COMPARATIVE STUDY ON RAINWATER HARVESTING PRACTICE BETWEEN TWO METROPOLISES: TOKYO (SUMIDA-KU) & SELANGOR, MALAYSIA

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***ABSTRACT*:** Rainwater Harvesting (RWH) has become one of the recent trends as a sustainable approach for supplementing public water supply as well as for serving several other purposes. Tokyo starts off the RWH practice in urban area few decades ago. In consequence, Tokyo is known for its well-developed RWH practice. Whereby, Selangor, the most developed nation in Malaysia is lack behind in implementing RWH since up till now, only several buildings are equipped with Rainwater Harvesting System (RWHS). This study aims to investigate the well-developed RWH practice in Tokyo mainly in Sumida-ku from several aspects which are policy & planning, design, technological, and social matters. Subsequently, this study compares Selangor's efforts on such aspects for proposal of betterment.

KEYWORDS: rainwater harvesting, comparative study

1. INTRODUCTION

According to Johann Gnadlinger, the vice-president of International Rainwater Catchment Systems Association, RWH offers a wealth of promising possibilities for developing and developed countries. It has to go in alliance with river and groundwater as equivalent freshwater resources by the political willingness to implement the system and ensuring the widest possible distribution (Klaus, 2001).

1.1 Problem Identification

Based on Tokyo's experience, Tokyo Metropolitan Government (TMG) realized that Tokyo needs more sustainable approach in dealing with the available water resources for the sake of future generation. RWH is identified as one of the essential element in Total Water Resources Management (TWRM) as it is incorporated in 'Water Conservation Plan' introduced by TMG in order to reduce per capita water consumption. The plan package comprises of measures from supply and demand side control under TWRM. It is initiated in 1973, during stabilized economic growth period of Japan. Before that, during high economic growth period, the water consumption pattern was in increasing trend from 264 l/p/d in 1965 to 408 l/p/d in 1972.

According to Matsushita J. (2006), Tokyo manages to overcome the problem by incorporating both measures. Table 1 summarizes the effects of the introduction of such plan in Tokyo base on a similar study conducted by Toshiharu F. (2002) in Fukuoka.

Table 1 Effects of the 'Water Conservation Plan' in Tokyo by Elements

Category	Element	Water Conservation Amount (l/p/d)	Total (l/p/d)
Pushing-Down Factors: *Demand Side Control*	SWT-Flushing Toilet	11.1	
	SWT-Washing Machine	20.4	
	WWR & RWH	6.7	
	In-Factory Reduction	8	
	Promotion Activities	α	46.2 + α
Supply Side Control	Leakage Reduction	55	
	Other NRW Reduction	20	75
	Total (from pushing-down factors)		121.2 + α
Pushing-up Factors	Change of Life-style & Family Structure	66.8	(-66.8)
	Total Reduction		54.4 + α

RWH together with wastewater recycling (WWR) contributes roughly 6.7 l/p/d for water conservation. WWR have relatively small impact for domestic sector compared to industrial sector. For RWH, although it is not utilized much in Tokyo, with roughly 0.03 l/p/d of conservation rate, there has been some serious investigation into the potential role that RWH could play in water supply, flood prevention and disaster mitigation strategies (J.Gould, 1999). By the policy package, Tokyo manages to reduce per capita water consumption up to 81 l/p/d in 30 years.

Whereby, Selangor is currently in the phase of economic growth period with rapid urbanization as in phase 1 of Tokyo. Selangor is experiencing similar problem as faced by Tokyo during the period as per capita water consumption in Selangor are in increasing trend which is approximately 177 liters in 15 years.! New water infrastructure development such as dam and inter-state water transfer is not easy to be executed since the government is facing opposition by NGOs and public as it will contribute to negative impacts on environment as well as too costly. In order to reduce per capita water consumption, such plan as practiced by Tokyo including RWH might be workable for Selangor which can avoid the wastage of treated water, and further to delay the execution of costly water supply approach such as the building of dams with treatment plants and water transfer projects.

