transported to markets in neighboring communities and sold as storage containers for much cheaper than new plastic buckets which have not contained mercury or other elements hazardous to human health.

Peru is the world's 6th largest gold producer globally (Martinez et al., 2018). In Madre de Dios, artisanal and small-scale gold mining has led to high levels of mercury, turbidity, and environmental degradation in the waters and river sediment around site (Martinez et al., 2018). Studies show that even if nearby communities avoid utilizing contaminated river water and its food sources, they are still at risk of mercury exposure by physical proximity (Yard et al., 2012). If illegal gold mining is not quickly regulated, the environmental and health hazards of mercury exposure are likely to expand far beyond mining sites and the communities which come in contact with used equipment. 42% of interviewees shared that they currently store water in bins or buckets. With the knowledge that used buckets from goldmining sites are a fraction of the price of new plastic buckets, there is room for clarification on what kinds of buckets were being utilized for storage among the interviewees.

All water sample tests were measured on a scale of below average to excellent levels of each element. In this case, the elements measured were dissolved oxygen, nitrate, pH, and phosphate. While the samples didn't contain any alarming or extremely varied levels among the elements tested, Alliance for a Sustainable Amazon's tap water had a uniquely low level of nitrate. Nitrate levels in water have increased in

many areas of the world largely due to an increase of inorganic fertilizer and animal manure in agricultural areas (Ward et al., 2018). The particularly low level of nitrate in the forest on Alliance for a Sustainable Amazon's property may be an effect of lack of drastic exposure to the impact of agricultural practices until 2023.

The summer drought of 2023 carried consequences of agricultural land clearing closer to the Alliance for a Sustainable Amazon's forest than it had ever seen. In July 2023, forest slashing and burning for agricultural land clearing on the neighboring property destroyed about 12 hectares (30 acres) of forest located on Alliance for a Sustainable Amazon's northern property border. In rural Madre de Dios, intentional slash-and-burn activities are an established cultural practice used for land management and soil productivity (Chavez Michaelsen et al., 2020). Locals during the interview period for this project shared that burning is typically planned for the peak of dry season to maximize the potential spread of fire, unhindered by damp soil or rain. This illustrates cultural and historical consistency with the annual slash-and-burn activities which took place during the droughts, fires, and high-speed wind events in Chavez Michaelsen et al.'s survey in 2020.

The neighbor's uncontrolled fire spread to the very edge of Alliance for a Sustainable Amazon's forested property line, where the flames were met by staff to diminish for the protection of the forest. If the property line had been unprotected at the time, the dwindling Amazonian forest in this area may have been entirely wiped out. As deforestation reduces forest area, less water can be recycled and dry seasons intensify regionally (Staal et al., 2020). Studies show that the more intense dry seasons become, the more deforestation tends to occur, creating a feedback loop between drought and deforestation (Staal et al., 2020). It is crucial to consider the impact of accidental fire spread for land clearing which is in close proximity to forests in times of extreme drought and water scarcity. Although deforestation for agriculture, goldmining, and highway construction may seem economically beneficial for those who work in these sectors, active preservation of Amazonian forests may be a key component in obtaining sustainable water security in this region.

Drought

62% of interviewees reported that they had experienced drought over the past year. These individuals shared that their access to water, water quality, and water usage had been impacted greatly. Many respondents reported that the streams which they depend on for water had dried out or were extremely low. This decreased access to water for those who routinely carry it home from nearby streams in buckets, as well as for those who rely on community-installed tanks, which also pump and pipe water from nearby streams. Adjectives used to describe tap and stream water included: "much dirtier", "green and ugly", "very turbid", and "like chocolate". Interviewees shared that the water at home and in schools were making their children sick. In addition to being worried about the status of access to water, interviewees were concerned for their future generations of family.

Interviewees also shared that the nearby streams used to maintain cool temperatures and were utilized by many community members for bathing. However, the streams had become too low, stagnant, and hot to bathe in. Interviewees who relied on tap water from community water tanks, which also sourced water from the rivers, shared that this water had poured out at a temperature too hot to bathe in as well.

Interviewees reported that the stream water turbidity had increased and that the riverbanks were dirtier. One interviewee reported that when the water pump is broken or there is a shortage over multiple days, most of the community resorts to bringing their all of their clothes, pans, and plants to the river for washing and watering. Another respondent said that since the Interoceanic Highway had been built and the population increased around the rivers, the water had become more contaminated. In total, 37% of interviewees shared that drought had impacted their water quality.

