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Flood Risk Perception and Land Use Change Analysis in Flood Affected-Communities: A Case Study of Temerloh, Malaysia

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Abstract

Floods are one of the most common natural disasters worldwide. In Malaysia, floods cause significant economic damage and loss of human life. The frequency and magnitude of floods are increasing due to climate change and related anthropogenic activities. This study surveyed 280 respondents living in the Temerloh district which is in the midstream zone of the Pahang River Basin. This paper highlights their flood experience and identifies the cause of floods from the view of lay people. Results show that respondents are experienced in flood and flood-related damages. However, their perception of the causes of floods focused on natural causes while ignoring anthropogenic activities such as land use changes. To identify the land use changes, we used a classified shapefile for the years 2000 and 2010 from the Department of Agriculture, Malaysia and used overlay procedure in ArcGIS 10.1. Within the ten years, significant land use changes took place which could increase future flood risks. This paper argues that a grassroots approach to solving flood-related problems is essential. Accordingly, policymakers and decision-makers should involve the local community in the decision making which may develop their flood risk perception and awareness about sustainable land use.

Keywords: Flood Disaster; Flood Damages; Perception; Land use change analysis; Malaysia.

1. Introduction

Globally, flooding is one of the most dangerous and widely dispersed natural disasters in both densely populated and highly developed regions (Dou *et al.*, 2018; Xu *et al.*, 2018). Flooding can occur from unexpected heavy rainfall, tsunamis or coastal storm surges, rapid snowmelt or even from a direct result of log jams, reservoir dams or protective dykes breaking (Noordwijk *et al.*, 2017). On the verge of the increasing rate of natural disasters, several mitigation attempts are being implemented worldwide such as structural measures. However, many experts suggested that flood protection should be done by ecosystem creation and restoration (Morris *et al.*, 2018; Reguero *et al.*, 2018; Temmerman *et al.*, 2013).

Floods have become common for a significant number of Malaysians who are affected by floods annually. Almost 9% of Malaysia total land area is a flood-prone area which affects more than 4.82 million people and cost nearly RM100 million every year (Chan, 2015; Janius *et al.*, 2017). The danger from floods has been increasing due to climate change.

However, significant increases in societies' vulnerability because of fast socioeconomic progress is also considered among the leading causes of flood risk (Akter *et al.*, 2018; Dottori *et al.*, 2018). This fast-socioeconomic progress has led to modifications in the environmental and physical conditions of an area of which land use change is among the most noticeable. Land conversion in the upstream can increase the flood hazard, while the rise of the population living in the flood-prone zone is expected to be affected because of the increased magnitude of floods (Marfai *et al.*, 2015; Tan *et al.*, 2015). Land conversion creates greater runoff because of the change in impervious surfaces which increase the likelihood of flooding in the downstream (Lin *et al.*, 2015; Sajikumar and Remya, 2015).

The rise of impervious surfaces is claimed to be the cause of higher runoff volumes and peak with a reduced interval time. Peak discharge can reach up to 80% with 50% impervious area (Rose and Peters, 2001). Moreover, runoff can increase to 200%-500% if impervious surfaces exceed 10% of the watershed. Therefore, inappropriate anthropogenic activities such as land use change and development can make more areas vulnerable to flooding (Lee

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and Brody, 2018). Such anthropogenic activities have altered a huge proportion of the earth's surface. Approximately 41% of the natural vegetation such as water body and vegetation cover has been converted to anthropogenic land cover (ALC) such as built-up land and croplands (Sterling *et al.*, 2013; Wheater and Evans, 2009).

In the Pahang River Basin, natural land cover changes into others land cover in such a complicated way because of people's lack of awareness and knowledge which accelerate the risks of flooding. Destruction due to floods will continue unless sustainable developing processes are introduced which will value the natural resources. According to several studies, a positive relationship between natural resources and human adjustment reduces the disaster risk and enhances their adaptive capacity (Aerts *et al.*, 2018; Richards *et al.*, 2017). However, in this study, we found that most people do not consider land use change as a leading cause of flood though they already experienced floods.

