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Physical Component's Resilience Criteria by Districts in Kelantan

Ezzat Fahmi Ahmad, Ida Nianti Mohd Zin
Centre of Studies for Construction, Department of Built Environment and Technology, Universiti Teknologi MARA Perak Branch Malaysia

Abstract
Natural disasters have become more frequent and intense around the world. Malaysia has no exception where the flood is the most devastating natural Disaster experienced by this country. Flood has caused massive damage and disruption, particularly to physical components such as energy and water supply, transportation and telecommunication systems, and critical facilities like hospitals and shelters. Thus, there is an extreme need to build and strengthen the resilience of physical components to resist, absorb, accommodate, and recover from the effect of flood in a timely and efficient manner in flood-affected areas. However, the community's flood-affected areas' needs may vary in different locations. Therefore, this study aims to determine a significant difference between the resilience criteria in different Kelantan districts. Thus, cross-sectional survey was conducted among one hundred and fifty-one (151) communities (government = 40; private sectors = 38; learning institution = 31; and communities = 32) in eight (8) districts which identified as flood-prone areas in Kelantan. A total of 23 resilience criteria (robustness = 5; resourcefulness = 6; rapidity = 6; redundancy = 6) to strengthen physical components were analyzed by SPSS version 22 subjected to descriptive and correlation analysis. The study found significant positive differences between the resilience criteria in different Kelantan districts.
Keywords: Disaster, Physical Components, Resilience.

Introduction

No person or place is immune from disasters. Disaster can lead to enormous scale consequences for the nation and its communities (Cutter, 2012). The risk of not paying attention to building and enhancing resilience can lead to severe community livelihood deterioration. Frequent small and medium-impact disasters and single intense events can severely disrupt community lifelines and the systems that provide energy and water supply, transportation and telecommunication systems and critical facilities locally and with the rest of the world (MERCY, 2016).

Table 1
Natural disaster events in Malaysia from 2010 to 2020

Year	Disaster Type	Location	Total Deaths	No Injured	Total Affected
2011	Flood	Johor	2	-	20000
2011	Landslide	Selangor	16	6	6
2013	Flood	Kuala Lumpur, Pahang, Terengganu, Johor, Kelantan	4	-	75000
2014	Flood	Sabah, Kelantan, Pahang, Terengganu, Perak, Johor, Selangor, Perlis	17	-	230000
2014	Drought	Kedah, Perak, Perlis, Pulau Pinang, Selangor	-	-	2200000
2015	Earthquake	Sabah	24	10	10
2015	Flood	Sarawak	1		3000
2016	Flood	Johor, Melaka, Negri Sembilan, Sarawak	-	-	6000
2016	Flood	Kedah, Pulau Pinang	-	-	441
2016	Flood	Terengganu	-	-	400
2016	Flood	Kelantan, Terengganu, Perak, Pahang, Johor, Sabah, Selangor	-	-	25000
2017	Storm	Sarawak, Sabah	-	-	426
2017	Flood	Kelantan, Terengganu	2	-	13000
2017	Flood	7 states in Peninsular Malaysia (Kelantan, Terengganu, Johor, Pahang, Malacca, Selangor, Perak, Sabah)	-	-	5481
2017	Flood	Penang, Kedah, Perak	7	-	3500
2018	Flood	Sarawak	-	-	4900
2018	Flood	Pahang, Johor, Terengganu	2	-	12000
2019	Flood	Sarawak	-	-	1000
2019	Flood	Peninsular Malaysia	-	-	2412
2019	Flood	Kelantan, Terengganu	2	-	15000
2019	Flood	Terengganu, Kelantan	-	-	4065
2020	Flood	Sarawak	-	-	2000
2020	Flood	Terengganu, Kelantan, Pahang	-	-	9273
2020	Flood	Sabah, Sarawak	-	-	9000
2020	Flood	Johor	-	-	1210
2020	Flood	Sabah	-	-	400

Based on **Error! Reference source not found.**, floods are the major natural disaster threat experienced by Malaysia, mostly every year during the monsoon season. Flood is the most significant natural disaster in Malaysia regarding population affected, frequency and extent of area, flood duration and economic damage. Having 189 river basins and 4,675 kilometres of coastline throughout Malaysia, including Sabah and Sarawak, the river basins and coastline areas fulfil a variety of functions both for human use and the ecosystem as well; at the same time, they might be the largest threat to human and ecosystem (Diya et al., 2014).

The flood situation has the great potential to affect physical components. The damaged physical components vital for communities' livelihood comprise electricity supply, water supply, sewage system, road and railway network, telephone and critical facilities (i.e., hospitals and shelters). Said et al (2013) found that damaged and insufficient physical components impacted by the flood have dramatically disrupted the livelihood in the affected areas. Physical components play a crucial role in providing services to the communities, particularly during flood disaster events.

