Sustainability Assessment of Community Water Supply: A Case Study of Asafa Community, Magalang, Pampanga

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Abstract- In the year 2021, former president Rodrigo "Roa" Duterte ordered the distribution of the idle or unused government lands to the poor. This act given by the former president helps a lot of people especially the indigenous peoples. The Department of Agrarian Reform (DAR) also planned to give lands for farmers to use it for agricultural purposes and it was eventually permitted by the former president. In this research, a quantitative method and a Descriptive-Investigative research design was used to collect the necessary data to present the current situation of ASAFA Community and also to guide the researchers to give recommendations and suggestions. And in the year 2023, ASAFA experiencing a serious lack of clean water access as well as a good management inside the community itself. Although this study is limited to just give the initial information about the unknown community of ASAFA, it still aims to give a warning for the residents about the danger of using the water from the solar-powered pump. It was found that both total coliform and E-Coli content exceeds the PNSDW limit. The distribution of water is also not enough though the observations and computations made by the researchers. Observations via testing of the water discharge, measuring the pipes, and determining the kind of pipes and connections used.

I. THE PROBLEM AND REVIEW OF RELATED LITERATURE AND STUDIES

1.1 Introduction

Next to air, water is the most valuable resource on the planet and is essential to the survival of all living organisms; without water, life cannot be sustained. According to the Water-Facts found in the website of Bureau of Reclamation in California, approximately 97% of the world's water is saline and unsuitable for drinking, for growing crops and most industrial uses except for cooling; the remaining 3% is fresh water with less dissolve salt, is palatable, and fit for consumption. The majority of freshwater is found in glaciers and ice caps at around 69%, while 30% belongs to groundwater, and only a small portion is present in bodies of water like rivers and lakes. If the world's water supply were only 100 liters (26 gallons), our usable water supply of fresh water would be only about 0.003 liter (one-half teaspoon). With this figure, we can only imagine how little the amount of water is for drinking.

The Philippines is richly blessed with natural resources. It is home to bodies of water like rivers and lakes, and with it having a tropical climate is abundant to precipitation and groundwater basins. Surface water is the primary water source of the country providing for agricultural, industrial and domestic usage. Groundwater is also an essential water source, particularly to rural areas where surface water is scarce. However, despite of the vastness of the country's water resources, it is still facing a lot of water-related challenges. These challenges include insufficient household access of water especially to rural areas and water pollution/contamination.

Water for domesticate use ranks after agricultural and industrial sector according to Asian Development Bank in 2013. Domestic water use is defined as the water use for personal needs and for household and/or sanitary purposes including but not limited to gardening and washing clothes and dishes. Universal access to safe water is a fundamental need and human right (UNICEF, 2021). An extensively reduce of household access to a safe water will negatively impacts the population, ranging from inconvenience to serious health risk that may lead to mortality.

There is a great disparity that persists between rural and urban areas in terms of the provision of water for domestic use and access to sanitation facilities. According to a World Bank report launched at World Water Week in Stockholm, Sweden, in August 2017, seventy-five (75 %) of people who lack improved sanitation live in rural areas, and only twenty (20%) of rural inhabitants have access to improved water. Rural communities usually do not have the financial resources, operational support, and technical expertise necessary for the development and maintenance of a reliable water supply. Although different government and non-government organizations are extending their helping hands to help communities improve urban and rural water supply service delivery and improve sector performance through policies, institutions, and incentives this is not enough to address all the underlying problems facing the world's smallest communities especially those residing in remote areas.

1.2 Review of Related Literature

This part reviews and evaluates some of the basic concepts of sustainability, water governance and community participation. The search for literature review for this study is initiated using Google Scholar and Science Direct search engine using keywords: sustainability, rural water access, and water governance. Search results of the aforementioned keywords showed great abundance of the study. The objective is to develop a definition of overall sustainability of a rural community water supply.

1.2.1 Sustainability

Based on the dictionary definition of “sustainability” it can be considered as an ability of something to continue to exist, maintain, and remain operational for an extended period of time (equal to or more than the design life) into the future without any significant interruptions, breakage or failure, resulting in improvement of the quality of life by providing strength, energy, and hope.

It is challenging for engineering purposes to work on the abstract concept of sustainability due to its ambiguous definition and reliance on unquantifiable criteria (Aslam, 2013). Sustainable development and sustainability are frequently used interchangeably. Both emphasize the peril of using up resources more quickly than they can be replaced. However, the concept of sustainability in the context of development, gained wider acceptance after the Brundtland Report titled "Our Common Future" of the World Commission on Environment and Development (WCED, 1987). The Brundtland Report defined sustainable development as “development that meets the needs of current generations without compromising the ability of future generations to meet their own needs”. Since then, this concept has been adopted as a key element for sustainability or sustainable development.

According to this definition, evaluating sustainability entails figuring out how well a project will be able to achieve its goals in the medium or even longer term after it has been handed over to the beneficiaries (Macharia, Mbassana, & Oduor, 2015). Social, environmental, and economic responsibilities in the community are described as three pillars of sustainability in the context of water governance (Berkes & Folke, 1994). These three pillars also represent people, planet and profit respectively. The three pillars are often visualized as a Venn diagram, with the area of sustainability at the center where the three pillars (represented as circle) intersect. Because the term "sustainability" carries significant everyday implications that give its various perceptions to various people, each organization may choose to view sustainability from a different perspective and give importance to different aspects (Hodgkin, 1994). When placed within its particular context, sustainability is more fully comprehended and understood. There are several contexts for sustainability, according to recent literature, and each one has the potential to have an impact on sustainability (Macharia, Mbassana, & Oduor, 2015). Table 1 summarizes five contexts by which sustainability in water resources is used.

Table 1. Sustainability Contexts

Context	Description
Technical sustainability	This refers to the reliability and proper functioning of the technology and the delivery of water within acceptable quality.

	Equity relates to the technology to meet the demands of all water users. Technical sustainability entails a good technical design that is adhered to during construction and operation, and executed professionally with first-rate materials.
Financial sustainability	Financial resources should meet at least the costs of operation, maintenance, and common repairs. Equity elements relate to willingness to pay for water services and how fair these payments are shared between and within households.
Institutional sustainability	Communities need institutions to operate well. These Institutions have cultural characteristics with agreed and valued procedures and operating rules. Equity considerations entail looking at the extent of participation of all the user groups.
Social sustainability	Users tend to sustain services that satisfy their needs and expectations. This means services they can easily access, and are in accordance with the socio-cultural preferences and practices of the locality with services worthy of the cost incurred to obtain them. Also considers how fairly the burdens and benefits from the services are shared across different socio- economic, gender, and ethnic groups.
Environmental sustainability	Water resources face multiple threats. Over-extraction and pollution of water sources threaten drinking water supplies. Water supplies and sanitation facilities are themselves a threat to the environment through the unsafe disposal of wastewater and human and solid waste. Lack of drainage in dry areas creates new risks of insect borne diseases such as malaria, dengue, and filariasis. Responsibilities among users are shared to protect the water resources.

