The Potential of Using Rain Water in Thailand; Case study Bangsaiy Municipality, Ayutthaya

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ABSTRACT

Rainwater has been widely use in developing countries including Thailand. In the study area, Ayutthaya, rainwater is not much in use due to the quality, abundance and low tariff of municipal water supply. However a survey of residents has shown that there is interest in using rainwater for drinking. The community purchases bottled water and treats water by boiling or by on-site purification devices. A high level of demand for rainwater use was found in this study and this is attributed to past practices and a local culture of using rainwater. It was found that more than 90% of respondents were interested in using rainwater if it was of good quality. Piped water tariffs are currently very low in the range of 4 to 5 THB per m^3. Approximately 70% of households from a questionnaire survey were satisfied with the current tariff. However, it should be noted that the true cost of water should be 9-11 THB per m^3. From the same survey, 63% of respondents who currently purchase bottled water are interested in using rainwater as drinking water subject to its acceptable quality. The estimation cost of pilot design is 50,000 to 80,000 THB or 1,200 to 2,500 US dollars.

KEYWORDS

Drinking water, Rainwater, Water Quality, Water tariff

INTRODUCTION

Rainwater is a significant water resource in Thailand due to its abundance. It has been widely used in sectors of the society especially in households and in agriculture. Being dominated by monsoons, rainwater can be harvested mainly in the rainy season which in most parts of Thailand generally starts in June and lasts until October with an average rainfall per annum at 1,500-1,600 mm [1]. Rainwater utilization has been in use for more than 2,000 years in the Thailand [2]. In the past cement and earthen jars have been used as containers for collecting and storing rainwater in Ayutthaya. There is an impending water crisis given the high growth in water demand, the corresponding shortage of water supply, and a possible increase in water tariffs in part due to the need to expand water supplies. This can be offset because of the existence of sufficient levels of rainfall and the availability of the option of rainwater harvesting. Undertaking a pilot project in a province like Ayutthaya which reflects the situation in central part of Thailand to promote rainwater harvesting is an effective way to demonstrate how combining current technologies with existing resources and materials in a cost-effective manner can resolve the water crisis in the years to come.

Given the progress of the country's development, access to basic infrastructure has increased considerably particularly in piped water supply systems serving domestic sectors. In 2002, 95% of Thailand's urban populace had access to some form of water supply but only 82% had the same access in rural areas [3]. It should be noted that only a small proportion of the rural population has access to piped water, which means they had to rely on rainwater and improved water storage. However in recent years, the Thai Government had set a target to provide piped water supply to all villages by 2008. As a result, based on a survey conducted in 2005, approximately 85% of the villages were provided with water supply systems [4]. Several surveys demonstrate that piped water in Bangkok meets official quality standards but those living in rural areas have a slightly lower quality drinking water. This can explain why 80% of rural dwellers used drinking bottled water whereas only 17.5% of urban dwellers drank piped water based on a survey conducted by the National Statistical Office in 2000. Although being inferior in quality to bottled water, the same survey showed that both urban and rural residents still used rainwater for drinking at 25.7 and 16.7 % respectively [5]. Residents in many areas of Thailand are still using rainwater, particularly those who live in remote areas, although the quality is doubtful because of contamination from a polluted environment. A combination of the increased access to piped water supply, availability of bottled water in the market and its coverage, and concerns about the quality of rainwater has caused a decline in rainwater utilization.

Demands for rainwater harvesting in the central part of the country are actually not as high as other regions such as in the northeast which is relatively dry and where alternative water supplies such as rivers and groundwater are of poor quality. However given the current water problems in terms of quality and quantity, seeking alternative water sources like rainwater is becoming essential. In addition water pricing is of concern to Thai residents because of the potential for government water supply agencies to increase water tariffs which are now set at artificially low rates and do not reasonably reflect the actual costs. Therefore, harvesting rainwater not only offers an alternative way of coping with water scarcity, it also can help users particularly in the household sector to save on water bills.

Among the other provinces located in Chao Phraya River Basin in the central region, Ayutthaya is one of the top ranked water users, apart from Bangkok Metropolitan Region[1]. Here water is predominately used for paddy and crop farming as well as in the industrial sector. Water supply in this province comes mainly from two sources namely surface and groundwater. Although the potential for harvesting rainwater is likely as the rainy season last up to 6 months with an average precipitation of 300 mm and a maximum of 900 mm, there is little evidence of rainwater utilization at present. As in other provinces in Thailand, cement and earthen jars were used as containers in the past for collecting and storing rainwater in Ayutthaya but they were abandoned when the local residents were able to access piped water and bottled drinking water.