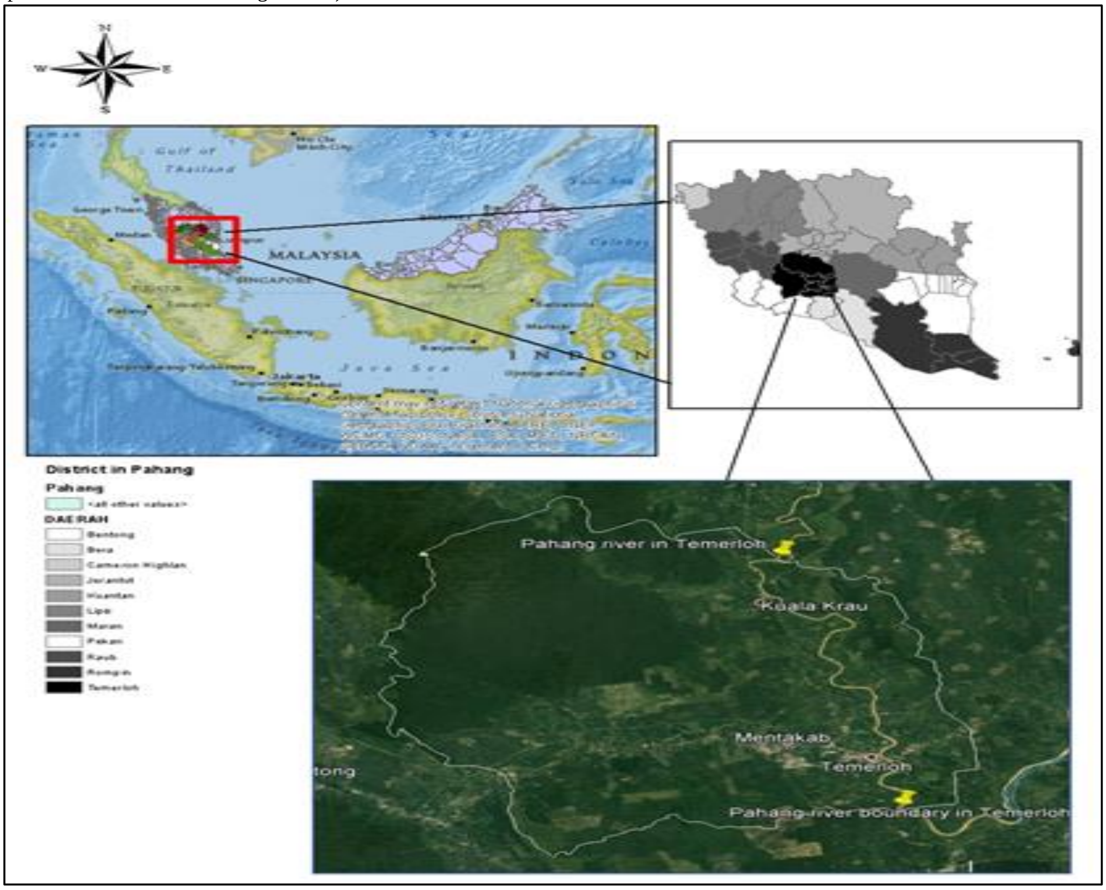
This study is based on a survey conducted in the district of Temerloh located beside the midstream zone of the Pahang River Basin. In this study, we identify the flood experience of locals regarding the impacts of flooding and their perception of its causes. We also identify changes in land use patterns in Temerloh district from the years 2000 to 2010 which will help decision-makers to form suitable policy to reduce the frequency and magnitude of floods and establish sustainable development that is environment-friendly and cost-effective.

2. Methodology

2.1. Study Area

Temerloh is a district in the middle of Pahang state, Malaysia, located at the junction between the Semantan River and Pahang River (Fig 1). Sixty-six villages within Temerloh district are located along the Pahang River Basin. The Pahang River Basin is situated in the eastern part of Peninsular Malaysia. Temerloh is located at an altitude of 163 feet above sea level, and its geographical position at 3 ° 26'55 "N 102 ° 24'58" E. The latitude of the Pahang River Basin is N 2° 48' 45" and N 3° 40' 24" and between longitude E 101° 16' 31" and E 103° 29' 34". The highest length and width of the catchment are 205 km and 236 km.

