Rainwater as a Potential Alternative Source of Water in Tanjong Malim, Perak

Air Hujan sebagai Sumber Air Alternatif yang Berpotensi di Tanjong Malim, Perak

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Abstract
Clean water resources play an important role in meeting the daily needs of human life. Lack of water resources and supply is highly associated with natural factors as well as the increased water pollution due to rapid development. Dependence on the system of water supply from the river solely affects the increasingly diverse needs of the community in Malaysia. As Malaysia receives a high rainfall throughout the year, relying on rainwater harvesting as an alternative water source should be given due attention. Thus, a study regarding the potential of rainwater as an alternative source of water for domestic use has been conducted in Tanjong Malim, Perak. Assessment is made on the annual rainfall trend for the last 40 years to see the long-term resource capacity and water quality tests were conducted to identify the level of cleanliness of water for domestic use. Based on this study, Tanjong Malim generally receives a high annual rainfall of over 2400mm per year since 1960 and it is most suitable for collection as an alternative to water resources. With this finding, it is hoped that members of the community can focus on making rainwater resource as an alternative source of water supply as well as save money on utility bills.

Keywords
Rainwater Harvesting, Water Resources, Alternative Sources, Water Quality

Abstrak
Sumber air bersih memainkan peranan penting dalam memenuhi keperluan kehidupan seharian manusia. Kekurangan sumber dan bekalan air sangat berkait dengan faktor semula jadi dan juga peningkatan kadar pencemaran air ekoran pembangunan yang pesat. Kebergantungan kepada sistem bekalan air yang berpunca dari sungai semata-mata boleh menjejaskan keperluan masyarakat yang semakin pelbagai seperti di negara Malaysia. Memandangkan Malaysia menerima hujan yang tinggi sepanjang tahun, kebergantungan kepada takungan air hujan sebagai alternatif sumber air perlu diberi perhatian sewajarnya. Justeru, satu kajian berkaitan dengan potensi air hujan sebagai sumber alternatif air bagi kegunaan domestik telah

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dilakukan di Tanjong Malim, Perak. Penelitian dibuat terhadap trend hujan tahunan untuk tempoh 40 tahun bagi melihat keupayaan sumber jangka panjang serta ujian kualiti air turut dilakukan bagi mengenal pasti tahap kebersihan air bagi kegunaan domestik. Berdasarkan kajian, kawasan Tanjong Malim sememangnya menerima hujan tahunan yang tinggi iaitu melebihi 2400 mm setahun sejak tahun 1960 dan amat bersesuaian untuk ditakung sebagai alternatif kepada sumber air. Dengan penemuan ini, diharapkan masyarakat boleh memberi tumpuan untuk menjadikan sumber air hujan sebagai sumber alternatif bekalan air selain menjimatkan perbelanjaan bil utiliti.

Kata kunci
Takungan Air Hujan, Sumber Air, Sumber Alternatif, Kualiti Air

Introduction

Human's daily activities are highly dependable on clean water resources and supply. In Malaysia, the rapid socio-economic progress towards Vision 2020 needs various sectors to depend on the abundance of water supply. Agriculture, industry and domestic demands have increased the pressure on the existing water resources especially in drought conditions that are often associated with El Nino, land-use change and global climate change (Mohamad Suhaily Yusri, 2007; Mohamad Suhaily Yusri & Zainudin, 2011).

The water supply crisis in 1997-1998 due to a long drought (April-September) had become a serious water crisis to more than two million people in the Klang Valley. Other states on the west coast of Peninsular Malaysia such as Selangor, Negeri Sembilan and Malacca had to deal with water rationing, as a matter of fact the state authorities took the initiative to implement the inter-state water transfer because most of the main dams experienced serious deterioration of water as well as were dry (Mohamad Suhaily Yusri, 2007). During this period, various walks of life including students in public higher education institutions (IPTAs) had to face the consequences due to the lack of water for daily use. Various questions were thrown by the various parties concerned with the sustainability of water resources in the west coast because generally Peninsular Malaysia receives an abundance of rainfall each year which is more than 3000 mm per year.

New water sources such as rainwater should be developed as an alternative to a variety of industrial, domestic, and agricultural use, particularly in the area of Tanjong Malim as the average annual rainfall received is above the national average (2500 mm per year) (Mohamad Suhaily Yusri, 2007). In addition, it provides the advantage of saving clean water use for the purposes of flushing toilets, watering plants and washing areas. Expenses incurred by members of the community to pay water bills to the water operator which is Perak Water Board (LAP) may be reduced as well as opening up a new educational sheet to the people to turn to the effort of conservation through rainwater collection.

Concept of Rainwater Harvesting

In brief, the concept of rainwater harvesting is the process of storing or harvesting rainwater through precipitation of rainwater from the sky and which fell on the roof's of houses which is then channelled into the storage tank. Rainwater is stored, especially in barrels, drums and tanks. Another method of harvesting which is not through the roof but by collecting directly from the sky by placing a piece of zinc in the barrel or drum which is widely practiced in agricultural areas of Cameron Highlands.

The study of rainwater harvesting in Malaysia is relatively new, although it has long been applied over the years traditionally (Figure 1). Perhaps this is because there are still a lot of other water supply sources and the importance of rainwater is given less attention. Studies on harvesting have been carried out internationally, especially in the island areas. The studies conducted can be used as a guide and help in disseminating information to the public so that this technique can be carried out efficiently and effectively. In terms of the use of rain harvesting system, there have been a number of institutions which use it in the buildings they own such as NAHRIM, JUPEM, UPM, UKM, One Utama business centre, a few schools and mosques around Kuala Lumpur.

