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IMPACT OF FLOOD ON WASTE GENERATION AND COMPOSITION IN KELANTAN

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ABSTRACT This paper presents an overview of generation and composition of waste generated from the flood that hit Malaysia from December 2014 to January 2015, particularly in Kelantan. This study recorded that during the flood event, the most abundant waste generated was wood (44%) and concrete (29%), which belong to the construction and demolition wastes category. As for waste generated within the affected area, Kuala Krai recorded the highest amount of waste during the flood which totaled 30,000 tonnes which is almost the daily generation rate in Malaysia. Values of recyclables estimated from the flood waste stream was calculated to be almost RM7 million, yet was not tapped at all due to its high contamination with other flood waste namely mud and putrescible wastes. This study concluded that flood waste generated in Kelantan is highly heterogeneous in nature but predominantly construction and demolition waste, which carried significant economic value.

ABSTRAK *Kertas kerja ini membentangkan gambaran keseluruhan penjanaan dan komposisi sisa akibat banjir yang melanda Malaysia, terutamanya di Kelantan dari Disember 2014 hingga Januari 2015. Kajian ini menunjukkan bahawa jenis sisa yang paling banyak dihasilkan semasa banjir adalah sisa pembinaan yang terdiri daripada kayu (44%) dan konkrit (22%). Dari sudut penjanaan sisa oleh kawasan yang terjejas, rekod menunjukkan bahawa Kuala Krai menhasilkan jumlah sisa yang tertinggi sebanyak 30,000 tan, sebanyak jumlah sisa munisipal yang dihasilkan oleh seluruh negeri di Malaysia dalam sehari. Nilai barangan kitar semula dianggarkan mencecah RM7 juta namun tidak dieksploitasikan kerana teruk dicemari oleh air lumpur dan sisa mudah reput. Kajian ini menyimpulkan bahawa sisa banjir yang dihasilkan di Kelantan sangat bercampur aduk dan didominasi dengan sisa pembinaan yang masih mempunyai nilai ekonomi.*

(**Keywords**: Waste management; flood; Malaysia, disaster wastes)

INTRODUCTION

Natural disaster is an event that usually occurs with varying degree of impacts; either they are physical, economic or social impacts. Disaster, which does not come routinely, produced situations that usually exceeded the expectations of the affected community to take action such as saving lives, preserving property, and maintaining stability of the affected area [1]. The frequency of disasters keeps increasing within the last few decades [2]. Shaw [3] stated that disaster impact, not only affect human lives, but also environment because of the destruction of property, collapsing of buildings and infrastructures, and destruction of crops. As disaster subsides, next obstacle that will be faced by the victims and government is the residuals management stemming from the disaster.

After a disaster event, generation of disaster debris have become one of the major problems, since the volume and types of waste generated are greatly different from normal waste, depending on the nature and severity of the disaster. A study by Reinhart and McCreanor [4] on United State's past disasters showed that the volume of debris generated from a single disaster event is 5-15 times greater than waste generated during normal days. Waste generation after the 2004 Indian Ocean Tsunami also generated a similar ratio [5]. The massive volumes of debris and waste have exceeded the capacity of waste managers of the affected area in handling the situation.

Flood disaster is one of the natural disasters that generate huge amount of waste [6], and a wide range of waste composition, depending on its severity [1]. This is because flood caused severe damage to infrastructures and properties, which resulted in the generation of tremendous amount of waste [6]. The type of waste generated during disaster event varies greatly, highly depending upon the type of infrastructure impacted, whether most of the buildings and houses constructed were using concrete or wood [1]. Flood waste that is generated from the destruction of masonry houses composed mainly of concrete, while in rural areas which mainly composed of wooden houses, will generate more wooden waste. According to Federal Emergency Management Agency (FEMA) of United States, typical waste type generated during flood disaster usually composed of construction and demolition (C&D) waste, vegetative waste, household items, white goods, soil and mud, and putrescent [7]. Figure 1 shows the heterogeneity of flood waste generated after flood subsided. Every waste category that is generated has its own disposal challenges during normal condition. With the effect of disaster, these types usually create new mixed categories that will increase the complexity to separate and dispose [8,9]. This resulting in economic and environmental burden to the victims and authorities involved in reconstruction of the affected area as well as in management of municipal waste [10,11].