Source: (Macharia, Mbassana, & Oduor, 2015)

1.2.2 Sustainability of Rural Water Access

Nearly 50% of the world's population still reside in rural regions and are from low-income socioeconomic categories, primarily in Asia and Africa. The poor rural population lack access to basic water supply (900 million) and safe sanitation, which result not only in tremendous human health and economic costs but also create gender and other societal inequalities (UNESCO, 2021).

The literature contains many broad definitions of sustainability, most of which are similar and frequently refer to common sources. The distinction, however, is in the emphasis. The financial aspects of providing water services were first linked to sustainability, emphasizing the need for water users to contribute to the costs of the water supply and sanitation sector (Black, 1998). From the viewpoint of these institutions, sustainability might mean either the continuous convenience of having access to household water or it can simply mean sustained health impacts.

It is not guaranteed that people will have access to reliable and sustainable water services, because of the presence of water supply systems in rural areas (Majuru et al. 2012; Penn et al. 2017). The difficulties and challenges related to insufficient maintenance activities as well as financial management generated by the service are indeed a matter of concern for rural water supply (Molinos-Senante et al. 2019). These inadequacies are the result of low population density (Wedgworth et al. 2014), incompetence of water point committees (ACF 2007), and low incomes of populations (Dhungana & Baral 2016; Githae et al. 2018). Moreover, there is no regulation of water service managers and thus poor quality services are provided (Galindo & Palerm 2016).

Local water districts have been unable to provide water services to the general population due to the slow pace of improvement in household access to water in rural communities in the Philippines associated with the high operational cost that goes with it. As a result, many rural homes continue to have level I or level II service access to water for domestic consumption. Table 2 details the three level of water access in the Philippines.

Water Access Service Level	Description
Level I	A protected well or a developed spring with an outlet but without a distribution system, generally adaptable for rural areas with houses thinly scattered. The farthest water user is not more than 250 meters from the point source.
Level II	A water supply facility composed of a source, a reservoir, a distribution network with treatment facility and communal faucets that serves 4 to 6 households. This level is generally suitable for rural areas where houses are clustered densely to justify a simple piped system. The inclusion of the phrase *'with adequate treatment facility'* emphasizes that the water supply source has passed the Philippine National Standards for Drinking Water. The farthest household user is not more than 25 meters from the communal faucet system.
Level III	A water supply facility with a source, a reservoir, a piped distribution network with adequate treatment facility and individual household taps. Level III is generally suited for densely populated urban areas. The inclusion of the phrase *'with adequate treatment facility'* emphasizes that the water supply source has passed the Philippine National Standards for Drinking Water.

Source: Philippine Statistics Authority (PSA) website at http://psa.gov.ph

1.2.3 Water Governance

According to Rogers and Hall in Hoekstra (2006) water governance is defined as the "range of political, social, economic, and administrative systems in place for the development of water resources and the delivery of water services to different levels of society." The water governance system must be able to equally allocate water for both food and urban security, as well as determine "for whom and for what" purposes water access is to be provided (Tropp, 2007). Water governance involves not only the consensus and discussion but deals with compunctions, conflicts and corruptive practices in governance (Miranda, Hordijk, & Molina, 2011). When establishing a society, we must realize that water serves as "humanity's learning-ground" for developing better communities, and it is crucial to combine democratic processes and the development of institutional capacity with efforts to intervene in the water cycle (Turton, Hattingh, Maree, Roux, Claasen, & Strydom, 2007).

The United Nations Water Governance Facility (UN-WGF) defined water governance in 2013 as addressing the principles of equity and efficiency in water resource and service allocation, and it calls for clarification of the roles and responsibilities of government, civil society, and the private sector based on ownership, management, and administration of water resources and services (UNDP, 2013). According to a survey conducted in the Philippines on Water Governance, managers of waters have little experience with policy changes and are not familiar with formal or traditional water rights when settling local conflicts by means of formal mechanisms that lead to interventions known as weak and useless for resolution of disputes (Hall, et. al 2015). Additionally, the countries water policy exhibits multi-layered fragmentation, with numerous entities coexisting at the same time with varying degrees of coverage, regulatory requirements, and customary obligations.

1.3 Background of the Study

A community-based study was undertaken in ASAFA, a small community nestled at the foothills on the western slope of Mount Arayat in the Province of Pampanga. The ASAFA acronym stands for Ayala San Agustin Farmers Association and is comprises of farmers originating from both barangays which makes the community partly Barangay Ayala and partly Barangay San Agustin in the municipality of Magalang. An article from the Development Academy of the Philippines (DAP) states that in 2010, when Pampanga State Agricultural University (PSAU) was still called the Pampanga Agricultural College, 30 families settled in the title land of the college. They engaged in the illegal charcoal business (kaingin farming) while burning slash to clear the land so that crops could be planted. The tension between the illegal settlers and the college administration as well as the depopulation of Mount Arayat's biodiversity was both caused by the unlawful kaingin. In total, 30 hectares of land were occupied by it.

To solve the conflict in an orderly manner the college administration initiated a management strategy and invited the 30 families and organize them into a farmer association and become farmers and co-managers of the 35 hectares of land. Since the informal settlers are from the nearby barangays of the college, namely Ayala and San Agustin the name ASAFA was coined. The college administration assisted the farmers in formalizing their association and registered ASAFA with the Securities and Exchange Commission (SEC) in 2011. Consequently, a Memorandum of Agreement was forged between the 30 members of ASAFA and PSAU where they established a joint project in the production of coffee and other crops. The MOA was signed on June 30, 2011 which entails that a designated piece of land (1 hectare per ASAFA member) within its reservation area to established a coffee plantation conjunctively managed by PSAU and the farmer-cooperators. Technical supports are provided to the ASAFA members in coffee production and other crops like tamarind, vegetables and bananas. Primarily, an electric-powered submersible pump was designed and installed to supply water for the coffee and crops production. Such project requires high maintenance and operational cost and because of the lack of assessment after the project's delivery and the lack of maintenance and participation from the community the project was put into a stop inevitably. To solve the perennial lack of water a solar-powered irrigation system was installed as a replacement, funded by the Department of Agriculture (DA) through the fund source of PSAU. The intended purpose of the solar-pump is to irrigate the crops planted by the members of ASAFA to meet the objectives of the joint project which is to provide a source of livelihood and income for the 30 families that form the ASAFA. Over the course of time, the population flourished and the original 30 families' increases. More informal settlers, as well as indigenous people from other parts of Pampanga and neighboring provinces seek shelter in the forest reserve area. The increase in population resulted in an increase in demand for domestic water use. Since its installation on May 11, 2018 the solar-powered pump has transpired to be the main water source of the entire community and become essential to the daily lives of the residents. As of May 2023, there are at least 120 households recognized as members of the ASAFA Community. Apart from these registered members of the community, unregistered and illegal settlers, as well as indigenous people who seek shelter in the area are relying to the solar-powered pump as their primary water supply for daily use.