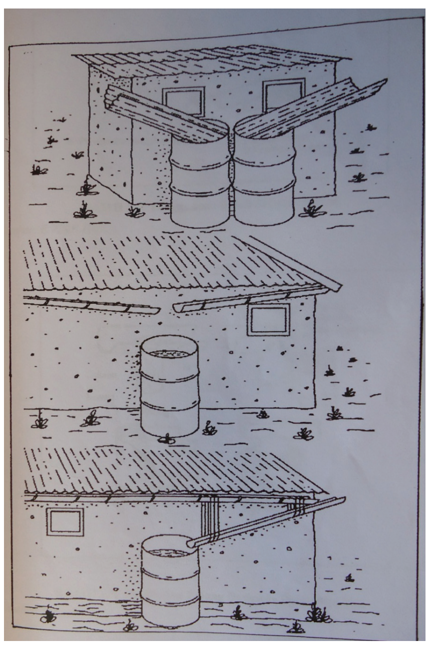

Figure 1 Traditional Technique of Harvesting
Source: Rainwater Club, (2012)

According to the Waterfall (2006), water harvesting is the storage of rainwater for drinking, household and agricultural use. This concept is commonly used in rural or remote areas through rainwater storage and direct usage. According to ESCAP (1989), rain harvesting means the process of accumulation of rainwater and storage from roofs directly to the storage area for additional requirements of the existing water supply for domestic use, irrigation and storage in the future. Pacey & Cullis (1989) stated that rainwater harvesting is a rainwater catchment technique that is economical and cheap to meet the needs of water supply in the future. Water supply can be received directly by the users from the roofs to the catchment area. This situation could prevent the occurrence of water contamination in terms of its quality and quantity.

Yoo Choon Wat (1999), who examined the potential of rainwater harvesting as a water source at Universiti Putra Malaysia, Serdang found that the model of rainwater harvesting system can be put into practice by building an additional model of rainwater harvesting system. The cost for the construction of this model was RM 45,700.00 based on the cost of raw construction materials. The study on rainfall patterns also showed that the process of harvesting rainwater is suitable to be applied in that area. However, air pollution could cause acid rain and disrupt the rainwater harvesting in terms of its quality.

In Malaysia, this rainwater harvesting technique has been given attention. The Collection and Reuse of Rainwater System (SPAH) was introduced and gazetted as a policy by the Kuala Lumpur City Hall (DBKL). The Ministry of Housing and Local Government has provided a guideline for the use of this harvesting technique. Collected rainwater is recommended for activities such as cleaning/washing toilet bowls, home floor, drains, and others, as well as watering plants and washing cars. The pilot project on the use of SPAH in a two-storey terraced house with six residents in Taman Wangsa Melawati, Kuala Lumpur was able to conserve the use of about 34 percent of treated water. This matter has been applied in the design of buildings in the vicinity of Putrajaya. This method is in line with the measure carried out by the Department of Irrigation and Drainage (DID) in addressing the flooding problem by introducing Storm Water Management System Manual (MASMA). Besides being able to increase the source of water, the rainwater harvesting system is also able to overcome the problem of flash floods in an area (DID, 2000).

Rainwater harvesting is an alternative source especially during droughts and emergencies such as fire. Therefore, initiatives have been undertaken to encourage government agencies and homes in urban areas to use the rainwater harvesting system. Government agencies such as the fire brigade should use rainwater harvesting by installing it in the administration building to secure water resources for emergency activities. Rainwater harvesting is also used in preparation for the dry season but the quality of the reserved water must be clean. According to Pandey *et al.* (2003) and Khawja (2012), SPAH is able to deal with drought problems due to changes in rainfall and temperature increase to two degrees Celsius which is forecasted to hit the country due to global climate change. With the expected doubling of the carbon dioxide content in the air, the temperature in Malaysia is expected to increase by two degrees Celsius. This condition would cause the country to receive rainfall at a lower rate as well as cause a long drought. Climate change needs planning of water resources and adapting it to the situations that may occur.

Methodology

This study was conducted in Tanjong Malim, located in the south of Perak. Its geographical location at the foot of the Titiwangsa Mountains is an advantage to Tanjong Malim in terms of rainfall and humidity received. Long-term annual rainfall data (secondary data) were obtained from DID and analysed to see rainfall trends (annual data) using rainfall trend graph display. Rainfall trend is important to ensure that Tanjong Malim has the potential source of high rainfall for an extended period. The size of the reservoir is also calculated based on the daily/monthly rainfall received to determine the capabilities/continuity of supply while considering the interval of days without rain. It is to enable the user to have the appropriate size of the reservoir to store water and can be used at an optimal level in the absence of rain.