In general, a lack of stakeholder involvement and assessment of user needs at the beginning often leads to a failure of project implementation. For water supply projects, past experience shows that communities only maintain and pay for water supplies when they feel it is an improvement over existing systems and consider it is worthwhile spending their limited resource on [6].

Hence, this study gives priority to a demand-based approach in investigating user needs to ensure the longevity of designed harvesting devices after they are installed. The identified needs of users in the study area can then be incorporated when considering the design of a pilot project for rainwater harvesting.

[1] Bangkok Metropolitan Region consists of 6 provinces which are Nonthaburi, Pathumthani, Nakornpathom, Samutprakarn, Samutsakorn and Bangkok.
[2] 1 USD = 29 THB

SAMPLING DESIGN

A questionnaire survey is one of the main tools used to identify gaps between current water supply services and to investigate user demands in rainwater utilization in the household sector. Stratified random sampling is a technique applied to design sampling of households by interview. 300 households in the study area were interviewed with a structured questionnaire. Out of 300 samples, the number of households surveyed in each sub-district is then divided to correspond proportionately to its number of households. The survey is designed to cover residents in every village located in study area. In addition the survey attempted to target women as far as possible because they are more involved in housework where water is primarily used.

RESULTS AND DISCUSSIONS

User Demands Assessment of Rainwater Harvesting Systems

In Bangsaiy municipality, there are three sub-districts namely Taoloa, Kaewfah and Bangsaiy. The number of households of each sub-district is shown in Table 1.

Table 1. Selected Users from Public Institutions

Institution	Name	Remark
Temple	Bangsaiy Nai Bangsaiy Nok	
School	Wat Bangsaiy Nai Bangsaiy witaya	Primary school Secondary school
Health station	Taolao	

User demands on rainwater usage in the household sector were assessed predominately by a questionnaire survey. The questionnaire was designed based on literature review to cover four dimensions of demands including quantity, quality, costs, and levels of service. For the operation and maintenance of rainwater harvesting devices after installation, the demand was assessed by interview and field observation. Apart from household users, institutions located in the study area which provide public services to the community including two temples, two schools and a health station were selected to represent the other key water users (Table 1). Their demand was assessed by questionnaire survey and field observation. The same questions in the household questionnaire survey were also used for interviewing those key public institutions.

Before concluding user demands for rainwater harvesting for the study area, focus group discussions were held to reconfirm results obtained from the questionnaire survey and field observation. A leader of each village located in the municipality area, a representative from key public institutions interviewed, officials from the municipality, responsible government agencies responsible for water and sanitation and other key stakeholders were invited to the focus group discussion (Table 2).

Table 2. Key Informants Invited to Focus Group Discussion

Sector	**Key Informant**	**Remark**
Household	Village leader	All leader from each village
Public Institution	Principal of the selected schools	Bangsaiy Nai School Bangsaiy Wittaya School
	Official of the selected health station	Taolao health station
NGO	Chief of Ayutthaya Natural Resources and Environment Volunteers Network	
Local government	Official of Division of Environment and Public Health, Bangsaiy Municipality	
	Official of Division of Water Supply, Bangsaiy Municipality	
	Member of Municipal Council	
Government authority	Official of District Health	

Table 3. Rainwater Characterization in Various Locations at Rajamangala University of Technology Thanyaburi and at Ayutthaya Province

