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Rainwater Harvesting, Quality Assessment And Utilization In Region I

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Abstract

The project harnessed the potential of house rooftops as rainwater harvesters for household use, principally as drinking water. It likewise assessed the system's technical soundness, environmental dimensions, economic feasibility as well as its social and political acceptability.

Technically, the rainwater harvesting system consisting of rooftops, gutters, down spouts, filter and storage tank is capable of collecting/impounding rainwater to supply and support the drinking water needs of 8-12 members of the family throughout the six-month dry period (January-June) of the year. In terms of rainwater microbiological quality, total coliforms and Escherichia coli were of low concentrations (i,e., less than 1.1 MPN/100 ml) meeting the allowable limits set by the Philippine National Standards for Drinking Water (PNSDW). Other quality and aesthetic characteristics of collected/stored rainwater such as the presence of inorganic and organic substances through total dissolved solids as well as its total hardness adequately met the PNSDW values indicating potability of the harvested rainwater. The harvester is economically feasible especially so if construction materials would be limited to locally available ones. Economic analysis showed that the cost of the rainwater harvesting system could be recovered in two years at most. Cost of the system could be significantly lower if more than three families would share in the construction and that the harvested rainwater would be utilized for purposes other than for drinking.

Demonstrating the importance of the system to the community, neighboring families were convinced that it provided water for drinking purposes microbiologically safer than the existing water they have been drinking for years. Result of the survey confirmed the desire of the community to put up similar system as they stressed that their health is of paramount importance and subscribed that the construction cost is not an issue at all. Local government units were likewise of the perception that the system would work in the locality and that they are willing to support the initiative of making the system an important and innovative part of their development plan.

Keywords: water, water scarcity, rainwater harvesting,

Introduction

Water is essential to all life – human, animal and vegetation. It is therefore important that adequate supplies of water be developed to sustain such life. The development of water sources must be within the capacity of the nature to replenish and to sustain. The application of innovative technologies and the improvement of indigenous ones should therefore include management of the water sources to ensure sustainability and to safeguard the sources against pollution. There is now increasing interest in the low cost alternative – generally referred to as "rainwater harvesting". (http://members.rediff.com/asitsahu/)

Rainwater harvesting, in its broadest sense, is a technology used for collecting, conveying and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Rainwater harvesting has been practiced for more than 4,000 years, owing to the temporal and spatial variability of rainfall. It is an important water source in many areas with significant rainfall but lacking any kind of conventional, centralized supply system. It is also a good option in areas where good quality fresh surface water or groundwater is lacking. The application of appropriate rainwater harvesting technology is important for the utilization of rainwater as a water resource.

Rainwater harvesting is simple to install and operate. Local people can be easily trained to implement such technologies, and construction materials are also readily available. Rainwater harvesting is convenient in the sense that it provides water at the point of consumption of family members have full control of their own systems, which greatly reduces operation and maintenance problems. Running costs, also, are almost negligible. Water collected from roof catchments usually is of acceptable quality for domestic purposes. As it is collected using existing structures not specially constructed for the purpose, rainwater harvesting has few negative environmental impacts compared to other water supply project technologies. Although regional or other local factors can modify the local climatic conditions, rainwater can be a continuous source of water supply for both the rural and poor. Depending upon the household capacity and needs., both the water collection and storage capacity may be increased as needed within the available catchmentarea.(http://www.gdrc.org/uem/water/rainwater/introduction.html)

The project was carried out at Barangay Sapilang, Bacnotan, La Union from October to December 2009.

Objectives of the Project

The project aimed at piloting/showcasing rooftop rainwater harvesting as an adaptation strategy against impact of climate change in an upland ecosystem. It showcased how a house rooftop could be effectively and efficiently harnessed to harvest rainwater for domestic or household use.

Specifically, it sought to determine the project's technical soundness, environmental safety, economic feasibility, social as well as political acceptability in terms of the assessed quality (microbiological and physic-chemical) and level of utilization of the harvested rainwater.