Findings and Discussion

Rain Trends in Study Area

In this study, rainfall data from four rainfall stations were analysed which were Tanjong Malim, Ladang Ketoyong, Ladang Sungai Behrang dan Ladang Bedford rainfall stations. These rainfall stations are monitored by DID. The rainfall period analysed was from 1948 to 2008 (a period of 50 years). All the rainfall stations are located on lowlands region and less than 50 feet above the sea level (Mohamad Suhaily Yusri, 2007). In addition, the location of the rainfall stations at the foot of the Titiwangsa Mountains caused all rainfall stations to record high rainfall due to the effects of relief or orographic rainfall especially during the transition periods, Northeast Monsoon (MTL) and the Southwest Monsoon (MBD) (Mohmadisa *et al*., 2012a, 2012b). Figure 2 shows the total annual precipitation from 1948-2008 for each station in Tanjong Malim. The highest annual rainfall was recorded at the Ladang Ketoyong station (3137 mm), followed by Ladang Behrang station (2999 mm), Tanjong Malim station (2850 mm) and Ladang Bedford station (2610 mm). On average, the rainfall in this area was 2899 mm. Based on the data recorded, the average rainfall in the study area is above the average annual rainfall in Peninsular Malaysia which is 2400 mm per year. The total minimum rainfall also exceeds 2000 mm. The total maximum rainfall is also very extreme at all stations which was more than 3800 mm (Mohamad Suhaily Yusri *et al.,* 2010). Thus, residents of Tanjong Malim can rely on rainfall for various related activities as an alternative water resource.

In analysing the long-term trend of rainfall, the Mann-Kendall Test (S) was used to identify significance of trend whether increases, decreases and no trend. The value of S

is used to spot the trends that exist. The value of *S* which is positive indicates increasing trend, negative value of *S* shows a decreasing trend and the value of 0 indicates no trend. Table 1 shows the analysis of the Mann-Kendall Test for each rainfall station in Tanjong Malim. Based on this analysis, it is clearly shown that two rainfall stations showed an increasing trend of rainfall and two stations showed a decreasing trend in the level of significance, $p \geq 0.01$ (99%). On the whole, the rainfall in the area shows an increasing trend. The increasing or decreasing trend of rainfall is related to the cycle of the current world climate, changes in local weather patterns, changes in land use from forest to developed areas with a variety of human activities, and others. However, it is most obvious that the recorded rainfall data shows that rainfall in Tanjong Malim is high as influenced by its natural factor of being located at the foot of the Titiwangsa Mountains which always receives the relief or orographic rainfall either during MTL or MBD.

Table 1 Mann-Kendall Test for the Rainfall Trends in Tanjong Malim, 1948-2008

Station	Rainfall Year	No. (*n*)	Mann-Kendall (*S*) Statistic	Normalisation Statistical Test (*Z*)	*Probability* (*P*)	Trend (at the Significance Level of 99%)
Tanjong Malim	1948-2008	61	66	0.405	0.6858	Increasing
Ladang Ketoyong	1948-2008	61	280	1.736	0.0825	Increasing
Ladang Sg. Behrang	1948-2008	61	-434	-2.695	0.0070	Decreasing
Ladang Bedford	1948-2008	61	-316	-1.96	0.05	Decreasing
Rainfall Area	1948-2008	61	44	0.268	0.789	Increasing

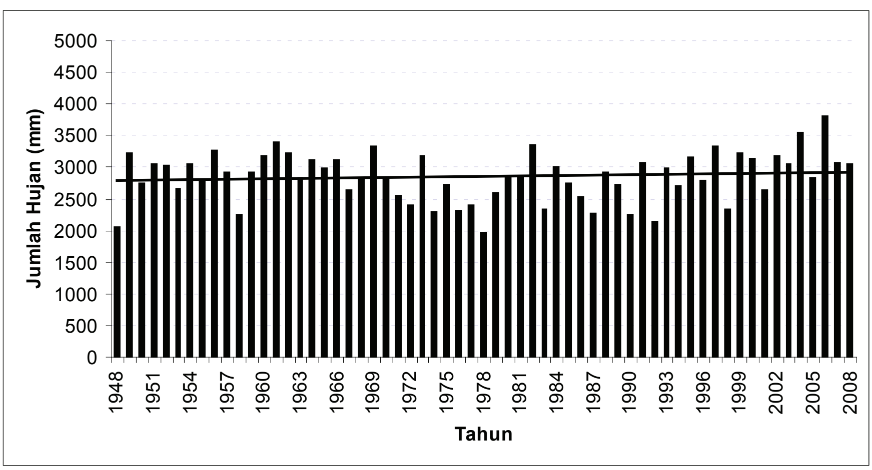

Figure 2 Total Annual Rainfall at Tanjong Malim Station, 1948-2008

Average Monthly Rainfall for Each Year

Figure 3 shows the average monthly rainfall for each year. The purpose of analysing this data is to identify the total monthly rainfall for each year. Based on Figure 3, the total monthly rainfall in Tanjong Malim were mostly above 200 mm per month. There were 22 years whereby rainfall exceeded 200 mm, 14 years of rainfall between 150 mm to 200 mm and a year of rainfall which was less than 150 mm per month. The highest total of monthly rainfall was in 1995 with the monthly rainfall of 278.9 mm. The second highest total was in 2006 with the monthly rainfall of 267.29 mm. The minimum monthly rainfall total was in 1977 with 147.19 mm per month. Based on these figures, it can be concluded that the total monthly rainfall in Tanjong Malim were mostly above 200 mm per month.