Parameter	**AWDG[1] (2004)**	**Ayutthaya[2]**	**RMUTT[3]**
pH	6.5 -8.5	6.4	6.7
Conductivity (EC) (dS/m)	<0.8	0.082	0.78
Total dissolved salts (mg/L)		55.31	60
Total suspended solids (mg/L)		400	428
Turbidity (NTU)	<5	5.07	42
Water hardness (mg/L $CaCO_3$ equivalent)	<200	47	59
Nitrate (mg/L N)	<50	14.1	18.6
Chloride (mg/L)	<400	1.45	1.35
Sulphate (mg/L)	<400	3.24	5.8
Phosphate (mg/L)		0.86	1.5
Calcium (mg/L)		10.30	21.1
Copper (mg/L)	<2	0.03	0.19
Iron (mg/L)	<0.3	0.54	0.875
Manganese (mg/L)	<0.1	0.001	0.006
Lead (mg/L)	<0.01	0.017	0.174
Zinc (mg/L)	<3	0.15	0.19
Arsenic (mg/L)		ND	ND
Cadmium (mg/L)		ND	ND
Total coliform (MPN/100 mL)	<2.2	6.8	≥1000
Fecal Coliform (MPN/ 100 mL)	<2.2	6.8	920
E. Coli (MPN/100mL)	ND	2	20
DOC[4]		2 .1	3 .3

ND = Non-detectable
[1]Australian Water Drinking Guidelines
[2]Average of 10 samples at each of 3 locations at Ayutthaya
[3]Average of 10 samples at each of 5 locations at RMUTT
[4] DOC = Dissolved organic carbon
Source: Areerachakul (2009).

Areerachakul (2009) [7] tested the quality of rainwater collected from tanks at two sites. Both sites were located in central part of Thailand. The first site was at the Rajamangala University of Technology (RMUTT) situated in the Pathumthani province. The rainwater was sampled from PVC tanks that harvest rainwater from three concrete roofs. The other site was located in the Ayutthaya province. The rainwater tested was sampled from clay jars at five households. The results of testing show that the quality of the water in Ayutthaya meets many of the parametric standards specified in Australian Drinking Water Guidelines (2004) [8] (Table 3). The concentrations of heavy metals were also at or below water quality standards. The quality of rainwater at Ayutthaya has better than the quality at RMUTT in terms of dissolved organic carbon, total coliform, fecal coliform, heavy metal, and minerals. This may be attributed to the heavier pollution in the more urban area of Thanyaburi where RMUTT is located compared to Ayutthaya, which is less urbanized.

Water users in Bangsaiy Municipality can be categorized into two main groups including users from the household sector and public institutions. The background of household users were collected first based on the questionnaire survey and then followed by the collection of background information on other users particularly public institutions based on questionnaire survey and field observation.

Household users

300 households were included in this survey as previously stated. 43% and 47% of all the respondents were males and females respectively. The average household size ranged from 3 to 5 members. Figure 1 presents the percentage of households with one or more families living together and the number of members per household.

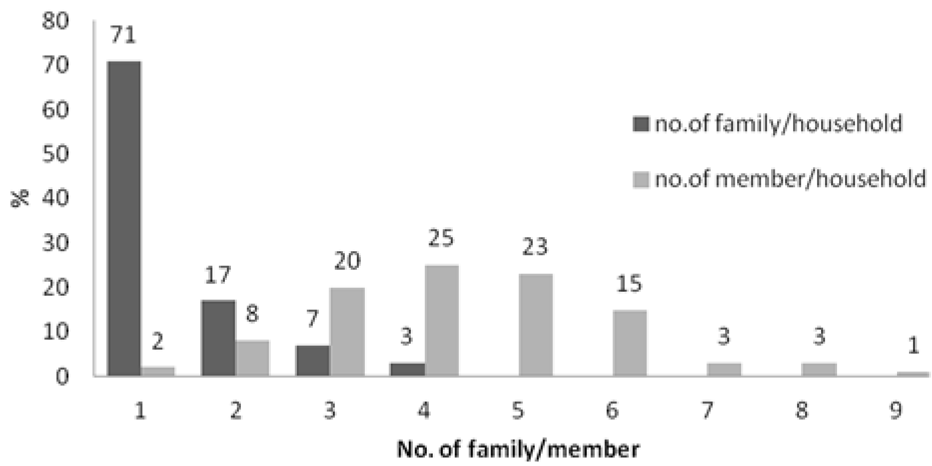

Figure 1. Household Size and the Number of Families per Household

Levels of income are classified into three groups according to the Gross National Income per capital for developing countries (GNI), calculated by using the World Bank Atlas method, which are low (<975 USD pa), low to middle income (976 - 11,905 USD pa) and high income (>11,906 USD pa). Based on the samples, the majority of inhabitants in this municipality can be categorized into the low to middle income group (Table 4) with an average income ranging from 3,500 – 20,000 THB[2] per month per household (approximately 1,050 – 6,000 USD per year).

