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A Study of the Rural Energy Technology in the Philippines

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Abstract

Rural renewable energy technologies have created significant opportunities for promoting rural development in Marubay, a small village in Northern Samar, Philippines benefitting from technical assistance. The water systems have directly contributed to the improvement of the social and economic wellbeing of the village—contributing to achieving the Sustainable Development Goals 6 ("clean water and sanitation for all"); providing the village with safely managed drinking water. Sustainable project replication is the ultimate measure of success or failure. Local institutions should continually seek to explore the dynamics of rural renewable energy technologies for water application as they can reliably operate with minimum maintenance. Several factors, however, must be adequately addressed: knowledge by the local population about the technology and what it can provide; provision of locally available equipment and services, capacity to pay for the technology, and access to financing mechanisms. Unique to the community is that the water service facility is appropriate due to the community's active participation. Thus ensuring an efficient sense of accountability and ownership of the project for sustainable and convenient access to the water supply system.

Keywords: water governance, rural renewable energy technologies, community accountability, social cooperation.

1. Introduction

The study of the Marubay water supply system rural renewable energy (hereafter RE) initiatives (solar energy) demonstrates it can be a potential strategy to promote rural development. The Marubay water system is a Level III service facility that began ten (10) years ago.

The purpose of the study is for the Renewable Energy Access for off-grid Communities and Households (REACH) Project to promote renewable energy technology. The REACH Project team will organize advocacy initiatives, business fora, and other events to showcase innovative renewable technology and stimulate investments and active participation in the sector. The water system is a model—by far the only reported renewable energy in the province of Northern Samar, the Philippines that is functional—having worth special attention and emulation. Lessons and best practices can be taken from the experiences, successes, and narratives of its beneficiaries and shared with interested groups.

In light of this, the study hopes to inspire, guide, and prompt action among municipal and barangay officials to explore the potential of renewable energy now, and provides a venue for multi-stakeholder dialogue to identify challenges to renewable energy deployment and to come up with solutions to existing barriers to entry. The study briefly presents and describes Marubay solar-powered water system experiences and best practices that have proven to accelerate the deployment of renewable energy technology and their implication on the long-term social, economic, and good governance benefits that such a system can generate for the community as a whole.

2. Background

2.1 Marubay Water Supply System in Context

The antecedent of the Marubay water supply system initiative came to be, as residents struggled for convenient access to clean, drinking water. A household that wants access to water must pay PhP7.00 ($392) per container, which hikes up to PhP15.00 ($840) per container during the village feast day *(barangay fiesta)*. The source of water is in the village center; downstream through deep wells; one is for drinking and the other is for washing only. For quite a decade the village or barangay had no form of centralized water distribution; rather, Marubay residents had to collect water from shallow wells, the water quality is poor and created a high-risk situation for the community's health as the water they acquired could lead to water-borne illnesses.

The Marubay water system is an example of a village-managed water supply system model in Northern Samar (Philippines) that has documented the lessons and best practices in taking rural renewable energy initiatives. This design project involved supplying clean water to Marubay residents, a small village with a household of 298 on Batag Island in the municipality of Laoang.

The lack of access to clean and potable water compelled the Marubay Village Council to invest in eight (8) PV modules for street lightings and to power the submersible water pump for the village-managed water supply system Level 1 project. The cost is PhP300,000.00 under Phase 1 Level 3 project with thirty-one (31) beneficiaries. Additional investment was derived from the water users‘ fees. For Phase 2, of the project, Malteser International provided funds to construct a storage tank delivering and supplying a Level 3 water system to twenty-six (26) households. The project cost was PhP400,000.00 including a submersible pump (drilled), PV modules, PVC pipelines, and a control system.

The combined households served by the water supply systems were fifty-six (56), with a users’ fee of PhP52.00 ($2,912) per cubic meter, or PhP1.00 ($56) per container.

4. The Renewable Energy in Brief

Renewable energy technologies are on the verge of a new era, and Marubay is by far the trailblazer of the renewable energy water systems in Northern Samar. Koch (2012) wrote, “in many countries and regions, renewable energy is already responsible for meeting a substantial share of energy demand.“ “The rapid and substantial progress of renewable energy in recent years has been driven by policies of local, national, and regional authorities, in close cooperation with the business community, as well as continued technological innovation and cost reductions in energy generated with renewable sources.“ Meanwhile, the real costs of renewables are often misperceived, and the reality of integrating decentralized renewable sources in grids is often misperceived as a hurdle that cannot be taken[1].

