Journal of Social Science and Humanities, 3 (1): 14-22, 2020
e-ISSN: 2600 - 9056

DOI: 10.26666/rmp.jssh.2020.3.3

The Rainwater Harvesting (RWH) as A Flash Flood Mitigation Measure in Ken Rimba Shah Alam, Selangor

M. Zainora Asmawi[1], Nur Syahinda Mustofa[1], Abdul Razak Abd Aziz[2] and Asiah Abdul Rahim[1]
[1]Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 53100 Jalan Gombak, Kuala Lumpur
[2]Faculty of Architecture and Built Environment, City University Malaysia, Menara City U, 46100 Petaling Jaya, Selangor

Abstract: Malaysia is one of the countries facing frequent flash flood problems in the urban area due to city expansion and rapid development, poor drainage system and the natural system. There is a dire need for all relevant agencies to adopt new strategies to reduce the frequencies of flash floods that are plaguing the fully developed river basins, such as the Klang River Basin. Thus, the objectives of the study are to assess the Rainwater Harvesting (RWH) practice in mitigating the occurrence of the flash flood in Ken Rimba Shah Alam, Selangor. Ken Rimba development was selected as the case study as the major interest of this research to view the community in Ken Rimba residences on awareness and acceptance towards RWH implementation in the study area as well as their perception towards RWH as a flash flood mitigation measure in the study area. The study considers the perception of the community as they are living in flood-prone areas and likely very much affected during the flash flood, especially during the heavy rain in the monsoon season. The work collected the primary data through the distribution of questionnaire surveys to 194 respondents shows that nearly half of the total respondents perceived towards RWH application as a flash flood mitigation measure in the study area. However, there is not enough awareness of RWH benefits. Thus, the study suggested promoting RWH through mass media to the public to achieve long-term sustainability and resiliency that can be a flash flood mitigation measure, particularly in the residential area. All recommendations have involved many parties to promote rainwater harvesting to safeguarding the urban areas in nurturing communities that are simultaneously coping with climate change in this rapid urbanisation area.

Key words: *urban flooding, flash flood mitigation measure, rainwater harvesting, implementation, acceptance, perception, benefits, green technology, sustainability*

INTRODUCTION

The centuries-old water supply technology, Rainwater harvesting system (RWHS) system is known as a resilience strategy to mitigate urban flooding, which is a relatively new area of Rainwater harvesting (RWH) research. RWHS is the collection and storage of precipitation for later human use at the same time the stormwater runoff could be controlled and subsequently mitigate the occurrence of a flash flood.

This practice has been implemented for many years in traditional and modern ways, especially in areas that receive heavy rainfall and do not provide a water supply system in adequate quantity and quality for the communities. The Ministry of Housing and Local Government (MHLG) in 2007 introduced The Rainwater Collection & Utilization System or called *Sistem Pengumpulan dan Penggunaan Semula Air Hujan* (SPAH) as one of the government initiatives in providing the best development practices, which are environmentally friendly. This research, therefore, put an aim to assess the RWH practice and implementations in Ken Rimba Shah Alam that also has experienced flash flood due to the pressure of urbanisation.

Corresponding Author: M. Zainora Asmawi, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 53100 Jalan Gombak, Kuala Lumpur, +603 6196 4000 (3725)

PROBLEM STATEMENT

The government needs finding other measures that can be implemented to minimise the flash floods impact, especially Kuala Lumpur and Shah Alam, which are a regular feature after a heavy downpour.

Moreover, there is a need to carry out this study to investigate the viability of rainwater harvesting system practices, as well as the barriers, occurred to implement the RWH in residential buildings the author felt the need to find appropriate ways to encourage the developers taking their part towards promoting green building environment as well can reduce the flash flood occurrence despite the cost constraint and space-consuming issues.

Thus, it is vital to explore the residents' knowledge, opinions and factors associated related to RWH by carry out a community perceptions survey and use it to propose appropriate recommendations to spread the awareness of harvesting rainwater that can help to mitigate flood as well as securing water to meet their basic needs.

