# [SV 14] FLOOD MITIGATION IN DISASTER MANAGEMENT: A CRITICAL LITERATURE REVIEW

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## ABSTRACT

*Floods are the most frequently reported natural disasters in Malaysia. The flood does not only occur in Malaysia, but also in Asia, Europe and other country. Flood mitigation is one of the phases in the disaster management cycle. Disaster management is a systematic process to reduce the impact of natural disaster and establish a plan to prepare the nation or community to face the impact on their economic, social and physical livelihood. Disaster management is really important as it is possible to prevent or at least mitigate damage that is brought upon by disaster. The aim of this research is to explore the existing knowledge on disaster management and to identify methods of flood mitigation currently applied. The research is based on published literature review and past research to achieve the objective. Online search such as Google scholar and online databases were used to search and collect the relevant literature, resulting 35 survey studies that fulfil the criteria. The literature and past research from years 2010-2016 were chosen as the limit option in order to get the latest flood mitigation published literature. The findings from this research can assist future research in identifying the gaps in the current literature on flood mitigation efforts, particularly in South East Asia.*

**Keywords:** *disaster management, flood mitigation, flood*

## INTRODUCTION

The number of floods has increased from year to year. According to World Disaster Report 2015, the amount of estimated damage caused by flood in 2012 recorded 27,199 million US dollars whilst 2014 recorded 37,838 million US dollars. It has increased 10,639 million of US dollars or 39.12% in 2 years. In Malaysia, the flood damage had an increase of 64.37% (RM589 million) in 10 years from RM326 million in 1992 to RM915 million in 2002 (Hamzah, 2005). The Malaysian Government have to spend a huge amount of money to recover the damage. The Government spent a lot of efforts in doing research on flood prevention and mitigation but the damage is still increasing from year to year. Floods and their impact are believed to increase in the future if government do not come out with a good plan. According to Malaysia's National Security Council (NSC), the flood of Kelantan in December 2014 identified as the worst flood in Malaysia. Datuk Seri Mustapa Mohamed as the Kelantan Flood Disaster Operations Committee Chairman mentioned that Kelantan's flood damage in December 2014 has reached RM200 million. This annual flood had forced almost 200,000 people to be evacuated to relief centres. 25 people died and 1600 homes were

damaged. Therefore, it is important to identify method of flood mitigation use in Kelantan to effectively reduce the flood damage.

## OBJECTIVE

The aim of this research is to determine the current issue with flood mitigation efforts applied in the disaster management field. This aim will be achieved via the following objectives;

1. To explore the flood mitigation knowledge in disaster management.
2. To identify methods of flood mitigation applied.

## LITERATURE REVIEW

### Important of mitigation

Mitigation defined as a continued action taken to minimize or eliminate risk to property or human (Kapucu, N. et al 2013). Actually mitigation is the least visible concept, but it plays an important role in protecting communities from disaster. The decision made about mitigation plan will affect the safety of an area in future when faced with disaster. Mitigation plan is for the long term and it is only become valuable or brings benefit when disaster occurs. According to Kapucu et al (2013) stated there are 3 main goals of mitigation strategy. First, mitigation involved efforts to change the natural of threat. Second, mitigation targets to decrease community vulnerability to damage brought upon by disaster. Third, mitigation aims to reduce the exposure to the threat of possible disaster. Actually these 3 goals have the same target which is to reduce risk of life and property.

Mitigation offers few benefit by minimizing the influence of potential disasters. First, mitigation reduce direct damage to property. Second, mitigation reduce direct damage to business activities. Third, mitigation provide safer natural environments for park and wildlife. Forth, mitigation reduce human casualties or homeless. Fifth, mitigation reduce the need for basic emergency first response. Sixth, mitigation help to create more prepared community. Seventh, minimize the financial impact on community as mitigation reduce the disaster damage.

A dollar spent in flood mitigation plan nowadays saves four dollars in term of future benefits. Hence, mitigation is really important in disaster management. A good mitigation strategy is able to withstand disaster and reduce the damage, loss of affected community.

### Types of flood mitigation

Generally, flood hazard mitigation are classified into 2 categories, namely structural and non-structural approach (Mohit et al, 2013).