The Sustainable Development Goals (SDG) 2015-2030 emphasized the importance of energy access, particularly clean energy, in improving development indicators and driving economic development. SDG 7 on ensuring affordable and clean energy is intertwined with the achievement of other goals on good health and well-being (SDG 3), quality education (SDG 4), and clean water and sanitation (SDG 6). The 2018 figures estimate that at least 780 million people lack access to electricity, while in some developing countries, 1 to 4 health facilities are not energized (https:www.un.org/goals/goal 7). UNESCO (2017) estimates that only 35.1% of primary schools in Sub-Saharan Africa and 50.7% in Southern Asia had access to electricity. In East Asia and the Pacific, this number is close to 100%, although no data is available for the Philippines.

The Philippines Energy Plan (2017-2040) aims to include: increasing energy security, expanding energy access through affordable, reliable, and modern energy sources, and promoting a low carbon future. The plan also aims to strengthen cooperation among government agencies, encourage multisectoral collaboration, and enhance consumer welfare and protection. Renewable energy is also a crucial tool in helping the government meet its target of providing electricity for all by 2030. 2018 data showed that out of 106.5 million Filipinos, 24.5 million—nearly one-quarter of the population—still does not have access to electricity. Among those who do, 82.3% get their electricity from the grid, 3.3% from mini-grid access, and nearly 3% from stand-alone solar power. The use of clean fuels for cooking has increased (53%), but improved cooking stoves remain low at 0.9%. The share of renewable energy to final energy consumption, however, is still quite low at 23%.

Through its Access to Sustainable Energy Program (ASEP), the European Union (EU) has allocated over PhP 3 billion in grants to help the Philippine Department of Energy (DOE) address some of its gaps. The Renewable Energy Access for Off-grid Communities and Households (REACH) is an ongoing initiative to reduce the vulnerability of poor rural communities to the adverse impact of climate change, through renewable energy. It does so by enhancing social welfare, disaster resilience, and economic growth in the remote communities of Northern Samar through innovative, scalable, and sustainable renewable energy technologies and systems. With that in mind, the strategy taken by the government to address the barangay drinking water problem for the past few decades is known as the “demand-responsive“ approach. The basic

principle of this approach is to treat water as an economic good. The idea of "water as an economic good" has value to users, who are willing to pay for it.

5. Methodology

The study involved small samples to systematically investigate; describe and characterize the Marubay water supply system to look into the household water use patterns of 'representative' case study families. However, these households were not randomly selected and the small sample size (a total of 16 families) do limit the conclusions that can be drawn. The survey and data collection methods employed are the use of a structured questionnaire. The study identified challenges and deficiencies affecting rural renewable energy and outlined interventions to relate such to resolve concerns relating to the operation and maintenance (O&M) of the Marubay water supply system's renewable energy development and deployment.

Key Informant Interview (KII) using a 'structured interview' at the sample's home was initiated to obtain research-relevant information on the study's research objectives. The five thematic areas included: 1) socio-demographic information, 2) existing water source for the household, 3) existing sanitation facilities and hygiene practices of the household, 4) operation and maintenance of water facility, and 5) economic status of the household. The independent variables are socio-demographic information, existing water sources for the household, existing sanitation facilities, and hygiene of the household. The dependent variables are related to the water operation and maintenance, scheme, modes of water supply, causes of water insufficiency, etc.

To complement the KII, a focus group discussion (FGD) involved fifteen (15) barangay officials having homogeneous characteristics, and sharing their individual views. The researcher made sure to keep the discussion going and would intersperse with probes whenever necessary to elicit insightful responses. These responses helped uncover patterns, trends, relationships, and structure in the information that may otherwise be difficult to capture; see or hear differences as raw responses from the questionnaire.

6. Data Processing and Analysis

Descriptive or qualitative analysis was used to identify and count the presence of a certain characteristic, e.g. finding out households' frequency of water use, satisfaction, contribution to social, economic welfare, and good governance. The responses were subsequently transcribed verbatim. After transcription, responses were grouped by the question and then collated to identify common answers.