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Materials and Methods

Site Identification and Characterization

The study site is located at Barangay Sapilang, Bacnotan, La Union, about 200 meters west of the Don Mariano Marcos Memorial State University- North La Union Campus (Figure 1). It is 16^{o}43'N longitude and 120^{o}21'E latitude. The area falls under Type 2 Climate, with two pronounced seasons, that is, dry from November to April and wet the rest of the year. The area is an upland rainfed usually grown with rice during wet season and vegetable crops during the dry months of the year. Fruit crops such as banana and citrus also abound. Raising of cattle and small ruminants on top of the native chicken and pigs is a common scene in the area. The source of water is a spring which has been observed inadequate to supply the water requirements of the barangay during the entire dry season.

As of 2007, the total population of the barangay under study is 858, equivalent to 140 households.

Project Preparation and Construction

Upon identification of the project site, survey of the house to serve as the rainwater harvesting unit was done. Two adjacent houses, about three meters separating them, were selected for the purpose. Assessment of the capability of the households was done through a personal face-to-face interview. On top of the series of questions asked was the willingness of the households to undertake simple data gathering during the project implementation as well as their share of responsibility in maintaining the project even after its completion.

Figure 1. Map of La Union showing location of the Municipality of Bacnotan

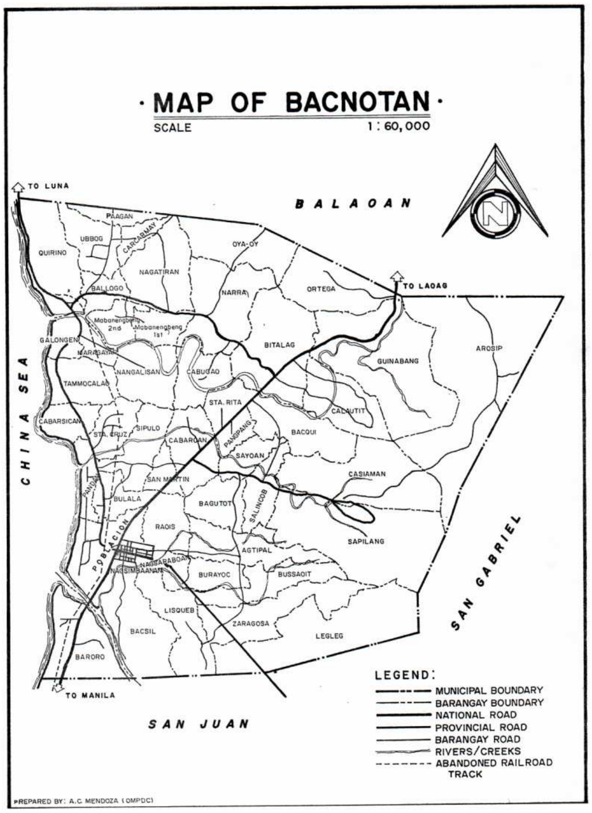

Figure 2. Map of the Municipality of Bacnotan showing the location of barangay Sapilang

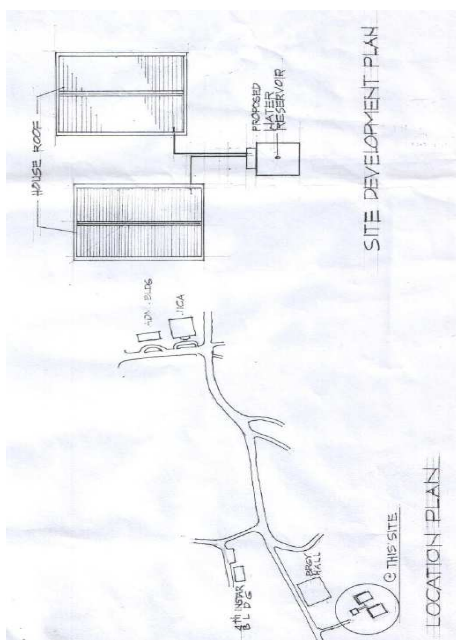

Figure 3. Location plan of the Rainwater Harvesting Project

Considering the subject households' willingness to work with the project management vis-à-vis data gathering and responsibility sharing, the necessary preparation of the project commenced. The roofings as well as their accessories such as gutters and downspouts of the two subject houses were then assessed for proper technical planning and budget considerations. Added to these were the needed calculations on the water requirements of the households as well as their animals and crops. This requirement was made basis in the design and development of the rainwater collecting tank.

