RAINWATER HARVESTING SYSTEM EVALUATION: A RESIDENT EXPERIENCE IN SABAH,MALAYSIA

A.I. Che-Ani
Department of Architecture, Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia
adiirfan@gmail.com

N. Shaari
Department of Architecture, Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia
archi_huda@yahoo.com

H. Yahaya
Department of Quantity Surveying, Faculty of Architecture and Built Environment,
International University College of Twintech Technology
achah80@gmail.com

A.S. Ali
Department of Building Surveying, Faculty of the Built Environment,
University of Malaya
asakwsp@tm.net.my

M.F.M. Zain
Department of Architecture, Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia
fauzi@vlsi.eng.ukm.my

ABSTRACT

This paper looks into the rainwater harvesting (RWH) practices in Sandakan, Sabah, Malaysia. As a background, the water crisis that occurred around 1998 is a starting move in implementing the RWH system in Malaysia. Malaysian government under Ministry of Housing and Local Government (MHLG) set up a working group that looks into the mechanism in incorporating rainwater system to the building in Malaysia. Among the earliest project implemented is the RWH system in Sandakan, Sabah. This study focusing into the residents experience towards the effectiveness of RWH system, in term of minimizing the environmental problems, the benefit of RWH as well as the implementation issue in relation to RWH. The research conducted among 25 respondents from Sandakan. The methodology adopted is using the personally-assisted questionnaire survey and the data is analyzed using the SPSS, in identifying their level of agreement towards the effectiveness measures. The main finding reveals that the implementation of RWH can reduce the problem of water crisis, reduce water bill and among the problems highlighted is not enough professional to design the RWH system, particularly for the housing scheme. The impact of this study is to the design professionals and Malaysian government, as to seek better solution in promoting the RWH in Malaysia.

Keywords: Building system, performance evaluation, rainwater harvesting, resident experience, sustainability

1.0 INTRODUCTION

Malaysia is one of the countries in the world nowadays that having a rapid growth of population and expansion in urbanization, industrialization and irrigated agricultural. In the global arena, Malaysia is now well developing because of the positive structural change in the economy since independence in 1957. With this development and from time to time, a lot of infrastructure and amenities such as water supply, electricity, transportation, environment and drainage has been strained because of the growth (Weng *et al.*, nd).

The impacts of the growth have put excessive demands on water supply and water resources. Pollutions are one of the threats that burden existing water resources production in order to meet the demand. In 1998, Malaysia facing the serious water crisis because of the drought from climate changes (El Nino Phenomena) and it is reported in the media as shown in Figure 1 (a. Drought cause the plant dry; b. and c. Water problem is getting critical). Due to this, Lembah Klang is one of the top critical places having the water crisis. The State Water Board has to ratio all the water supply to make sure the entire user get enough water at that time. Government has listed some of the effort that can be used for water shortage; rainwater harvesting system is a part of it (Mohd.-Shawahid *et al.*, 2007).

Figure 1: News on water crisis in 1998 (Berita Harian)

Malaysian government under Ministry of Housing and Local Government (MHLG) set up a working group that looks into the mechanism in incorporating rainwater system to Malaysian building. Among the earliest project implemented is the rainwater harvesting system in Sandakan, Sabah. This study focuses on the rainwater harvesting (RWH) practices in Sandakan, Sabah, Malaysia and the residents experience towards the effectiveness of this system. 25 respondents from Sandakan were selected to conduct this research. The methodology adopted is using the personally-assisted questionnaire survey and the data is analyzed using the SPSS, in identifying their level of agreement towards the effectiveness measures in term of minimizing the environmental problems, the benefit of RWH as well as the implementation issue in relation to rainwater harvesting. The main finding reveals that the implementation of RWH can reduce the problem of water crisis, reduce water bill and among the problems highlighted is not enough professional to design the RWH system, particularly for the housing scheme. The impact of this study is to the design professionals and Malaysian government, as to seek better solution in promoting the RWH in Malaysia.

2.0 RAINWATER HARVESTING SYSTEM AND ITS SCENARIO

Rainwater is a part of hydrologic cycle; the never-ending exchange of water from the atmosphere to the ocean and back again. Every raindrop like hail, rain, sleet, snow and all the consequently movement of water in nature forms from this cycle is very soft and the cleanest water sources in this world (Texas Water Development Board, 2005). The falling raindrop acquires slight acidity as it dissolves carbon dioxide and nitrogen (MHLG, 2008).

Rainwater quality always exceeds the surface water as comparable to ground water because of it does not come in contact with soil and rocks where it can dissolve salts and mineral which is harmful for potable and non-portable uses. In the other hands, rainwater is valued for its purity and softness. The rainwater quality usually can be influenced by geographic location, activity in the area and storage tank (Texas Water Development Board, 2005). However, with minimal treatment and adequate care of the system, rainwater can be used as potable water as well as for irrigation.

Rainwater harvesting is a traditional practice that dates back hundreds of years ago. According to the archeological evidence, the concept of rainwater harvesting has been used as far as 6,000 years ago in China (Texas Water Development Board, 2005). Rainwater has been the main source of water supply for potable and non-potable uses in the old days because the water supply systems were not developing yet. The method of rainwater harvesting at that time was very simple. Usually, the rainwater was mostly collected from roofs and sometimes directly collected (Thamer et al., 2007). Usage of the collected water volume from rainwater harvesting was direct and without any treatment.