Figure-1. Geographic location of the study area (shown in the red box). The map is focused on the Temerloh district which is located in Pahang (Base map from ArcGIS 10.1 and Google Earth)



The basin has yearly precipitation of around 2,170 mm, a vast extent of which happens during the North-East Monsoon between mid-October and mid-January. The mean yearly temperature is 26.4°C with the mean relative stickiness of 86%. The mean stream of Pahang River measured at Lubok Paku is 596 m3/s (Hod *et al.*, 2017). Several major floods happened in the last few decades in the Pahang River Basin which caused extensive damage. Pahang state experienced three major floods in the years 1971, 2007-08 and the most recent flood happened in 2014-15. In terms of flood magnitude and damage, the 2014-2015 flood had been described as the worst in decades. In Pahang, almost 10,825 people were evacuated, and three people died during this flood (Hod *et al.*, 2017).

2.2. Data Collection and Data Analysis

This study adopted the questionnaire survey method to collect the relevant data from the stakeholders. The stakeholders are the local community from Temerloh district who are living near the midstream zone of Pahang River basin and have experienced flooding. In this study, simple random sampling and clustered sampling methods were used to collect and generate data from the questionnaire. The random sampling methods were used to avoid systematically excluding certain types of respondents so that every household should have an equal opportunity of being selected for the survey. To avoid biases when selecting respondents for the survey, clustered sampling was used (Singh and Masuku, 2014). A pilot study was conducted before the main survey in order to test the suitability of the questionnaire to check whether it can answer its objective. After the pilot study, the questionnaire was revised, and the necessary changes were made. The survey started from 15 May 2018 and completed on 5 June 2018. We were able to distribute 300 questionnaires to the respondents. However, due to incomplete answers from 20 respondent, we consider 280 respondents with ± 6% margin of error. Questions were asked to the head of the household and in some cases the senior member of the house. Respondents were initially asked about their family and socioeconomic status and then their experience with flooding and other related questions sequentially. In some areas, the interviewers found that respondents already made alterations to their house to avoid future flood risk. The interviewers noted structural alterations. If the respondents were positive about their flood experience, then we asked them other questions which are related to flood.

Moreover, we visited the Department of Irrigation and Drainage (DID) and Temerloh Municipal Council (TMC). Rainfall data were collected from three different stations in Temerloh and Department of Drainage and Irrigation (DID). At the time of field visit, we communicated with the community leader, village leader and with some political representatives to understand their perception about the flood and to know their opinions as to how to reduce flooding. All completed questionnaires received from the enumerator were initially entered into SPSS (version 22). Descriptive statistics were performed in SPSS to understand the socioeconomic status of the respondent.

Land use is identified in this study not as the physical condition of the earth surface, but as people utilising the land cover. Land use classes were organised and evaluated at the 1:5000 scale for two different years, based on the shapefile of two the years 2000 and 2010 obtained from the Department of Agriculture, Malaysia. In total, we recognised 22 land use categories in 2000 and 2010 which were clustered into four main classes: agriculture, forest cover, water body, built-up area and newly cleared land. ArcGIS 10.1 was used to identify the land use change of Temerloh during the years 2000 to 2010. Ground truth data were also collected from some points using the Geographical Positioning System (GPS). We calculated the total area (hectare) of 2000 and 2010 of the Temerloh district. The overlay method was used to identify the significant changes in land cover from 2000 to 2010.

3. Result and Discussion

3.1. Sociodemographic Profile of the Respondent

The sociodemographic profile is an important factor for society. Sometimes the development of a society influences the social factors positively or negatively. The natural and human activities of a society directly affect the structural and non-structural development trends which are also responsible for floods (Rakib *et al.*, 2017). As shown in Table 1, from 280 respondents, 127 (45.4%) were male, and 153 (54.6%) were female. The mean age of the respondents was 47 years, and the majority (20% or 56 respondents) are aged 46-50. The youngest respondent was aged 21 years and the oldest 70 years. More than 60% of respondents were aged 40-60 years. Only 10% of respondents were more than 60 and the remaining 30% respondents less than 40 years. Most of the respondents were married and had families comprising more than five people. Only three respondents (1.1%) had families with more than ten people. However, many family members were living in other cities.