One way to reduce disasters' impacts on the nation and its communities is to build and enhance resilience (Ahangama & Prasanna, 2015; Mayunga, 2009; Renschler et al., 2010). United Nations International Strategy for Disaster Reduction (UNISDR) defines resilience as *"the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions"* (UNISDR, 2009).

Therefore, it is crucial to strengthen the physical components' resilience in affected areas. In this way, the community in affected areas can withstand flood disaster events, simultaneously reducing the effects of disruption of livelihood of the communities in affected areas (Cutts et al., 2015; Reiner & McElvaney, 2017). The significance of strengthening the community's physical components' resilience in flood-prone areas aligns with the expected outcome of the Sendai Framework for Disaster Risk Reduction 2015 – 2030 (UNISDR, 2015), which reduces disaster risk and losses in lives and livelihoods of communities.

However, in several scholars' research on disaster resilience, the community's disaster-hit zone needs may vary by different locations (Kafle, 2012; Norris et al., 2008; Ostadtaghizadeh et al., 2015; Renschler et al., 2010; Shaw & Sharma, 2011; Sherrieb et al., 2010). This statement can be linked with this study, where the different flood-affected areas have different priorities regarding resilience criteria in that area. It is important to identify whether the flood-affected area's location impacts resilience criteria to strengthen physical resilience components. Thus, this study aims to determine a significant difference between the resilience criteria in different Kelantan districts.

Resilience Criteria

This section conducted a comprehensive review of literature research on the resilience criteria towards floods. Based on previous research analysis, authors have identified the resilience criteria and sub-criteria to strengthen physical components' resilience. The group of researchers discovered the resilience criteria in this study at MCEER (Multidisciplinary Centre of Earthquake Engineering to Extreme Events), which identified four (4) main criteria that can strengthen resilience (Cimellaro et al., 2010). These criteria are robustness, resourcefulness, rapidity and redundancy (Bruneau et al., 2004). Robustness can be defined as physical components' ability to withstand disaster forces without significant degradation or loss of performance (Bruneau et al., 2004).

Meanwhile, resourcefulness relates to identifying problems, establishing priorities, and mobilizing resources when conditions threaten to disrupt the physical components. Sajoudi et al. (2007) added resourcefulness refers to the ability to expertly get ready for, react to, and manage a disaster as it occurs and the capacity to organize needed resources and services in natural disaster events.

Moreover, rapidity is defined as the capacity to promptly meet priorities and achieve goals to contain losses and avoid future infrastructure systems disruption (Bruneau et al., 2004).

Finally, redundancy can be defined as the extent of infrastructure systems that are substitutable and capable of satisfying the functional requirement in disruption, degradation or loss of functionality (Bruneau et al., 2004).

Meanwhile, the sub-criteria to strengthen infrastructure systems in this paper was discovered through a literature review that covered several topics: resilience for transportation systems, energy systems, and sewerage systems. A summary of the resilience criteria and sub-criteria to strengthen infrastructure systems from various researches can be viewed in **Error! Reference source not found.**.

Table 2
Resilience criteria to strengthen physical components

Resilience criteria	**Sub-criteria**
Robustness	Corrective maintenance
	Preventive maintenance
	Safe design
	Material upgrade
	Newer structures
Resourcefulness	Information to reduce flood damage
	Training and planning
	Availability of material
	Availability of equipment
	Availability of financial aid
	Availability of manpower
Rapidity	Mobilization of material
	Mobilization of equipment
	Mobilization of financial aid
	Mobilization of manpower
	Restoration
	Reconstruction
Redundancy	Duplication of components
	Alternative components
	Capacity of components
	Stability of components
	Reduce the risk of complete failure of components
	Avoidance of failure for redundant components

Research Methodology

The questionnaire survey method was utilized for this study. Thus, the 5-point Likert scales ranging from 1 "strongly disagree" to 5 "strongly agree" were adapted to measure the extent of the importance of physical components' resilience criteria. Respondents were asked to indicate the level of agreement on the importance of those criteria. Purposive sampling was used for this study based on respondents' experience with flood disaster events. However, the selection was mainly focused on the community in flood-affected areas in identified districts in Kelantan. Based on Pour & Hashim (2016) and Syed Hussain & Ismail (2013), the flood-affected areas in Kelantan involving several districts such as Kota Bharu, Pasir Mas, Tumpat, Tanah Merah, Machang, Kuala Krai, Jeli and Gua Musang. These districts are located at several main rivers, including Sungai Kelantan, Sungai Lebir, Sungai Galas and Sungai Pergau. Hence, the survey was distributed to these several districts recognized as flood-affected areas in Kelantan. Besides, by referring to MERCY (2016), the community can be categorized into four (4) main groups: government, private sectors, learning institutions, and communities in terms of disaster. Thus, the survey was distributed among the four most important target groups in these districts. The questionnaires' outcomes were then analyzed using IBM SPSS Statistics Version 22 for descriptive and correlation analysis.