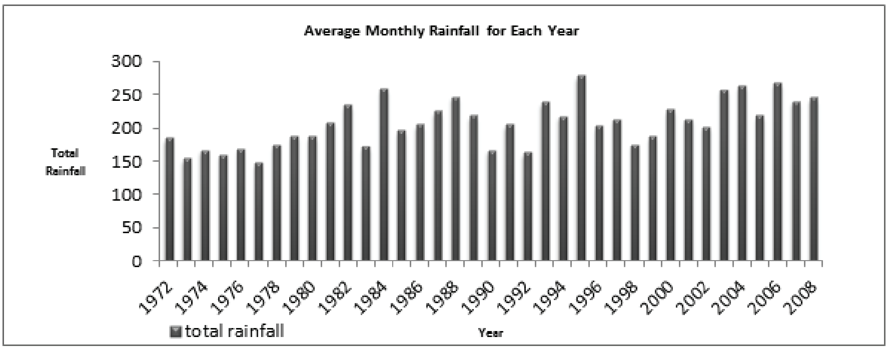

Figure 3 Average Monthly Rainfalls for Each Year

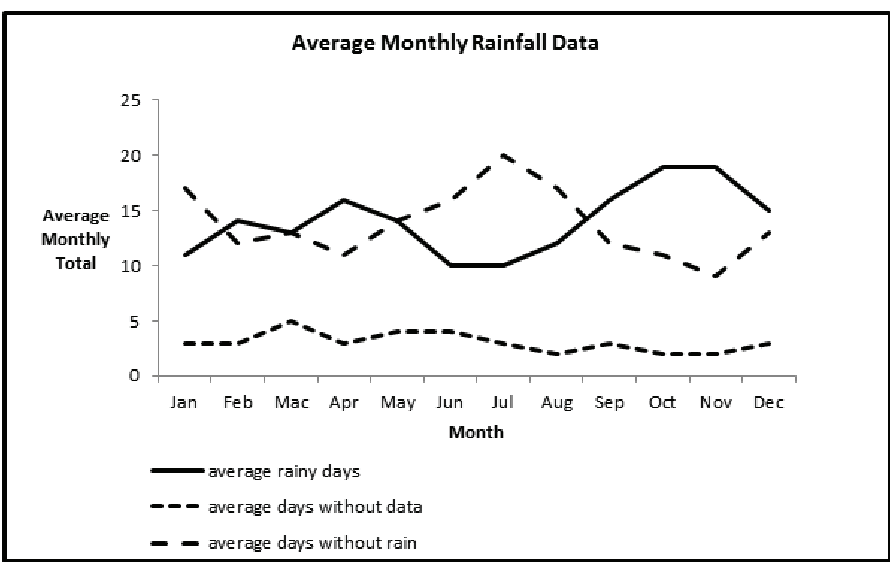

Figure 4 Average Monthly Rainfall

Based on the data obtained from DID, the highest monthly rainfall recorded at Tanjong Malim was in November 2003 with 707 mm rainfall per month. The second highest total was in April 2004 with 628 mm rainfall per month (Figure 4). Within a month, the maximum amount of rainfall was recorded on 28 April 2001 which was 140.5 mm of rainfall in a day. Whereas within three days, the maximum rainfall recorded was in April 2001 with a total rainfall of 204.8 mm. Based on the results of this analysis, it is evident that the intensity rate of rainfall in Tanjong Malim was high compared to other areas. The possibility of flooding in Tanjong Malim was great but this phenomenon did not occur in Tanjong Malim which might be due to the lack of development activities carried out. From the analysis, it is shown that the amount of annual rainfall, the total rainfall by month, the number of rainy days and rainfall intensity rate were high. Therefore, the practice of rainwater harvesting in Tanjong Malim is appropriate and does not interfere with the reduction in the natural flow of the existing drainage system in particular river.

Total Rainwater Harvested

The quantity of rainwater harvested depends on several aspects such as the area of the rooftop of the building, the amount of rainfall and the size of the reservoir or storage. The roof of the building is the catchment area to collect rainwater and is channelled to the storage tank or ponding. The more extensive the roof size, the more rainwater can be harvested (Pacey & Cullins 1986). The total rainwater harvested can be measured using the following equation:

Total rainfall(mm) x Size of roof (m2) = Total of rainwater harvested litres /day

The analysis of the volume of rainwater harvested is based on a house with a complete rainwater harvesting system. The roof has an area of 75.2 metres/square (Table 3). Therefore, the amount of rainfall that can be collected depends on the amount of rainfall in a given period. If the amount of rain that falls in a certain period is 15 mm, the amount of water that can be collected is 1128 litres. Based on the analysis of rainfall data conducted, the average rainfall in Tanjong Malim is 7.9 mm per day. Therefore, this value will be multiplied by the area of the roof resulting in 594.08 litres of rainwater collected. Within one year the rainwater that can be collected is 216839.2 litres per year. To collect rainwater, the water tank must be able to harvest rainwater effectively. Thus, the capacity of both the top and bottom tanks can store 13.21 cubic metres of water which is equivalent to 13,210 litres. The capacity of the water tank can be filled if there are 22 rainy days. Thus, the capacity of the tank used is appropriate with the amount of annual rainfall in Tanjong Malim.