There are four identified stations that branch out from the main source where water is also being supplied apart from the communal pipe of the main source where most of the residents collect their water. The stations usage of water ranges from domestic to agricultural purposes. The people of ASAFA Community are currently experiencing a lack of sustainability in their water supply. The lack of accessibility of water for household use required them to fetch it directly from the source. Traditionally, the people of this community fetch their water by climbing up and walking a few kilometers towards the source, and only those fortunate enough to own a means of transport or is nearby the solar-powered pump has the convenient access for their household water supply.

The location of ASAFA Community being in the far flung areas and considered to be a developing community is what makes the community known for having limited access to household water. To resolve their insufficient supply of water the community is operating on a water regulation schedule.

1.4 Study Area

- General

The study was carried out in a small community of ASAFA in the highlands of Magalang, province of Pampanga. ASAFA Community is originally an idle 35 hectare government-owned land distributed to the qualified and rightful agrarian reform beneficiaries (ARB) under the comprehensive agrarian reform program (CARP) through Executive Order No. 75 Series of 2019. The community's livelihood and main source of income is planting different crops. According to the association's secretary, as of May 2023 ASAFA is comprises of 120 families. The community itself has a total population of 396 persons.

The community's primary water source is located at approximately 15°12'38.32" (N) latitude and 120°42'13.36" (E) longitude. The elevation on this location is estimated at 103 meter above mean sea level. Specific points from the solar-powered-irrigation system (categorized as Stations) where water is being distributed and used are located as well.

Picture 1: ASAFA Community Area Sited from Google Earth

Picture 2: Solar-powered Irrigation System

The study aims to assess the current sustainability of water supply in the small community of ASAFA Magalang, Pampanga. The researchers' specific goals are to demonstrate how helpful the water supply source in ASAFA Magalang are in meeting the needs of people living in this type of situation. In addition, researchers wanted to know what the alternatives were that the people in this small community could do to be able to sustain at a certain level the need for water supply in their area. Finally, to assist residents in improving the distribution and quality of water obtained from the source by generating significant information.

1.5 Objectives of the Study

1.5.1 General Objective

The research study aims to assess and evaluate the sustainability of the current water source of ASAFA Community in Magalang, Pampanga. The purpose of the study is to provide information for future reference of government and non- government organizations in developing future projects for sustainable water supply for the ASAFA Community in Magalang that the residents can use for domestic purposes.

1.5.2 Specific Objectives

The study's specific goals are as follows:

- To assess the current water source (Solar-powered Irrigation System) used by the residents of ASAFA Community in Magalang, Pampanga in terms of its quantity for domestic use through quantitative approach
- To assess the quality of the current water source with the following parameters: coliform content, E. coli, heterotrophic plate count, total dissolve solids and acidity and to determine whether it is safe for human consumption base on the required parameters for drinking water recommended by the Philippine National Standards for Drinking Water (PNSDW)
- To propose suggestions and recommendations on the improvement of water distribution and management of the current water system of the ASAFA Community, also to provide recommendations in providing the Community an access to a safe and clean water for consumption and domestic use as recommended by the Philippine National Standards for Drinking Water (PNSDW)

1.6 Significance of the Study

The beneficiaries of the study are as follows:

ASAFA Community, their situation in water access and sustainability still lack accurate data, only studies that support the fact that rural communities and remote areas have low access to a quality water service. Clean water is essential for healthy human life, and "human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights" (CESR, 2003). Despite acknowledging these fundamental human rights, ASAFA community along with other small communities around the globe are still living without sustainable access to for domestic household use, which results in a poor quality of life and several environmental and socio-economic issues. The community will benefit from this study; especially this study aimed in developing information to enable further developments for a sustainable water supply to the community. The assessment conducted in the study intends to help the people of ASAFA to identify possible solutions for them to have an access to a safe, reliable and convenient water supply.

Government and Non-Government Organization, it will contribute to the efforts done by the government in improving the current water access and service of rural communities in the country. In addition, this study will contribute and assist existing knowledge to develop more local strategies for the improvement and maintenance of water supply conditions in rural areas.
Future Researchers, it will be used as a reference and guide in conducting their study. Through this study, people will be inform about the current situation of the rural communities and may open up opportunities for more research to improve their situation. The findings of this study will be useful to potential study as a guide material for conducting similar studies or any research related to water access and sustainability.

1.7 Scopes and Limitations

The study aimed at assessing the sustainability of the current water source of the ASAFA Community in Magalang, Pampanga. The scope of the study focuses to the location of the Solar-powered Irrigation System that serve as the community’s main water source and the coordinates of surrounding stations that branch out from the source as well. This study aims to determine the discharge or flow rate of the solar-powered pump as well as the remaining 4 stations where water is catered to, through site investigation and observational data. Additionally, the study covers only the five parameters of water quality namely: coliform content, E.coli, heterotrophic plate count, total dissolved solids and acidity.

The study does not include provisions of water-based and mechanical-based solutions, but rather it will provide an assessment to make recommendations for the improvement of the performance and efficiency of the main water source.

To satisfy the drinking water quality standards recommended by the Philippine National Standard for Drinking Water (PNSWD) collected sample are tested by the following parameters: coliform content, E.coli, heterotrophic plate count, total dissolve solids and acidity.

However, even if the study results cannot apply to other areas, its underlying theoretical assumptions and methodology must be able to provide information on future related studies (Macharia, Mbassana, & Oduor, 2015).