AIM OF RESEARCH

This paper aims to assess the RWH practice in mitigating the occurrence of the flash flood in Ken Rimba Shah Alam, Selangor. A discussion of recommendations for the future, followed by the conclusion as to conclude in assessing the aim of this research.

LITERATURE REVIEW

According to the Emergency Events Database (EM-DAT) or Center for Research on the Epidemiology of Disasters [1], the research highlighted that floods were the most frequent disaster occurring in Malaysia with 62.5% that affected the socio-economic of the livelihood in mortality and economic issues. The Department of Irrigation and Drainage (DID) also classified floods in two categories, which is a flash flood and monsoon flood. Based on the hydrological perspectives, the clear difference between these two disasters is the period taken by the river flow to recede to the normal level.

Kean Hua [2] viewed monsoon flood can last for a month while flash floods happen suddenly due to prolonged heavy rain and take only some hours to return to the normal water level. These floods happen in a very fast and short time due to the failure of the drainage system in an urban area, such as Kuala Lumpur. Figure 1 and Figure 2 presented an example of a monsoon flood and flash flood that occurred in Malaysia.

Fig 1 Monsoon flood in Pengkalan Chepa, Kelantan in 2014
Source: Aizyl Azlee [3]

Fig 2 Flash flood strike Jalan Ampang and Jalan Sultan Ismail, Kuala Lumpur in 2014
Source: Melizarani T.Selva [4]

Besides, three main factors cause flooding, as follows.

1. Flooding due to city expansion

The highest population density is always located in the city centre of the city due to the influx of migration in the city, searching for better working opportunities, services, and facilities. As urbanisation is growing, the number of exposed properties, people and business premises is also increasing.

2. Flooding due to the poor drainage system

Azliana (2010), as cited in Norashikin Samsuri [5], highlighted most of the existing drainage seems to insufficient as the water overflow to the road. Besides, the old drainage constructed system and poor maintenance contribute to flooding. The local authorities are responsible for keeping their drainage system to be well maintained with the right amount of maintenances and services.

Moreover, communities' social attitudes and environmental awareness also play a role in helping to reduce flash floods The 'little' rubbish throw by the irresponsible public along the road accumulate at the drainage and often cause clogging to the drainage system. Lack of continuous monitoring on this simple,

responsible attitude and clogging leads to greater impact during heavy rain flooding of the main road and drainage.

Fig 3 Workers dredge garbage and silt from a storm drain near the Pasar Seni LRT Station following flash floods in March 2017
Source: Jonathan Edward [6]

3. Flooding due to the natural system

Floods can also occur naturally. The main cause of the flooding is increased rainfall. According to Baharuddin et al. (2012), as cited in Norashikin Samsuri [5] found that with rainfall exceeding the annual rainfall and in exceptional condition with heavy rain in a short period which affects the drainage system cannot contain too much water and flooding occurs.

To summarise, a flash flood commonly occur in a short period due to high rainfall, and in conditions where the landscape is not able to accommodate runoff urban areas that have been developed where surfaces are covered impervious materials such as concrete and bitumen, coupled with improper drainage system and sediment barriers are more likely to be impacted. Increased built-up areas have also made it difficult for the upgrade of streams, ditches, and ponds to accommodate runoff. Other factors include the old sewage system not being well irrigated. Insufficient retention ponds built to control runoff from flowing into the drainage system.

Additionally, the sewers and drains constructed are not large enough to accommodate the runoff that causing overflows, and with more land use changes and development of new projects will probably increase the flow rate of runoff, necessitating drainage design that takes into account environmental changes.

METHOD OF RESEARCH

This research used both types of data collection, which are qualitative and quantitative data for data collection and data analysis. The research process conducted profoundly by collecting data from two main sources, which are primary data and secondary data.