Generally, rainwater harvesting system is the direct collection of rainwater from roofs and other purpose built catchments, the collection of sheet runoff from man-made ground or natural surface catchments and rock catchments for domestic, industry, agriculture and environment use. Normally, the size of rainwater harvesting was based on the size of catchment area (Thamer *et al.*, 2007).

Rainwater harvesting system has been implemented in many countries such as United States of America, United Kingdom, Japan, China, India, Africa, Germany and Australia to support the increasing water demand (Thamer *et al.*, 2007). The integration between rainwater harvesting system and existing conventional water supply systems will help to meet the demand and contribute in the sustainability of the water supply.

Collected rainwater can be use not only for potable and non-potable; but also can be used for irrigation and landscaping. Plants can thrive on rainwater very well because of its purity; free of salts and other minerals that harm root growth. Rainwater forces salts down and away from root zone when it percolates into the soil. This process allowing roots to grow better and makes plants more droughts tolerant.

There are six main elements in rainwater harvesting system as in Figure 2. They are catchment area, gutter and downspout, filtration system, storage system, delivery system and treatment. Due to the previous research (Gould, 1999; MHLG, 2008; Porter *et al.*, 2008; Rainwater Harvesting, 2006; Texas Water Development Board, 2005), rainwater harvesting has a lot of benefits; not just for users but also to environment and government. In short, Figure 3 shows some of the benefits from rainwater harvesting system.

Extreme climate events such as drought and flood happened frequently nowadays because of the global weather change. This event affected the water resources utilization for various purposes. As a result, many countries adopting strategies to conserve the available water resources including promoting the usage of rainwater harvesting system not only for households users; but also for landscaping and agricultural.

Malaysia receives plenty of rainfall throughout the year and because of that Malaysia experiences a wet equatorial climate regime. In fact, there is no distinct dry season in any part of the country (Weng *et al.*, nd). Malaysia has an average rainfall around 3,000 mm a year -

Peninsular Malaysia averaging 2,420 mm; Sabah averaging 2,630 mm and Sarawak averaging 3,830 mm (Salmah and Rafidah, 1999). Figure 4 show the average rainfall pattern since 1997 to 2007.