The necessary installation of the needed parts of the subject houses such as roofing, gutters, and downspouts alongside the construction of the rainwater collecting tank and its accessories began after the completion of the project technical plan. The DMMMSU-NLUC Planning Office was requested to do the technical plan for the project.

Project Implementation

The project implementation consisted of two parts, the quality assessment and the utilization of the harvested rainwater.

Upon completion of the construction and installation of the necessary accessories of the project, project implementation and data gathering followed. Simple manual for the project implementation to include operation and maintenance activities as well as data gathering instructions was provided to the households. The first few days of the project implementation was confined to do's and don'ts of the operation and maintenance of the rainwater harvesting system as well as the what, where and how to gather data. To ensure accurate gathering of data, qualified research assistants were assigned to assist during the implementation and data gathering period.

Quality Assessment. Determination of the microbiological and physic-chemical data such as total coli form count, *Escherichia coli* (E. coli) count, total hardness, total dissolved solids and acidity of both rainwater before and after rooftop harvesting formed part of the quality assessment phase. Rainwater samples (at 500 ml each) were collected and taken to the Department of Science and Technology Laboratory, Region I at San Fernando City, La Union for analysis. The results of the analyses served as guide in determining the utilization of the rainwater after its collection by way of rooftop as harvester.

Utilization. Utilization of the harvested rainwater was for drinking water and for other household use such as for cooking, dishwashing, house cleaning, bathing, etc. Other uses were in the form of vegetable crop irrigation and provision for backyard animal water requirement.

Other Information and Observation

Kinds of materials used and their costs as well as other economic parameters were also gathered for the purpose of assessing the economic feasibility of the rooftop as rainwater harvester for household use (i.e., cooking, drinking, bathing, washing, and others to include irrigating vegetable crops and supplying water needs of backyard animals).

In terms of social and political acceptability of the rooftop rainwater harvesting project, a simple survey instrument was prepared and was later distributed to the barangay constituents. About 30 percent of the total households (or 40 households) who served as respondents of the study were randomly selected to determine the perceived level of acceptability of the harvester. Barangay as well as municipal officials were also referred to as to the acceptability of the same rainwater harvesting project in their jurisdictions. The level of acceptability ranges from 1-5, with 5 as the highest level described as highly acceptable and 1 as the lowest interpreted as not acceptable at all. For the purpose of getting fresh and accurate responses from these two groups of respondents, they were all invited to the project site to see how the rainwater harvester worked.

Data Treatment and Analysis

Descriptive analysis was done for all the data obtained in the project, which includes frequency, percentage and means determination.

Results and Discussion

Rainwater Harvesting

Figure 1 shows the completed rainwater harvesting system utilizing house rooftops to collect rainwater for multiple household uses. It consists of the following major parts, namely: (a) rooftop as catchment, (b) gutter and downspout as rainwater conduit to the tank, (c) filter, and (d) collecting tank. Each of these composite parts is described below.

a. Catchment

The rainwater catchments are the rooftops of the two houses made of painted galvanized iron (G.I.) corrugated sheets which directly receive the rainfall providing water to the system. The two houses are of gable-type roofs and were designed to withstand the dead load as well as the forces of wind and rain. The rooftops of the two houses (owned by Mr. Nillo family and Mr. Antipolo family) have total surface areas of 56 sq m (7m x 8m) and 30 sq m (3m x 10m), respectively.

b. Gutters and Downspouts

Gutters are channels placed at the edge or end of the gable sloping roof to collect and transport rainwater to the concrete collecting tank. These are called "Spanish gutter" and in semi – circular shape. Downspouts, on the other hand, are pipelines or drains linked to the gutters that carry rainwater from the catchment or rooftop area of the two houses to the harvesting system. They are made up of polyvinyl chloride (PVC).