1. Content Analysis

Qualitative data analysis made from the literature review gave the author an important perspective and organized critical appreciation of relevant literature through Physical Plan, planning guidelines, journals, books, references, newspapers, internet information, and others. This content analysis used in this study such as to describe the condition of RWH tanks, the environment of the Ken Rimba residences, flood-prone map water catchment distribution and others.

2. Site visit and observation

A site survey was conducted at Ken Rimba, Shah Alam, Selangor to observe the condition of the installed RWH in the residential properties and the existing land use, and it is surrounding the area.

3. Questionnaire survey

Simple random was chosen as the best sampling technique for this research. One hundred and ninety-four (194) respondents were interviewed as the residents of Ken Rimba Shah Alam and were conducted a face-to-face interview. The questionnaire is a close-ended structured, and it is distributed to the respondents on the day of the site visit and was collected immediately after the survey completed.

4. Data Analysis and Synthesis

From the site visit survey and questionnaire survey, the data transformed in the numerical format to suit the statistical analysis. The site visit survey is analysed through mapping by using a computer system, Geographic Information System (GIS), while the questionnaire survey is computed by using the IBM Statistical Package for Social Sciences Version 20 (SPSS). The type of statistical analysis used in this study such as the frequency distribution, cross tabulation, and chi-square.

BACKGROUND OF STUDY AREA

The study area of Ken Rimba Residences falls under the district of Klang in the Mukim of Kapar. The site locates in Shah Alam, Selangor, surrounded by federal territories of Kuala Lumpur and Putrajaya. It is under the authority of Majlis Bandaraya Shah Alam (MBSA) under Development Planning Block, Blok Perancangan Kecil 1(BPK 1). Specifically, the study area is located in the west zone of Seksyen 16. Figure 4 illustrated the location plan of Ken Rimba under the jurisdiction of the Shah Alam City Council (MBSA).

Ken Rimba owned by KEN Holdings Bhd is a premium township built in 60 acres comprises of Ken Rimba Legian Residences, Ken Rimba Jimbaran Residences, Ken Rimba Commercial Centre and condominium developments. Ken Rimba is a freehold development and Malaysia's first Green Township that popular for its tropical paradise-like residence and well known for adopting green principles and environmental-friendly methods in its design.