Based on the analysis, the maximum value of rainfall in Tanjong Malim is 172 mm per day. If this value is taken into account, then the amount of rainfall that can be gathered in a single day is 12934.4 litres of rainwater. Within a year, the accumulated amount of rainfall is 4721056 litres per year. Maximum rainfall is able to fill both the top and bottom storage tanks within a day and a half. This means that the capacity of rainwater tank is incompatible with the rainfall. Therefore, a larger tank capacity is needed to allow maximum rainwater harvesting but this situation rarely happens as the average rainfall in Tanjong Malim is 7.9 mm per day.

Table 3 Estimated Period of Time and Total Rainwater Harvested (Minimum, Average and Maximum Rainfall Data Taken From Tanjong Malim Station)

Item	Tank Capacity (litre)	Roof Area (metre per square)	Total rainfall per day	Total harvesting per day (litre)	Total harvesting per year (litre)	Period of full tank (day)
Minimum	13210	75.2	1 mm	75.2	27448	176
Average	13210	75.2	7.9 mm	594.08	216839.2	22
Maximum	13210	75.2	172 mm	12934.4	4721056	1 ⅓

The minimum rainfall value is about 1 mm of rain per day. Zero value should be the minimum value but to show the amount of rainfall differences, the value of 1 mm is calculated as the minimum value. With the minimum rainfall of 1 mm per day, the amount of rainwater that can be harvested is 75.2 litres. Within one year, a total of 27,448 litres of rainwater can be collected per year. To fill both the top and bottom tanks, it took a relatively long period of 176 days. If this situation occurs throughout the year, the rainwater tank capacity does not have to be large. Maybe just the top tank or the 1000 litres tank is needed and does not require a long time to wait for a tank to be full.

To show clearly the effectiveness of this system, this study used data for the three years of rainfall observations at the station in Tanjong Malim which had the highest annual rainfall which was in 1995, the lowest amount of rainfall in 1983 and a moderate amount of rainfall in 2002. The selection of these years is based on the last 37 years starting in 1971 to 2008 in Tanjong Malim station. Based on the analysis, the average rainfall in Tanjong Malim in 1995 was 9.1 mm per day (Table 4). Therefore, this value is multiplied by the area of the roof resulting in 684.32 litres of rainwater collected. Within one year the rainwater collected is 249776.8 litres per year. The capacity of the water tank is filled if there are 19 rainy days. Thus, the capacity of the tank used is appropriate with the amount of annual rainfall in Tanjong Malim.

Table 4 Estimated Period of Time and Total Rainwater Harvested (Mode, Average and Maximum Rainfall Data Taken From Tanjong Malim Station In 1995)

Item	Tank Capacity (litre)	Roof Area (metre per square)	Total rainfall per day	Total harvesting per day (litre)	Total harvesting per year (litre)	Period of full tank (day)
Maximum	13210	75.2	115 mm	8648	3156520	1 ⅔
Average	13210	75.2	9.1 mm	684.32	249776.8	19 ⅓
Mode	13210	75.2	14.5 mm	1090.4	397996	12 ⅓

The maximum value of rainfall in Tanjong Malim in 1995 was 115 mm per day. If this value is taken into account, then the amount of rainfall that can be gathered in a day is 8648 litres of rainwater. Within a year, the accumulated amount of rainfall is 3156520 litres per year. Maximum rainfall is able to fill both the top and bottom storage tanks in more than one day. On average, within two days the storage tanks are full. This means that the capacity of the rainwater tank is incompatible with the rainfall. Therefore, a tank with a larger capacity is needed to allow maximum rainwater to be harvested but this situation rarely happens as the average rainfall in Tanjong Malim in 1995 was 9.1 mm per day.

Rainfall frequency or mode for the year 1995 was 14.5 mm of rain per day. With the mode of 14.5 mm rainfall per day, the amount of rainwater that can be collected is 1090.4 litres. Within one year, a total of 397,996 litres of rainwater can be collected. To fill both the top and bottom tanks, it takes a relatively long period of time which is 12 days. Looking at the capacity of the tank used, it is compatible with the trend of rainfall in 1995.

Table 5 shows the least amount of rainfall in the period of 37 years at the Tanjong Malim station. Based on the table, the average rainfall in Tanjong Malim in 1983 was 5.6 mm per day. Therefore, this value is multiplied by the area of the roof resulting in 421.12 litres of rainwater collected. Within one year, the rainwater collected is 153708.8 litres per year. The capacity of the water tank capacity is filled if there is rain for the next 31 days. Thus, the capacity of the tank used is appropriate with the amount of annual rainfall in Tanjong Malim.

Table 5 Estimated Period of Time and Total Rainwater Harvested (Mode, Average and Maximum Rainfall Data Taken From Tanjong Malim Station In 1983)

Item	Tank Capacity (litre)	Roof Area (metre per square)	Total rainfall per day	Total harvesting per day (litre)	Total harvesting per year (litre)	Period of full tank (day)
Maximum	13210	75.2	100 mm	7520	2744800	1⅞
Average	13210	75.2	5.6 mm	421.12	153708.8	31⅓
Mode	13210	75.2	8.5 mm	639.2	233308	20⅔

The maximum value of rainfall in Tanjong Malim in 1995 was 100 mm per day. If this value is taken into account, then the amount of rainfall that can be gathered in a day is 7520 litres of rainwater. Within a year, the accumulated amount of rainfall is 153708.8 litres per year. Maximum rainfall is able to fill both the top and bottom storage tanks in more than one day. This means that the capacity of the rainwater tank is incompatible with the amount of rainfall. Therefore, a bigger tank capacity is required to allow maximum rainwater to be harvested.