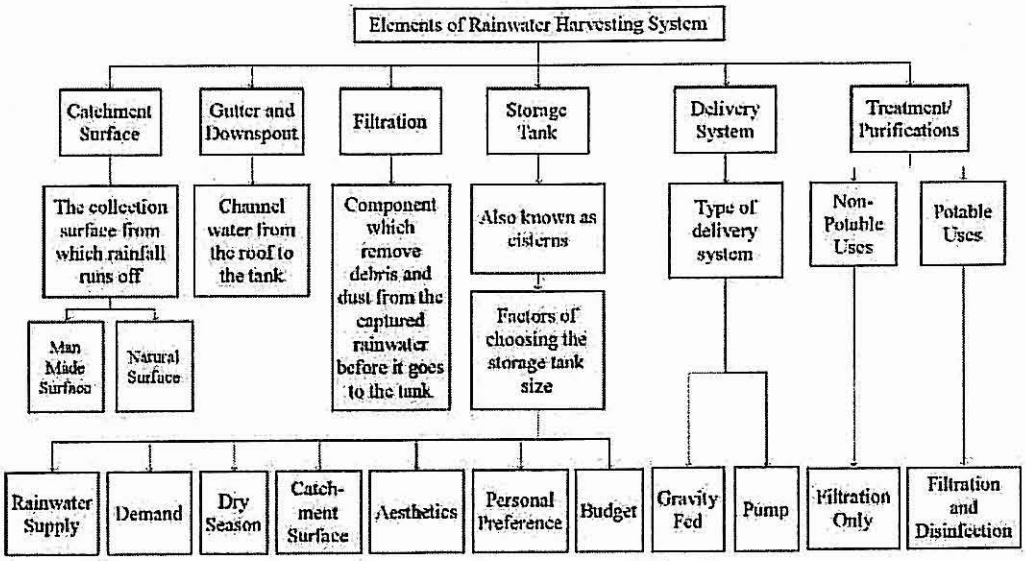

Figure 2: Elements of Rainwater Harvesting System

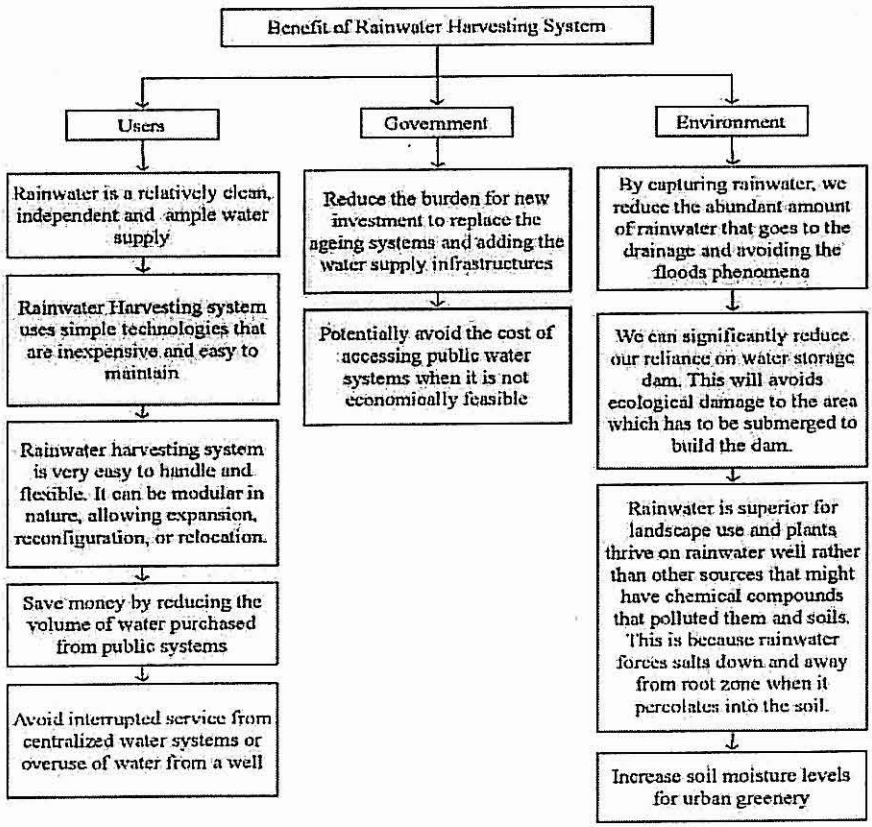

Figure 3: Benefits of Rainwater Harvesting

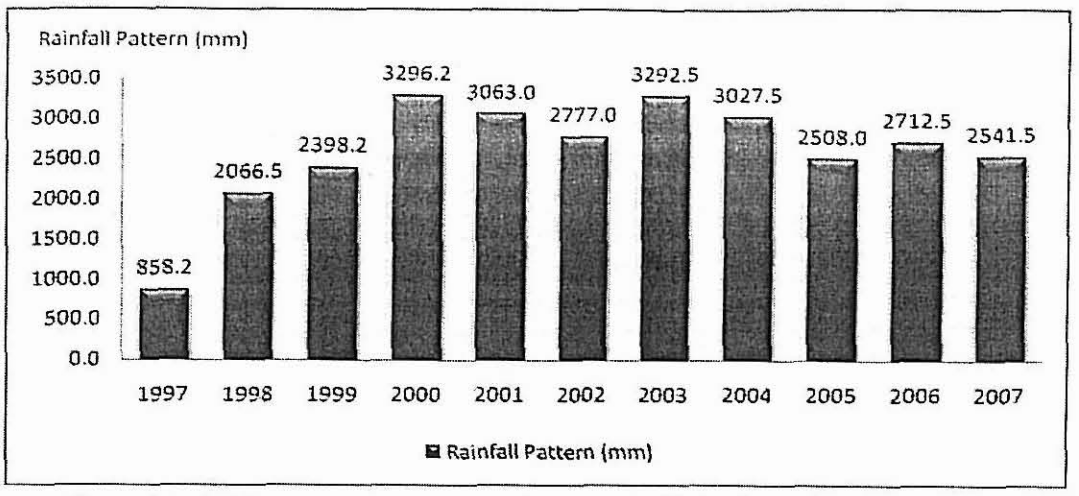

Figure 4: Rainfall Pattern (Adapted from Department of Irrigation and Drainage, 2008)

Presently, the existing water supply systems have improved but the demand is increasing due to the population growth and expansion in urbanization, industrialization and irrigated agricultural. The prolonged dry period due to global weather change can be considered as another factor effecting water supply. The available water resources are limited and/or seasonal which made the experts working in the water sector to search for solution to the water shortage (Thamer *et al.*, 2007). A systematic support to local innovations on rainwater harvesting could provide substantial amounts of water and reduce demand on water supply systems.

Rainwater has a lot of potential in Malaysia as main water resource for the future because of its high quality. Every raindrop acquires slight acidity as it dissolves carbon dioxide and nitrogen from air pollutants (Texas Water Development Board, 2005; MHLG, 2008). Usually, contaminants captured by rain from the catchment surface and storage tanks. The catchment areas may have dust, dirt, animals fecal and plant debris such as leaves and twigs. Simple treatment such as filtration and disinfection equipment can be used to improve the quality of rainwater. There are five factors affecting the rainwater quality; (i) pH, (ii) particulate matter, (iii) chemical compounds, (iv) catchment surface and (v) tanks (Texas Water Development Board, 2005).

Rainwater can be used for potable and non-potable uses. Drinking, bathing, cooking and dish wash are categorized as the potable uses while non-potable are the other from these. Rainwater must be treated to remove contaminants for potable uses to avoid any dissemination disaster. Contradictory from non-potable uses, treatment is not required. With high quality and minimal treatment, rainwater will help the user to meet their demand for the quality living in the future.

According to National Hydraulic Research Institute of Malaysia's (NAHRIM) research, 34 percent of collected rainwater has be used by household of six people (two adults and four school going children) for non-potable purpose per month. It means that 34 percent of treated water has been saving from non-potable use per month. As a result, the water bill also can be reduced.

3.0 IMPLEMENTATION OF RAINWATER HARVESTING IN MALAYSIA

Rainwater harvesting system was introduced after the 1998 drought by Ministry of Housing and Local Government (MHLG). The 1999 'Guidelines for Installing a Rainwater Collection and Utilization System' can be seen as the initial phase of the rainwater harvesting policy in Malaysia. The main purpose of these guidelines is to reduce the dependence on treated water and provides a convenient buffer in times of emergency or a shortfall in the water supply. It also proposed the construction of 'mini dams' or rainwater tanks in urban area instead of continuing to build giant dams upstream (Mohd.-Shawahid *et al.*, 2007). This guidelines is intended as an 'ideal manual' for

reference for those who want to install a rainwater harvesting and utilization system (MHLG, 2008).