Finding

The analysis is to discover the extent to which the level of resilience criteria in flood-affected areas in Kelantan. The comparison was made between different flood-affected areas in Kelantan (i.e., Machang, Jeli, Gua Musang, Kuala Krai, Tanah Merah, Pasir Mas, Kota Bharu and Tumpat). The comparison is to identify any variations from the mean score result in **Error! Reference source not found.** and **Error! Reference source not found.**. **Error! Reference source not found.** and **Error! Reference source not found.** show a mean value comparison of the extent to the resilience criteria level in the different flood-affected areas in Kelantan. There are differences between the most important resilience criteria and the location of flood-prone areas in Kelantan. These findings then led the study to further analysis of the difference between the resilience criteria and the location of flood-affected areas in Kelantan, as suggested by (Kafle, 2012; Norris et al., 2008; Ostadtaghizadeh et al., 2015; Renschler et al., 2010; Sherrieb et al., 2010).

Using the Pearson Correlation Coefficient, an attempt was made to develop a significant relationship between flood-affected areas and resilience criteria. As the location of flood-affected areas in Kelantan, it is expected that there are differences in terms of resilience criteria to strengthen physical components. Hence, the Pearson Correlation Coefficient was used to identify the relationship between flood-affected areas' location and the resilience criteria. Pallant (2010) suggested that using the Pearson correlation coefficient as a statistical technique for exploring the relationship is suitable. The Pearson correlation coefficient is explored to evaluate the effect of resilience criteria on flood-affected areas in Kelantan, such as Gua Musang, Kuala Krai, Tanah Merah, Jeli, Machang, Pasir Mas, Kota Bharu and Tumpat. There was a significant positive correlation between resilience criteria and flood-prone areas in Kelantan. **Error! Reference source not found.** shows a significant positive correlation between the two variables, where the Pearson Correlation Coefficient is 0.420.

A positive correlation is a relationship between two variables in which both variables move in the same direction. A positive correlation exists when one variable increases as the other variables increase, and vice versa. In statistics, a perfect positive correlation is represented by the correlation value of 1.0. However, Cohen (1988) in Julie Palant (2011) suggest different interpretations. According to Cohen (1988), the Correlation Coefficient can be assessed as r = 0.10 to 0.29 (small), r = 0.30 to o.49 (medium) and r = 0.5 to 1.0 (large). Since the Correlation Coefficient, r between physical resilience components and flood-affected areas in Kelantan resulted in a value of 0.420, indicating that the correlation coefficient lies at the medium level. Hence, this study is aligned with research done by Kafle (2012); Norris et al (2008); Ostadtaghizadeh et al (2015); Renschler et al (2010); Sherrieb, Norris, & Galea (2010) on the disaster resilience where the needs of the community in the disaster-hit zone may vary by different locations.

Table 3

Resilience criteria by districts in Kelantan

Resilience criteria	Sub criteria	Machang		Jeli		Gua Musang		Kuala Krai	
		N = 17		**N = 22**		**N = 17**		**N = 19**	
		Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
Robustness	Corrective maintenance	4.4118	2	3.7727	14	4.4706	1	3.6316	16
	Preventive maintenance	4.2941	3	3.7727	15	3.8824	13	4.2105	3
	Safe design	4.4706	1	3.2727	21	4.2353	5	4.3158	2
	Material upgrade	4.118	11	4.000	7	4.000	10	4.000	10
	Newer structures	4.1765	8	4.0000	8	3.8824	14	3.7368	12
Resourcefulness	Information to reduce flood damage	4.0000	13	4.2727	1	4.0588	7	4.0526	7
	Training	4.2941	5	4.2273	3	4.0588	8	4.0526	9
	Availability of material	4.2941	4	4.0909	5	4.2941	2	4.1053	5
	Availability of equipment	4.2941	6	4.2273	2	3.9412	12	4.1053	6
	Availability of financial aid	4.0000	14	4.0000	9	4.0588	9	4.0526	8
	Availability of manpower	4.1765	9	4.1364	4	4.2941	3	4.4211	1
Rapidity	Mobilization of material	4.2353	7	4.0455	6	4.2353	4	4.1579	4
	Mobilization of equipment	4.0588	12	3.8182	11	3.9412	11	3.5263	17
	Mobilization of financial aid	4.1765	10	3.8182	12	4.1765	6	3.8421	11
	Mobilization of manpower	3.5882	22	3.2727	22	3.5882	19	3.7368	13
	Restoration	3.8824	16	3.9091	10	3.7647	16	3.4737	18
	Reconstruction	3.8235	18	3.7727	13	3.7647	17	3.4211	19
Redund	Duplication of components	3.7647	20	3.5000	16	3.7647	15	3.6316	15