Collected data included manual cleaning and editing/cross-checking from the encoded results of questionnaires. The data was tabulated, collated, categorized, and analyzed. It was then classified into patterns to arrange and conclude results. The data was summarized in a meaningful way to show patterns that might emerge from the data; analyzed to detect common responses and interpreted together to determine trends and tendencies in the answers of the respondents. In this case, only descriptive statistics were performed. Triangulation was likewise employed to compare data using different methodologies that hopefully will converge, resulting in answers that reinforced each variable that will ensure the reliability and validity of data. After encoding and verifying the results, the statistical tables generated summarized the data in a meaningful way using frequency counts, averages, and percentages to show patterns that might emerge. Finally, the tables were analyzed to detect common responses which were then collated and interpreted together to determine trends and tendencies in the answers of the respondents.

7. RESULTS AND DISCUSSION

7.1 Water source of the sample households

The samples have indicated that they obtained water from an unprotected deep well in the barangay: one was used for drinking and the other for washing purposes. These water sources were frequented daily for collecting drinking, cooking, washing clothes, bathing, livestock washing, etc. Since 2010, the samples (93.75%) reported that they had access to the water service facility that was owned and operated by the village. The samples (62.5%) rated the quality of water as a "good" source for drinking and washing. A noteworthy fact was that the sample population (100%) claimed that the schedule of water supply was "seasonal", i.e. water delivery to the households was not 24/7 due to the limited capacity of

the storage tanks. The samples (100%) reported that the scheduled water supply to the residents was between 6:00 am to 9:00 am daily.

It should be noted that the barangay residents allowed other residents without water connections to buy or share water with their neighbors with access to the barangay water service facility. The samples reported that the community water system was only used for cleaning, washing, cooking, and toilet flushing. The samples argued that there was no regular or fixed time of water supply by the barangay water supply system. They had to store it in containers such as plastic pails or drums so that they can use water anytime they need it. The sample population (100%) has no taps or water faucets inside the house, rather the water meter was connected to a long flexible hose to supply water to the containers.

7.2 Barangay sanitation facilities and hygiene practices

Sanitation was being promoted by the Barangay Health Workers (BHWs) as a public health condition related to clean drinking water and adequate treatment and disposal of human excreta and sewage. Preventing human contact with feces was part. As in handwashing, all the sample population (100%) reported handwashing with soap after going to the latrine and before eating. The rating (100%) was not necessarily in that order but was done in the basin or using the hose connected to the water meter. Containers were used to store drinking water inside the house, and water in the storage tanks was chlorinated. The most common (100%) reported sanitation technology and approach that existed among the samples was a pit latrine. A pit latrine collects human feces in a hole in the ground. Urine and feces enter the pit through a drop hole in the floor, which is connected to a squatting pan.

7.3 Barangay solid waste management

Solid waste management was practiced by the residents. The most common form of solid waste management was segregation. The sample population (100%) reported that they were required to divide solid waste into dry and wet. The barangay collected all dried solid waste (non-biodegradable) while wet (bio-degradable) was retained at home for the household to dispose of. In keeping with the Ecological Solid Waste Management Act, or R.A. 9003, and the R.A. 8749, or the Clean Air Act, the barangay prohibits and penalizes open burning. The barangay maintained and practiced good sanitation to protect the community's vulnerability to waterborne diseases by collecting non-biodegradable solid wastes every end of the month.

7.4 Economic status of the household

The sample population (100%) interviewed reported a combination of self-employed and employed as an economic activity. Common challenges to unleashing the potential of the community included low productivity (no livelihood opportunities); under-investment in agriculture and fisheries which was the resource of the community, lack of off-farm rural employment; lack of adequate infrastructure; and limited or no access to services, including financial services.

Forty-four (44%) samples maintained that they were engaged in farming; followed by employment (37.5%) as a teacher, barangay council member, and barangay health worker. The costliest things the household came upon were medicine and other living expenses. Finally, the samples expressed approval of the good governance demonstrated by the village officials in the water system management.

7.5 Water and poverty impact the social and rural livelihoods

Water is an essential element for human health, nutrition, and agricultural production, and enables job opportunities in numerous key sectors across the community. People require water for a wide range of activities essential to their livelihoods, including both domestic (drinking, washing, cooking, and sanitation) and productive needs (vegetable gardening, livestock, etc.) Supplying water for these different needs has contributed to poverty alleviation in the barangay. There is either too much rainfall in a short period resulting in flood and loss of property, or too little rainfall resulting in drought. In these myriad ways, water is directly linked to poverty–making access to water a means of ending poverty.