1.8 Conceptual Framework

The Input-Process-Output for framework was utilized in the figure shown below:

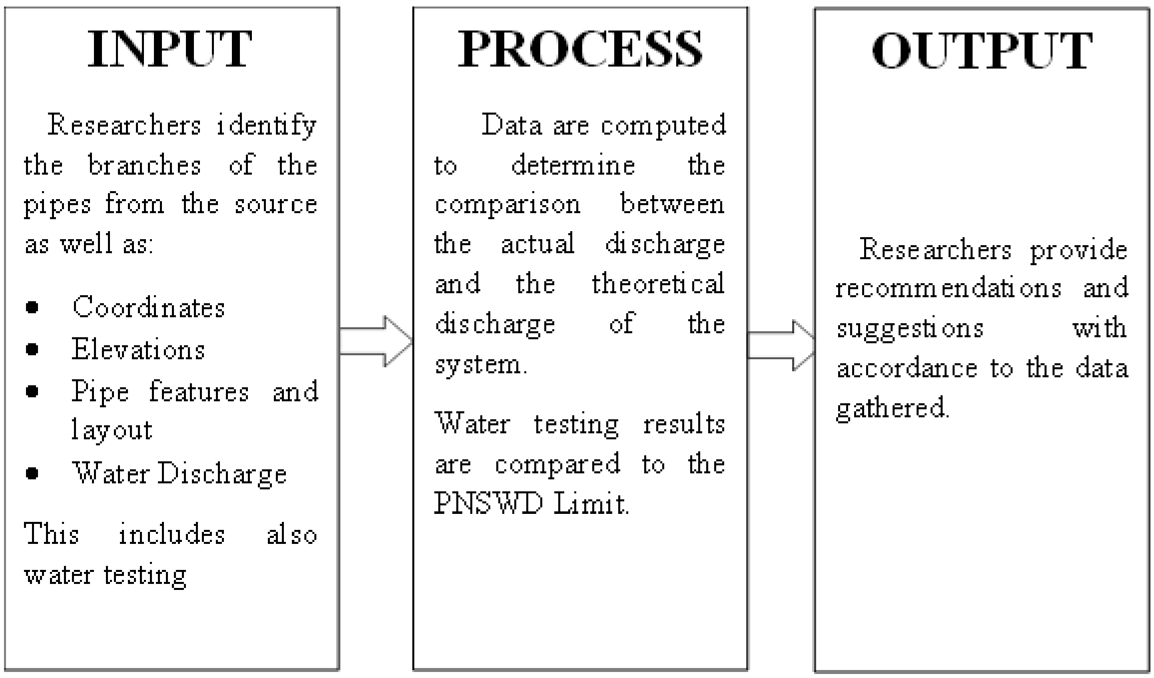

Figure 1: Conceptual Framework

The input entails the coordinates, elevations and the features of the piping layout of the whole water distribution system and collected actual discharge through site investigation and observational data. Additionally, the data needed for drinking water quality standards as per the recommendation of PNSWD. The process involves the comparison between the theoretical discharge and expected water supply based on the system with that of the actual discharge obtained for the community. Also the comparison between the water quality data obtained through sample and test results and the PNSWD standards. Finally, the output is to make an assessment of the water quantity and quality and the second output is to propose recommendations for the improvement of water supply for the community in terms of improvements of the system and improvements of the water quality.

1.9 Definition of Terms

The following terms are defined for this study:

- Acidity: Acidity of water is quantitative capacity to react with a strong base to a designated pH. All water samples having a pH lower than 8.5 contain acidity.
- ASAFA Community: ASAFA stands for Ayala San Agustin Farmers Association is a community that lies in the border of Barangay Ayala and San Agustin in the municipality of Magalang.
- Coliform Content: Total coliform bacteria in drinking water typically don't have a health risk

associated with it and if water testing only detects it, the source is probably environmental and not fecal contamination. Total coliform bacteria are often considered an indicator there may be something more serious contaminating a drinking water system, specifically E. coli bacteria. Total coliform bacteria are colorless, odorless, and tasteless and the only way it can be detected in drinking water is through submitting a sample for laboratory testing.

- CFU: In microbiology, CFU stands for colony-forming units. It is a unit that we use for estimating the number of viable bacteria or the fungal cells in the sample
- Discharge: A discharge is a measure of the quantity of any fluid flow over unit time. The quantity may be either volume or mass.
- Domestic use: It describes the different uses of water by household, such as cooking, bathing, washing, drinking, garden and sanitation (UNDP, 2013).
- E.Coli: Escherichia coli (E. coli) is a bacteria that is commonly found in the lower intestine of warm-blooded organisms. Most E.coli strains are harmless, but some can cause serious food poisoning.
- Governance: The use of economic, political and administrative authority in managing all levels of a country’s affairs (UNDP, 1997).
- Heterotrophic Plate Count: Heterotrophic plate count (HPC) is a method that measures colony formation on culture media of heterotrophic bacteria in drinking water. Thus the HPC test (also known as Standard Plate Count) can be used to measure the overall bacteriological quality of drinking water in public, semi-public and private water systems.
- Household: A social unit that consists of a person who lives on his own, or group of persons living together in the same place and has an arrangement relating to food preparation and consumption (PSA website at http://.psa.gov.ph/glossary/popn.asp accessed on January 14, 2019)
- MPN (Most Probable Number): The most probable number
- Photovoltaic cells: A photovoltaic (PV) cell, commonly called a solar cell, is a non-mechanical device that converts sunlight directly into electricity.
- PNSDW (Philippine National Standard for Drinking Water): The Department of Health (DOH) today presented the Philippine National Standards for Drinking Water (PNSDW) of 2017 to various stakeholders. The said policy is embodied in the DOH Administrative Order No. 10 series of 2017, which prescribes the standards and procedures on drinking-water quality aiming to protect the public and consumer’s health.
- Pump: devices, either mechanical or electromechanical, designed to transport water through pipes or hoses by producing a pressure difference and moving water through the system.
- Quality: It can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics.
- Quantity: is a measure of the quantity of any fluid flow over unit time. The quantity may be either volume or mass.
- Solar-powered Irrigation System: provide reliable and affordable energy, potentially reducing energy costs for irrigation.
- Sustainability: Ability of humans to continue to live within environmental constraints (Saunders & Becker, 2015). In addition, sustainability is seen as a way of managing water resources so that it benefits the generations to come.
- Sustainable Development: development that satisfies the demands of the present without compromising the capacity of future generations to satisfies their own wants without interfering with the ability of previous generations to satisfy their own needs.
- Total Dissolved Solids (TDS): are the amount of organic and inorganic materials, such as metals, minerals, salts, and ions, dissolved in a particular volume of water; TDS are essentially a measure of anything dissolved in water that is not an H2O molecule. Since it is a solvent, when water encounters soluble material, particles of the material are absorbed into the water, creating total dissolved solids. TDS in water can come from just about anywhere, including natural water springs, chemicals used to treat the municipal water supply,

runoff from roads and yards, and even from your home plumbing system.