Flood is one of the climate-related natural disasters that hit various parts of Malaysia every year, due to the influence of the Monsoon. The 2014 flood event was recorded as the worst flood disaster in Malaysian history, which hit Kelantan, Terengganu, Pahang, Perak, Johor, Perlis, and Kedah [12]. About 500,000 victims were affected and 25 lives were lost from this catastrophic disaster [6]. Since there are no guidelines on the management of disaster waste in Malaysia, it was handled in an *ad hoc* manner. Without any appropriate framework, flood waste was indiscriminately disposed off into disposal sites in the country. This situation not only contributes to serious environmental contamination, but also inhibits any opportunity to reuse, recycle or recover the valuable materials from the waste stream. Therefore, this study was aimed to form a basis for future comprehensive and cohesive data on flood waste composition, to estimate the amount of flood waste generation, and to conduct the economic analysis of flood wastes generated in Kelantan.

a.Piles of wooden waste generated during the flood event

b.Collapsed house caused by flood generated heterogeneous waste

c.Mixture of wooden waste and concrete waste generated during the flood event

d.Piles of wooden waste generated during the flood event

Figure 1. Heterogeneity of flood waste generated after flood subsided

METHODS

This study was divided into two main parts which involved the collation of data from various agencies and relevant stakeholders, and the study of waste generation and composition from selected areas in Kelantan. In the first part of the research, data was collected from reports reviewing, analysis of questionnaires, and face-to-face interviews. Interviews were carried out with related stakeholders who were directly and indirectly involved during the flood disaster event in December 2014. The institutions and organizations involved in this study are Majlis Keselamatan Negara (MKN) or National Security Council, district offices, municipal councils and private bodies such as Alam Flora Sdn Bhd. and landfill management companies. Reports obtained from these agencies were also thoroughly reviewed to collate as much data as possible.

For the second part of the study, waste composition analysis and waste generation estimates were conducted at selected areas in Kelantan. The selected areas were mainly the most affected areas in the state namely Kota Bharu, Tumpat, Tanah Merah, Kuala Krai, and Gua Musang (Figure 2). Waste composition study was conducted at 30 houses while the waste generation data was obtained via interviews with the flood victims and calculation based on the loss experienced by the victims. Detailed classification of flood waste in Table 1 was used as a guideline. For the purpose of the interview, a set of questionnaires were prepared to assist and guide the response of respondents. Data obtained were analyzed statistically to determine its variants and statistical significances.

The economic value of flood waste was also investigated. Based on the weight of waste generated per house and number of houses involved, total waste was extrapolated from the generated data. Estimation on the monetary value of the wastes generated can be derived as there was no waste minimization activities such as recycle, reuse or reduce practiced in the study area.