Table 4. Levels of Income and Education of Respondents

Level of income per month (THB)[2]	**%**
<3,500 - 20,000	71
20,001 - 35,000	14
35,001 - 65,000	8
65,001 - 85,000 up	7

Education influences the perception and decision making of people that choose to use rainwater. Table 5 shows that 55% of respondents either do not have a primary school education or only received a primary school education. Assuming that those that received a primary school education are literate, Table 5 shows that the majority of respondents in this municipality were at least literate.

Table 5. Educational Level of the Residents Surveyed

Educational level	**%**
primary school or less	55
secondary school	24
diploma	11
bachelor degree	10

Public institutions

In this municipal area, there are several water users other than households such as public institutions. Two temples, two schools and one health station were selected as representative public institutions and their background covers only an average number of users in these institutions as shown in Table 6.

Table 6. Number of Users of Selected Public Institutions

Institution	**Name**	**Number of users**
Temple	Bangsaiy Nai*	10
School	Bangsaiy Nok*	6
	Wat Bangsaiy Nai	250
	Bangsaiy Wittaya	800
Health station	Taolao	15

Note: * The number presented includes only monks living in the temples. In a monk holy day and special events of Buddhism, local residents come to the temples to do some activities. The average number of users for such activity could rise up to one hundred per day.

Each household uses rainwater for different functions. Some households use rainwater for more than two functions such as drinking and housework. Figure 2 shows that 37% and 35% of the respondents of the survey who harvest rainwater used it for drinking and gardening respectively.

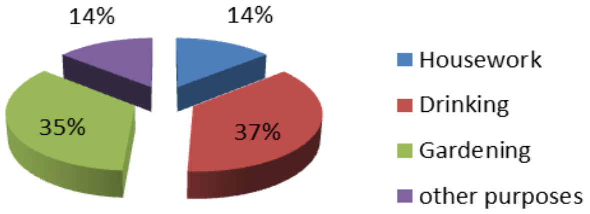

Figure 2. Percentage of Residents using Rainwater in Different Purposes

In terms of responses to the quality of rainwater, the top concerns are water quality and dust contamination. Although the other problems such as smell, turbidity, brackish water and taste were not highly significant, these concerns would still be taken into consideration when a pilot project is designed, (Figure 3). It should be noted that the respondents could select more than one concern for rainwater quality.

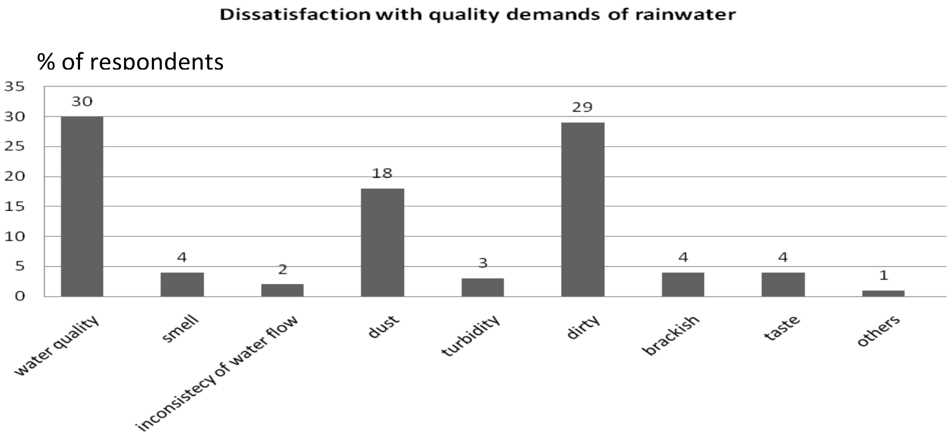

Figure 3. Percentage of Residents using Rainwater in Different Purposes

DEMAND IN WATER SUPPLY AND DRINKING WATER

Household users

The survey showed all respondents are connected to the piped water, Figure 4.