- Water Accessibility: The most frequently used definition is that of the United Nations Development Program (UNDP), which states that those with access comprise: “The proportion of the population using any piped water, public tap, borehole with a pump, protected well, and springs or rainwater”
- Water Sources: This term refers to bodies of water that serve as sources of drinking water for the general population as well as private wells.

II. METHODOLOGY

The methodology used for this study is described in this chapter. The research design, field of study, how data are gathered, the way it's analyzed and ethics considerations which can be brought to bear on these activities will be discussed in this chapter.

2.1 Research Design

The study utilized a quantitative research method in assessing the water quantity and water quality of the current water source. This involves collecting numerical data to understand the water distribution of the ASAFA Community. The researchers used a descriptive investigative approach, in order to better understand the sustainability of community water access for domestic use. The Descriptive-Investigative Research Design is an effective model for studying the criteria and parameters of the current water source and examining the community's actual situation. This type of research design is based on a theoretical framework in which the researchers gather data, analyze the data, organize and present it comprehensibly. The most prevalent form of research design, this one simply observes and quantifies the data that has been collected and does not attempt to manipulate and exert control over the phenomenon being studied. In addition, it does not examine causal relationship between variables. It also helps to identify and analyze unexpected issues that may arise in the future.

2.2 Research Locale

This study is conducted at the Community of ASAFA, a 35-hectare land located at the foothills of Mount Arayat with an estimated elevation of 103 m above sea level. This place was selected for the reason that it is considered a highland and remote area and the data within the community is still lacking and unknown on the Records of the Municipality of Magalang. This study will assess the place and provide the municipality the data gathered and the condition of the said community.

2.3 Data Collection

The systematic process of obtaining and collecting observations and measurements (both numerical and non-numerical data) is known as data collection. The process by which data collection will be collected is divided into two stages. The first stage includes ocular visitation of every identified points of the water distribution system of the ASAFA community. The second stage involves the collecting of water sample from the main source and proceeding to a laboratory testing center for the water quality test.

2.3.1 Water Quantity

These are the necessary data needed to collect for assessing the water quantity of the ASAFA

Community water source:

- Coordinates and Elevations of every Stations
- Actual features and layout of the Water Distribution System
- Properties of the PVC and HDPE pipe use

Another part of assessing water quantity is the actual discharge from the main water source gathered through site investigations and observations.

2.3.2 Water Quality

For the assessment of water quality of the solar-powered pump a sample is collected from the main source. Five parameters of water quality are to be tested namely:

- Microbiological factors (coliform content, E.coli and heterotrophic plate count)
- Physico-chemical properties (total dissolved solids and acidity)

The researchers collected sample from the main source and placed into two containers; a 120 mL borosilicate bottle use for testing the presence of microbiological organisms present in the water and a 1L ordinary plastic bottle use for testing the physico-chemical properties. In microbiological water quality testing, the 120 mL bottle contains a compound sodium thiosulfate which is recommended to ensure that results accurately reflect the water quality sample collection. The collected sample will then be put inside a container filled with ice. At least two-thirds of the 120 mL bottle should be submerged in ice. On the other hand, water sample for Total Dissolved Solids (TDS) and Acidity Test is collected using an ordinary plastic bottle. Consequently, the collected samples are then transported to Eminent Water Laboratory Center located at San Agustin, City of San Fernando Pampanga for testing. Travel time of the collected water sample from the main water source to the water testing laboratory should not exceed 6 hours. According the Eminent three trials are to be conducted in performing the water quality test: presumptive, confirmatory and end-result. References for the compliance of the sample for a standard drinking water are to be compared from the parameters from PNSWD.

2.4 Data Analysis

Following the collection of data, the results are interpreted and analyzed using Descriptive – investigative analysis.

- Water Quantity

Using the actual distribution layout the theoretical discharges of the aforementioned layout will be computed and consequently the theoretical charges will be compared to the actual discharges that have been collected using observation to determine the efficiency of water distribution system in catering water to the community.

- Water Quality

A comparison between the obtained test result from the water laboratory center and the PNSWD standard parameters to determine whether the sample from the source is compliant to the standard quality for a safe drinking water. The table below shown the minimum values required for each parameter.

2.5 Ethical Considerations

In line with the principle of anonymity and confidentiality, care was taken not to use the name of any informant directly. Before recording any in-person interview, the researcher obtained permission from each of the informants. This was necessary to ensure that informants' involvement in the research was voluntary. The informants were made to be aware that they could withdraw or refuse to answer any question from the researchers about the study when they desire without any penalty. Finally, prior to collecting data, the researcher sought approval from the officials of ASAFA Community, and communicated respect and gratitude to the informants where necessary.

III. DATA ANALYSIS, RESULTS AND DISCUSSIONS

3.1 Summary of Data Collection

The researchers in this study utilized observational data, samples, and in-person interviews to obtain the data needed for this study. Observational data is used to measure the coordinates and elevation of the location of each stations, the length of pipes from the main source to the stations, and the water quantity or water discharge of every stations including the main source. The researchers also utilized water sample to examine the presence of microbiological organisms; such as E-Coli, in the water coming from the solar-powered irrigation system. In addition, this type of data collection was also used to check the potability of the water. In order to gather more explicative data, researchers also conducted in-person interviews with those who work closely with the irrigation system.

3.2 Presentation Data

3.2.1 Quantity

Data collected for the quantity factor of the entire solar-powered irrigation system are collected by the researchers using different tools to satisfy the collection for the measurements of coordinates, elevations, length, and water discharge. The researchers utilized an app DA (Department of Agriculture) Geo Cam and Google Earth in determining the coordinates and elevations of every station. Tape measures are used in in measuring the length of PVC and HDPE pipes of the solar-powered irrigation system.