After five years of this guidelines, namely in 2004, the Ministry of Housing and Local Government has prepared another cabinet paper to the National Water Resources Council to encourage government buildings to install a rainwater collection and utilization system. The Council has later announced that rainwater utilization is to be encouraged, but not mandatory. The Department of Irrigation a nd Drainage and The Ministry of Energy, Water and Communication (KTAK) are the two government agencies that implement the rainwater harvesting system in the early. The acceptance on rainwater harvesting system in the beginning is not good enough. Only few areas like Sandakan and Shah Alam that has introduced rainwater harvesting system in new housing developments (Mohd.-Shawahid *et al.*, 2007).

In 2005, the Federal Constitution has been transferred all matters related to water supply services from State List to Concurrent List (Mohd.-Shawahid, *et. al.* 2007). This enable the Federal Government involvement in the water services sector and to establish regulated water services industry. Due to this, Ministry of Energy, Water and Telecommunication (KTAK) has come up with two new water related laws; Water Services Industry Act 2006 and Water Services Commission Act 2006. In the new act, the Ministry is actively involved in the water saving programs which encouraging rainwater harvesting system implementation. Figure 5 shows the development of rainwater harvesting implementation development in Malaysia since 1975 until present.

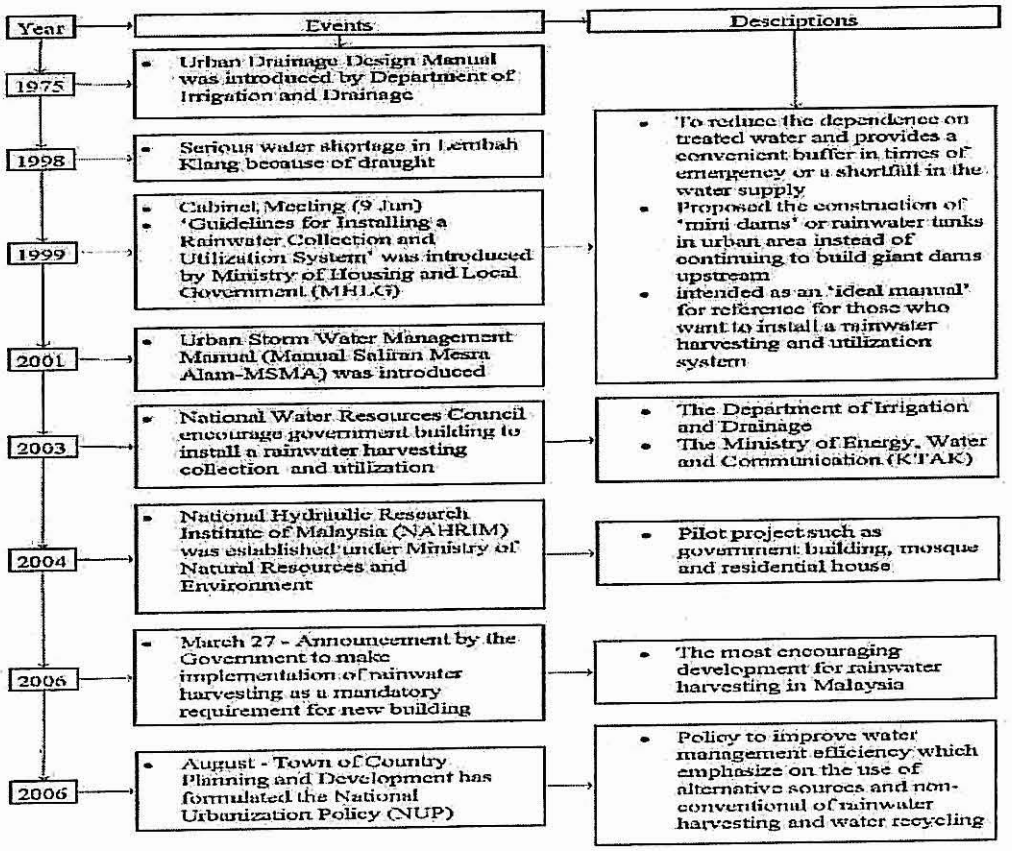

Figure 5: Development of Rainwater Harvesting System Implementation in Malaysia

4.0 CASE STUDY: RAINWATER HARVESTING FOR SANDAKAN HOUSING DEVELOPMENT

Situated in the East Coast of Borneo Island, Sandakan was the second largest town in Sabah. In 1984, Sandakan has forcing the critical water shortage when government cannot supply enough water for the people. Due to this, the local authorities of Sandakan have planned the policy guideline to encourage the housing developer to provide a rainwater storage tank for new residential building. Each tank provided by housing developer should collect at least 400 gallons of water. The implementation of this policy was suspended when the new water supplement system at Kinabatangan River was constructed a few years later.

In early 2000s, Sandakan once again having the critical water shortage due to the global warming. The main sources for the water supplement system; Kinabatangan River water level has declined and affected the daily water supply to the users. The State Water Board has to ratio all the water supply; around twice a week in different places in Sandakan to make sure all the people get enough water every day. The only five days of treated water per week is not enough for the people to do their activities such as washing, cooking, watering plants and etc.

As solution for the problem, Sandakan people established the Sandakan Water Watch Committee to scrutinize this crisis on 14th May 2001. As the conclusion, they once again determine to publish rainwater policy that have been use before and make it compulsory for all housing developments in Sandakan on 1st June 2001.