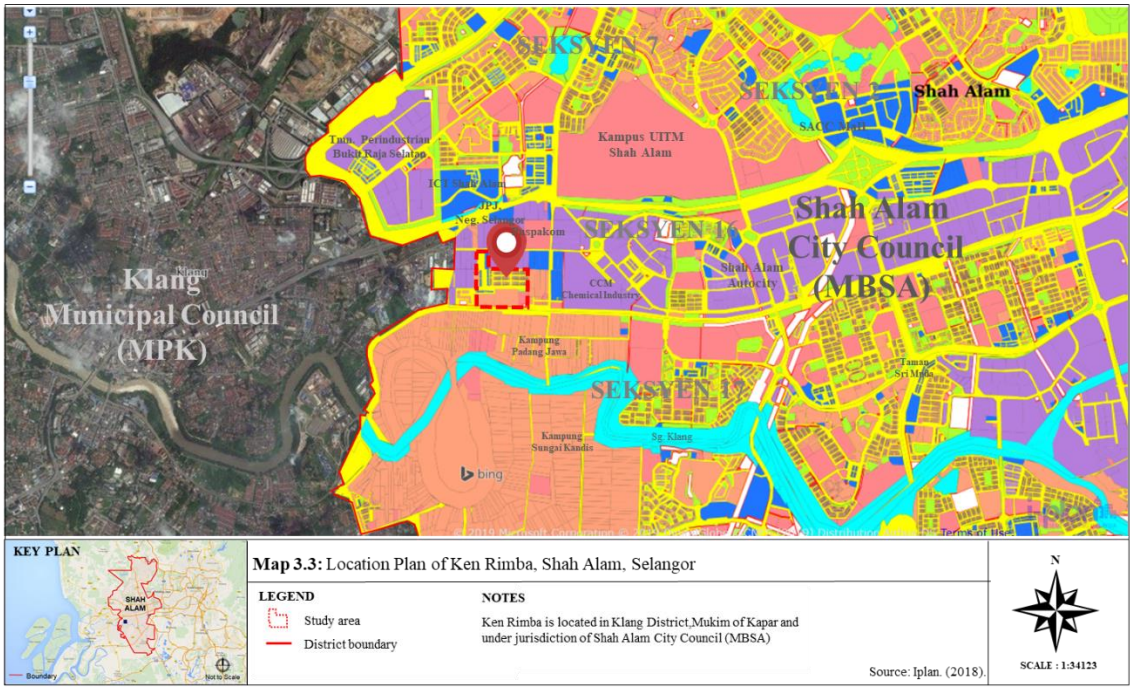

Figure 4 Location plan of Ken Rimba under the jurisdiction of Shah Alam City Council (MBSA)

RESULT AND DISCUSSION

1. Physical Aspect of Rainwater Harvesting RWH in Ken Rimba

There were 992 RWH tanks installed in 496 houses in the study area. Each house was equipped with two RWH tanks strategically located on the first floor and backyard of their houses. Figure 5 and Figure 6 illustrate the location of the installed RWH tank in both residences, Legian, and Jimbaran of Ken Rimba. These RWH tanks can store rainwater for non-consumption purposes such as for gardening and car or porch washing that helps the tenants save water and reduce their water bill, respectively.

Figure 5 Location of the installed RWH in the residence of Legian and Jimbaran, Ken Rimba
Source: Iplan. [7] and via site survey on February 24th, 2019

Figure 6 location of the two installed RWH tanks for each house in Ken Rimba
Source: site survey on February 24th, 2019

The RWH system provided in Ken Rimba residences is functioning well as each house was equipped with two RWH tanks located on the first floor and backyard of their houses. It is an assurance that the owners are using the system either actively or vice versa.

2. Implementation of RWH in Ken Rimba

60.3% were Malay and lived in Ken Rimba within 1 to 5 years and 67% of total respondents in Ken Rimba who participated in the survey owned their houses and 64.9% of total respondents claimed they attended university as their highest education level. According to the age category, 58.8% of respondents who participated in the survey aged between 20 to 40 years old, which 40.2% of them earned RM5000-RM10,000 per month as their household income. In terms of respondents' disaster experience, only 10.8% of respondents had experienced with flood disaster claimed they experienced the tragedy in Ken Rimba in which there are about 3.61% have stayed in the study area for more than 15 years.

In terms of individual awareness for the installation of RWH and acceptability of the users of the RWH system, the study found that 68% of the total respondents' claimed they know the Rainwater harvesting (RWH) with 41.8% of them know the RWH implementation in general.

Overall, we can see positive remarks where 77.84% of total respondents were aware of RWH location, and 81% of residents knew the purpose of RWH installation. 27.8% of them need RWH as necessary, followed by 49% of them to need RWH as necessary. Figure 7 below portrayed the distribution of respondents' awareness of the location of RWH.

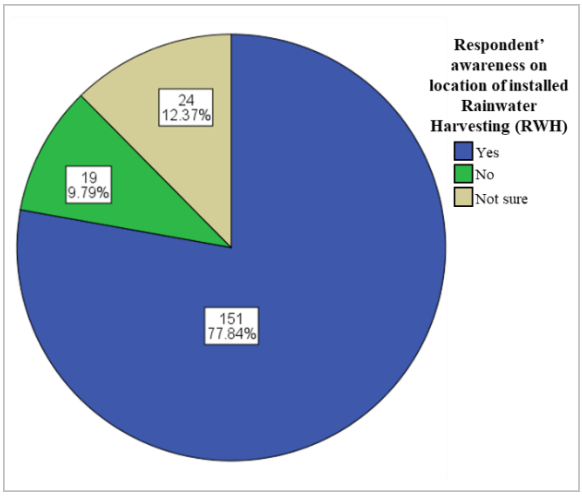

Figure 7 Respondents' awareness of the location of installed RWH in their houses

Despite that, there are about 7.9% of total residents who answered do not have to use RWH and not sure about the purpose of installing RWH in their homes. Moreover, only a few houses renovated their backyard and relocated, and some removed the RWH tank as well.