3.2.1.a Coordinates and Elevations

Stations	Latitude (N)	Longitude (E)	Elevation
Main Source	15°12’38.32”	120°42’13.4”	103
Station 2	15°12’43.1”	120°42’05.2”	85
Station 3	15°12’34.46”	120°42’16.8”	111
Station 4	15°12’41.2”	120°42’19.4”	103
Station 5	15°12’54.4”	120°42’14.1”	95

Table 2. Coordinates and Elevations

This table shows the coordinates and elevations gathered by the researchers. The data collection utilized DA Geo Camera and Google Earth to determine the coordinates and elevations of every point and station of the study. DA Geo Camera is a tool recommended by Engr. Jayson Galang, key personnel from Department of Agriculture. According to Engr. Galang, this tool is widely used by the department to pinpoint the coordinates especially to remote areas that the Google Earth has no data about the said area. The following are the photo taken using DA Geo Cam and Google Earth:

Picture 3. Locations of every station

Station 1 or the Solar-Powered Irrigitation System located at 15°12’38.32”N, 120°42’13.4”E at an estimated elevation of 103 meters above mean sea level. It is a drip irrigation installed to provide water supply for the crops but consequently became the source for consumption, bath and domesticate use for the entire community.

Station 2 or the Animal Farm and Residential area located at 15°12’43.1”N 120°42’05.2”E at an estimated elevation of 85 meters above mean sea level. It is a faucet-ended pipe installed to provide water supply for the Goat Farm but it is also used by the residents living near the farm.

Station 3 or the Residential area near the ravine located at 15°12’34.46”N 120°42’16.8”E at an estimated elevation of 111 meters above mean sea level. It is a drum-storage ended pipe that is for storing water for residential use and consumptions.

Station 4 or the Residential area located at 15°12’41.2”N 120°42’19.4”E at an estimated elevation of 103 meters above mean sea level. It is an open-ended pipe regulated by a valve that is used mainly for residential use and consumptions.

Station 5 or the Tamarind Farm located at 15°12’54.4”N 120°42’14.1”E at an estimated elevation of 95 meters above mean sea level. The pipe ends with a storage tank to store water primarily used to water the tamarind trees of the farm as well as the neighboring crop plots.

3.2.1.b Length of Pipes

LENGTH OF PIPE OF EVERY STATION FROM SOURCE (m)	
STATION 2 (ANIMAL FARM & COMMUNITY)	308.33
STATION 3 (COMMUNITY)	162.88
STATION 4 (COMMUNITY)	225.81
STATION 5 (TAMARIND FARM)	925.528

Table 3. Length of Pipe from source to stations

The table shown at *Table 2. Length of Pipe from source to stations*, are the gathered length measured by the researchers. The data collection utilized measuring tape to measure pipes connected from the main pump or source to the different stations. Although the researchers had a hard time that some of the pipes are not accessible to measure especially those inside households or community fences, yet, most of the pipes are visible and scattered beside the roads exposed to weather and above ground. Pipes used are primarily PVC pipes.

Measuring the pipes is one of the key factor to compute the discharge of water from the main pump to the stations. Straight measurements point-to-point is only considered just to help the researchers determine the average discharge on different stations. On Picture 7, some pipes are curved and exposed above ground without clips or clamps to hold the pipes still.

PVC and HDPE pipes are used in the piping system of the current water distribution system of the ASAFA Community. All pipes are in a constant 1 inch diameter.

3.2.1.c. Discharge

In analyzing the water distribution system, two different idealized scenarios were considered:

To be able to cater the distribution of water equally to all of the stations, a management of water distribution in the community of ASAFA is operating in a regulation schedule. Stations 2 and 3 are operational during Mondays, Wednesdays, Fridays, and Sunday morning of the week. Meanwhile, stations 4 and 5 are operational during Tuesdays, Thursdays, Saturdays and Sunday afternoon.

During a portion of the week, only Stations 2 and 3 are working simultaneously. The idealized water distribution system for Stations 1, 2, and 3 is illustrated below.

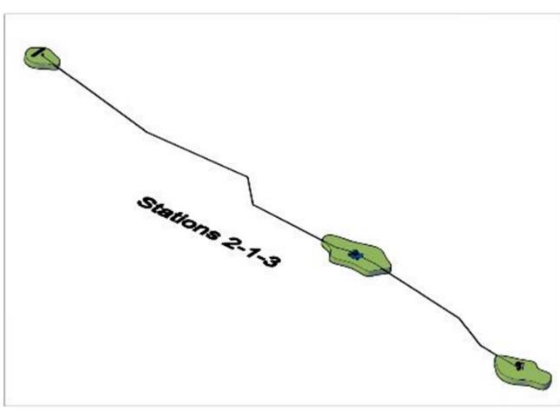

Figure 3. Idealized Water Distribution System during MWF

Groundwater is extracted at Station 1 and pumped through the system to reach Stations 2 and 3. During this cycle, the pump, which adds energy to the flow of water in the system, is assumed to have the minimum power input of 456 W and a minimum efficiency of 50%, to be conservative. Using the specifications of the system and idealizing the major and minor head losses, the expected discharges at the three stations were computed.

Station	Theoretical Discharge (L/s)
1	0.4389
2	0.3377
3	0.1012

Table 4 Computed Theoretical Discharges for Idealized Water Distribution System during MWF

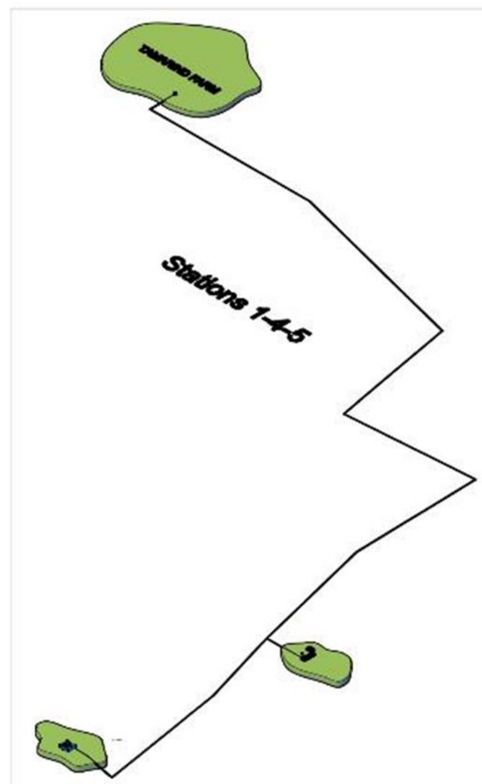

Figure 4. Idealized Water Distribution System during TThS

During the other times of the week, only Stations 4 and 5 are working simultaneously. The idealized water distribution system for Stations 1, 4, and 5 is illustrated above.

Same with the initial system, groundwater is extracted at Station 1 and pumped through the system to reach

Stations 4 and 5. During this cycle, the pump, which adds energy to the flow of water in the system, is also assumed to have the minimum power input of 456 W and a minimum efficiency of 50%, to be conservative. Using the specifications of the system and idealizing the major and minor head losses, the expected discharges at the three stations were computed.