Before the Marubay water supply systems, the sample population claimed that their livelihoods were often dependent on adequate water supply, and their experience before the supply of water has affected their livelihoods. Access to water is vital to ensure the community obtains sufficient, clean, and easily accessible water sources. Local demand for water may continue to increase, as the number of residents increases. Sustained operation of the water supply will allow residents to open opportunities for social and economic welfare. As an offshoot of the water service facility, a barangay resident has opened a water purifying business sourced from this facility. This suggests that there is an increasing demand for water in the community in the future.

8. Main Solar Water System Component

The Marubay solar energy pumping system is composed of several PV (photovoltaic) modules. Solar cells are the building block for solar panels. Each solar cell has two or more specially prepared layers of semiconducting material that produce direct current (DC) electricity when exposed to sunlight. The DC is collected by the wiring in the panel. This DC is converted to AC by using an inverter and this AC is used to run the AC submersible pump that pumps water whenever the sun shines, stored in overhead water tanks. The output of the solar power system varies throughout the day, and with changes in weather conditions. The photovoltaic module, the power source for solar pumping, has no moving parts, requires no maintenance, and lasts for decades. A properly designed solar pumping system will be efficient, simple, and reliable.

The main components of the Marubay solar water systém:

1. **The Source**: The water sources were deep wells (drilled) below the storage tank using submersible AC motor pumps. The pump can recharge at a rate that is equal to or greater than three gallons per minute (inset photos).

2. **The pump**: This is the heart and soul of the solar water pumping system. The submersible AC motor pump set was drilled onto the source. The pump produced a unique combination of flow and pressure; with a combination of performance characteristics.

3. Photovoltaic (PV) panels: The photovoltaic modules or panels made up most (up to 80%) of the cost of the system. The size of the PV system was directly dependent on the size of the pump, the amount of water that was required (m^3/d), and the solar irradiance available. A panel was rated in watts of power it can produce with a sufficient number of modules in series and parallel producing the required PV array power output.

4. Mounting structures and tracking system: To enhance the performance of the water pumping systems, the PV modules were mounted next to the storage tank on steel structures in an appropriate design, which can withstand a load of modules and high wind velocities. The support structure is fixed and welded.

5. Controller: The controller matches the input power available from the solar panels, and was set up below the storage tanks. It provides low voltage protection, where the system was switched off if the voltage was too low or too high for the operating voltage range of the pump thus increasing the lifetime of the pump and reducing the need for maintenance. The control panel included an inverter, which changes the DC from the solar panels into AC for the pump. The panel and inverter were sized accordingly to accommodate the inrush characteristic of the AC motor.

6. The water distribution system: PVC pipes in combination with black polyethylene piping were used (1.5 diameters) to connect to the metered water system of households. This component used a conduit that conveys water from the deep well to the storage tanks and from the storage tanks to the access points, and households.

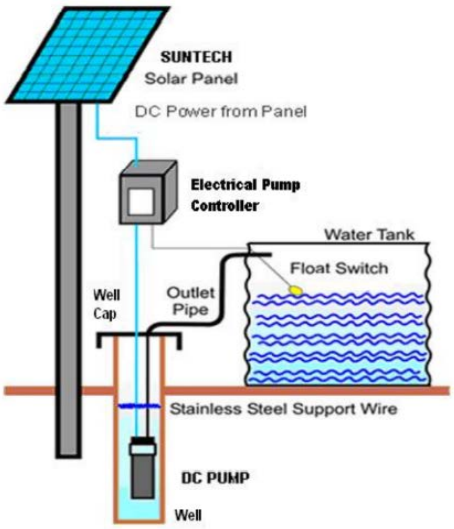
7. Water meter: Measures the amount of water consumed by the household that passed through a certain point per unit of time using this device. It will be read off by the barangay water utility attendant and used the readings to determine the bill to be paid by the water users.