Climate zones can be defined using parameters such as temperature and rainfall. Sandakan is having the tropical climate because of the location which is near to the Equator Line. The important features of the climate are the continuous warm temperatures (21°C to 32°C), high moisture ratio and the seasonal distribution of rainfall.

Normally, there are three types of rainfall in Malaysia. They are convection, hill and cyclone. However, there is considerable variation in the averages of annual and monthly distribution of rainfall by location. This situation same goes to the Sandakan. The average annual rainfall ranges from 1,500 mm to 4,000 mm in Peninsular Malaysia while Sabah and Sarawak about 20 % to 40 % more rainfall than Peninsular Malaysia. Thus, Sandakan receives annual rainfall about 3,500 mm every year. Figure 6 shows the average monthly rainfall receives in Malaysia.

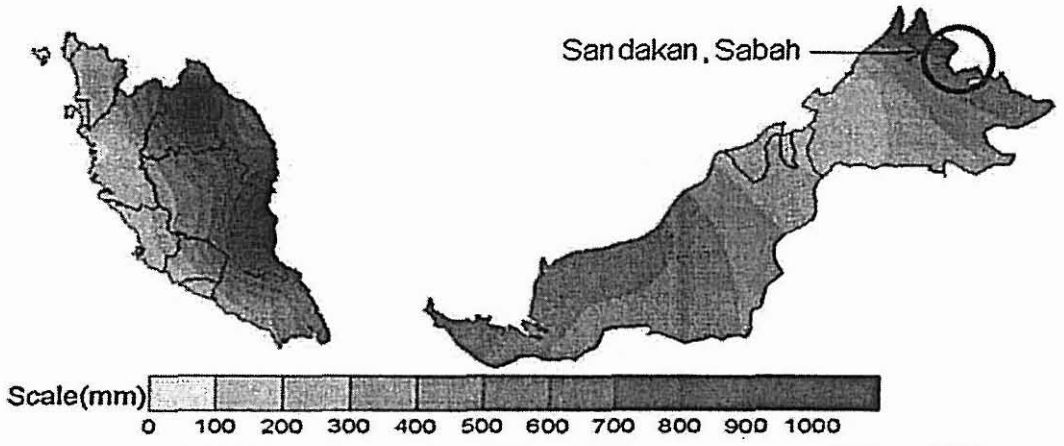

Figure 6: Rainfall Total for a month in Malaysia (httpwww.met.gov.my/iklim terkini/)

There are three types of rainwater harvesting system in Sandakan; backyard system, frontage system and underground system, as summarized in Figure 7. These systems should have the storage tank with 400 gallons capacity. Rooftop rainwater is collected by the gutter device and discharge to storage tank above the ground through rainwater down pipe.