Table-1. Sociodemographic profile of the respondent

Variable	Category	Frequency (n)	Percentage
Gender	Male	127	45.4
	Female	153	54.6
	Total	280	100
Age	21-25	6	2.1
	26-30	14	5
	31-35	29	10.4
	36-40	26	9.3
	41-45	40	14.3
	46-50	56	20
	51-55	46	16.4
	56-60	33	11.8
	61-65	23	8.2
	66-70	7	2.5
	Total	280	100
Family Member	1-2	29	10.4
	3-5	103	36.8
	6-7	119	42.5
	8-10	26	9.3
	>10	3	1.1
	Total	280	100
Education Level	20	7.1	
	Secondary School	61	21.8
	Post-Secondary School	126	45
	49	17.5	
	Degree	24	8.6
	Total	280	100
Occupation	Farmer	15	5.4
	Fisherman	7	2.5
	Government Job	71	25.4
	Employed	72	25.7
	Not working	51	18.2
	Others	64	22.9
	Total	280	100
Income	<1000 (<US$ 239)	63	22.5
	RM 1001 - RM2000 (US$ 240 – US$ 479)	83	29.6
	RM 2001- RM 3000 (US$ 479 – US$ 719)	83	29.6
	RM 3001- RM 4000 (US$ 719 – US$ 959)	29	10.4
	> RM 4000 (>US$ 959)	22	7.9
	Total	280	100

Almost 100% of respondents had at least a primary level of education. However, only 24 respondents (8.6%) completed higher education. 45% or 126 respondents completed post-secondary school. More than 25% of respondents had primary and secondary education. Also, 18% of people had a diploma. Almost half of the respondents were employed. However, almost 85% of people's income is less than RM 3000 (<US$ 719), and only 8% of people's income is more than RM 4000 (US$ 959). Around 8% of people worked as a farmer and fisherman, and 23% of people are studying or engaged in business. Fifty-one respondents (18.2 %) are not working, and most of them are aged 55-70.

3.2. Flood Experience and Damages in Temerloh

Our study focuses on the households that are affected by the floods in the last five years. Within the full sample of 280, more than 85% (241 respondents) people live in a single storey house, of whom 155 (55.4%) reported having experienced flooding. Moreover, 9% of people experienced floods twice a year. Most of the respondents have been living in the same place for at least ten years and believe that the magnitude of the flood is increasing every year. Of the 155 respondents who experienced floods, 74% of people's property (e.g. furniture, crops, car and motor etc.) was damaged due to flooding. Regarding the height of the flood water, 70% reported that the height was more than 1 metre. According to the field observation, most of the respondents' houses are not high enough from the ground, and if flood water exceeded 1.5 metres, then 80% of houses would become flooded. In describing the duration of flooding, most respondents indicated 1-4 days of flooding. However, some respondents have experienced flooding for more than five days in 2015 and most considered the 2014-2015 flood as being the worst.

Table-2. Flood victims and property damage experience among the respondents

	Flood Experience	Frequency	Percent
Flood Victim	Yes	155	55.4
	No	125	44.6
	Total	280	100
Flood Frequency	1 time	140	90.3
	2 times	15	9.7
	Total	155	100
Property Damage	Yes	115	74.2
	No	40	25.8
	Total	155	100

The respondents expressed that they still feel depressed and stressed when remembering how the floods destroyed most of their belongings and they could not do anything but witness the destruction. From interviews with the Temerloh Municipal Council and the public and private sector, the Public Works Department has to bear most of the expenses caused by the flood in 2014-2015. The cost of damages was over RM 1 billion (Table 3). The Public Works Department is responsible for federal roads, state roads, water supply systems, government offices, hospitals, schools, port and airports, police and army facilities, etc. Moreover, the Temerloh Municipal Council spent over RM 6.8 million (US$ 1.6 million) due to floods[1]. Many businesses were affected due to flooding and lost their regular transaction which directly affects the Malaysian's economy, especially the agricultural sector. From our interviews with businessman involved in palm oil and rubber production, palm oil and rubber production decreased significantly as flood waters did not subside for many days. As a result, the price hiked, and supplies of palm oil from Malaysia to other countries were also disrupted.