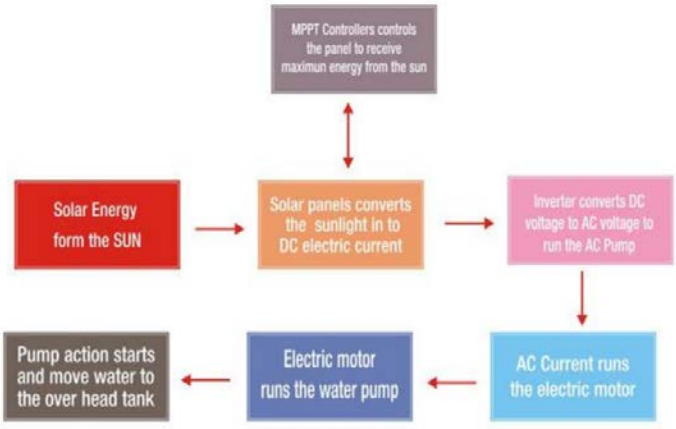
8. Battery charger. An additional device has been added to the basic components to provide electricity to convert into stored chemical energy for storage in batteries by running an electric current through it. The battery charger is beside the batteries in the control panel.

Photovoltaic modules should last 20–25 years. This is dependent on being maintained (keeping it clean from bird droppings, or debris, and securely mounted), and protected from strong winds, lightning, storms, and falling objects such as tree branches.

The submersible pump should be expected to last about 10 years more or less, while the maximum life of the rechargeable batteries is a one-year plus. The other electronics and controls with little electrical maintenance. The system is inspected at least once per week checking the pumping rate, operation of the controller, and condition of PV modules, tanks, wires, and pipes (for leaks/corrosion). Another important aspect to consider is system security. Can the PV modules be secured properly or will they be stolen? It is obvious that without a functioning PV module, the whole system is worthless. The PV modules are one of the most expensive components of the system and should be protected from theft. The PV modules in Phase 1 were located behind the Village Hall while Phase 2 was on the east side of the village.

Figures 1 and **2** show the mechanism of the solar-powered pumping working system





Source: Adopted from Ratterman W., and Cohen J., Garwood A.

9. The leadership of Marubay community-managed water system

The Marubay rural renewable energy model for water supply projects has been in service for 10 years. It is the only renewable energy initiative in Northern Samar that employs a solar energy water pumping system. The challenge is "how one perceives and defines the performance and sustainability of the water system projects is somewhat more complicated than one might imagine". The current status of the water system is its capacity to deliver clean water service to water users. "There are several approaches used to determine which factors are most critical to water supply systems' sustainability", said Whittington (1993)[1], arguing that" this approach will provide insight into the many factors during renewable energy planning, design, installation, operation, and maintenance that affect the sustainability of the water system, as well as the actions taking place during the ongoing operation and maintenance stage of the water project", he added.

The Marubay water supply system is an engineered solution that operates through the social cooperation of the community. This contributes to better outcomes for each resident that would not be achieved through entirely individual efforts. The concern facing the Marubay water system is leadership succession, at which point there is a need for the barangay council to realize that current and future success is heavily based on having the right leaders in the right roles at the right time and with the right skills. Leadership succession planning is an "urgent" or "important" priority to sustain the projects.

10. Water Governance

10.1 Economic, political, and environmental change

Water governance, according to Rogers & Hall (2003), "relates to the range of political, social, economic, and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society". Moench (2003), supports the view of Rogers (2003) that "water governance is much more about how decisions are made (i.e. how, by whom, and under what conditions decisions are made) than the decisions themselves". Simply put, water governance is the set of systems that control decision-making about water resource development and management.

The barangay's fundamental challenge is to continually establish systems of water governance that take account of and adapt to the community, socioeconomic, and environmental conditions that are characterized by uncertainty, variability, and change. The water governance capacity of the barangay must be developed (i.e. information systems, water users' platforms, and local regulatory mechanisms, capabilities, and conflict resolution systems) to enable the community to respond to and adapt to uncertainty, variability, and change that could be local, short or long term, political, economic or environmental. The achievement of effectiveness and efficiency in the delivery of barangay water services should be given greater importance by the barangay council. It is reasonable to assume that Marubay's improvements to water governance are a necessary part of the solution to the specific challenges that fall within this link of water ecosystem management and poverty reduction within the context of climate change.

The following five principles of good governance were adopted to measure Marubay water supply system's good governance (https://www.pubs.iied.org). The participants of the focus interview were asked to give their views on the following principles:

1. **Community Participation**. The barangay council revealed there was direct participation of stakeholders in decision-making, represented by the community in the planning stage of the water system.