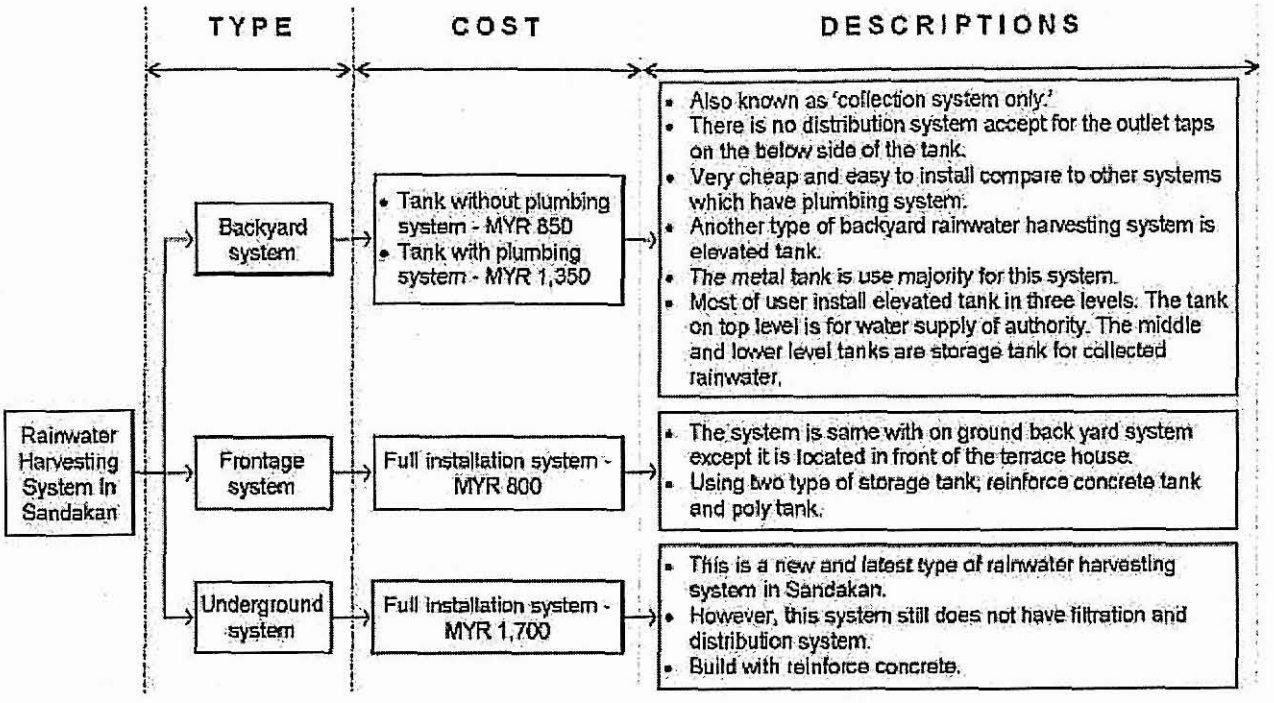

Figure 7: The Type of Rainwater Harvesting System in Sandakan

Backyard System

This system is one of the most popular among the residents in Sandakan because it is very cheap and easy to install compare to other systems which have plumbing system. Backyard system also known as 'collection system only' because of there is no distribution system accept for the outlet taps on the below side of the tank. These systems have two kinds of style to locate the storage tank; on the ground and elevated. Elevated tank usually installed in three levels. The top level is for water supply of authority while the middle and lower level tanks is storage tank for collected rainwater. Users normally use metal tank for elevated style and poly tank for on ground style.

The cost for the installation tank without plumbing system is only MYR 850.00. The owners have to pay about MYR 1,350.00 if they want to include the plumbing system for this installation. The installation of exposed storage tank is obtaining a very good support from housing developers and owners because of low cost and easy to install. In addition, the front and back setback for Sandakan housing a least 15 feet is make the maintenance and replacement work became easily.

Frontage System

Normally, frontage system also has a same installation concept with backyard system. Poly tank has been replace with reinforce concrete tank to maintain the maintenance process. Poly tank still can be used in certain circumstance however, concrete is more endurance than poly tank which make it more reliable. The total cost for this installation is only MYR 800.00.

Underground System

Underground system is a new system that has been installed in Sandakan. This system provided with a pump but does not have filtration and distribution system. It was build with reinforce concrete. According to developer, average cost for underground tank installation is around MYR 1,700.00.

5.0 METHODOLOGY

The research was conducted towards 25 respondents from Sandakan. The data collection was carried out using a set of questionnaires, with the approach of personally-assisted questionnaire survey. The evaluation was set on nominal and ordinal scale given as 0% disagree to 100% agree, that is interpreted as 'disagree at all', 'disagree', 'neutral', 'agree' and 'very agree. In order to simplify this report, answer belonging to 75% agree and 100% agree are group together as "agree" and answer belonging to below 25% agree and not agree at all are group together as "disagree" while 50% agree and not sure are group as "neutral". For this report, the figures of respondent's agreement level are for "agree". The questionnaire contains three main section; respondents' profile, water consumption and effectiveness of rainwater harvesting system. For the purpose of this paper, only a few parts of the questionnaire that has been analyzed.

6.0 RESULTS AND DISCUSSION

Respondent Profile

Analysis of the data indicates that out of the 25 respondents, it was found that 48% of the respondents are male and the other 52% of the respondents are female. Most of them are Chinese (52%), followed by Malay (32%) and the other 16% of respondents are Bumiputera. Besides gender and race, their education level also was identified. 40% of respondents come from secondary level, 32% of them from college, 24% of them have certificate from universities and 4% of the respondents come from primary level category. Table 1 shows the summary of the respondent profile.

Table 1: Summary of the Respondent Profile

Profile	Respondent	Percentage (%)	Total (%)
Gender	Male	48	100
	Female	52	
Races	Bumiputra	16	100
	Malay	32	
	Chinese	52	
Education Level	University	24	100
	College	32	
	Secondary	40	
	Primary	4	

Rainwater Usage in Sandakan

According to the questionnaire, 80% use the rain water for gardening, 68% for cleaning house (outdoor) and 64% use rainwater for cleaning vehicle and flushing toilet. Figure 8 shows the percentages of respondent in utilizing the rainwater.

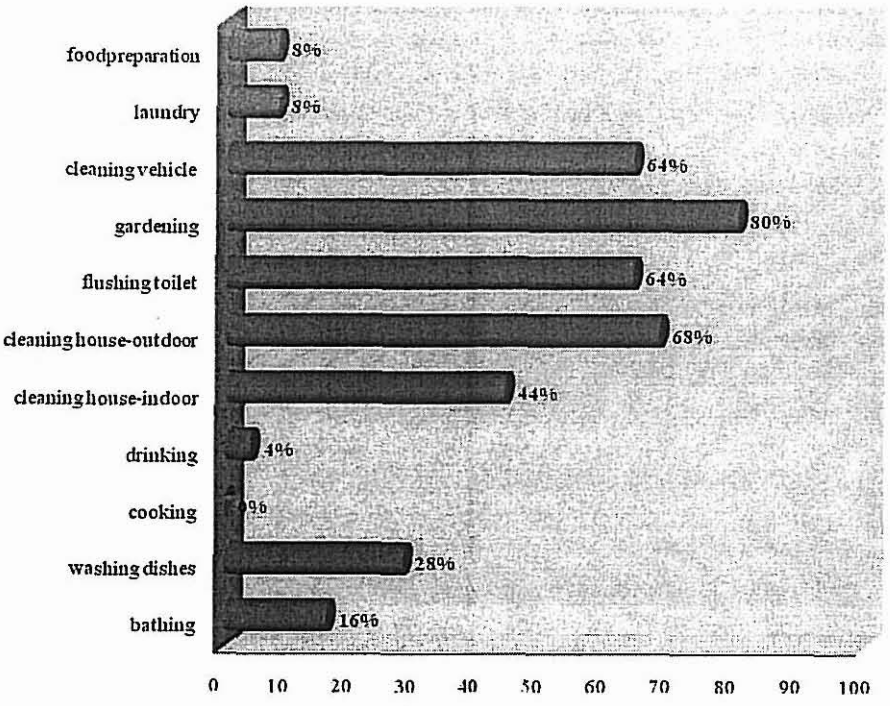

Figure 8: The Rainwater Usage in Sandakan

6.1 Resident Experience of Rainwater Harvesting System In Sandakan

Minimise Problems

Rainwater harvesting can minimize the problem of water crisis, radiation, air pollution, acid rain, global warming, prevent hot spot and flashflood. Based on Figure 9, the residents feel that the implementation of rainwater harvesting system can minimize the water crisis which has a score of 52% (the highest score). The second problem that can be minimized is prevention of hot spot and follow by the third one, namely flashflood.