*Structural approaches*

Structural approach used to control floods based on engineering structures. Structural approach focus on “hard” engineering measures. Brody et al. (2010) analysed structural mitigation can classified into 3 groups which are modification of built environment, channel phrase and land phrase. Modifications of built environment involve the

building of fills, floodwall and levees. Example of structural method in channel phrase is reducing bed roughness and deepening, dykes, dam, reservoirs. For structural method in land phrase is slope stabilization, revegetation, soil conservation and so on. Structural approach are based on engineering technique such as building revetments, channels, levees, seawalls to control flood.

*Non-structural approaches*
Non-structural approach is designed to reduce vulnerability to floods. This approach is focus on "soft" engineering measures. Non-structural approaches can be perform by local government such as emergency and recovery politics, training and education, land use planning tool and insurance as flood programs.

**Factors of flood mitigation**
In the course of this study, the researcher had found that there are some key success factors of flood mitigation plan. The key factors are crucial to ensure the authorities are able to manage disaster successfully.

*Information Communication Technology (ICT)*
Technology is the main factor of flood mitigation. It cannot be denied that many research of flood hazard is done based on technology. ICT is a multi-purpose tool which can be used to store, disseminate, communicate and generate information (Rahman et al, 2016). Example of ICT is Geographical Information System (GIS), Global Positioning System (GPS), Remote Sensing (RS) and Early Warning System (EWS). Accordingly, the ICT tools mentioned not only can use in flood disaster but also other disaster like earthquake. Satellite data can be used effectively for mapping and monitoring floods area, floods damage assessment, floods hazard zone, and protection works. Besides that, people use ICT such as radio broadcasting, social media and electronic media to receive information of disaster. ICT applications alert people to evacuate their home when they detect disaster coming. As a conclusion, ICT in disaster management helps saving property and lives of people.

*Local community knowledge for flood forecasting*
In some rural community, there are large numbers of climate monitoring indicator. The indicator learned the knowledge from their father generation to monitor the temperatures and celestial bodies, speed and direction of wind, movement of insects and behaviour of animals as an early prediction for coming disaster. This knowledge help them survived settling in a place for a long time ('Ainullotfi et al, 2014). Local authority have to communicate nicely with the local community to get this useful information as it will help during mitigation phrase. This gather information should be documented to assist in mitigation of flood.

Golian et al (2015) proposed flood risk is a "social construction". Hence community have to play an important role in flood mitigation plan. Community are the people who faced the flood before and they are more familiar with culture, community and local condition. This mean affected people are the information due to their flood experience. Information from local community help authorities know which part they should focus when forming mitigation plan. It concluded that the experience of previous floods and flood mitigation can significantly affect the forecast information available, interpretation and prediction of risk and protection decision that made.

*Participation of Public-Private Partnership (PPP)*
PPP has become popular in many countries as it is a good way for government to engage the private sector in disaster management. The involvement of private sector provide the most advantage combination of cost, quality of infrastructure and service. Cooperation between government and public sector provide better result in prevent threat of disaster. Farlam (as cited in Auzzir et al, 2014) defined PPP is a collaboration between public sector and private sector where the private sector provide technical and financial in the project.

Individuals, families and businesses are consider as part of the private sector. They take mitigation action before disaster event to be better prepared and to recover quickly during the disaster. Private sector can provide a wealth of expertise, service and support to partnership effort. The public sector is led by the government. In some cases, the public sector can provide financial support when the private sector is unable to pay the fund by its own. However the main role of private sector is to overcome the weakness of government side. Working collaboratively can reduce the cost of mitigation.

An example of the use of PPP for flood mitigation can be seen in the city of Quincy, Massachusetts, United States had a significant flooding issue. Many of the houses were built more than 60 years ago and only a little efforts was paid in the flood mitigation. In 2001, Quincy resident had experienced serious flood due to serious rainfall, snowstorms, hurricanes and storms. Hence, the government decided to apply PPP to connect the community and focus on flood mitigation strategy. A pumping station was constructed for serious storms and high tides, and prevented flood in lower area through Hazard Mitigation Grant Program (HMGP). After the flood problem was solved, the additional fund were used for various mitigation project. The city of Quincy has been successful in solving flooding issue by applying PPP.