	Alternative components	3.8235	19	3.4545	18	3.4118	23	3.2632	22
	Capacity of components	3.8824	17	3.3636	20	3.6471	18	3.7368	14
	Stability of systems	3.7059	21	3.4091	19	3.5294	20	3.1579	23
	Reduce risk of complete failure of systems	4.0000	15	3.4545	17	3.5294	21	3.3684	20
	Avoidance of failure for redundant systems	3.4118	23	3.1364	23	3.4706	22	3.3158	21

Table 4
Resilience criteria by districts in Kelantan

Resilience criteria	Sub criteria	Tanah Merah N = 20		Pasir Mas N = 13		Kota Bharu N = 23		Tumpat N =20	
		Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
Robustness	Corrective maintenance	4.4500	1	4.3077	2	4.5217	1	4.4000	2
	Preventive maintenance	4.0000	8	4.1538	4	4.3913	5	4.1500	10
	Safe design	4.1500	3	3.8462	12	4.0870	12	4.1500	11
	Material upgrade	3.950	10	3.769	14	4.304	7	3.950	14
	Newer structures	3.8500	12	4.0000	9	4.2609	8	4.3000	5
Resourcefulness	Information to reduce flood damage	4.0500	7	4.0769	6	4.3913	4	4.2000	8
	Training	4.1000	4	3.7692	13	3.9130	14	4.3000	4
	Availability of material	4.1000	5	4.0769	7	4.4348	3	4.6000	1
	Availability of equipment	4.2000	2	4.1538	5	4.3043	6	4.2000	7
	Availability of financial aid	3.8500	13	4.0000	10	4.2609	9	4.2000	9
	Availability of manpower	4.1000	6	4.3846	1	4.2174	10	4.3500	3
Rapidity	Mobilization of material	3.9000	11	4.0769	8	4.4348	2	4.2500	6
	Mobilization of equipment	4.0000	9	3.9231	11	4.1739	11	3.9000	15
	Mobilization of financial aid	3.7500	14	4.1538	3	4.0435	13	4.0000	12
	Mobilization of manpower	3.5500	16	3.6154	15	3.5217	17	3.7000	18
	Restoration	3.2500	21	3.4615	18	3.5217	18	4.0000	13
	Reconstruction	3.3500	19	3.2308	23	3.2174	22	3.7000	10
Redundancy	Duplication of components	3.6500	15	3.6154	16	3.4348	19	3.5500	22
	Alternative components	3.4500	18	3.3846	19	3.3478	21	3.6500	20

	Capacity of components	3.5000	17	3.4615	17	3.2174	23	3.7000	17
	Stability of systems	3.2000	23	3.3077	22	3.5652	16	3.6000	21
	Reduce risk of complete failure of systems	3.2500	22	3.3846	20	3.6522	15	3.8500	16
	Avoidance of failure for redundant systems	3.3500	20	3.3077	21	3.3913	20	3.3000	23

Table 5
Pearson Correlation Coefficient Test for the relationship between flood-affected areas (districts) in Kelantan and resilience criteria

Correlations			**Flood-affected areas in Kelantan**	**Resilience criteria**
Pearson Correlation	Flood-affected areas in Kelantan	Pearson Correlation Coefficient	1	0.420
		Sig. (2-tailed)		.608
		N	151	151
	Resilience criteria	Pearson Correlation Coefficient	0.420	1
		Sig. (2-tailed)	.608	
		N	151	151

Conclusion

Floods are an event that occurs worldwide, particularly in Malaysia. Floods leave a remarkable impact on livelihood and are utterly devastating. Although flood is caused by nature and inevitable, being aware and prepared should look thoroughly. The flood has adverse effects on physical components like energy and water supply, transportation and telecommunication systems, and critical facilities. However, this adverse effect can be significantly reduced by strengthening infrastructure systems' resilience in the face of future floods expected to increase.

The authors believe this paper has provided a general view on strengthening the physical components of floods. The authors believe it can serve as a platform for other researchers to launch into this field and find a way to strengthen the physical components of natural disasters in general.

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Corresponding Author
Ezzat Fahmi Ahmad
Centre of Studies for Construction, Department of Built Environment and Technology, Universiti Teknologi MARA Perak Branch, Perak, Malaysia.
Email: ezzatfahmi@uitm.edu.my

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