1.2 Objectives

In order to compare with Tokyo on how it managed to accomplish a well-developed RWH practice, all aspects leading to success implementation of RWH are looked into comprehensively, from policy & planning to design, technological and further on social matter aspects. Subsequently, this study compares Selangor's efforts on such aspects for proposal of betterment.

2. COMPARISON OF RWH PRACTICE IN TOKYO (SUMIDA-KU) & SELANGOR

Tokyo and Selangor both are currently implementing RWH as ongoing practice. The comparisons of relevant aspects in RWH practice for both regions are discussed in the following sub-headings.

2.1 Tokyo (Sumida-ku)

2.1.1 History & Development of RWH

In case of Tokyo, most development related to RWH started in Sumida City. RWH was introduced in Sumida Ward as early as 1982. According to officers in Sumida City Hall, to date, there are 750 facilities with RWHS both in private and public buildings. Table 2 summarizes the history and development of RWH in Sumida-ku.

Table 2 History & Developments of RWH in Sumida City

YEAR	RWH HISTORY & DEVELOPMENTS
1983	RWH was introduced in Sumida-ku (model system is in the building for young children
1985	National Sumo Arena was completed with utilization of large scale RWH
1988	"Rojison" – a communal RWHS is installed in Mukojima area in Sumida Ward
1994	International Rainwater Conference was held (8,000 participants from 16 countries)
1995	Planning guidelines for RWH promotion, Subsidy system for rainwater tank, Mandatory system for RWH, and People for Rainwater (PR) was established
1996	Rainwater Utilization Liaison Council: 125 local government joined the network
2000	- International Association of Local Government awarded Sumida Ward for best RWH - Japan Business Association for Rainwater Utilization was set-up
2001	RWH Museum was opened in Sumida City (the world's first museum of its kind)

2005	Tokyo International Rainwater Conference was with Sumida Ward's coordination
2006	Environmental Local Ordinance: RWH promotion by collaboration among stakeholders
2007	Environmental Planning in which RWH is stipulated as one of high priority measure
2008	The first congress of rainwater network was constituted

2.1.2 Overview on Policy & Planning Aspect of RWH

The key elements under policy & planning aspects for Tokyo are the subsidy system, mandatory system and registration system. Tokyo can pride with its well-known subsidy system. The subsidies are given base on tank size. Table 3 summarizes the details of the subsidy system. Furthermore, in term of planning for RWH, TMG execute registration system, wherein if the company is registered, they receive subsidy for installing RWH tank. Thus, organized database for the RWH implementation can be recorded for the purpose of research & developments and future reference. Moreover, starting from 2003 onwards, for the development or construction of new building with floor areas more than 10,000m², TMG encourages the owner to install RWHS. Previously, it was not mandatory. However, according to an officer in TMG during the hearing survey, owners of new building especially in Sumida City did not oppose the instruction of the local government to install RWHS. The local government proposed to make it mandatory and only recently building with such floor area is enforced to install RWH. This mandatory system led to increasing number of RWH installation and utilization in Tokyo.

Table 3 Details of Subsidy System in Sumida-ku

TANK SIZE	SUBSIDY DETAILS
Small Size Tank (less than 1cu.m)	50% of the tank cost; maximum subsidy amount = ¥ 40,000
Medium Size Tank (> 1cu.m to < 5cu.m)	Maximum subsidy amount = ¥ 300,000
Large Size/Underground Tank (more than 5cu.m)	Maximum subsidy amount = ¥ 1 million

2.1.3 Overview on Design Aspect of RWH

In term of design, the focus for RWH is on tank design and harvested water quality design. The tank design is calculated by following formulas:

[The Size of Storage Tank = Population in the Building x 50litre x 3 days]

Or

[The Size of Storage Tank = Roof Area x 1.5m (Average Rainfall in Tokyo) ÷12 months]

For the quality of harvested rainwater, the design is based on the standard set by Tokyo Health Office. The measures includes on the existence of bacteria such as e-coli, chloride contains, the pH value, odour and turbidity of the water.