Station	Theoretical Discharge (L/s)
1	0.4342
4	0.1292
5	0.3050

Table 5. Computed Theoretical Discharges for Idealized Water Distribution System during TThS

For both scenarios, only Station 1 is present. Thus, it is necessary to compare whether the obtained values for the volumetric flow rate in this station for both scenarios are the same. During half of the week (MWF) where only Stations 1, 2, and 3 are operational, the computed theoretical discharge for the first station is 0.4389 L/s, while a theoretical flow rate of 0.4341 L/s was computed for the other half of the week (TThS) where only Stations 1, 4, and 5 are operational. Since both models yielded almost equal expected discharges for Station 1, it could be said that the idealization of the water distribution system is sufficient to analyze it.

To further specify the details on that particular station, the average value for the flow rate of Station 1 is obtained. By getting the average of the two values from the two scenarios, the theoretical discharge for Station 1 is 0.4365 L/s.

After idealizing the water distribution system and computing what amount of water is expected of it to yield, the actual discharges from each station were measured.

DISCHARGE RATE IN LITER PER SECOND L/s (USING 20-LITER CONTAINER)					
TIME	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
8:00 AM	0.2667	0.2532	0.0826	0.0813	0.0613
8:30 AM	0.2703	0.25	0.0851	0.0784	0.0579
9:00 AM	0.2597	0.2703	0.099	0.1052	0.0712
9:30 AM	0.2632	0.2597	0.0837	0.1042	0.0719
10:00 AM	0.2777	0.2898	0.1053	0.1105	0.1112
10:30 AM	0.2941	0.2778	0.1005	0.1026	0.1351
11:00 AM	0.3125	0.303	0.1136	0.1081	0.2326
11:30 AM	0.3125	0.3125	0.1093	0.0995	0.1667
12:00 NN	0.2941	0.2985	0.0803	0.0909	0.1098
12:30 PM	0.2857	0.2857	0.0797	0.0901	0.0752
1:00 PM	0.2985	0.2941	0.0826	0.08	0.0667
1:30 PM	0.2898	0.303	0.1064	0.0772	0.0599
2:00 PM	0.2941	0.2857	0.0826	0.0858	0.0662
2:30 PM	0.2778	0.2985	0.0837	0.0837	0.0439
3:00 PM	0.2703	0.2531	0.0784	0.08	0.0558
3:30 PM	0.2703	0.2597	0.0778	0.0781	0.0444
4:00 PM	0.2564	0.2469	0.0743	0.0717	0.0422
TOTAL	4.7937	4.7415	1.5249	1.5273	1.472

Table 6. Discharge Rate in L/s

Legend: HIGHEST

LOWEST

The table above shows the discharge rate in liter per second that are gathered by the researchers on each stations including the main source. The researchers utilized 3 20-Liter (three twenty-liter) containers and stopwatch to measure discharge every 30 minutes of a chosen day. Using the 20-L containers, the researchers fill the 3 containers to full while timing it how long it will take a container to get full. With that data, discharge rate is calculated by using the formula V/s or the container's volume divided by the seconds of how long a container to get full. Data shown that discharge rate fluctuates higher at 11:00 am to 1:00 pm and consistently low at 4:00 pm of the observation day. The table shown below is the computed average discharge in cubic meter per sec or L/s.

Station	Actual Discharge (L/s)
1	0.2820
2	0.2789
3	0.0897
4	0.08984
5	0.08659

Table 7. Actual Discharges for the Water Distribution System

Since the actual and theoretical discharges for all the specified stations were already obtained, a comparison between the two could be performed.

Station	Actual Discharge (L/s)	Theoretical Discharge (L/s)
1	0.2820	0.4365
2	0.2789	0.3377
3	0.0897	0.1012
4	0.08984	0.1292
5	0.08659	0.3050

Table 8. Actual versus Theoretical Discharges for the Water Distribution

The percent difference, $\%\,diff$, for the volumetric flow rate for each station was computed using the formula:

$$\%\,diff = \frac{Q_a - Q_t}{Q_t} \times 100\%$$

where: Q_a is the actual discharge per station (in L/s) and

Q_t is the theoretical discharge per station (in L/s).

Station	Actual Discharge (L/s)	Theoretical Discharge (L/s)	% difference
1	0.2820	0.4365	−35.40%
2	0.2789	0.3377	−17.41%
3	0.0897	0.1012	−11.36%
4	0.08984	0.1292	−30.46%
5	0.08659	0.3050	−71.61%

Table 9. Actual versus Theoretical Discharges for the Water Distribution System

The table above shows that there is a huge difference between the theoretical discharge and the actual discharge measured from every stations. Station with station 5 that caters water for agricultural use having an actual discharge that is 71.61% less from the expected discharge of the system. Station 1 which is the main source and where most people of the community are fetching their water supply has a loss of almost 1/3 of the expected discharge. Stations 2 and 3 are the only stations that has less than 20% of loss of the expected discharge.

Several reasons may contribute as to why there is a huge percentage difference of discharge loss:

- Improper installation and management of the piping system
- Longer measurement of pipes
- Poor maintenance of piping system
- Unauthorized pipe connections

3.2.2 Quality

Data collected for the quality factor of the solar-powered irrigation system are collected by gathering water sample directly from the main pump and testing it for potability and checking if the water is safe for human everyday consumptions. The researchers collected sample from the main source into two containers; a 120 mL borosilicate bottle containing sodium thiosulfate and 1L ordinary plastic bottle. In microbiological water quality testing, sodium thiosulfate is recommended to ensure that results accurately reflect the water quality sample collection. On the other hand, water sample for Total Dissolved Solids (TDS) and Acidity Test is collected using an ordinary plastic bottle.