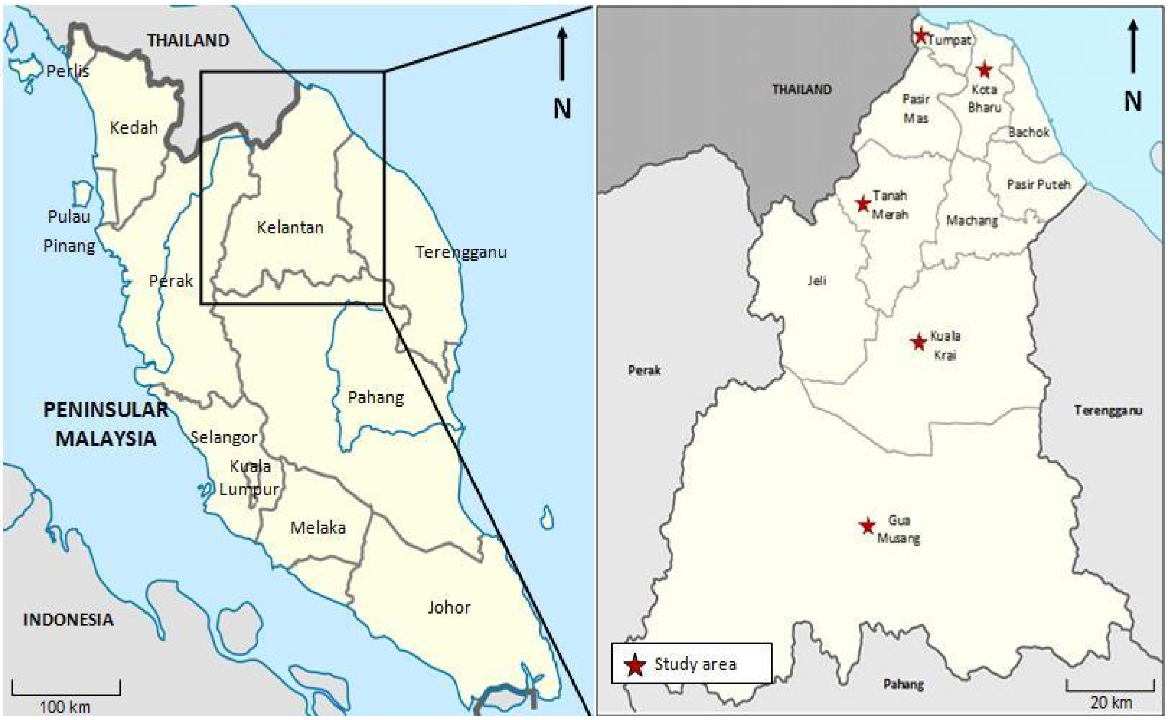

Figure 2. Location map of the study area

Table 1. Detailed classification of flood waste

Waste Types	Waste Group	Example
Kitchen waste	Food waste	Vegetable, fruits skin, left-over food etc.
	Food (not–consumed)	Expired food, rotten food etc.
Paper waste	Mixed paper	Coloured paper, heterogeneous paper
	Corrugated Paper	Box, cartons
Plastic waste	Plastic (rigid)	Plastic toys, Plastic pails
	Plastic (film)	Plastic bags and non-rigid, film like plastics
	Plastic (polystyrene)	Food containers, electrical appliances, fixing polystyrene etc.
	Disposable Diapers	Diapers
Textile waste	Textile	Clothes, rags
Rubber / leather	Rubber/leather	Shoes, tyres, etc.
Wood	Wood	Wooden furniture, wooden crates etc.
Green waste	Green waste	Leaves, tree branches, grass
Glass	Clear glass	Non-coloured glass, window glass etc.
	Coloured glass	Coloured or dark glass
Metal	Metal	Kitchen utensil, metal furniture, water barrel etc
	Tin	Food can etc.
	Aluminium can	Drinking can
	Other aluminium	Aluminium foil etc.
Construction and demolition waste	Wood	Wooden door, wooden roof truss, wooden house frame etc.
	Metal	Concrete pile, house grill, fence, roof (zinc) etc.
	Concrete	Brick, concrete wall, tiles etc.
Mixed waste	Mixed waste	Sofa, mattress, table and other waste which have mixed material
Sand / dirt	Sand/dirt	Mud, sand etc
Non-organic waste	Non-organic waste	Ceramic, garden clay pot, inorganic material etc
Hazardous wastes	Electical and electronic appliance	Television, washing machine, refrigerator, computer, electrical switch etc
	Hazardous wastes	Aerosol spray, gas cylinder, fluorescent lamp, battery, medicine etc.