The rainfall mode for 1983 was 8.5 mm of rain per day. With the mode of 8.5 mm of rain per day, the amount of rainwater that can be harvested is 639.2 litres per day. Within one year, a total of 233,308 litres of rainwater can be collected in a year. To fill both the top and bottom tanks, it takes a relatively long period of time which is 20 days. Looking at the tank capacity used, it is compatible with the trend of rainfall in 1983. Although in 1983 there was a little rain received but the high mode of rain was able to fill the storage tanks within 20 days.

The year 2002 was a year of moderate rainfall in Tanjong Malim. The total rainfall received was 2417 mm per year. Based on Table 6, the average rainfall in Tanjong Malim in 2002 is 6.6 mm per day. Therefore, this value is multiplied by the area of the roof resulting in 496.32 litres of rainwater harvested. Within one year, the rainwater collected is 181156.8 litres per year. The capacity of the water tank is filled if it rains for 26 days. Thus, the capacity of the tank used is appropriate with the amount of annual rainfall in Tanjong Malim in 2002.

Table 6 Estimated Period of Time and Total Rainwater Harvested (Mode, Average and Maximum Rainfall Data Taken From Tanjong Malim Station in 2002)

Item	**Tank Capacity (litre)**	**Roof Area (metre per square)**	**Total rainfall per day**	**Total harvesting per day (litre)**	**Total harvesting per year (litre)**	**Period of full tank (day)**
Maximum	13210	75.2	98.2	7384.64	2695393.6	1⅞
Average	13210	75.2	6.6	496.32	181156.8	26⅔
Mode	13210	75.2	24.7	1857.44	677965.6	7⅛

The maximum value of rainfaill at Tanjong Malim in 2002 was 98.2 mm per day. Therefore, the amount of rainfall that can be gathered in a single day was 7384.64 litres of rainwater. Within a year, the accumulated amount of rainfall is 2695393.6 litres per year. The maximum rainfall was able to fill both the top and bottom storage tanks in one day or more. This means that the rainwater tank capacity is incompatible with the amount of rainfall. Therefore, a greater tank capacity is required to allow the maximum rainwater to be harvested.

The rainfall mode for 2002 was 24.7 mm of rain per day. Therefore, the amount of rainwater that can be collected was 1857.44 litres. Within one year, a total of 677965.6 litres of rainwater can be collected per year. To fill both the top and bottom tanks, it took a relatively long period of time which was 7 days. Looking at the tank capacity used, it was not compatible with the rainfall trend in 2002. Therefore, a larger tank capacity is required to balance the daily rainfall received. Although there was a little rain received in 2002, the rain mode was able to fill the harvesting tank within 7 days.

Table 7 shows the estimated rainfall based on the rainy days in the year. It aims to identify the rainy day interval to fill the harvesting tank. Only the average rainfall is included in this analysis. For the year 1995 which received the highest amount of rainfall during the last 37 years, the rainy day interval was 1 day. For the year 1983 which received the least amount of rainfall in a period of 37 years, the rainy day interval was 2 days and in 2002 the rainy day interval period was the same as in 1983. Although the year 1983 received a little rain, but the rain frequency was high but the level of intensity of rainfall for that year was less. On the whole, the capacity of the tank made in the home was in accordance with rainfall trends in Tanjong Malim although some analysis showed inappropriate tank capacity, but this situation was rare.

Table 7 Estimated Interval Duration of Rainy Days (Average From Station Tanjong Malim 1983, 1995 and 2002 Rain Data)

Average	Tank capacity (litre)	Total rainfall per day (mm)	Total collection per day (litre)	Duration of full tank (day)	Total rainy day	Rain interval Duration
1995	13210	9.1	684.32	19 ⅓	207	1 day
1983	13210	5.6	421.12	31⅓	139	2 days
2002	13210	6.6	496.32	26⅔	145	2 days

Cost Saving

According to Tuan Pah Rokiah *et al.,* (2004), the usage of water for domestic use of an individual is 996.5 litres per day. Generally, about 60 percent water savings could be reduced if the aspect of accumulated daily rainfall is divided by gross domestic use. For this study, researchers emphasise the use of water to wash the car. Aproximately, the use of water to wash a car in a professional manner is 0.1219 cubic metres or 33.80 gallons for each car (Mohamad Suhaily Yusri *et al.,* 2011). The rainwater storage capacity is 13.21 cubic metres. Thus, the number of cars that can be washed with the capacity of water in the storage tank is 108 cars. This happens if the amount of water is used entirely to wash cars. According to LAP, RM 5.25 is needed to fill the water tank with the capacity of 13.21 cubic metres. The calculation is based on the LAP monthly water bill payments. On the other hand, if the water usage is less than 1 cubic metre, the minimum charge imposed is RM 3.00. For professional car wash, water usage of 0.1219 cubic metres is required. For car wash wastage, the use of water is 0.1734 cubic metres. This value if calculated based on the LAP requires a cost of RM 0.07 sen. If a consumer washes the car at a shop with the use of the same quantity of water, then the charge is RM 15. Within a month, the user would spend about RM 60.00 and RM

720.00 in one year. The difference of value for car wash at the shop and at home is RM 716.64 (Table 8). If rainwater harvesting tank is used, the amount of money used to wash cars can be kept and used for other purposes as rainwater harvested need not be paid. This saving is in terms of differences in car wash at the shop and at home.