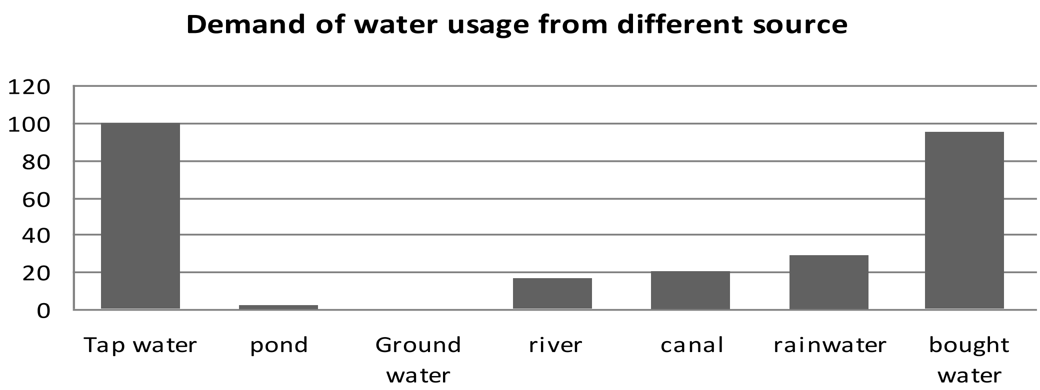

Figure 4. Frequency of Water Users from Different Water Sources

Given various sources of water, the proportion of respondents using water from each source is shown in Figure 4. There are 29% of households using rainwater and 20% of households using water from the river or canal.

In terms of water uses, it is found from the survey that different sources of water were used for different purposes. For example a household may use piped water for housework and showering while bottled water is bought from vendors for drinking while water from the river is taken for gardening. Figure 5 shows that water is mostly used for housework such as cooking and cleaning with the highest proportion of respondents selecting this use as the first rank (42% of respondents). Other than being used for housework, respondents used water for gardening purposes more than drinking as a larger proportion of respondents put gardening usage ahead of drinking.

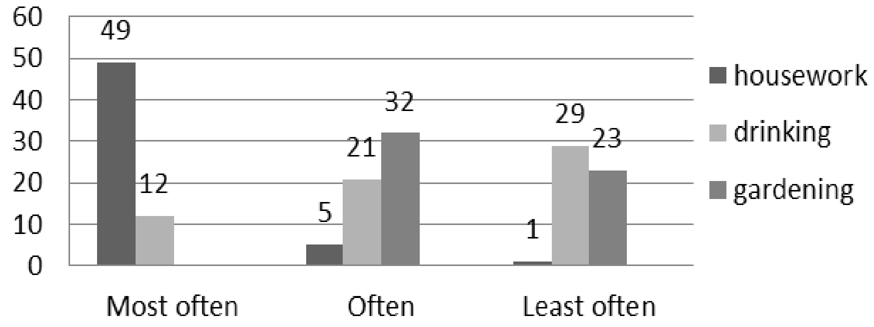

Figure 5. Water Demands in Different Functions

Demands in water include quality and quantity. In terms of quantitative demands, as shown in Table 7, 34% and 33% of the surveyed households use water at the range of 400-600 and 100-400 m^3 respectively. More than 90% of the respondents use less than 800 m^3 of water per month.

Table 7: Frequency Distribution of Volume of Water Demands per Month

Volume of water usage per month (m^3)	**%**
4-10	4.3
10-40	33.0
40-60	34.0
60-80	22.3
80-100	4.3
100-120	2.1
Total	**100.0**

In terms of qualitative demands, those who use piped water are not fully satisfied with the quality of service. Continuity of supply (flowing) is the first concern. Water quality and smell are the other top concerns (Figure 6).