The World Health Organization (2023) defines drought as a prolonged dry period in the natural climate cycle, characterized by lack of precipitation, resulting in a water shortage. 46% of the people who reported that they had not experienced drought described experiencing symptoms of drought, including a combination of record-breaking absence of precipitation, excessive heat, and dried up, unusually hot, or low rivers. One community member who lived in the area for 5 years and led community education programs for reforestation advocacy suggested that the concept of drought may be evaluated locally as an issue for only forested or farmed areas, where lack of precipitation impacts biodiversity, rather than in a town where some individuals are not seeing changes in the diminishing steams from where their water tanks are pumping water through tubes and into their homes.

Governance

80% of interviewees stated that they were unfamiliar with any local or regional government plans to address their water needs during drought or water scarcity. However, 94% of respondents expressed a desire to participate in local planning in times of water scarcity. In each community visited, there was some mention about a community member-elected water and sanitation management board. Knowledge on where to find contact information or any kind of documentation on water regulation was scarce. One of interviewee was a close family member of the president of the water and sanitation management board for the community and they were still unaware of the board's official entity name. They confirmed that the organization did not have a website and did not share any alternative forms of contact.

There is an online PDF from 2016 that describes the processes for creating and maintaining these administrative water and sanitation administration boards, elected and run entirely by volunteers. The online document includes the specific roles and responsibilities of the board of directors, general assembly, treasurer, and associates. Evaluation forms for board members, guidelines for meeting itineraries, and annual timelines for maintenance and community engagement are also provided. The associates, defined as representatives of the families in the register for water sanitation and hygiene services have the right to elect and be elected as a member of the Board of Directors, receive timely notice of service interruptions, and be informed about the status from service. Although there was an inventory page and receipt book template provided, there were no guidelines for creating sustained communications systems.

Many interviewees shared that there was no regular communication with their water management board. A few shared that they were unsatisfied with their board because projects for wells or other water sources had not been implemented despite payment. One interviewee shared that they believed this was a national government issue and

named a national water authorization which they felt was poorly managing the region's finances and natural resources.

There was also a lack of agreement on the ideal next steps for water treatment. Some interviewees didn't want any chlorine in the water tanks because they believed it wasn't safe for drinking or watering plants. Other interviewees wanted more chlorine in the water tanks because they believed an increase in chlorine would improve the quality of the water.

Although there were some interviewees who reported satisfaction with their municipality's water management, this does not detract from the fact that 80% of the total sample population were unaware of any kind of plan to address their water needs and that an even larger majority expressed interest in participating in local planning during times of drought or water scarcity. When information was shared for further contact via email and WhatsApp, a free and globally popular application for texting, many of the interviewees were familiar with or already had the application. A few interviewees reached out within a week of the interview.

Recommendations

Throughout off-site travels across Peru in 2023, TikTok was ubiquitous among most generations who operated a phone. Streaming videos via TikTok requires much more data than simple text-based chat messages. Therefore, if it has not already been implemented, a WhatsApp group chat is recommended for each municipality that has a water management board. In this WhatsApp group chat, the times for meetings, water quality updates, and service requests can be shared among the community. To meet the needs of those who have a handicap or a financial limitation that restricts technological use and WhatsApp enablement, in-person meetings with every registered participant in the water management registry are recommended to gain an understanding and agreement of the most accessible form of communication.

Interviewees also shared that there are no official websites for connecting to these community water management boards. The development of a basic website on a free website building platform, such as Google, that serves as a resource for information about water management as well as active lines of communication for all community members is recommended. A contact page or online forum for associates and community members to share their requests and recommendations may enable stronger connection between the management board and its community. Some of the requests from interviewees included: cleaning and sanitary management of the river banks, creeks, lakes; increased reach of water piping from the pueblo or community water tanks; wells provided by the state government; larger water tanks; plans specific to various climate emergencies; established lines of communications for sharing plans and updates on water emergencies, as well as routine updates on water quality; more structured support from the state; more advanced equipment for water treatment and other services; improved water quality in schools.

As a long-term solution to restoring natural resources which have been impacted by drought, multiple interviewees recommended reforestation. One interviewee specified that reforestation around the water belt would be an ideal place to start for improving water quality. This has also been recommended for areas of drought in the Amazonian Loreto region

by the Shawi community (Torres-Slimming et al., 2020). A solution the Shawi suggested was the use of aguaje palm trees for reforestation. The aguajes would strengthen riverbank sediment, lower rising water temperatures with the return of shade, decrease turbidity, and provide fruit for increased livelihood (Torres-Slimming et al., 2020). During surveys around the Alliance for a Sustainable Amazon site, aguajes were also observed to be thriving and supporting a wide range of biodiversity in very clear and cool temperature waters.