RESULTS AND DISCUSSION

This study carried out quantitative and descriptive research to determine various aspects related to flood waste generated in 2014 flood event that has paralyzed majority of the city in east coast of Peninsular Malaysia. Number of victim, estimated loss, and estimation of total flood waste during the flood event are some of the important data acquired from interview sessions during the site visits. By using these data further extrapolation was done to obtain additional data such as the amount of total flood waste generated, the composition of waste and the economic value of recyclable flood waste.

Generation of Flood Waste

Figure 3 shows the total amount of waste generated during the flood event in Kelantan districts. Among the five districts in Kelantan, Kuala Krai generated the highest amount of flood waste with 29,851 tonnes, followed by Tanah Merah, Tumpat, Gua Musang and lastly, Kota Bharu. According to data obtained from National Security Council, Kuala Krai has the highest number of flood victims, and was recorded to be the most severely affected district during the flood event. This might be the reason why Kuala Krai is the highest flood waste generator. The severity of flood in Kota Bharu is milder compared to other districts. Consequently lower amount of flood waste was generated in Kota Bharu.

Figure 3. Total amount of waste generated during the flood event in Kelantan districts

To estimate the impact of flood disaster on waste generation, percapita of flood waste generation was calculated. The per capita waste generation in Figure 4 shows the same trend as the total waste generation in Figure 3, with Kuala Krai has the highest per capita waste generation (532.8 kg), followed by Tanah Merah (419.4 kg), Tumpat (372.1 kg), Gua Musang (374.9 kg) and Kota Bharu (3.9 kg). Kuala Krai recorded the highest flood water level, 34.17 m which exceed the danger level (25.00 m) fixed by the Department of Irrigation and Drainage, Malaysia [13]. Futhermore, the flood water currents in Kuala Krai was very strong that it created a massive destruction to the infrastructures, buildings, and crops. This had eventually generated tremendous amount of waste. Kota Bharu showed the lowest per capita generation, which is parallel to its actual total waste accumulated. Even though Kota Bharu has the highest number of victims, as reported by MKN, the water level and water current during the flood were much lower than that of other districts [13]. The low severity of flood results in less damages to the infratructure, buildings and properties in Kota Bharu was recorded.

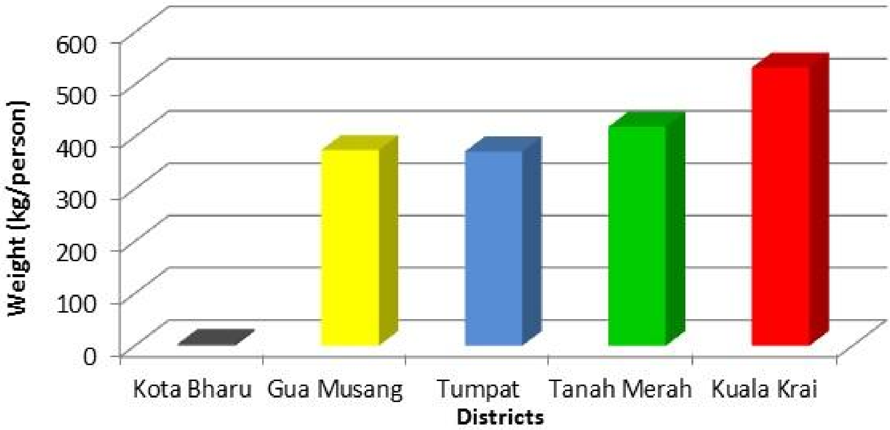

Figure 4. Percapita of waste generated during the flood event in Kelantan districts

Composition of Flood Waste

Figure 5 shows flood waste composition in Kelantan. It shows that 44% of waste generated during the flood is C&D waste that consists of woods. The main reason is that most of the affected areas are rural areas that predominantly consist of wooden houses. This is agreeable to the findings by Brown et al. [1]. The strong water currents during the floods brought down many of these wooden houses, and consequently generated high amount of C&D waste. The second highest flood waste generated was also a type of C&D waste namely concrete. Even though the area affected by flood were mostly rural area, concrete is still a fundamental construction material in Kelantan. The vigorous water current flow of the floods has caused major damage to the buildings, especially old buildings, thus resulted in the high volume of concrete waste in the waste stream.