From this finding, it shows that the resident had experienced the rainwater harvesting system can minimized the water crisis, prevent hot spot and flashflood. The pushing factor for this finding is perhaps the resident have experienced the impact of serious water shortage some other time ago such as rationing water supply twice a week from the State Water Board. This make them strongly believed and agreed that rainwater harvesting can minimize the water crisis problem.

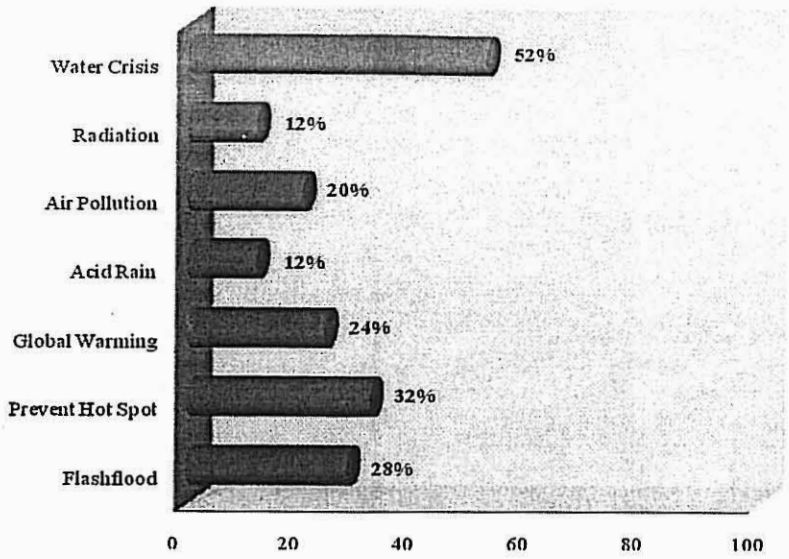

Figure 9: Respondent's Agreement Level on Minimize Problems

Benefits

Rainwater harvesting has a lot of benefits such as control climate change, improve river mgt, reduced soil erosion, reduced water bill, increased groundwater level and agricultural productivity. Based from Figure 10, the residents feel that rainwater harvesting can increased agricultural productivity and reduce water bill which has a score of 56% (the highest score). The second benefit of rainwater that respondent noticed by using rainwater harvesting is increase groundwater level and the third; reduce soil erosion.

From this finding, it shows that respondent had experienced the rainwater harvesting increased agricultural productivity, reduce water bill, increase groundwater level and reduce soil erosion. The main factor for this finding is perhaps the residents experienced the impact before and after using the system. Besides, some of the benefits can be calculated to determine the advantages before and after using the system such as monthly water bill. Residents still agreed that rainwater harvesting can giving those benefits such as reduce soil erosion, improve river management and control climate change. However it portrays the lower percentage from the others as this benefit is not giving the resident direct impact.

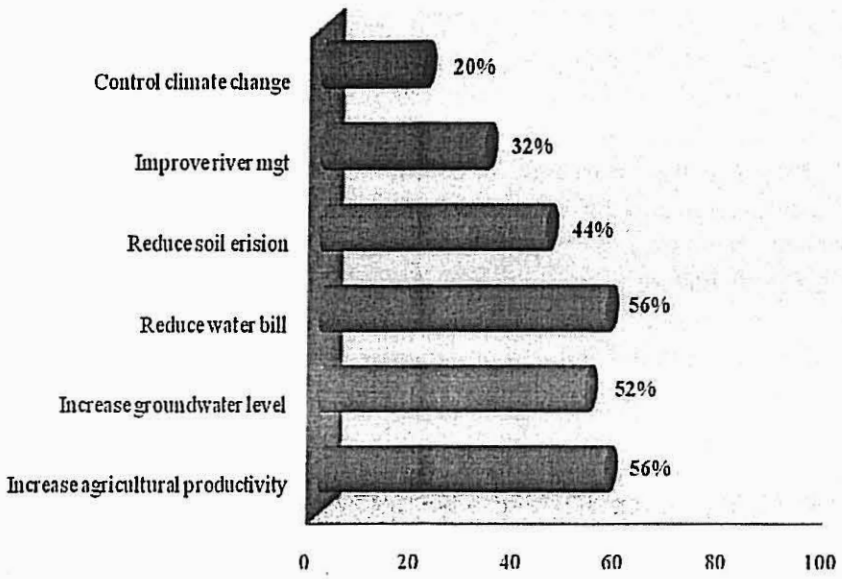

Figure 10: Respondent's Agreement Level on Benefit of Rainwater Harvesting System

Implementation Issues

Figure 11 shows the percentage for respondent agreement level on rainwater harvesting implementation issue. From the figure, 40% of respondents agree that there are not enough professional to design the rainwater harvesting, and 40% of the respondents also think that the government seems not very supportive towards rainwater harvesting systems. The residents also feel that there is an issue on mosquito breeding (32%), as well as not enough awareness on rainwater harvesting benefits and difficult to maintain the system (both have 28% agreement level).