2.1.4 Overview on Technological Aspect of RWH

RWH consists of various subsystems including catchments, conveyance, filtration, storage, pumping and plumbing subsystems. Some RWH installation and utilization have all the subsystems while some RWH have several subsystems only, depending on the requirement and conditions of installation or utilization. In Tokyo, previously, RWH installation involves separate individual subsystems combined to produce full RWH system ready for use. However, efforts from TMG to encourage RWH product makers to manufacture readymade system contribute to the current market of RWH complete package system for ease of installation and to reduce cost. This prefabricated innovation in RWH rather than on-site constructed RWH is believed to have positive impacts to promote RWH to public as it is simple and uncomplicated. This is in line with the Tokyo's guiding principle to persuade RWH practice which is as according to Makato Murase, a RWH expert in

Japan from hearing survey, the RWH system should be as simple and cheap as possible.

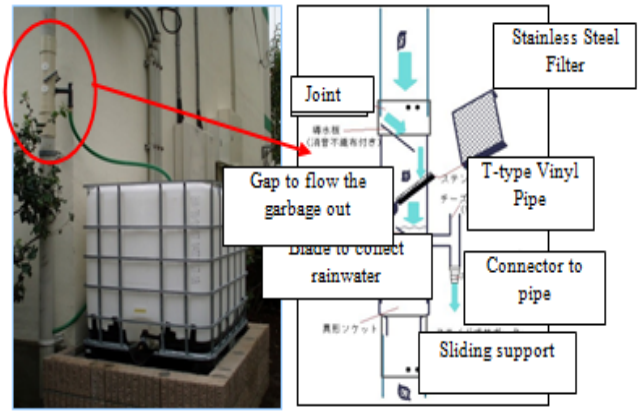


Fig. 1 Remarkable advances in RWH technology in Tokyo – complete RWH package system

**Source: http://www.greenangels.to/ (accessed 20th May 2009)*

2.1.5 Overview on Social Aspect of RWH

Beside good policy & planning equipped with efficient design and technology, another key component to look into for promoting RWH is the people's perception itself. With the intention to promote RWH by increasing awareness of the people, numerous endeavours had been practiced by the local government in Tokyo. Sumida Ward also renowned as Amamizu (rainwater) City in Tokyo is an example of successful region in inspiring her people to actively involved in RWH implementation. The details of each approach are as follows:

Rainwater Museum. The rainwater Museum located at Sumida City is the world's first museum of its kind. The visitors to the museum include people from around the world. There are model of RWH facilities exhibited in the museum. Such museum is crucial for inspiring people to start practicing RWH as ideas, cultures, information and experiences related to RWH can be obtained by visiting the museum. New Skywater Museum will be completed in Sumida City in 2012.

Rainwater Awareness Programme for School Children. There are activities specially designed to expose school children with RWH practice. Other than that, visits to rainwater museum & rain library are arranged together with talks on RWH and other interesting activities for the children.

People for Rainwater (PR). Established in 1995 and previously known as People for Promoting Rainwater Utilization (PPRU). It is a voluntary group established to promote RWH culture around the world by conducting rainwater fair, developing social systems & technical standards, developing rainwater education programme, organizing conferences, forums, seminars etc. PR also serves as a driving force for the RWH Museum, Rain Library and other social matters. Besides, PR involves in publication related to RWH such as Rain Encyclopedia. The establishment of such voluntary group that acts as main player to promote RWH in Tokyo is great endeavour because it is not easy to persuade people to joint non-profitable activities.

Rain Library. The rain library is located inside the RWH museum. There are a lot of books and other references on RWH. There is also section for children with RWH comic books referring to RWH experience from around the world. The library serves the purpose toward information dissemination regarding RWH.