The flood waste composition according to district is shown in Figure 6. In Kuala Krai alone, it is estimated that 25,000 tonnes of C&D waste were generated in the flood disaster (Figure 6). Tanah Merah also generated a huge amount of C&D waste, which is approximately 22,000 tonnes. A study conducted by Karunasena [14] states that the largest component of disaster waste generated, in most cases is C&D waste, which is similar to the flood waste composition in Kelantan. Similar scenario during 2004 tsunami event in Banda Aceh, Indonesia, resulted with the generation of C&D waste that more than 725 000 m^3 of land was used for disposal purpose [15]. C&D wastes that arise from disaster can be divided into recyclable materials (wood, concrete, masonry, and metal), non-recyclable materials (organic materials, inert materials) and hazardous waste (chemicals) [16].

Proper management of disaster waste is very crucial to prevent the spread of hazards tothe public and environment. Some components within C&D waste generated from flood in Kelantan pose a potential risk to health and environment. It was reported that components including gypsum, organic pollutants [17], arsenic treated woods [18] and asbestos can cause harm to the environment and human health. Thus, it would require special management, which failed to be provided by the Kelantan municipality. This is because disaster waste, including flood waste should not be mixed with normal municipal waste, as it poses health hazards to the public [19]. If disaster wastes are dumped into the landfill with normal waste, it will cause leaching of unwanted hazardous chemical. Furthermore, mixing of flood waste with normal municipal solid waste makes waste separation harder. Waste separation is the initial step in many waste treatment options, as many of the waste generated from the flood disaster can be reused, recycled, or treated, which may contribute to beneficial outcomes.