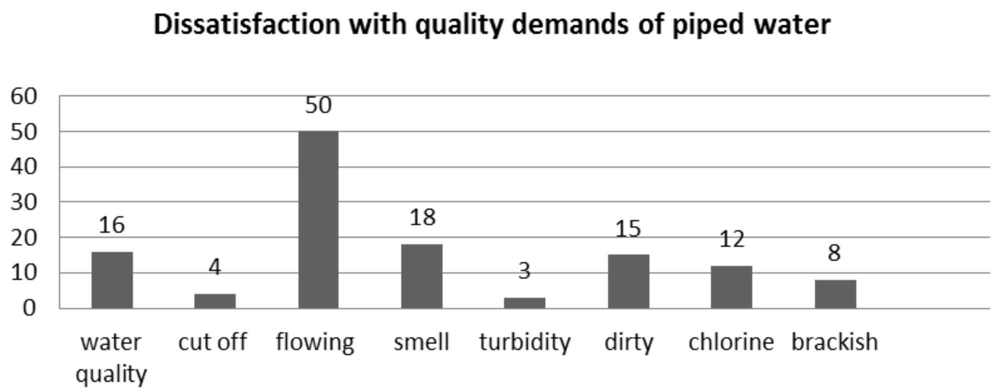

Figure 6. Frequency of Dissatisfaction with Quality Demands of Piped Water

In terms of affordability to pay for water tariffs, 94% of respondents are able to pay on a monthly basis while 6% cannot at times afford the tariff and skip payments. 70% of the respondents perceive that the water tariff is appropriately priced while 30% perceive that it is expensive (Table 8).

Table 8. Percentage Distribution of Perception in Water Tariff

Price Satisfaction	**Percent**
Very Expensive	0
Expensive	30
Appropriate	70
Cheap	0
Total	**100%**

For drinking water, there are three main water sources which are rainwater, piped water and bottled water. There are 65 surveyed households buying bottled water from vendors, 50 surveyed households filtering or boiling piped water before drinking and 16 surveyed households filtering or boiling rainwater before drinking. Bottled water is the most popular while no respondents use raw rainwater as a drinking water source (Figure 7). It should be noted that some respondents obtain drinking water from more than one source. For example, some households buy drinking water from vendors as well as boiling rainwater for drinking.

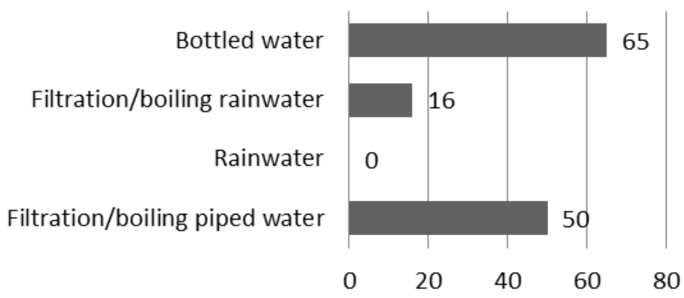

Figure 7. Frequency Distribution of Different Sources of Drinking Water

Public institutions

The demands in water supply and drinking water of selected public institutions were similar to the household sector. All the institutions are connected to piped water. The two temples and Bangsaiy Wittaya School have their owned groundwater wells located on-site while Bangsaiy Nai School and Taoloa Health Station are connected to municipal piped water systems. None of them use rainwater although some of them such as Bangsaiy Nai School have rainwater tanks and jars in place. All the institutions use both piped water treated with an on-site filtration device and bottle water except Bangsaiy Nok Temple which relies solely on bottled water.

Roles and Perceptions of Stakeholders in Rainwater Utilization

Below is a list of stakeholders who play key roles in water supply and sanitation services in the Bangsaiy Municipality. Their roles in being responsible for water supply services and their perceptions in rainwater utilization of each stakeholder are described in this section based on the interview and focus group discussion that was undertaken.

Municipality – The policy of the municipality on provision of water supply and drinking water services are influential in the success of promoting and implementing a rainwater utilization project. Currently, groundwater is only one source of water supply for domestic use. Quantity is not an issue in the municipality area due to the abundance of groundwater resources. Although quality of the piped water is not poor at the moment, the municipality has planned on installing treatment systems to improve water quality for non-potable use. Given that the water tariff charged by the municipality is relatively low, increasing the tariff is likely and it will probably be an issue in the future due to the high cost of electricity for pumping groundwater. At present, the municipality does not have policy in promoting using rainwater as an alternative water source. However if a pilot project of rainwater harvesting is proven to have benefits and the potential is clear, the municipality can provide financial support for replicating the pilot.

Environment NGO – There is an active environmental NGO in the municipality. It consists of students and a group of teachers from the schools in Bangsaiy District. This NGO has a strong linkage with similar NGOs in the other districts of the Ayutthaya province. At present, water saving or coping with water shortage is not a mission of this NGO and neither is rainwater harvesting. However this NGO has a potential to teach and encourage children in the municipality area to make them aware of benefits gained and the importance of rainwater harvesting. The Chief of the NGOs perceives that rainwater harvesting would bring benefits to the local residents as rainwater is a free water resource. Repairing existing collection and storage devices is seen as worthwhile to help reduce the cost of water. Given that rainwater quality is a concern, the NGO suggest that monitoring quality of collected rainwater after installing a pilot project is needed in order to prove the advantages of a pilot project and to educate water users.