Interestingly, majority of respondents likely preferred to use stored water in RWH for outdoor activities such as outdoor cleaning, watering the garden, a recreation pool and toilet purposes other than indoor purposes such as drinking after boiling, laundry and cooking activities due to hygienic issue and suitability of using storm water in a domestic area likely for outdoor uses. Table 1 below is to show the respondents preferred activities by using water from RWH.

Table 1 Rate in using stored water in RWH

Respondents' rate in using Rainwater Harvesting (RWH) in their daily activities		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**
Cooking	F	**65**	67	30	20	12	194
	%	**33.5%**	34.5%	15.5%	10.3%	6.2%	100.0%
Laundry	F	20	65	46	33	30	194
	%	10.3%	33.5%	23.7%	17.0%	15.5%	100.0%
Toilet use	F	3	18	30	44	99	194
	%	1.5%	9.3%	15.5%	22.7%	51.0%	100.0%
Cleaning house-indoor	F	7	50	51	35	51	194
	%	3.6%	25.8%	26.3%	18.0%	26.3%	100.0%
Cleaning house-outdoor	F	2	6	22	49	**115**	194
	%	1.0%	3.1%	11.3%	25.3%	**59.3%**	100.0%
Drinking after boiling	F	64	56	38	23	13	194
	%	33.0%	28.9%	19.6%	11.9%	6.7%	100.0%
Washing dishes	F	36	73	40	24	21	194
	%	18.6%	37.6%	20.6%	12.4%	10.8%	100.0%
Washing vehicles	F	1	4	26	50	113	194
	%	0.5%	2.1%	13.4%	25.8%	58.2%	100.0%
Watering garden	F	1	2	8	48	**135**	194
	%	0.5%	1.0%	4.1%	24.7%	**69.6%**	100.0%
Recreation pool	F	3	17	23	41	**110**	194
	%	1.5%	8.8%	11.9%	21.1%	**56.7%**	100.0%

Furthermore, A Chi-square test was conducted, as shown in Table 2, to compute the relationship between respondents' rate of awareness and perception towards RWH against the length of stay, ownership status, and educational level. The result shows that the significant value of ownership status (0.016) and (0.001) as well as the educational level (0.025) on the understanding level on RWH and location awareness of installed RWH are less than the significant value 0.05. Thus the null hypothesis can be rejected. The result shows that length of stay, ownership status and educational level of the respondents have influenced their awareness and perception towards RWH. Ownership status has influenced much in awareness and perception towards RWH.

Table 2 Respondents' rate of awareness and perception towards RWH against the length of stay, ownership status, and educational level

Awareness and Perception towards RWH		**Length of stay in Ken Rimba**	**Ownership status**	**Educational level**
Knowledge on RWH	Chi-square	14.812	10.812	10.840
	df	6	4	8
	Sig.	.022[a,b,*]	.029[a,b,*]	.211[a,b]
Understanding level on RWH	Chi-square	9.315	12.243	9.283
	df	6	4	8
	Sig.	.157[a]	.016[a,b,*]	.319[a,b]
Awareness on the location of installed RWH	Chi-square	9.165	19.646	17.530
	df	6	4	8
	Sig.	.165[a,b]	.001[a,b,*]	.025[a,b,*]
Knowledge on the purpose of RWH installation	Chi-square	4.066	6.770	3.298
	df	6	4	8
	Sig.	.668[a,b]	.149[a,b]	.914[a,b]
Level of need in using RWH	Chi-square	8.517	9.037	7.135
	df	6	4	8
	Sig.	.203[a]	.060[a,b]	.522[a,b]