Community Involvements. Programmes for RWH such as conference etc. especially in Sumida-ku is conducted with involvement of local community. This lead to increasing awareness on RWH practice among the community members. Besides, the community level involvement especially by inventing 'Rojison', a communal RWH facility in Sumida has create the culture of rainwater harvesting and it became the symbol of the community.

2.1.6 Analysis on Potential of RWH in Sumida-ku

Base on calculation for overall Tokyo, conservation rate by RWH stands at 0.03 l/p/d. However, actual amount of conservation if considering Sumida-ku only base on currently implemented projects, the

conservation rate might stand at 1.51 l/p/d as RWH are mainly practiced in Sumida-ku. Table 4 summarizes the estimated amount of water conservation if RWH are practiced in other potential area/building in Sumida-ku.

Table 4 Estimated Amount of Water Conservation for Potential Implementation of RWH in Sumida-ku

	Type	Number	Catchment Area(m²)	Tank Capacitty(ℓ)	Amount of Water Conservation (l/p/d)
Current Implemented RWH	Large Buildings	27	36,773	6,662,000	0.79
	Private Buildings	110	69,850	5,734,000	0.68
	Individual houses	21	288	288,700	0.03
	Total	158	106,911	12,684,700	1.51
Potential 1 (Introduce RWH to existing buildings)	Large Buildings	6	52,000	5,200,000	0.62
	Apartments	3	30,000	3,000,000	0.36
	Private Buildings	579	289,500	28,950,000	3.45
	Total	584	371,500	37,150,000	4.43
Potential 2 (Base on the forecast in future urban renewal place)	Large-scale Development	2	47,700	4,770,000	0.57
	Joint rebuilding	162	40,450	4,045,000	0.48
	Small Buildings	89	5,963	89,000	0.01
	Total	253	94,113	8,904,000	1.06
	GRAND TOTAL	995	572,524	58,738,700	7.00

2.2 Selangor

2.2.1 History & Development of RWH

The introduction of RWH in urban areas only started in 1999 with the establishment of "Guidelines for Installing a Rainwater Collection and Utilization System" after Selangor faces severe drought in 1998. To date, only some government buildings such as Department of Irrigation & Drainage Headquarters, several pilot projects conducted by National Hydraulic Research Institute of Malaysia, in example double storey terrace house in Taman Melawati and few private buildings for instance One Utama Shopping Complex is equipped with RWHS. Table 5 summarizes the history and development of RWH in Selangor.

Table 5 History & Developments of RWH in Selangor

YEAR	RWH HISTORY & DEVELOPMENTS
1998	Government state the interest in RWH after experiencing severe drought in Klang Valley
1999	"Guidelines for Installing a Rainwater Collection and Utilization System"
2004	- Ministry of Housing & Local Government prepared a cabinet paper to encourage government buildings to install rainwater collection & utilization system - National Hydraulic Research Institute of Malaysia (NAHRIM) was established to conduct research in all water hydraulic & water environment aspects including RWH
2006	- National Urbanization Policy (NUP) was formulated which emphasize on the use of alternative water resources including RWH and WWR. For the long term plan, it aims at installing RWHS in new government buildings and schools - the government announced to make rainwater harvesting mandatory to large buildings

2.2.2 Overview on Policy & Planning Aspect of RWH

Up to now, RWH practice in Selangor can be concluded as only at policy and planning stage. This is because so far there are only small numbers of RWH projects implemented. The new Selangor government had revised the policy of water for the state. Starting from June 2008, the first 20 m³ of

water from public water supply is not charged. It is given free to each household. Based on early response of some water experts, i.e. Datuk Randhir Singh Johl, the president of Selangor and Wilayah Water Watch, the Selangor's free water policy could prove detrimental as it encourages waste. He added that conservation should be made priority and efforts like RWH should be encouraged (Malay Mail, 2009).