Health stations and District Public Health Office – Public health agencies are responsible for the quality of drinking water. These agencies can help test the quality of rainwater harvested and determine whether it meets standards.

Village committees – At present, water supply services in 9 villages of the Bangsaiy Municipality are run by their village committees. Some committees have the potential to manufacture bottled water. Generally, based on questionnaire survey and focus group discussion, rainwater is a preferable source of drinking water for the Bangsaiy residents, if it is treated properly. Hence it is likely that a pilot project can be implemented in such villages where manufacturing of bottled water is taking place. By implementing a rainwater harvesting system which substitutes some groundwater extraction, the villages will be able to save on some of the cost of electricity required to pump groundwater.

Summary in water demand in study area

Water conservation is not a key issue in the Bangsaiy Municipality because of the current low water tariff and abundance of groundwater. The demand in terms of water quantity is being fulfilled. If rainwater is to be used as a source for drinking water its quality needs to be improved. When rain first falls, dirt and dust is washed in the first flush from rooftops.

From the survey, it is found that expenses incurred for drinking water are relatively high. This can be interpreted based on the survey findings that the local residents cannot afford to pay for the high capital investment like installing an on-site purifying water device. This is also evident from the high percentage of local residents who currently buy bottle water. There are two levels of service for the bottled water. In general, private operators offer delivery services at a more expensive price. By contrast, community-owned-enterprises sell bottled water at lower rates but buyers have to collect the water themselves. Based on the ability to pay, a pilot project which has a lower level of service but provides drinking water at a low price is more likely to succeed than a system with a high level of service at a high price. Community-owned-enterprises seem to match these requirements but they need to receive financial support from the government for the initial investment and reserve operating funds.

In the municipality, more than half of households already have devices for collecting and storing rainwater, so designing a pilot project to serve households should not be different from the existing systems to allow people to adapt to it conveniently and successfully. In addition, no additional large budget is required if a pilot project can build upon the systems which have been abandoned. A large pilot project with complicated operation and maintenance system are more suitable for community-owned-enterprises as they are better able to cope with the advanced operation and maintenance systems.

Storage water cost calculation

A heavy duty Ferrocement vessel 20000 L with 2.5 m height is about 40,000 THB or 1,380 USD. For household rainwater jars, costs vary among 2,000 to 8,000 THB.

Urban design approach

Based on the survey of user demands, two scales of rainwater harvesting systems are appropriate to the context of Bangsaiy Municiplaity. One pilot system should serve household users and the other serves public institutions.

Capacity: The maximum volume of rainwater can be calculated by using the below equation.

$$\text{Run off (litres)} = A \text{ x } (\text{rainfall} - B) \text{ x roof area } (m^2) \quad (1)$$

where
A = 80-85% collection efficiency [10]
B = the lost associated with absorption and wetting of surfaces a value of 2 mm per month (24 mm per year) [10]

The estimate tank size can be calculated by using following equation for each month;

$$Vt = Vt\text{-}1 + (\text{ run off} - \text{Demand}) \quad (2)$$

where
V_t = theoretical volume of water remaining in the tank at the end of the month
V_{t-1} = Volume of water left in the tank from the previous month

The volume of run off could be calculated by using 80-85% collection efficiency of using system in first flush**.**

Pilot 1

Technology: The simple treatment for developing countries is a practical treatment method which is inexpensive. Improvement of rainwater quality can be simply made by installing a first flush device which is cut off the first flush of rainwater event. It is easily to be installed, simple operated and available in a number of different sizes to suit to different requirements.

For disinfection, filtration with membranes, radiation with UV and chlorination can be applied. For drinking water, a filtration system with a low- pressure membrane of a pore size of 0.1 mm. can be effectively removed protozoa, bacteria, algae and other microorganisms. A membrane module can consist of a fine-meshed sieve with some 10,000 porous plastic fibers that forms a web within a cylindrical housing. A pump propels contaminated water from outside of the module through the membrane to the inside. Any particle exceeding 0.1 mm. - which includes all bacteria – literally gets stuck. However, the treated water may still be contaminated with some viruses. With a diameter less than 100 nm, viruses are small enough to slip through the pores. That is why a filtration device is therefore coupled with a disinfection system. The study by Areerachakul (2009) demonstrated that the combination of Granular Activated Carbon

(GAC) – biofilter- and submerge membrane could be another option to treat the rainwater to meet the drinking water standard.