3. Community perception towards RWH as a flash flood mitigation measure in the study area

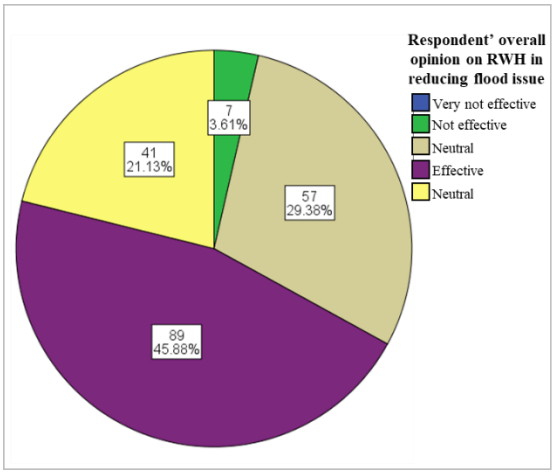

Figure 8 Respondents' overall opinion on RWH in reducing flood issues.

Figure 8 above illustrates respondents' overall opinion on RWH implementation to reduce flood occurrence, and 45.9% of the total respondents respond for effective, followed by 29.4% of respondents claimed for neutral. 21.1% responded for effective and 3.6% for not effective. Besides, there is no respondents' rate very not effective on their overall opinion towards RWH implementation.

The findings have drawn attention to the fact that 45.9% of the total respondent's rate RWH was effective, with 35.4% of them identified that RWH could reduce flood issues due to the capacity of the RWH tank to store a large amount of rainwater. From this statement, we can see nearly half of the total residents perceived towards the RWH application as a flash flood mitigation measure in the study area.

RWH tanks installed in Legian Residences itself received the BCA Green Mark Gold Award and was GBI-certified. Indeed, RWH can reduce flood issues as the capacity of the RWH tank to trap and harvest 450 gallons of rainwater per house in Legian residences.

Based on the site survey in February 2019, it can be assumed RWH tanks installed in both residences are of the same size. Hence, it can be estimated that 32 acres of Legian and Jimbaran residences in Ken Rimba were able to catch the rainwater and to prevent runoff as calculated below.

Total houses x RWH tank capacity per house
(Note: Assume that all installed RWH were functioning well)
=496 houses x 450 gallons
= 223,200 gallons/84, 4904 litres/844.90m^3

Overall, it can be concluded that Ken Rimba residences succeed to collect and store 223,200 gallons of rainwater before it is lost as surface runoff that would reduce the flooding caused by heavy rainfall at the same time can be used as a water source for washing, toilet flushing, gardening, and others.

Furthermore, the usage of Chi-square analysis was to test the goodness of fit and correlation analysis resulted ownership status did influence the overall opinion towards RWH where respondents who are the house owner agreed on the RWH implementation as a flood mitigation measure. According to Table 3, all statements (0.000) are less than the significant value of 0.05. Thus the null hypothesis of no relationship between variables can be rejected. Hence, respondents' awareness, knowledge on the purpose and level of need for RWH have influenced respondents' overall opinion on RWH in reducing flood issue.

Table 3 Distribution of respondents' awareness, knowledge on the purpose and level of need for RWH

Respondents' overall opinion on RWH in reducing flood issue		**Respondents' awareness of the location of installed Rainwater Harvesting (RWH)**			**Respondents' knowledge on the purpose of Rainwater Harvesting (RWH) installation**			**Respondents' level of need in using Rainwater Harvesting (RWH)**		
		Yes	**No**	**Not sure**	**Yes**	**No**	**Not sure**	**Necessary**	**Necessary**	**No need**
Very not affective	F	0	0	0	0	0	0	0	0	0
	(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Not affective	F	4	1	2	2	2	3	0	3	4
	(%)	57.1	14.3	28.6	28.6	28.6	42.9	0.0	42.9	57.1
Neutral	F	34	8	15	23	8	26	4	23	30
	(%)	59.6	14.0	26.3	40.4	14.0	45.6	7.0	40.4	52.6