Instead of subsidizing the free water, the state government can alternatively provide subsidy to Selangor citizen for installing RWH facility especially the storage tank which is the most costly component of RWHS. At present, the amount of money allocated for the free water is estimated roughly at RM1.8million a month which Selangor government has to pay to Syabas, a water concessionaire company. If the money is allocated for subsidizing RWH facilities, public will still enjoy the free water but by more sustainable means. RM 1.8million of subsidy for free water paid by the government at the moment is equivalent to giving subsidy for 1,385 tanks if for example, 50% of the tank cost is subsidized as practiced in Tokyo. The 5 m^3 tank cost (RM2, 600) is taken from the result of pilot project conducted by NAHRIM for double storey terrace house in Taman Melawati.

For mandatory system, although the government openly announced to make RWH compulsory particularly for large buildings, nevertheless so far from literature reviews and observation, there is no further significant action taken to realize it. Thus, it is not mandatory for new developments in Selangor to be equipped with RWHS. In term of planning, the major step taken to promote RWH in Selangor is effort by NAHRIM by conducting pilot projects to study the effectiveness of it in water resources management. Other than that, there are no other measures taken in term of planning such as registration system etc.

2.2.3 Overview on Design Aspect of RWH

There is no special formula to calculate the storage tank size. However, in term of tank design, NAHRIM had built-up a software named "Tangki Nahrim". The main purpose of this software as mentioned in NAHRIM's official website is as a guide in estimating the size of rainwater tank. It can predict the amount of rainwater captured, total rainwater volume delivered, reliability of the system, coefficient of rainwater utilization, storage efficiency, and the percentage time of tank empty. Twenty years of rainfall data for different cities/towns throughout Malaysia are available in this software. While for harvested water quality, it is compared with World Health Organization (WHO)'s standard.

2.2.4 Overview on Technological Aspect of RWH

Since the available technology for RWH in Selangor is still the separate subsystems, if Tokyo's technology is transferred to Selangor, the complaints from people on complicated installation of RWHS can be resolved, subsequently RWH can be popularized. The transferability of such Japanese technology to Selangor needs further quantitative and qualitative evaluation as future task.

Fig. 2 Example of RWH installation in Selangor – separate system

**Source: http://www.nahrim.gov.my/download/pksa/DoubleStoreyTerraceHouse.pdf (accessed 15th May 2009)*

2.2.5 Overview on Social Aspect of RWH

So far, to promote RWH by increasing people's

awareness, Ministry of Water, Energy & Communication (MWEC) in collaboration with Federation of Malaysian Consumer Association (FOMCA) initiated National Water Conservation Campaign which among others encourages rainwater harvesting at domestic level. Brochures are distributed to public under an activity of the campaign called 'Consumer Education and Information' to practice rainwater harvesting. It is the only approach taken by the government to campaign for RWH implementation. It will be necessary to examine such approaches practiced in Tokyo in order to promote RWH in Selangor as non-structural measures.

3. RESULTS AND DISCUSSION

Table 6 summarizes the findings of this study which compares related aspects in RWH practice between the two above-mentioned metropolises. From the comparison, it is obvious that Tokyo is in leading position in term of RWH development as well-balanced measures are considered comprehensively in order to implement RWH. For Selangor, since only recently she started RWH practice, a great deal of lessons can be learnt from Tokyo's experience.

Table 6 Comparison of Relevant Aspects in RWH Practice Between Tokyo & Selangor

ASPECTS	TOKYO	SELANGOR
Policy & Planning	• Subsidy System • Registration System • Mandatory System	• Guidelines for Installing a Rainwater Collection and Utilization System
Design	• Tank Sizing (2 formulas) • Harvested Rainwater Quality (standard set by Tokyo Health Office)	• Tangki NAHRIM (tank size) • Harvested Water Quality (WHO standard)
Technological	• Complete Package Tank System	• Separate Subsystems
Social Matter	• Rainwater Museum • Rainwater Awareness Programme for School Children • People for Rainwater • Rain Library • Community's Involvements	• Consumer Education & Information – to encourage RWH

4. CONCLUSIONS

From Tokyo's experience, RWH does not contribute to significant impact in water conservation as the development of RWH for urban areas just started few decades ago. However, the foundation for RWH is better in Tokyo compared to Selangor and most other countries. Furthermore, there are continuous efforts from the stakeholders in Tokyo to increase the promotion of RWH and it has started to expand quite rapidly in term of implementation.