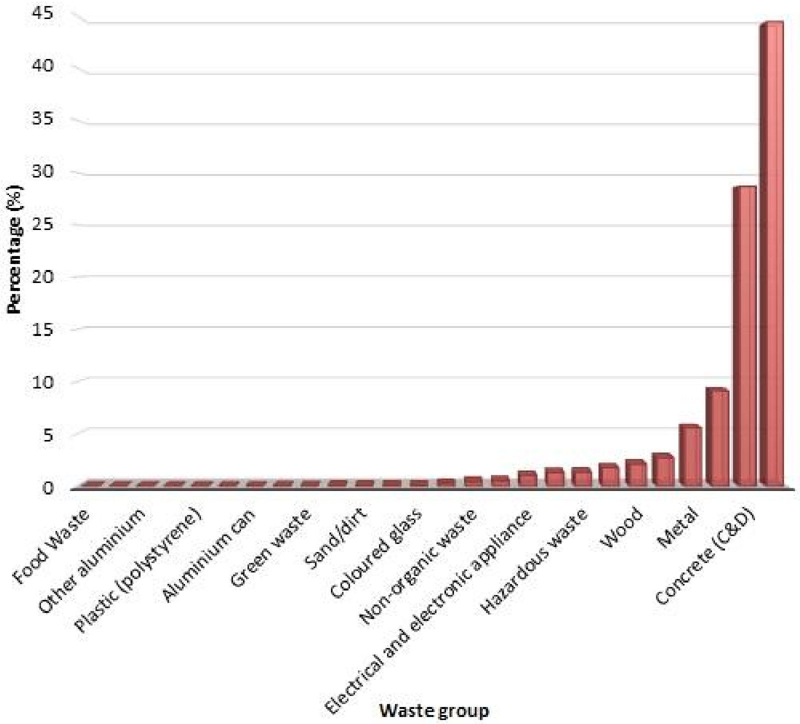

Figure 5. Flood waste composition in Kelantan

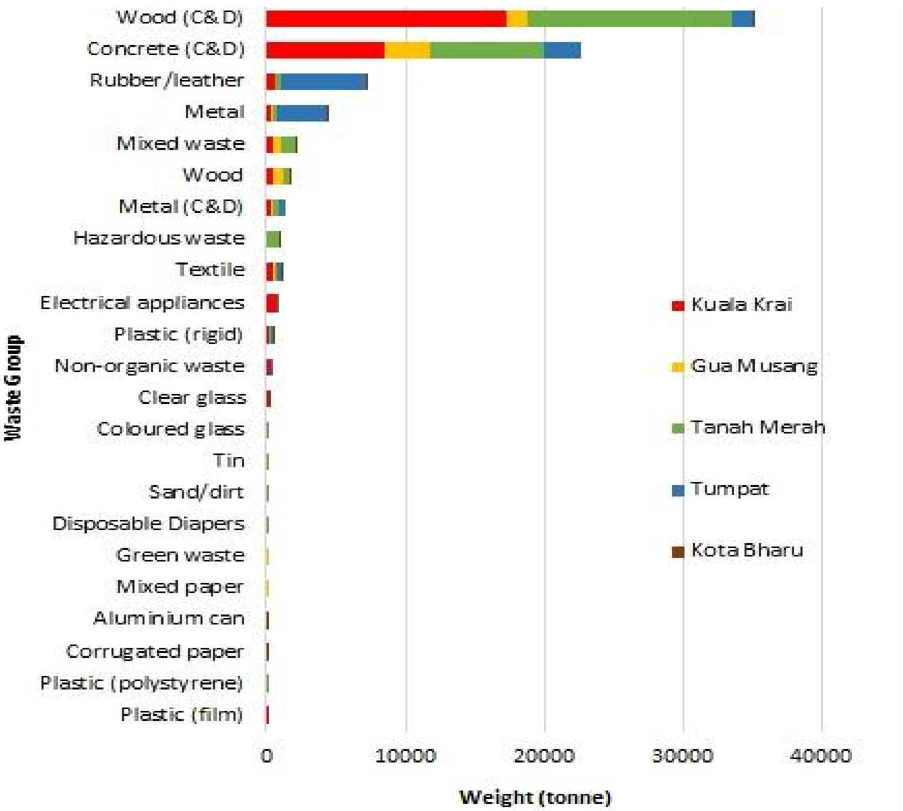

Figure 6. Composition of flood waste generated in Kelantan districts

Estimation of Economic loss

The flood disaster has caused many victims to incur economic burden due to the damage to their properties [1]. The management of flood waste in Kelantan had seriously impacted the Kelantan government financially since it required immediate attention to avoid health and environmental hazard. It has been reported that disaster waste disposal can cost to about 27% of total disaster management cost [7]. In the case of Hurricane Katrina, the totaled cost of waste clean up has totalled to more than USD 4.4 billion [20]. However, recycling create the opportunity to lessen the disposal cost and obtain some revenue. Recycling price in Malaysia is considered low as compared to other countries. A kilogram of paper fetched only RM 0.20, while a kilogram of metal, glass, wood, and concrete will only be at RM 0.40, RM 0.10, RM 1.25, and RM 0.08, respectively. Even though the price is not highly attractive, but the enormous amount of recyclable waste indicates that significant amount of revenue can be generated. Based on the average amount of waste generated per house for each waste classification during the flood event and the number of houses involved, estimation of the total revenue from recyclables is given in Table 2. It depicts the detailed calculation for each type of wastes for selected districts in Kelantan which could have been recycled. Potential revenue estimated from recycling activity is almost RM 7 million or USD 1.62 mil.