Effective	F	73	9	7	63	7	19	23	59	7
	(%)	82.0	10.1	7.9	70.8	7.9	21.3	25.8	66.3	7.9
Very effective	F	40	1	0	40	1	0	20	21	0
	(%)	97.6	2.4	0.0	97.6	2.4	0.0	48.8	51.2	0.0
Pearson Chi-Square Tests										
Chi-square		25.499			41.648			70.701		
df		6			6			6		
Sig.		.000*,b,c			.000*,b,c			.000*,b		

4. Community recommendations on the utilisation of RWHS in promoting the green habit and sustainable living area

Figure 9 below illustrates the percentage of respondent agreement levels on the RWH implementation issue.

From the figure, 53% of respondents agreed that there is not enough awareness of RWH benefits, and 37% of the respondents agreed that the government seems not very supportive and inattentive towards rainwater harvesting systems. 31.4% of respondents also felt that they are still lacked knowledge in maintaining RWH.

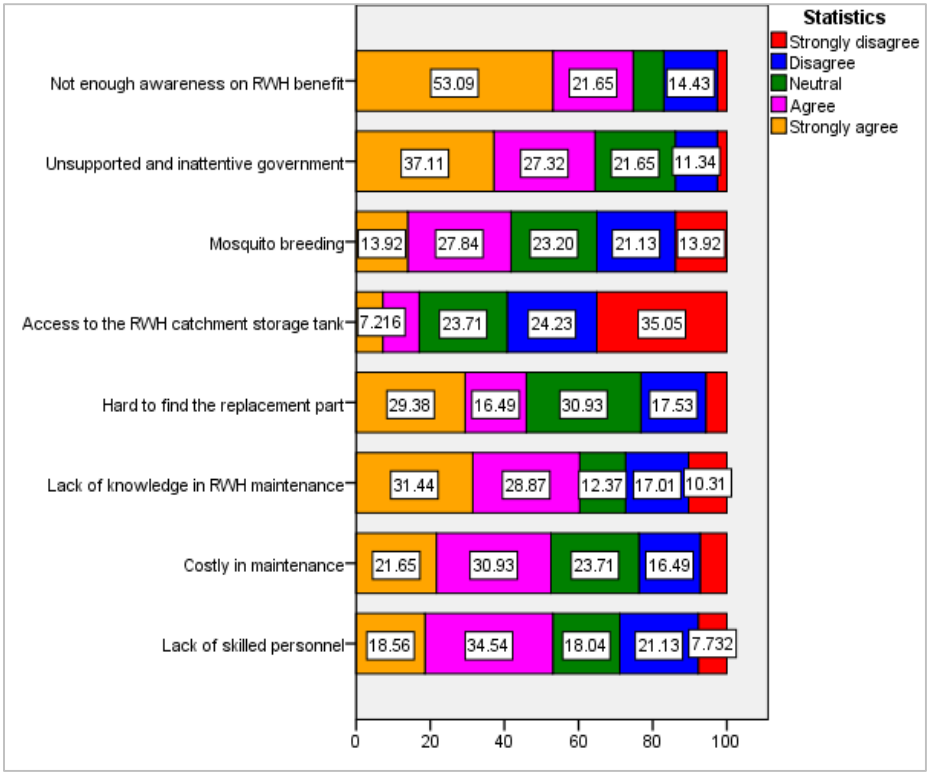

Figure 9: Percentage of Respondent's response to the Likert scale on the implementation issue of RWH

Thus, this result confirmed to the statement by Mohamad, Mohammad, Yusof, & Musa [8], that there are no proactive moves such as campaign or publicity taken by the relevant agencies in promoting and explaining the cost benefits, operation and maintenance of rainwater harvesting system to the public in which, this situation also can be found in Ken Rimba, Shah Alam. Of this issue, most of the respondents, with 58%, suggested improving mass media in promoting RWH to the public. Promoting and, at the same time educating in mass media regarding the necessity and benefits of rainwater preservation and harvesting are the easiest way to gain a huge impact on the public despite their levels of the education system.