Table-3. Total estimated damages due to flooding in 2015

No.	Responsible Authority	Total Estimated Damages	Percentage of Damage
1.	Public Works Department (JKR)	RM 112 million (US$ 2.9 million)	79 %
2.	Temerloh Municipal Council (MPT)	RM 6.9 million (US$ 1.6 million)	5 %
3.	Private Sector	RM 6,87,800 (US$ 1,64,388)	0.5 %
4.	Department of Irrigation and Drainage (DID)	RM 7.4 million (US$ 1.7 million)	5 %
5.	JAKDA	RM 1,80,000 (US$ 43,020)	0.5 %
6.	Department of Agriculture	RM 3.6 million (US$ 8,64,528)	2.5 %
7.	SMIDEC	RM 1 million (US$ 2,39,000)	0.5 %
8.	Veterinary and Fish	RM. 4.3 million (US$ 1.02 million)	3 %
9.	CIDB	RM 6.2 million (US$ 1.5 million)	4 %
	Total	RM 142 million (US$ 3.4 million)	100

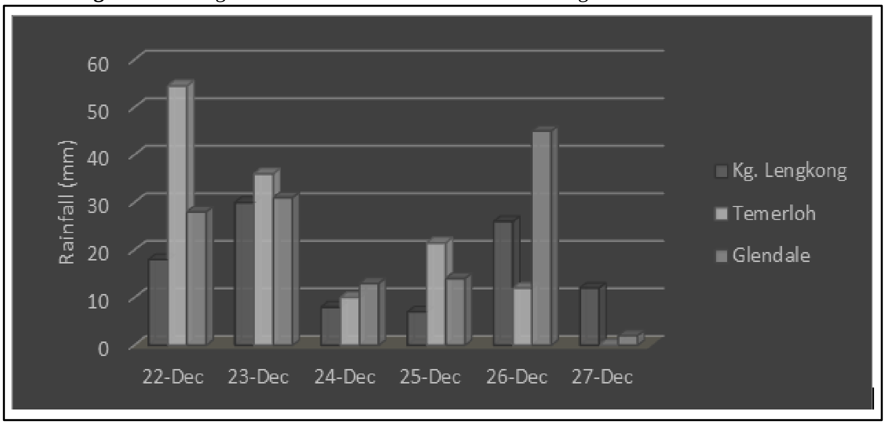
Source: Temerloh District and Land Office, JKR, TRGS, 2015

3.3. Rainfall and Flood Water Level in Temerloh

Intense rainfall can generate serious flood impacts. However, flooding can be influenced by other factors such as catchment size and types of land use. Along with the inability of catchments to reserve water, the natural floodwater reservation capacity has decreased significantly due to land use changes and development of land surfaces into agricultural plantation, urbanisation and industrialisation.

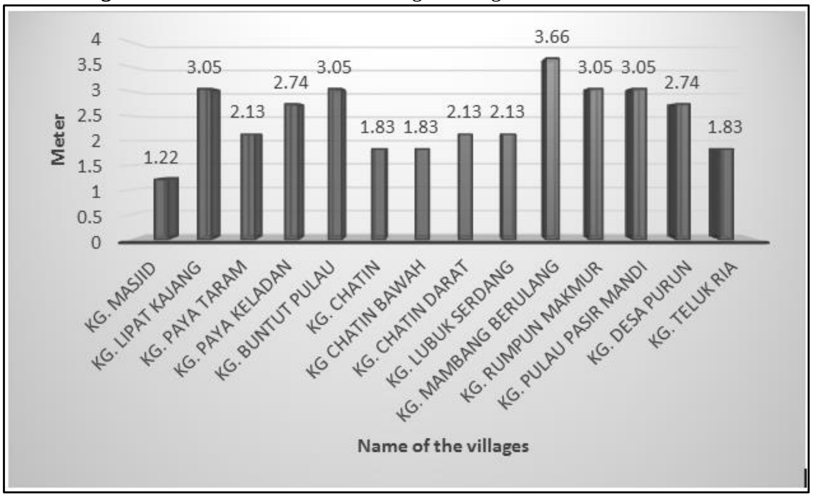
[1] TRGS, 2015. Integrated Approach for Aiding Decision Making Process for Better Flood Disaster Risk Management: A Case of Pahang River Basin.Post-flood research in Pahang

Figure-2. Average rainfall record from three stations during the December 2014 flood