RWH might be significant contribution in water conservation in near future if there is political willingness to implement the system and by ensuring the widest possible distribution. Although current water conservation rate by RWH implementation stands at 1.51 l/p/d in Sumida-ku, however potential of RWH might contribute to 7 l/p/d of conservation rate if RWH are implemented seriously in future. From this study, base on comparison of the mentioned relevant aspects of RWH, Tokyo is advanced and have well-developed practice. Measures in all such aspects taken by Tokyo especially Sumida Ward has big impact contributing to increasing number of RWH practice in the metropolis.

On the other hand, Selangor is lack behind. Therefore, Selangor can learn from Tokyo's experience to expedite the process to make RWH popular option for water conservation and to serve other purposes by mitigating unnecessary events by referring to all above-mentioned aspects.

REFERENCES

Furumai, H. (2008). *Rainwater and Reclaimed Wastewater for Sustainable Urban Water Use*, Physics and Chemistry of the Earth, v. 33, iss. 5, p. 340-346.

J.Gould. (1999). *Contributions Relating to Rainwater Harvesting*. http://www.dams.org/ docs/kbase/contrib /opt163.pdf (accessed 29 April 2009)

Klaus W.K. (2001).*The Rainwater Technology Handbook*

– *Rainwater Harvesting in Building*. Wilo Brain. Berlin.

Matsushita J. (2006). *Appropriate Basin Management Systems under Very Rapid Urbanization -Strategic Approach based on Japan's Previous Experience*, Proceedings of International Conference in Urban Area.

Shaaban A.J. et al. (1999). *Alternative Water Supply Options: Rainwater Harvesting*. Paper presented in a Workshop on Sustainable Management of Water Resources, Shah Alam, Malaysia.

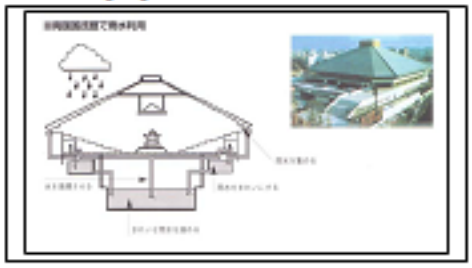
Toshiharu F. (2002): *Evaluation on Save Water Policy Package in Fukuoka-Shi*, Journal of Japan Water Supply Systems, Vol. 71, No. 7, pp 3-13.

(1999). *Rainwater – Guidelines for Installing a Rainwater Collection and Utilization System*. Ministry of Housing and Local Government Malaysia.

5-Minute Interview - Datuk Randhir Singh Johl: Crisis on the horizon, Malay Mail (11th May 2009)

APPENDIX

Table 7 Comparison of Types of WH in Sumida-ku and Selangor

REGION / TYPE	SUMIDA-KU	SELANGOR
Individual RWHS	• small-scale facility called a "Tensui-son", which stores rainwater from gutters of a private home 	• small-scale facility connected in each individual house 
Collective RWHS	• large-scale facility, which stores rainwater of high-rise buildings and large-scale structures like multi-purpose stadium 	• large-scale facility, which are public & private high rise & large-scale structure building, such as office buildings, apartments, shopping complex, etc. 
Communal RWHS	• community level of RWH practice, called "Roji-son, where rainwater is collected from the roofs of nearby houses, stored in an underground tank and can be pumped up with hand pump, mainly for fire-fighting during earthquake 	• RWH in community centres such as mosque, National zoo, wet market, community hall etc.