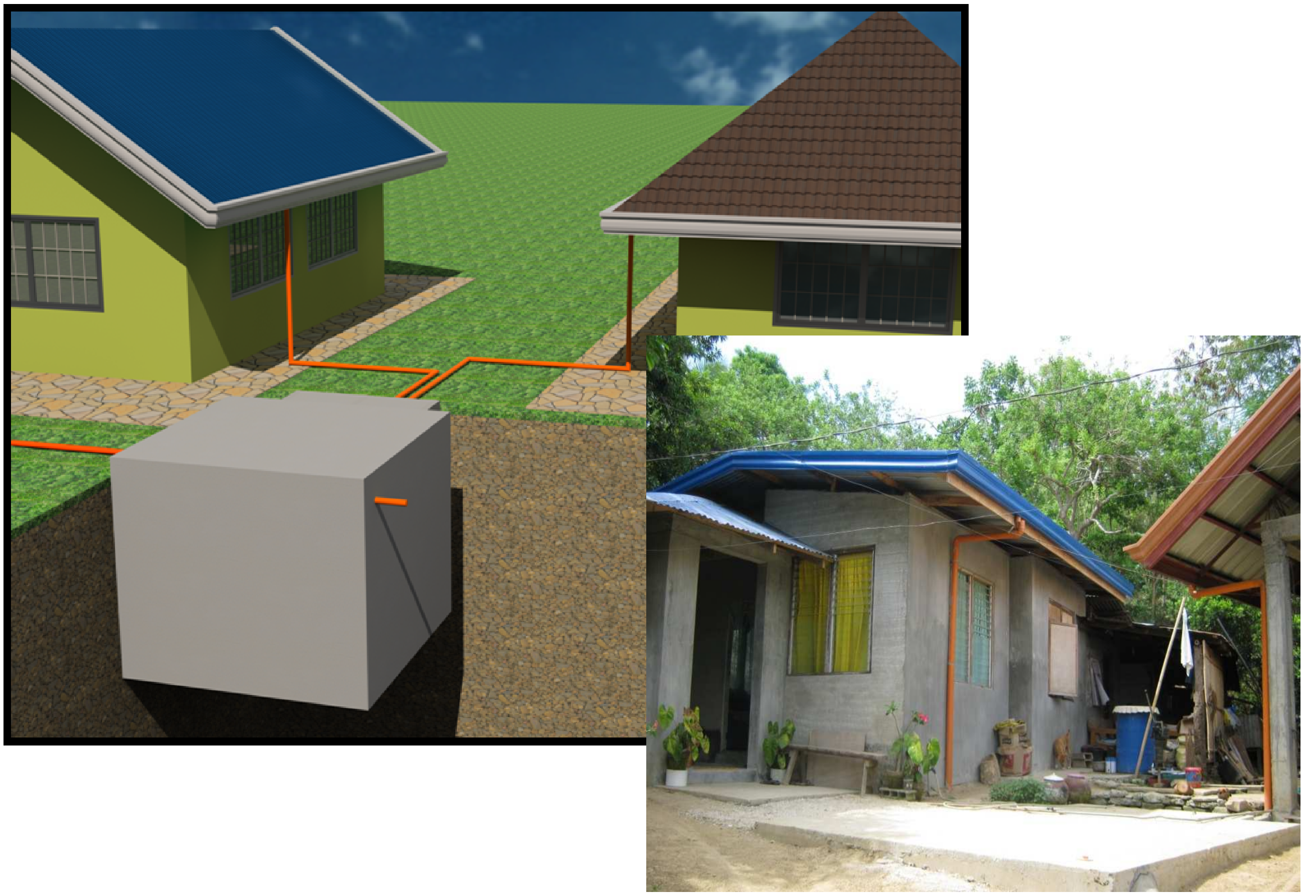

Figure 1. Overview of the Rainwater Harvesting System

c. Filter

The harvester as a system requires first flush device to ensure that runoff from the first spell of rain is flushed out and does not enter the system. This was done since the first spell of rain carries a relatively larger amount of pollutants from the air and catchment surface.