2. **Responsiveness.** The barangay council attended to the needs of the community whenever concerns were brought to the fore. For instance, when a repair is undertaken on the system they make sure there is the optimal usage of the equipment and time to reduce or avoid buying new parts if it could be repaired or remedied.

[1] Water resources issues in the developing countries. Water Resources Research 29 (7):1883-1888

3. **Effectiveness & Efficiency**. The Barangay Council was quick to act to make an immediate effect on community needs regarding the water system. It was worthy of attention that the barangay chairman and the council find a way to improve outcomes, by doing something very differently to improve the delivery of the water system. Efficiency was demonstrated by the Council's exertion to ward off wastage of materials, efforts, and money to produce the desired result.

4. **Open and transparent**. All transactions that the barangay committed, in particular, the water system operation and maintenance were legitimate and open.

5. **Rules-based**. The barangay council, particularly the barangay chairman adhered to rules-based decision-making. Local water good governance was tied to prescribed regulation in detail adhering to a set of policies, or rules.

11. Socio-Economic Alleviation

Water and poverty are inextricably linked. Lack of safe water and poverty are mutually reinforcing; access to consistent sources of clean water is crucial to poverty reduction. According to the World Health Organization (WHO), safe drinking water from a source less than 1 kilometer (.62 miles) away and at least 20 liters (5.28 gallons) per person per day (http://www.who.int/water_sanitation_health/mdg).

The operation of the Marubay water supply system has provided residents access to water which played an important role in ensuring equitable, reliable, and productive community. In addition to being an essential element for livelihoods such as agricultural production, nutrition, and human health, water enabled job opportunities such as the setting up of one water purifying station in the community in which the water used c comes from the barangay water service facility. In addition to being an essential element for livelihoods, water has provided appropriate occasions for an enterprising resident to set up a water purifying station in the community in which the water used comes from the barangay water service facility.

12. Community Involvement & Ownership

Water is recognized as a human right that "entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses". The Marubay residents' acceptance of the water project was an important factor in the reliable operation and maintenance of the water system. In the planning phase, community consultations were held to determine their willingness to embrace rural renewable energy technology. Community participation is a quintessential factor in rural renewable energy development and encourages the furtherance of more-human centered approaches in rural energy planning practice.

In Marubay, community ownership was key to the longevity of the water system—which has been 10 years in operation. The community takes pride in its water system and gained a sense of ownership from the service it provides. The fees collected from water users were used to maintain the facility and upgrade the system as needed, with funding assistance from an INGO for Phase 2 of the village or barangay water supply project. To strengthen policies and processes on rural water, the barangay may explore the possibility of creating a Barangay Water and Sanitation Association (BAWASA). BAWASA is a local organization of water supply and sanitation beneficiaries whose objective is to own, operate, and maintain (Level I, II, or III) water system and sanitation facilities in the barangay.

13. Sustainability of Renewable Energy System

The long-term costs and ability of the Marubay renewable energy systems conformed to local changing demands and were considered into the feasibility of the systems. This process was also significantly related to the ability of the village to adapt to changing demands. And more importantly, the greatest concern for the village that shifted to renewable energy water systems was the availability of a local skilled person who designed, installed, and maintained the systems; otherwise, the facility will not last long. The village chairman was taking action to train the village utility to operate and maintain the renewable energy systems; the barangay treasurer controls and manages the income from the water service facility which they could raise themselves. The profit earned from selling systems can be reinvested in new systems.

14. Summary, Conclusion, Challenges, and Lessons Learned

The Marubay rural renewable energy technologies have created considerable opportunities for promoting rural development. Such systems have directly improved the social and economic welfare of the community. Thus, contributing to achieving the Sustainable Development Goals 6 ("clean water and sanitation for all") of providing rural people with safely managed drinking water. However, sustainable project replication is a project's ultimate measure of success or failure. Local institutions (i.e. the local government), including the village, should continually seek to explore the dynamics of rural renewable energy technologies for water application which has demonstrated it can operate reliably with minimum maintenance. For replication to be substantial, several factors must be adequately

addressed: the local population must know the technology and what it can provide; quality equipment and services must be available locally, and must be able to pay for the technology. For the last reason, access to applicable financing mechanisms is the key. The village water service facility is a tailor-made approach unique to this barangay with community participation that has ensured an efficient sense of accountability and ownership of the initiated project for sustainable and convenient access to the water supply system.

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