Table 2 . Estimated of Economic Value for Recyclable Flood

Type of recyclable wastes	Price per kilo (RM/kg)	Total value estimated for waste in Kuala Krai (RM)	Total value estimated for waste in Gua Musang (RM)	Total value estimated for waste in Tanah Merah (RM)	Total value estimated for waste in Tumpat (RM)	Total value estimated for waste in Kota Bharu (RM)
Plastic	RM0.20/ kg	(14,007 houses x 15.99kg/house) (RM0.20/kg) =RM44,794.39	(4390 houses x 21.42kg/house) (RM0.20/kg) =RM18,806.76	(19,453 houses x 11.66kg/house) (RM0.20/kg) =RM45,364	(11,213 houses x 7kg/house) (RM0.20/kg) =RM 15,698.20	(20,363 houses x 0.49kg/house) (RM0.20/kg) =RM1995.57
Metal	RM0.40/ kg	(14,007 houses x 57.81kg/house) (RM0.40/kg) =RM323,897.86	(4390 houses x 29.81kg/house) (RM0.40/kg) =RM52,346.36	(19,453 houses x 59.71kg/house) (RM0.40/kg) =RM464,615.45	(11,213 houses x 396kg/house) (RM0.40/kg) =RM1,776,139.20	(20,363 houses x 34.34kg/house) (RM0.40/kg) =RM279,706.17
Glass	RM0.10/ kg	(14,007 houses x 9.75kg/house) (RM0.10/kg) =RM13,656.82	(4390 houses x 4.346kg/house) (RM0.10/kg) =RM1907.9	(19,543 houses x 7.31kg/house) (RM0.10/kg) =RM14,285.93	(11,213 houses x 0.9kg/house) (RM0.10/kg) =RM1009.17	(20,363 houses x 0.07kg/house) (RM0.10/kg) =RM142.54
Wood	RM1.25/ kg	(14,007 houses x 30.60kg/house) (RM1.25/kg) =RM535,767.75	(4390 houses x 183.78kg/house) (RM1.25/kg) =RM1,008,492.75	(19,543houses x 19.22kg/house) (RM1.25/kg) =RM469,520.56	(11,213 houses x 5kg/house) (RM1.25/kg) =RM70,081.25	(20,363 houses x 0.07kg/house) (RM1.25/kg) =RM 0
Concrete	RM0.08/ kg	(14,007 houses x 607.14kg/house) (RM0.08/kg) =RM680,336.80	(4390 houses x 737kg/house) (RM0.08/kg) =RM258,834.40	(19,543houses x 423.63kg/house) (RM0.08/kg) =RM662,320	(11,213 houses x 234.5kg/house) (RM0.08/kg) =RM21,0355.88	(20,363 houses x 0.0kg/house) (RM0.08/kg) =RM0
Total estimation value for recyclable waste for each district		RM 1,598,453.62 USD 0.375 mil	RM1,340,388.17 USD 0.315 mil	RM1,656,106 USD 0.389 mil	RM 2,072,274.53 USD 0.487 mil	RM 281,844.28 USD 0.66 mil
		Estimated total value for the recyclable items is RM 6,949,066.54 or USD 1.62 mil (1USD = RM4.26) .				

CONCLUSION

In conclusion, Kuala Krai generated the highest amount of flood waste which was 30,000 tonnes followed by Tanah Merah, Tumpat, Gua Musang and Kota Bharu. Construction and demolition waste such as wood and concrete, was the highest type of flood waste generated due to the damages to buildings in the affected area. The economic analysis estimated potential revenue of RM7 million or USD 1.62 million if proper recycling took place in Kelantan to manage the flood waste. It implies the need to practice recycling of the flood waste for economic gains. Nevertheless, further study needs to be conducted to propose appropriate guidelines in handling flood waste. It will ensure that a more sustainable approach can be adopted in managing future disaster waste.

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REFERENCES

1. Brown, C., Millke, M., Seville, E. (2011). Disaster Waste Management: A Review Article, *Waste Management*. 31(6): 1085-1098.