- MICROBIOLOGICAL TESTs

ANAL YSIS	METHOD OLOGY	PNSD W LIMIT	RESU LTS	FIND INGS
TOTA L COLIF	SM 9221 B. Multiple	Less than 1.1	Greater than 8.0	Fail

ORM (ALPHA 9221 B)	Tube Fermentation Technique	MPN/100mL	MPN/100mL	
E. COLI (ALPHA 9221 E)	SM 9221 E. Multiple Tube Fermentation Technique	Less than 1.1 MPN/100mL	Greater than 8.0 MPN/100mL	Fail
HPC (ALPHA 9215 B)	SM 9215 B. Pour Plate	Less than 500 CFU/mL	770 CFU/mL	Fail

Table 10. Microbiological Tests

This table shows the result from Microbiological tests done by the researchers with the help of EMINENT Water Laboratory Center as per recommendation by the Department of Science and Technology (DOST). According to the results, Total Coliform, Escherichia coli (E. coli) and Heterotrophic Plate Count (HPC) exceeds the Philippine National Standards for Drinking Water (PNSDW) Limit resulting the test to fail. The PNSDW Limit for both Total Coliform and E. coli should be less than 1.1 Most Probable Number (MPN) per 100mL, these tests determine the water condition in terms of bacteria exposure from the soil and animal or human wastes. Furthermore, HPC limit should be less than 500 Colony Forming Unit (CFU) per mL, this test is to determine the how much bacteria were present upon testing the presence of bacteria in water. It is also called as total bacterial count and commonly describe count of clumps of bacteria.

- PHYSICO-CHEMICAL TESTs.

PARAMETER	METHOD	LIMIT	RESULT
ACIDITY	SM 2310 B. Titration	-	159 mg/L
TOTAL DISSOLVED SOLIDS	SM 2540 C. Gravimetric	600 mg/L	276 mg/L

Table 11. Physico-Chemical Tests

This table shows the results from Physico-Chemical test as an additional part of the test conducted by the researchers. The test is only limited to present the concentration of Acidity and Total Dissolved Solids. The PNSDW provided limit for TDS that should not exceed 600mg/L. The result did not exceed the limit therefore, TDS is negative. Meanwhile, the test provided the study a raw result for the acidity. It requires further professional assistance to interpret the data.

IV. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This chapter is represented in four sections. The first section entails the overall summary of the study followed by the summary of the researchers' observations and findings, the conclusion, and lastly, the recommendations constructed by the researchers with the help of some professionals.

4.1 SUMMARY OF THE STUDY

ASAFA Community is an example of a community that is far from civilization. Lack of leadership, lack of access from electricity or electrical grid of a town or city, and etc. The main reason this study is conducted because water access on every remote areas is always a problem. By stating remote areas and water access, mountainous part or high lands is a great subject for the study about clean water access.

ASAFA Community is a 35m-hectare land located approximately 15°12'41.2" (N) Longitude 120°42'19.4" (E) Latitude, 103 meters above mean sea level. Pampanga State Agricultural University (PSAU) is the nearest landmark of the community. The community lies also at the mountainous bottom part of Mt. Arayat.

Solar-powered irrigation pump is located at 15°12'38.32" (N) latitude and 120°42'13.36" (E) longitude, estimated 103 meters above mean sea level. The researchers identified that this pump is currently distributed among 4 stations scattered inside the community. Station 2 or the Animal Farm and Residential area located at 15°12'43.1"N 120°42'05.2"E at an estimated elevation of 85 meters above mean sea level, about 308.33 m of length of pipe from the main source. Station 3, 4 and 5 is connected through a single pipe only regulated by a ball valve. Station 3 or the Residential area near the ravine located at 15°12’34.46”N 120°42’16.8”E at an estimated elevation of 111 meters above mean sea level, about 162.88 m of length of pipe from the main source. Station 4 or the Residential area located at 15°12’41.2”N 120°42’19.4”E at an estimated elevation of 103 meters above mean sea level, about 225.81 m length of pipe from the main source. Station 5 or the Tamarind Farm located at 15°12’54.4”N 120°42’14.1”E at an estimated elevation of 95 meters above mean sea level, about 925.528 m length of pipe.

Water discharge is also measured and compared with the theoretical discharge with the accordance of pipes and pump’s motor. The result shows that the percent difference between the actual discharge and theoretical discharge is much lower and not enough to support or give enough access of water to every stations at once.

On the other hand, water quality is also tested and it is only limited to determine if the water coming the pump is potable and safe for daily consumption. The data gathered and results from the EMINENT Water Laboratory Center states that E. coli, Total Coliform and HPC are all positive. Tests also provided the Acidity and TDS of the water.

4.2 SUMMARY OF THE RESEARCHERS’ OBSERVATIONS

The researchers always do an onsite observation by group or by pair to satisfy every data that is needed for the study. This study is a type of a descriptive-observational approach or investigative approach about the situation happening on the solar-powered irrigation system or the water source that ASAFA Community is currently using. These are the lists that the researchers observed throughout the study:

- ASAFA Community is completely unknown community according to the Municipality of Magalang
- Data about the solar-powered pump is not available
- Pipes throughout the system are not properly connected and installed
- The researchers also noticed some illegally connected pipes that are directly going to some households
- The residents approach to the researchers are unfriendly but still cooperative. The residents are on guard for every visits the researchers made
- Lack of maintenance for every stations, pipes, and especially at the main source or the solar-powered pump
- Lack of leadership

4.3 CONCLUSION

Based on the findings of the study, a conclusion where drawn:

As of these days, the people of ASAFA Community is experiencing an insufficient supply of water for their domestic use. The overall water distribution system is inefficient and a huge amount of discharge and system loss is apparent. There is a lack of management and community participation as well in managing their water distribution system. The current water source in the area is not sustainable in providing for the needs of the people of the ASAFA community and an improvement is needed.

Furthermore, the water that is catered to every station is not suitable for human intake and consumption. The members of the community are inevitably reliant to their only water supply and it is possible that the people of community may suffer from water-related diseases. Although there are no reported cases of people getting sick from the continuous usage of the water supply, this may be also due to the lack of proper governance and structured management of the community with regards to heath and sanitation since they are situated in a remote and uncivilized area.

4.4 RECOMMENDATIONS

Based on the results of the water quantity and water quality assessment, the proposed recommendations for the improvement of the water distribution system and the water quality from the source are listed below:

Recommendation for Quantity

- Introduce a more organized water distribution system

- By improving the actual water distribution system, it will avoid illegal and unauthorized connections between stations that may contribute to the amount of head loss and system less going through stations.
- Proper maintenance and operation of water distribution system

Recommendation for Quality

- Further testing of the water quality for other parameters to identify more about the condition of the water
- The study is limited to give an initial data showing that the water was not potable, further testing could help for the classification of treatment facility needed by the system.
- Water distribution system prioritizing stations with residential area that using the water for household use

Considering the mentioned findings and conclusion, the following recommendations are hereby suggested:

- Introduce a more organized water distribution system
- Proper management and leadership in managing the community's water source
- Conduct another study seeking to identify other water source available around the area
- Extensive treatment of the water quality since it is not suitable for drinking but requires further assessment and verification

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