From this finding, it shows that respondents feel there are not enough professional to design the rainwater harvesting system and the government seems not very supportive to implement this system. The main cause for this finding is perhaps the system seems to be very new in Malaysia since it is officially introduced in 1998. Therefore our building industry consultant is not aware of its implementation. Furthermore, we do not have the special training program for rainwater harvesting design; unlike in India they have this kind of program under its Centre for Science and Environment (CSE), New Delhi. The residents also feel that the government not very supportive perhaps of this rainwater harvesting is not made mandatory in Malaysia until 2006. The slow progress of the development of this RWH system in Malaysia had made these two issues highlighted by the residents at the fore front.

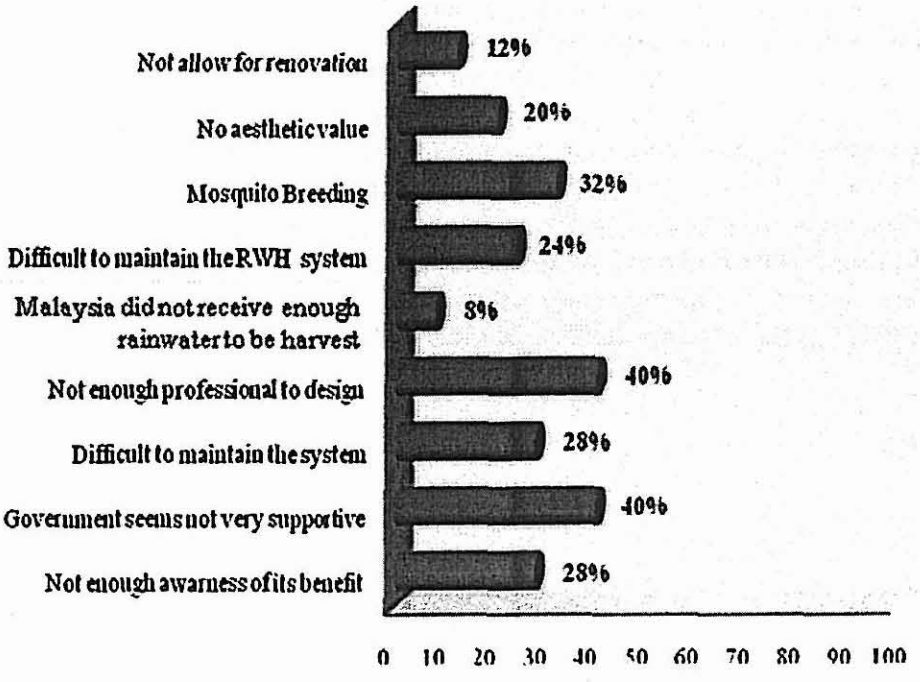

Figure 11: Respondent's Agreement Level on Implementation Issue of Rainwater Harvesting

7.0 CONCLUSION

Demand on water resources has increase day by day due to the population growth and expansion in urbanization, industrialization and irrigated agricultural. Adopting the concept of sustainability and conservation of water resources can help to cope with the global water shortage. Rainwater harvesting system is one of the concepts that can be implemented to meet the water shortage problem.

In Sandakan, the rainwater harvesting approach had fulfilled the needs of the people demand on water resource. They are using rainwater for all the non-potable uses. Sandakan is the early place that did not get enough treated water supply from State Water Board in Malaysia since 1984. The scarcity of water due to the rationing (around twice a week) from State Water Board has made them aware of the important of rainwater harvesting system as an alternative water supply. Sandakan people build the system as it suitable with their needs and reasonably priced. In the other hand, the system has become a part of housing scheme in Sandakan. By using rainwater, they can minimize the usage of treated water for non-potable uses. This situation proved that by using rainwater a lot of saving can be done.

Successful implementation of rainwater harvesting system at Sandakan is a great contribution for future rainwater harvesting system development. More importantly, it is also will support the development of sustainable approach for any kind of building in Malaysia. Government agencies are playing an important role to promote the practice like offering incentives for fees of concerned authorities. Sandakan Municipal Council has prove that rainwater harvesting system improve Sandakan's people quality of living because of the benefits expand from the system. From the respondent's perception, they agree that by utilizing rainwater, water crisis problem can be minimized. The respondents also agree that RWH can increase agricultural productivity and can reduce bill water. The point to ponder is about the implementation issue i.e. not enough professional to design and government seems not very supportive. Therefore, we have to take consideration of this feeling of the respondents in promoting RWH system. Among the steps to be taken are educating our building industry consultant and government to provide incentives to the project that is going to installed the RWH system.

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Author's Biodata

Sr Dr. Adi Irfan Che Ani is currently a Senior Lecturer at Department of Architecture, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia (National University of Malaysia). He attained his PhD from University of Malaya, Malaysia in the discipline of facility management (performance measurement). His research interests are building performance evaluation, real-life performance of rainwater harvesting and building maintenance management. By profession, he is a Registered Building Surveyor in Malaysia. He is also a Corporate Member of The Association of Building Engineers (ABE), United Kingdom. Sr Dr. Adi actively involved in many research in relation to his research interest. He is also the author of several journal papers and had presented numerous research and technical papers at both reputable local and overseas conference.