The filtering device measures 2 meters long, 0.5 meter wide and 0.5 meter deep. It is divided into two compartments by a concrete wall having 0.3 meter high allowing water to overflow upon reaching this level moving to the second compartment prior to entering the concrete collecting tank.

The first compartment was filled with three different filtering materials. These are dried empty shells placed at the bottom , coarse white sand at the middle and gravel with medium size at the top and a thickness of 2 cm, 3 cm, and 4 cm, respectively. It is covered with a pre – fabricated reinforced concrete.

d. Rainwater Collecting Tank

The tank measures 3 meters long, 3 meters wide and 2.5 meters deep (or a volume capacity of 22.5 cu m equivalent to 22,500 liters). The walls measure 40 cm long and 15 cm wide and are plastered by a mixture of cement – sand ratio of 1:2 and tiled flooring. It is covered by a pre – fabricated reinforced concrete. A manhole (0.5 m x 0.5 m) was placed neatly at one of the corners.

e. Hand-pump

The hand-pump is used to draw water from the rainwater collecting tank. It is permanently installed between the two houses and about 2.5 meters away from the rainwater collecting tank.

Quality Assessment of Harvested Rainwater

Reflected in Table 1 are results of the microbial and chemical analysis done on the rainwater samples collected from the collecting tank.

Table 1. Summary of the results of the microbial and chemical analyses on the rainwater collected (tank-based)

Microbial Parameter	Level
Total coliform count	< 1.1MPN/100 mL
Escherichia coli (E. coli) Count	< 1.1 MPN/100 mL
Total hardness	122.0 mg/L
Total dissolved solids	68-238 mg/L
Acidity	-68 to -113.0 $CaCO3$/L

Philippine National Standards, 2007: < 1.1 MPN/100 mL (for drinking water); 300 mg/L (for total hardness); 500 mg/L (for total dissolved solids); no standard value for acidity

Multiple Tube Fermentation Technique was used in determining the total coliform count of the water samples. The values reflected in the table are indices used to indicate the number of tubes in which the samples were found positive of coliform. Based on standards set for by the Philippine National Standards for Drinking Water (PNSDW) of 2007, drinking water should be negative of coliform, indicated by an index of < 1.1 MPN/100 mL. With this standard value as guide, the harvested rainwater was therefore safe for drinking.

Coliform bacteria are indicator organisms which are used in water biological analysis. Coliforms are a group of bacteria which are readily found in soil, decaying vegetation, animal feces and raw surface water. “Total coliform” is the collective name used for all coliform groups. The presence of these coliforms is an indication of contamination of the source of water samples. These indicator organisms may be accompanied by pathogens (i.e., disease causing organisms), but do not normally cause disease in healthy individuals. However, individuals with compromised immune systems should be considered at risk (Buenafe, 2005).

Results of the analysis showed that collected rainwater from the tank met the standard of PNSDW for the E. coli count, that is, <1.1 MPN/100mL. Tank water samples did not contain *E. coli* ably meeting the standards set by PNSDW. Todar (1997) stated that there are harmless bacteria that live in digestive tract of animals. These bacteria enter water bodies from human and animal wastes. If a large number of coliform bacteria (over 200 colonies/100 mL of water sample) are found in water, it is possible that pathogenic organisms are also present in water. Coliforms by themselves are not pathogenic; they are an indicator organism, which means they may indicate the presence of pathogenic bacteria (Brown, 1995).

In terms of total hardness, ethylenediaminetetraacetic acid (EDTA) Trimetric Method, 2310B was used in determining the properties of water samples. Hardness is a term used to express the properties of highly mineralized water (high TDS concentrations). Water with more than 300 mg/L of hardness is generally considered to be hard, and water with less than 75 mg/L is considered to be soft. Very soft water is undesirable in public supplies because it tends to increase corrosion in metal pipes; also some health officials believe it to be associated with the incidence of heart disease (Nathanson, 1997).