This wasn't the only parallel between these two communities. Many Shawi interviewees desired community training from the government for managing river contamination and reforestation along river. The Shawi spoke about road development as an introduction to new foods and sources of work, but also as a facilitation of deforestation and erosion of riverbanks due to ease of human contact with the forest's natural resources (Torres-Slimming et al., 2020). Similarly, interviewees for this project shared that they'd noticed environmental degradation in forms of deforestation and river contamination following the construction of the Interoceanic Highway in Madre de Dios.

To begin reforestation and environmental restoration efforts for improved and sustained water quality, grant applications under the responsibility of the municipal water managers may support the costs of labor. The funding of these grants can be allocated to local nonprofits who are working to increase reforestation areas and have expertise in these fields.

Conclusion

This study observed the logistics of water transportation and treatment, the experience and impact of drought on water consumption, and the governance of water management in times scarcity in rural Madre de Dios. There are challenges on multiple levels of water insecurity, from identifying the causes to finding and agreeing on sustainable paths forward. The interviews studied indicate that stronger communication across a diverse set of community roles is necessary for implementation of short and long-solutions across the region. The vital role that humans play in climate mitigation and adaption must not be underestimated as humans and all of Amazonia's biodiversity is impacted by drought.

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Interview Questions

Basic information

1) What is your name/ ¿**Cual es tu nombre?**

2) How old are you/ ¿**Cuántos años tienes?**

3) What is your occupation/ **¿A qué te dedica?**

4) Are you from Monterrey/ Madre de Dios (for households outside of Monterrey)? If not, how long have you lived here? Where did you move from?

¿Eres de Monterrey/ Madre de Dios (para hogares fuera de Monterrey)? Si no, ¿cuánto tiempo has vivido aquí? ¿Desde dónde te mudaste?

5) How many people do you live with?
¿Cuántas personas viven contigo?

Logistics

1) Do you use different water for drinking and for other general purposes, like cleaning, washing, or farming?
¿Utiliza agua diferente para beber y para otros fines generales, como limpiar, lavar o cultivar?

2) Where do you get your drinking water from? How do you get water from x (natural source) to your home?
¿De dónde sacas tu agua potable? ¿Cómo llevas agua de x (fuente natural) a tu hogar?

3) Do you store water for use at home? If so, how?
¿Almacena agua en casa, por ejemplo, en tachos o baldes? Si es así, ¿cómo?

4) Do you grow any of your own fruits/vegetables? If so, do you irrigate, do you use the same water source for farming and drinking?
¿Cultivas alguna de tus propias frutas/verduras? Si es así, riega, utiliza la misma fuente de agua para la agricultura y el consumo?]

5) **The water source that you retrieve water from – does anyone else also take water from that source?**
¿El agua que usa en su casa viene del mismo lugar de la que usan sus vecinos o viene su agua de una fuente sólo para Ud (como un pozo sólo para su casa)?

6) Do you feel your access to water is reliable, secure, and sanitary? If not, why?
¿Siente que el agua nunca va a faltar en tu casa y que el agua que usas es de buena calidad? Si o no, ¿por qué?

Drought

1) Have you ever experienced drought in this area? Have you noticed any other changes in weather patterns?
¿Alguna vez ha experimentado sequía en esta zona? ¿Ha notado algún otro cambio en el clima que ha afectado tu consumo de agua?

2) Would you say drought impacts or has impacted your water usage? How so?
¿Diría que la sequía impacta o ha impactado su uso de agua? ¿Si lo ha hecho, ¿puede explicar de qué forma lo ha hecho?

3) Would you say drought impacts or has impacted your water quality? How so?
Diría que la sequia impacta o ha impactado la calidad del agua? ¿Cómo es eso?

4) Do you have any household plans for adapting to strained water access during droughts or prolonged dry seasons?
¿Tiene algún plan familiar para adaptarse al difícil acceso al agua durante sequías o estaciones secas muy largas?

Water scarcity and governance

1) Is there anyone who is officially responsible for managing the water usage in Monterrey/around this land?
Hay alguien que sea oficialmente responsable de gestionar el uso del agua en Monterrey/ de este terreno?