2. Karunasena, G., Amaratunga, D., Haigh, R., Lill, I. (2009). Post Disaster Waste Management Strategies in Developing Countries: Case of Sri Lanka. *International Journal of Strategic Property Management*. 13: 171-190.

3. Shaw, R. (2006) Indian Ocean tsunami And Aftermath: Need for Environment-Disaster Synergy in the Reconstruction Process. *Disaster Prevention and Management*. 7(1): 5-20.

4. Reinhart, D. R., McCreanor, P. T. (1999). Disaster Debris Management-Planning Tools. *US Environmental Protection Agency Region IV.*

5. Basnayake, B. F. A., Chiemchaisri, C., Visvanathan, C. (2006). Wastelands: clearing up after the tsunami in Sri lanka and Thailand. *Waste Management World*. March-April 2006, 31-38.

6. Ibrahim. (2015). Lecture 2: Bencana Banjir Besar 2014 (Respons Dasar, Tindakan dan Penyelidikan) Retrieved from Dialog Bencana Banjir 2014.

7. FEMA. (2007). Public Assistance Debris Management Guide. Retrieved September 4, 2015 from http://www. fema.gov/pdf/government/grant/pa/demagde.pdf

8. Fetter, G., Rakes, T. (2012). Incorporating Recycling into Post-Disaster Debris Disposal. *Socio-Economic Planning Sciences.* 46: 14-22

9. Kobayashi, Y. (1995). Disasters and the problems of wastes. In: IETC, ed. International Symposium on Earthquake Waste, 12-13 June 1995 Osaka. Shiga: UNEP, 6-13.

10. Bandara, N.J.G.J. and Hettiarachchi, P.J. (2003). Environmental Impacts Associated with Current Waste Disposal Practices in a Municipality in Sri Lanka - A Case Study. Workshop on Sustainable Landfill Management, Chennai, India, 3-5 December 2003, 19-26.

11. UNEP. (2005). Sri Lanka post tsunami environmental assessment, United Nation Environment Program (UNEP). Geneva: UNEP, (DEP/0758/GE).

12. Star. (2014). More than 100,000 evacuated. Retrieved October 3, 2015 from http://www.thestar.com.my/ Ne ws/Nation/2014/12/27/More-than-100000-evacuated-Rescue-efforts-ramped-up-as-floods-show-no-sign-of-abating/

13. PPN (2015). Taklimat Bencana Banjir Negeri Kelantan. Pusat Kawalan Operasi Bencana Banjir Negeri Kelantan. 2 February 2015.

14. Karunasena, G., Rameezdeen, R., and Amarathunga, D. (2012) 'Post-disaster C&D Waste Management: The Case of COWAM Project in Sri Lanka', *Australasian Journal of Construc-*

tion Economics and Building, Conference Series, 1 (2) 60-71

15. Agamuthu, P., Fauziah, S. H., Sakai, S. I. (2012). Disaster Waste Management Challenges. *Waste Management & Research.* 30(2): 113-114.

16. Baycan, F., Petersen, M. (2002). Disaster Waste Management-C&D waste, in: ISWA, ed. Annual Conference of the International Solid Waste Association, 8-12 July 2002 Istanbul. Turkey:ISWA.

17. Jang, Y. C., Townsend. T. (2001). Sulfate Leaching From Recovered Construction and Demolition Debris Fines. *Advances in Environmental Research*. 5:3

18. Dubey, B., Solo-Gabriele, H. M., Townsend, T. G. (2007). Quantities of Arsenic-Treated Wood in Demolition Debris Generated by Hurricane Katrina. *Environmental Science and Technology*. 41:5

19. Jackson, N. M. (2008). Cleaning up after Mother Nature. *Waste Age 3.*

20. Stephenson, J. B. (2008). Hurricane Katrina: Continuing Debris Removal and Disposal Issues. Washington, DC: General Accounting Office.