The average rainfall scenario is directed from 22 December 2014- 27 December 2014 from Kampung Lengkong, Temerloh, Glendale stations (Fig 2). Among three stations, Temerloh experienced significantly high rainfall compared to other stations. On 22 December, Temerloh received 54.5 mm rainfall, and Lengkong and Glendale received 18 mm and 28 mm rainfall respectively. On 23 December, rainfall decreased to 36 mm from 54 in Temerloh. However, it slightly increased in Lengkong and Glendale stations. The next day, three stations around 8 mm to 13 mm of rainfall. On 25 December, Temerloh station received 21.5 mm, and the other two stations received the same amount of rainfall as the day before. On 26 December, rainfall increased in the Glendale station increased significantly and received 45 mm where Kg. Lengkong received 26 mm, and Temerloh station received 12 mm. Rainfall significantly decreased on the next day for both Temerloh and Glendale stations while the Kg. Lengkomg station received 12 mm on 27 December.

Figure-3. Flood water level in 14 villages during the December 2014 floods

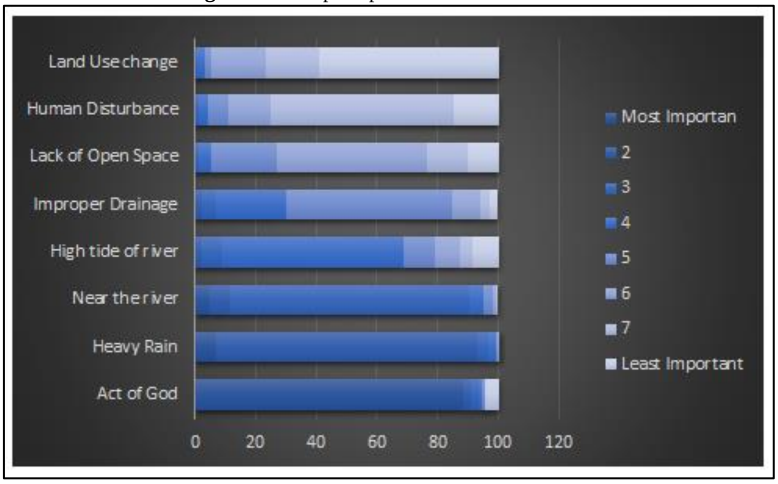


Among the 14 villages in the Temerloh Municipal Council, Kg. Mambang Berulang received 3.66-metres of water which is higher than other villages (Fig 3). According to some locals, they used to believe that their area flooded because of being near the river. Kg. Chatin located close to Kg. Mambang Berulang also flooded due to being close to the Semantan river. Moreover, the water level of Kg. Rumpun Makmur, Kg. Pulau Pasir Mandi and Kg. Lipat Kajang received 3.05 metres of rainfall on the same day, and these three villages are located near the same river basin area. Kg. Chatin, Kg. Masjid and Kg. Teluk Ria is also near the river basin area, but the water levels were below two metres. This indicates that other factors also influence the level of rainfall in this area.

3.5. Lay People's Flood Risk Perception

During the survey, we asked the respondents regarding the cause of floods. Recent studies suggest that direct experience can influence perceptions and behaviour (Reser *et al.*, 2014). We developed a scale from 1 to 8 where 1 is the most important cause, and 8 represents the least important cause. Respondents were asked to prioritise the cause of floods. Results from this question are surprising as some of the significant factors are overlooked and should not be the least important cause. Figure 4 shows us that 88% of people think that 'act of God' is the most important cause for flooding. Some of the respondents strongly believe that maybe this is a punishment from God. Only 4% of respondents do not think that this is the main cause of flooding. Heavy rain is the second most important (86%) cause. Following heavy rain, 79% of respondents reported that living near the river can be the third most important cause of flooding. However, not all of them are living near the river but have experienced flooding. High tides are considered by 60% of respondents as the fourth important cause of flooding.