Table 8 Comparison of Cost of Car Wash at Home and Shop

Type	Quantity of Water used (metre square)	Price (RM)	Month (RM)	Year (RM)	Difference
House	0.1734	0.07	0.28	3.36	716.64
Shop	0.1734	15	60	720	

From the aspect of constructing a harvesting tank, the estimated construction cost is RM 4000. This value is based on the construction cost of a harvesting tank that has been done in a home while installing the rainwater harvesting system. Hence, the capital of RM 4000.00 can be redeemed if the user is to wash his car at the shop in the next few years. Table 9 clearly shows the rate of return on capital based on car wash at the shop. Based on Table 9, the cost or capital to build a rainwater harvesting system can be redeemed in 4 years and 8 months if the user washes his car once a week. On the other hand, if the user washes his car twice a week, then the time taken to make up for the capital construction is two years and four months.

Table 9 Rate of Capital Return Based on the Rate of Car Wash At Home

Number of time car washed in 1 week	Capital for the construction of harvesting tank (RM)	Price of completed car wash (RM)	The value of car washed in a month (RM)	The value of car washed in a year (RM)	Estimated return of harvesting capital
1 time per week	4000	15	60	720	4 years 8 months
2 times per week	4000	15	120	1440	2 years 4 months

Table 10 shows the analysis of the conservation in using the harvested rainwater and use of LAP water in a month. The utilisation capacity of water depends on the user who uses it. The value of 25 cubic metres is taken from the cost of water usage (domestic use) in a house in Tanjong Malim. If the user uses LAP water, the usage is unlimited. The user can use unlimited water but using the harvested rainwater depends on the capacity of the harvested tank. The harvesting capacity for both (top and bottom tanks) is 13.2 cubic metres. The amount of water harvested depends on the amount of rainfall. From the analysis carried out, the rainfall in Tanjong Malim is high and the daily rainfall frequency interval is 3 days. Therefore, the rain harvesting tank always contains water. Based on Table 10, the price of RM 15.00 is charged for the use of 25 cubic metres of water. For the harvesting tank, RM 5.24 is charged for the capacity of 2.13 cubic metres. If the user uses the harvested water for washing purposes, cleaning and washing the car, can save water payment of RM 5.24. If this situation occurs, then the monthly bill of household consumption would be RM 9.76 per month. On the other hand, when the user uses the harvested water fully, then the payment of bills for water consumption need not be paid because the use of 25 cubic metres requires the water harvesting tank to be filled twice. In terms of the amount of water used, water saving of 52.8 percent is obtained when using water harvested and in terms of bill saving, the user is able to save 40 percent. Therefore, the use of harvested water can reduce the cost of water bill payments per month for each household consumption.

Table 10 Water Conservation in a Period of a Month

Type	Water capacity (cubic metre)	Estimated water usage in a month (cubic metre)	Price of water (RM)	Estimated new monthly bill (RM)
LAP	Unlimited	25	15	9.76
Harvested	13.2	13.2	5.24	

Proposed Rain Harvesting Set

The proposal submitted relates to the installation cost of rainwater harvesting system at home as well as efforts to educate the consumer. If seen from a cost-benefit analysis, the capital of rainwater harvesting installation can be redeemed earliest within two years and four months and latest within four years and eight months, by assuming that the calculation includes car wash only, not taking into account that the harvested water can be used to wash corridors, ditches, watering plants/crops and other uses outside the home. If all these aspects are taken into account, the saving in terms of resources and cost is definitely more significant to users who install the complete harvesting set. The estimated installation of a moderate rain harvesting set for a residential home is as shown in Table 11.

On the whole, the cost for installing a rainwater harvesting system is RM 2698.00. This amount depends on the type of device that is used either to install a high quality material or otherwise. Furthermore, the selection of the model to be built by the user also affects the rainfall harvesting installation expenses. If the model used is simple, then the required capital is low and vice versa. Generally, to install a simple rainwater harvester needs a capital of RM 1000 only including wages. The tools needed include a 300-gallon poly tank, gutter, 3 inch pipe, half-inch pipe, stop corks and taps. The value of these items is around RM 600.00 only and if added with installation charges

Table 11 Estimated Installation Cost of Rainwater Harvesting System

No.	Type of Material	Unit	RM
1	300 gallons Poly Tank	1	RM 500
2	Auto Electric Pump	1	RM 400
3	Gutter	25 feet	RM 100
4	3 inch pipe	1	RM 36
5	Half inch Pipe	2	RM 12
6	Stop cork	2	RM 30
7	Water Tap	2	RM 20
8	Bottom Tank	1	RM 1000
9	Wages		RM 600
Total			RM 2698

may reach RM 1000. For the installation of a complete harvesting system, the rain harvesting system installation capital is RM 2698.00. This amount may increase if the user utilises quality materials and if the user wants to install many rainwater harvesters. Generally, the minimum amount of RM 1000.00 per household is affordable to install when compared with the cost of water bill payments which is increasing from time to time. Therefore, users should be aware of the advantages of this rainwater harvesting technique if applied for the use of a lot of water resources.

Conclusion

Rain is the main source of water for human life. Dependence of the state's water management on river water resources as a source of clean water for various human use is high. The importance of rainwater sources is becoming increasingly important now, after several western states of Peninsular Malaysia faced resource decline since the events that hit the Klang Valley in 1998. The crisis has prompted the government to strive to find other avenues of alternative water sources such as rainwater.