Table 9. Components of a Pilot Project and its Cost Estimation Designed for Household Users

Components	Cost (THB)	Specification
Storage system		
A plastic tank	20,000 - 30,000	Volume of 6,000 to 7,500 L per tank
A pump	7,000 to 10,000	0.367 kW shallow-well at 138-207 kPa
Screen covering the cistern	<3,000	
Plastic pipes	Costs are varied depending on length and diameter	PVC for outdoor and CPVC for indoor
Conveyance system A roof-washer	Varied based on roof area but <10,000	
Water diaphragm pressure storage tank	5,000	Volume of 6,000 L
Treatment system		
A series of filters	800 THB each	Pore sizes at 20 and 5 μm
Replaceable filter cartridges	3,000	
An ultraviolet light	15,000	• Sterilizing capacity at 38 L per minute • 40 W

Therefore, the pilot project of rainwater harvesting system for potable use should compose of i) first slush device, ii) gutter, iii) pipes, iv) storage tanks and v) treatment systems. For the pilot project materials of harvesting systems could be available in various materials based on catchment size, rainfall daily, and cost of material.

Capacity: ≈ 20,000 L

Location: In this study, a possible site suitable for the pilot project is the household where water treatment systems for drinking water are put in place and its location is at the centre of the community. This house which is a grocery currently provides drinking water for their relatives and sells bottled water. Additionally, its catchment area is large enough to serve for 3-4 households.

Cost estimation and financial assistance: Costs of a pilot project of rainwater harvesting system serving for a household without water treatment systems are estimated at less than 50,000 to 80,000 THB. Such system consists of below components.

Maintenance costs are approximately 5,000 THB per year which include costs of cleaning the gutters, cisterns and screen. Replacement of UV lamps and filters need to be done periodically. Cost of a fluorescent tube is about 3,500 THB.

Appendix III-A gives an example of detailed designing and cost estimation of a rainwater harvesting system with a 20,000 L of ferrocement vessel.

For the system without treatment process because of existing treatment system, the cost could less than 100,000 THB as shown in Table 9.

Critical success factors: Public health authorities recommend periodic testing of water for faecal coliform bacteria to make users confident in rainwater quality.

CONCLUSIONS

Integrate water resources management are necessary in Thailand. The only use of ground water now can cause subsidence of land. In Ayuthaya, ground water is major source of water supply. It is also use as source of drinking water. Based on its quality, cost of treated ground water is much higher than rainwater. Thus, rainwater could be high potential as alternate resource for drinking water.

Similar to other regions in Thailand, rainwater has been an important source for domestic water supply for both non-potable and potable use in the study area of Bangsaiy Municipality for a long period of time. Being located in Ayutthaya where the average annual rainfall is 1,347 mm and although not as high as other regions such as the southern part of Thailand, if harvested, the rainfall in the municipality is sufficient for portable use particularly drinking and cooking throughout the year and for other domestic purposes during the long rainy season. Although the quality of rainwater has been of much concern to the local residents due to increased pollution in the environment, in accordance with past studies and research, chemical parameters particularly heavy metals still meet the drinking water standards. High biological contaminants which mainly come from flushing rooftops when rainwater is harvested at the beginning of the rainfall can be alleviated by improving rainwater collection methods, installing simple treatment systems such as first flush devices and hygienic handling of rainwater. According to the questionnaire survey and field observation, approximately, one third of households have rainwater conveyance and storage facilities in place, although some of their facilities are not in good conditions. Based on supply side considerations, there is no doubt, there is a high potential in rainwater harvesting in small urban areas like Bangsaiy Municipality.

A pilot project must be designed in a way that can prevent these contaminants from polluting the harvested rainwater. Apart from designing a pilot project to meet the user demands, educating water users to realize the benefits to be gained from rainwater harvesting pilot project is very important. Community education should be conducted to make them appreciate the quality of rainwater.

The example of appropriate design are shown in the estimate cost about 50,000 to 80,000 THB.

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