Figure-4. Local perceptions about the cause of floods



It is important to note that respondents focused only on the natural cause of flooding while they were free to choose any of the cause from the scale. Most of them claimed that natural causes are the main reason for flooding as other causes are not directly noticeable by the individual on a seasonal or daily basis. A significant number of respondents do not think that the anthropogenic activities such as human disturbance and land use change are the most important causes of flooding. Recent studies suggest that people's perceptions are important for determining their action (Bockarjova and Steg, 2014; Grothmann and Patt, 2005). Although in the past decades these research fields have come a long way, more comparability, definition and clearer methods are needed (Gotham *et al.*, 2018). Most of the respondents (54.6%) considered the improper drainage system on the scale of 5 which is leading towards the least important cause. However, we found 23% of people think that it can be the fourth important cause of flooding. Similarly, lack of open space and human disturbance are ignored by most respondents as 49% and 60% people place it on a scale of 6 and 7. It was surprising to find that land use change was also overlooked as the most important cause of flooding. Rather, land use change was chosen as the least important cause for flooding by 59% of respondents. Only 15 respondents (5%) think that land use change can be an important cause of flooding and graded it 2 to 5. The remaining 35% marked 6 and 7 for land use change as the less important cause of flooding. The results suggest that perception will influence people's action over time which may increase the frequency and magnitude of the future flood. However, the perceptions of locals are important to reduce not only the magnitude of the flood but also to understand the consequences of their action. If they can relate the impacts and consequences, their perception may change which may lead to influencing their behaviour.

3.6. Land Use Change Detection

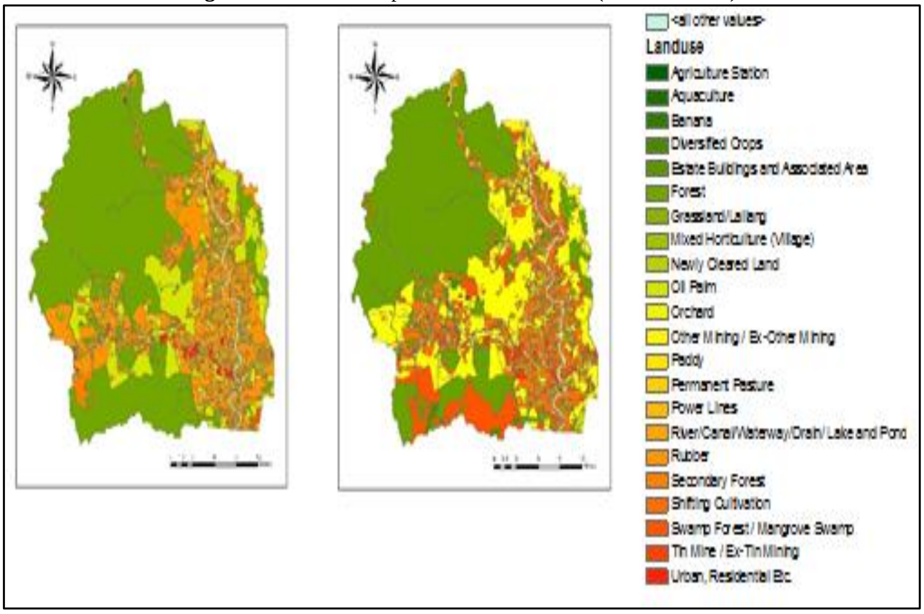
The locals are not aware of the consequences of land use changes, especially the relationship between land use change and flooding. As a result, people easily develop the land for economic benefits. Here, we identify the land use changes in Temerloh from the year 2000 to 2010. Land cover is classified as agriculture cover, built-up area, vegetation cover and waterbody (Table 4).

Table-4. Land use/land cover classes explained based on classification

Sl. No.	Class name	Description
1.	Agriculture	Crop fields, Banana, Paddy, Palm Oil, Rubber, Orchard
2.	Built-up area	Urban residential area, estate buildings, road, powerlines, railway
3.	Vegetation cover	Forest, secondary forest, Grassland, Permanent pasture
4.	Waterbody	River, canal, drain, Marshland/swamp forest/mangrove, lake, pond

The overlay method is applied in ArcGIS 10.1 to identify the significant changes. From 2000-2010, significantly land use changes took place in Temerloh. The comparison of 2000 and 2010 classified maps show the land use/land cover changes of different land class (Fig 5). The socioeconomic factors such as income, food expenditure and other household expenditure play a significant part in transforming local demand for better income. This increased demand also influences the land use change and land clearing activity (Nguyen *et al.*, 2017). Figure 5 shows significant changes in the study area within ten years. Land use change for built-up areas is easily noticeable. However, the built-up area replaced forest cover which turned the land cover to an impervious surface. In 2000, the built-up area was 3216 ha which increased to 4537 ha in 2010. Forest cover decreased dramatically from 121092 ha to 103356 ha. Forest cover replaced with human-made secondary forest increased to 21497 hectors in 2010 from 10642 hectors in 2000 (Table 5).