The 122 mg/L total hardness of the rainwater harvested and collected was within the standard set by the PNSDW which means that it is safe for drinking.

Total dissolved solids dried at 180^0C, 2540C were the method used in determining the combined content of all inorganic and organic substances present in the water samples. Total dissolved solids (TDS) are an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants (Wikipedia, 2009).

Water samples collected from the storage tank were far below the standards set by PNSDW which is 500 mg/L and, therefore, were acceptable for drinking purposes.

As to acidity, Potentiometric Method, 2310B was the method used in determining the acidity of the water samples. Acidity may pertain to the level of pH between acidity and alkalinity. Palintest Alkaphot test which used a colometric method covers the total alkalinity range 0-500 mg/L $CaCO_3$ to check the suitability of natural drinking water. Results of the test indicate that all water samples met the standard of PNSDW.

Utilization of Harvested Rainwater

Beside its use for drinking purposes, the harvested rainwater was likewise utilized for supplying the water requirements of different vegetable crops (*ampalaya*, pechay, okra, squash, pole beans, eggplant and tomato), banana and calamansi grown and backyard animals such as cattle (carabao and cow), small ruminants (goat and sheep) as well as native chicken and pigs raised by the households in the project site. With this add-on utilization of harvested rainwater, the more the rooftop rainwater harvesting became highly economically feasible and viable under the village conditions.

Acceptability of the Rainwater Harvester

Barangay Sapilang is an identified area that lacks supply of water. Based on the information gathered from the community people, this area is seriously experiencing water scarcity most of the time throughout the year due to poor source of water supply. The residents rely largely on a reservoir that was constructed in the school campus. Considering the population in the area, the water supply coming from this reservoir could not completely provide the required volume of water for their daily personal and farm needs. They even organized themselves to plan out other ways and means for another possible source of water. They constructed a deep well somewhere

in their area as a supplemental source of water. Hence, the establishment of the Rainwater Harvesting Project in the area was very timely and a welcome relief in the community.
The community found the rainwater harvesting system as convenient in the sense that it provides water at the point of consumption, and family members have full control of their system, thereby greatly reducing the operation and maintenance problems.

Aside from knowing that rainwater harvested is suitable for drinking, the community noted that it can be used for other purposes such as those mentioned above, that is, for irrigating vegetable and fruit crops as well as supplying the water needs of the animals tended in the backyard. This alone, according to the barangay respondents, justifies the putting up of the rainwater harvesting project in their locality.

Political Acceptability
Various levels of governmental and community involvement in the development of rainwater harvesting technologies in different parts of Asia were noted. In the Philippines, both governmental and household-based initiatives played key roles in expanding the use of this technology, especially in water scarce areas like barangay Sapilang.

Upon showing the advantages and benefits that could be derived from the rainwater harvesting system, the local officials agreed to include the system as priority project of the barangay. The same project was planned to be indorsed to the Local Government Unit of Bacnotan for possible integration to its five-year development plan so that the greater number of barangays in the municipality could benefit from the project.

Conclusions and Recommendations

Conclusions
Based on the findings of the project, the following conclusions were derived:

a. The rainwater harvesting system harnessing house rooftops is technically feasible, environmentally sound, economically viable, socially and politically acceptable.
b. Harvested rainwater is safe for drinking and could be utilized to augment the water requirement of different crops grown and animals raised in the backyard.

Recommendations
Taking into account the above findings, the following recommendations are forwarded:

1. Initiative of piloting the house rooftop rainwater harvesting system be intensified and expanded to far- flung barangays especially to those areas experiencing water quality problems for drinking purposes.
2. The rainwater harvesting system be part of the initiative or part of the ordinance of the local government units under their water for all programs so that regular budget allocation be given to the project.
3. Wide dissemination of the project be done at the LGUs level as an adaptation strategy to address water scarcity attributed to climate change and El Niňo.

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