Harvesting rainwater is a great way to meet the needs of the deteriorating water supply now. Each day the index of water quality in Malaysia has deteriorated and the price of water is increasing. Deterioration of water quality is a major cause of increased water prices due to the cleaning costs incurred by users. Therefore, use of alternative water especially rainwater harvested can reduce the users' burden. Moreover, the cost of installation does not require a high capital. If the capital invested to install a rainwater harvesting system is calculated, it can be redeemed in a few years only if water use is at its maximum. Furthermore, the cost of maintaining this system is simple and can be done at any time.

The high amount of rainfall in Tanjong Malim and availability of long-term rainfall trend, which was 37 years indicate suitability for implementing rainwater harvesting systems in residential homes or related institutions as an alternative source of water supply for various human use. This is because it is evident that the Tanjong Malim area receives among the highest rainfall in Peninsular Malaysia, with high intensity and high frequency of rainy days in a year, besides the aspect of land use development which is still at a small scale. The rainwater harvesting system used will also not be threatening in terms of availability of water resources in the drainage systems in Tanjong Malim particularly Bernam river. Users will benefit in terms of saving the usage costs, cost saving in terms of management that provides clean water system and appreciating the importance of natural resources in a more meaningful way.

References

Economic and Social Commission for Asia and the Pacific (ESCAP). (1989). Rainwater harvesting techniques and prospects for their application in developing island countries. Dlm. Water resources development in Asia and the Pacific: Dam safety evaluation and monitoring, water tariffs and rainwater harvesting. *United Nations Water Resources Series 63,* 101-108.

Jabatan Pengairan dan Saliran Malaysia, (DID). (2000). *Garis panduan manual mesra alam (MASMA).* Kuala Lumpur: Kementerian Perumahan dan Kerajaan Tempatan.

Khawja, S. H. (2012). Understanding climate change and its impact. Diperolehi daripada http://www.ahsaniamission.org.bd/knowledge/The%20Science%20of%20Climate%20Change%20and%20its%20Consequences_January_2011.pdf, 15 Disember.

Mohamad Suhaily Yusri Che Ngah, Yazid Saleh, Mohmadisa Hashim, Nasir Nayan & Haryati Ibrahim. (2011). Penggunaan sumber air bersih dalam perkhidmatan mencuci kereta di Tanjong Malim , Perak dan Hulu Bernam, Selangor. *Perspektif Jurnal Sains Sosial dan Kemanusiaan 3 (2),* 75-86.

Mohamad Suhaily Yusri Che Ngah & Zainudin Othman. (2011). Impact of land development on water quality and water quantity in Peninsular Malaysia. *Malaysian Journal of Environmental Management 12(2),* 113-120.

Mohamad Suhaily Yusri Che Ngah, Nasir Nayan, Mohmadisa Hashim & Mohd Faris Dziauddin.(2010). Kajian hidrologi di kawasan kampus Sultan Azlan Shah, Universiti Pendidikan Sultan Idris. Laporan Geran Penyelidikan Universiti Pendidikan Sultan Idris yang tidak diterbitkan.

Mohamad Suhaily Che Ngah. (2007). Impact of land use change on water yield and water quality in Peninsular Malaysia. Phd Thesis. Unpublished. Laoughborough University.

Mohmadisa Hashim, Mohamad Suhaily Yusri Che Ngah & Nasir Nayan. (2012a). Trend hujan jangkamasa panjang dan pengaruhnya terhadap hakisan permukaan: Implikasinya terhadap tapak kampus baru Sultan Azlan Shah, Tanjong Malim. *Geografia Malaysian Journal of Society and Space 8(2)*, 38-51.

Mohmadisa Hashim, Wan Ruslan Ismail, Nasir Nayan, Mohamad Suhaily Yusri Che Ngah & Mohd Hairy Ibrahim. (2012b). Analisis trend hujan di Bandaraya Ipoh Perak 1970-2007. *e-Bangi Journal of Social Sciences and Humanities 7(1)*, 149-164.

Pacey, A. & Cullis, A. (1989). *Rainwater harvesting: The collection of rainfall and runoff in rural areas.* London: WBC Print Ltd.

Pandey, D. N., Gupta, A. K. & Anderson, D. M. (2003). Rainwater harvesting as an adaptation to climate change. *Current Science 85(1)*, 46-59.

Rainwater Club. (2012). *Posters*. Diperolehi daripada www.rainwaterclub.org, 21 Disember.

Tuan Pah Rokiah Syed Hussain, Hamidi Ismail & Wahida Ayob. (2004). Sikap masyarakat terhadap penggunaan bekalan air bersih: Pembaziran dan penjimatan. Diperolehi daripada http://ebookbrowse.com/tuan-pah-rokiah-syed-hussain-2004-01-pdf-d186944487, 21 Disember 2012.

Waterfall, P. H. 2006. *Harvesting rainwater for landscape use (2nd ed.)*. Tucson: Cooperative Extension College of Agriculture and Life Sciences, University of Arizona.

Yong Choon Wat. (1999). Potential of rainwater harvesting as supplementary clean water supply: A case study in Department of Environmental Sciences. Tesis Sarjana Muda Universiti Putra Malaysia yang tidak diterbitkan.