Figure-5. Classified maps of Temerloh District (2000 and 2010)



Rapid deforestation near the catchment area increased the soil erosion whereby heavy rain washed away the soil. Runoff carries the soil into Pahang River. In 2010, river sand was 10.44 hectare which raises the river beds and creates sandbars. Due to sandbars, the Pahang River getting has become shallow, and the river flow also changed its direction. Where forests decreased by 5% in ten years, oil palm production increased 10% during the same period. For oil palm production, land near the mainstream or in the catchment area was chosen which were vegetation cover before being converted to oil palm. The GIS analysis also exposed that, newly cleared land has increased from 2010 to 2000. From 751 ha in 2000, cleared land increased to 1777 ha in 2010. Vegetation cover was cleared for agricultural production or other economic activities. However, land use for paddy production has decreased significantly in ten years. Also, built-up areas are frequently bounded by agriculture areas which are also near the mainstream or in the catchment area. Waterbody replaced by agriculture land and built-up area also increased around the agriculture land. All this means that area surrounding residential areas have been cleaned for crops production (Butt *et al.*, 2015). This increasing pattern of land use change near the catchment area indicates that economic forces are a major cause for anthropogenic change of land and is the primary reason as to why the area close to the main water bodies, streams and watersheds has been used for such purposes.

Table-5. Comparison of different land cover from 2000-2010

Land use/ Land cover		**2000 (ha)**	**%**	**2010 (ha)**	**%**
Urban and built-up area		3216	1.4	4537	2.07
Forest	121092	52.58	103356	47.21	
Grassland		2360	1.02	3272	1.49
Mixed Hori culture		4933	2.14	5129	2.34
Newly cleared land		751	0.33	1777	0.8
Secondary forest		10642	4.62	21497	9.82
Other crops		168	0.07	264	0.12
Swamp forest / Marshland		6908	3	2252	1.03
Total		230294	100	218927	100

According to Verburg and Chen (2000), land use changes were mainly related to the rise of population and severe agriculture expansion. The cause of this expansion was the increase in the rapid and disorganised settlement with the spread of everchanging cultivation in order to get higher profits from areas which were previously used as forest cover or water body. Because of financial reasons, rubber and oil palm production increased dramatically. This produced more revenue per unit area and had whole year production. However, the open spaces or water bodies near the catchment area can be a reservoir for flood water during heavy rain or overflow of the main stream; These have been destroyed because of local people's lack of knowledge about the effect of land use change on flooding even though they are living in a flood-prone area. It is obvious from our analysis of the maps that land use change has caused decreases in the water body and vegetation cover. The agricultural land conversion alone has taken over a huge portion of forest area as well as the water body. Both kinds of natural land settings are crucial for flood mitigation services.

4. Conclusion

Globally, people are witnessing the increasing frequency and magnitude of flooding. A better understanding of the causes of the flood may reduce the flood risk. Land use change is a global phenomenon, and rural communities are closely related to this conversion for their livelihoods. Policymakers must take care of the local context as it has a significant influence on land use change and flooding. Information and education programs can be designed to improve the knowledge of locals about their role to reduce future floods. Understanding and analysing the factors responsible for flooding are important to minimise flood risk. In this regard, the government should take the steps necessary to identify the major factors causing floods and educate locals in flood risk reduction. Non-government organisations should support the government in this regard. The relationship between locals and natural land cover is a major issue influencing them to modify the land use which increasing future flood risk. However, the priorities of locals concerning the uses of land must be recognised within their socioeconomic context to assure their economic benefits. We recommend more studies on measuring the relationship between the community's socioeconomic context and its effect on land use. Improved understanding among the local and research community can create collaboration within and across disciplines. A well-connected collaboration can make major changes regarding understanding the causative factors of land use change and its relationship with recent floods which can change people's perception about the cause of flood and future flood damages.

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