Moreover, 54.6% of the respondents agreed there should be a strong move by the developer to promote RWH as via the elements in Green Building Index (GBI) at the

same time one of Green "Infrastructure" Technologies underwater efficiency category including flash flood reduction as well.

Besides, near to half of the total respondents, with 49.5% taught efficient enforcement of RWH policies and guidelines by the government, could improve the RWH installation as a flood mitigation measure. The government should tighten the policies and guidelines to the property developers and make the regulation towards rainwater harvesting system installation mandatory.

On the other hand, 17% of total respondents were strongly disagreed with increasing the tank size for RWH improvement as a flood mitigation measure. With regards to Mohamad et al., [9], bulky tank size would be space-consuming and downgrade the aesthetics of the environment, especially in the residential area. Nevertheless, design concern was still an important factor while improving RWH as a flood mitigation measure.

CONCLUSION

In conclusion, the findings found overall the achievement in implementing RWH in Ken Rimba due to the positive response on the awareness and acceptability for the installation of RWH, therefore, respondents' awareness, knowledge on the purpose and level of need for RWH indeed influenced respondents' overall opinion on RWH in reducing flood issue. However, overall the success is still inadequate and needs more efforts from the authorities, property developers, and society for implementing RWH at wider scales.

After all, it is clear that Rainwater harvesting (RWH) taking small steps leads to safeguarding the urban areas from flash flood occurrences, especially in the residential area. All recommendations and approaches should be adopted to achieve multiple aims of mitigating flash floods and nurturing communities that are simultaneously coping with climate change in this rapid urbanisation area. Last but not least, it is obvious that rainwater harvesting is one of Malaysia's sustainable approaches to flash flood mitigation.

REFERENCES

[1] The Center for Excellence in Disaster Management and Humanitarian Assistance (CFEDM), *Malaysia Disaster Management Reference Handbook*. Hickam, Hawaii, 2016.

[2] A. Kean Hua, "Monsoon Flood Disaster in Kota Bharu, Kelantan Case Study: A Comprehensive Review," *Int. J. Sci. Eng. Res.* , vol. 3, pp. 2347–3878, 2014.

[3] Aizyl Azlee, "Worst floods in Kelantan, confirms NSC," *Malay Mail*, 2015. [Online]. Available: https://www.malaymail.com/news/malaysia/2015/01/05/worst-floods-in-kelantan-confirms-nsc/813959. [Accessed: 28-May-2019].

[4] Melizarani T.Selva, "No solution yet to address KL's flash flood issues," *The Star Online*, 2014. [Online]. Available: https://www.thestar.com.my/news/community/2014/12/22/no-solution-yet-to-address-kls-flash-flood-issues/. [Accessed: 28-May-2019].

[5] R. A. B. & T. U. Norashikin Samsuri, "Flash Flood Impact in Kuala Lumpur-Approach Review and Way Forward," *Int. J. Malay World Civilis.*, vol. 6, no. 1, pp. 69–76, 2018.

[6] J. M. Jonathan Edward, "Poor drain maintenance causing floods in the city," *Malay Mail*, 2017. [Online]. Available: https://www.malaymail.com/news/malaysia/2017/04/04/poor-drain-maintenance-causing-floods-in-the-city/1348775. [Accessed: 28-May-2019].

[7] Jabatan Perancang Bandar dan Desa (JPBD), "Sistem Maklumat Gunatanah Perancangan Bersepadu." [Online]. Available: https://iplan.townplan.gov.my/public/geoportal?view=zoning. [Accessed: 08-Sep-2019].

[8] S. Mohamad, M. F. Mohammad, M. R. Yusof, and M. F. Musa, "The Awareness Among Developers on Rainwater Harvesting System (RWHS)," in *International Colloqium n Science and Technology*, 2014, vol. 2014, no. March, pp. 97–102.