2) Do the dry and wet seasons affect your water usage routine differently? For example, do you choose to use less water in the dry season?
Las estaciones seca y húmeda afectan su rutina de uso del agua de manera diferente? Por ejemplo, tu elegir que uso menos agua en las estaciones secas?

3) Do climate change and increased drought ever make you feel concerned for your access to water for the most basic needs, such as drinking, cooking, and cleaning?
Alguna vez ha sentido preocupación de que en algún momento se vaya a quedar sin agua en casa incluso para hacer cosas mínimas como beber, cocinar, y limpiar?

4) Are you familiar with any local or regional government plans to address your water needs during drought or water scarcity?
Está familiarizado con algún plan del gobierno local o regional para abordar sus necesidades de agua durante tiempos de sequía o de escasez de agua?

5) Would you like to be involved with local planning for water management during scarcity?
Si se lo ofrecieran, ¿le gustaría participar en el desarrollo de planes para asegurar una buena gestión del agua durante las temporadas de escacez?

6) Is there anything that you'd like changed or created to improve sustainability of water use in this area?
Hay algo que le gustaría cambiar para mejorar el acceso o calidad del agua en esta área?

Water Testing Methodology and Numerical Results

Dissolved Oxygen

1. Start by taking the temperature of sample water using a thermometer.
2. Submerge the tube in the sample water, then remove the sample tube while making sure it remains filled to the top.
3. Put 2 tablets of Oxígeno Disuelto 3976A in the test tube. The water should overflow when the test tablets are inserted.
4. Close the test tube. As the lid is tightened, the water should continue to overflow. Make sure there are no air bubbles.
5. Mix the test tube by turning it upside down over and over again, until the tablets have disintegrated. Don't stop turning the test tube for 4 minutes.
6. Wait 5 minutes more to let the color of the water develop.
7. Compare the color of the sample to the Dissolved Oxygen Chart and record in ppm.

Nitrate

1. Fill the tube with 5 ml of sample water
2. Add 1 Nitrate Wide range CTA tablet – 3703A. Immediately close the test tab and put it in the protective cover (for UV rays)
3. Shake to mix the test tub for 2 minutes to dissolve the tablet
4. Leave the test tube in the protector and wait 5 minutes for a red color to develop
   Note: The tablets are sensitive to UV rays. The protector keeps the tablets from reacting to UV light. If the test is done inside, it's not necessary to use the protector.
5. Compare the color of the sample water to the color graph and record in ppm

Phosphate

1. Fill the tube with 10 ml of sample water
2. Add 1 Phosphorus tablet 5422A
3. Close the tub and mix the contents, turning the tube upside down until the tablet is dissolved. It doesn't matter if some tablet particles are still suspended in the sample.
4. Wait 5 minutes for the color blue to appear in the sample
5. Compare the color of the sample to the Phosphate Color Table

pH

1. Fill the tube with 10 ml of sample water
2. Add 1 pH Wide Range tablet 6459A
3. Shake and mix the tube to dissolve the tablet. Some tablet particles may still be visible and dispersed in the tube
4. Compare the color of the sample to the pH color graph

	Finca las Piedras	Aguajal	Rural Farmland 1	Rural Farmland 2	Rural Farmland 3
Dissolved Oxygen	30C, 8ppm, 106: excellent (excellent, good, average)	26C, 8ppm, 99, excellent	30C, 8ppm, 106: excellent	30C, 8ppm, 106: excellent	30C, 6 ppm, 106: good
Nitrate	>5 (excellent, average, below average)	5ppm: average	5ppm: average	5ppm: average	5ppm: average
Ph	6, bueno (excellent, good, average)	6, good	7, excellent	7, excellent	6, good
Phosphate	2ppm, regular (excelente, bueno, regular)	2ppm, bueno	4 ppm, regular	2ppm, good	4 ppm, average
	Municipality 1, Sample 1	Municipality 1, Sample 2	Municipality 1, Sample 3	Municipality 2,	Municipality 3
Dissolved Oxygen	30C, 8ppm, 106: excellent	30C, 8ppm, 106: excellent	30C, 8ppm, 106: excellent	26C, 8ppm, 99, excellent	30C, 8ppm, 106: excellent
Nitrate	5ppm: average	5ppm: average	5ppm: average	5ppm: average	5ppm: average
Ph	6, good	6, good	6, good	6, good	6, good
Phosphate	2ppm, good	1 ppm, excellent	1 ppm, excellent	2ppm, good	2ppm, good