As a conclusion, many previous studies agree that PPP will increase the successful of mitigation. PPP provides a value added solution to mitigation plan and provide a better service to community.

*Flood experience*
Another factor of flood mitigation is flood experience. Learning from the previous experience is the best way to correct the mistake. For flood hazard, the authorities have to learn from previous relief and recovery operation. Firstly, lessons from past experience suggest that structural and non-structural approach is a good mitigation to control flood. Secondly, the community living in flood prone area have to better prepare than people living in the occasional flooding area. Thirdly, the stakeholders have to monitor previous data and come out with a better flood mitigation plan. The stakeholders have to survey what the causes of flood and comes out with a solution. Hence, flood experience is another factor of flood mitigation.

## RESEARCH METHODOLOGY

### Methods
The objective of this research is to explore the existing flood mitigation knowledge in disaster management and identify methods of flood mitigation applied. Online search such as Google scholar and other linked databases were used to search in order to collect

relevant research from the published literature to achieve the objective. In the first stage, the key words used were "flood", the result shows there are many related literature. "Flood mitigation" were used as the key words in second stage to minimise the search. In conclusion, the key words used were "flood mitigation", "structural flood prevention measure", "flood control", "flood protection", "structural flood mitigation", "non-structural mitigation", "flood susceptibility mapping" to collect the relevant information. The literature or past research from years 2010-2016 were chosen as the limit option in order to get latest flood mitigation published literature. All the articles that have been studied were published in English. To ensure the selected literature is fulfil the objective of the research, a specific inclusion and exclusion were used, as shown in Table 1. Each of the article were investigated to ensure the contents were relevant to flood mitigation knowledge. In the end, 35 selected literature and past research were identified that fulfil the requirement. Any article that include the flood mitigation knowledge were also included in this research.

**Table 1**
Showing criteria for inclusion and exclusion for literature

| Inclusion | Exclusion |
|---|---|
| Years from 2010-2016 | Years before 2010 |
| Flood in Asia, Europe, American, Africa, Pacific | Not relate to flood mitigation knowledge |
| Consists flood mitigation knowledge | |

## DATA ANALYSIS

### Analysis of data collected

The data presented in this paper is the result of 8-week literature study on Google Scholar (for an undergraduate term paper assignment) which is meant to provide a snapshot of what is currently being studied with regards to Flood Mitigation in general. Therefore, there are limitations in the aspect of breadth, identification of gaps and contradictory ideas in this field. The analysis of literature focused on area of knowledge, number of publications and the data source of publication (by continents) from 2010-2016.

First, the researcher classified 35 selected literature to the area of study. The researcher found there are several flood mitigation knowledge focused by other researchers when analysing the 35 articles. The 35 articles were analysed to determine which flood mitigation knowledge were covered. The flood mitigation knowledge are then categorised as shown in Table 2.

**Table 2**
Knowledge categorized in literature for flood mitigation

| Knowledge categories | Details |
|---|---|
| Non-structural mitigation | Technology (remote sensing, GIS, Hazus-MH), flood insurance, land use planning, policy |
| Structural mitigation | Floating urbanization, detention ponds, recharges well, reservoir, dam |
| Factors influencing flood mitigation | Organization, household, various aspect |

All the knowledge covered in each article were marked as "X" in the table, as shown in the following Table 3. According to this analysis, knowledge related to non-structural mitigation had the highest coverage (16), followed by knowledge related structural mitigation (12), risk perception, awareness and household preparedness (5), climate change and factors influence flood mitigation (3) respectively. Environment impact assessment and evaluate the effectiveness of flood mitigation recorded (1) article each.

Unsurprisingly, non-structural mitigation had the highest coverage by researchers in flood mitigation. Most of the articles were related to technology and flood insurance. There were 6 articles that studied technology and 4 articles studied on flood insurance. A lot of literature seem to focus on technology when it comes to mitigation. There are many researcher working on GIS and remote sensing. GIS and remote sensing can used to forecast coming flood. This is because the technology is easy to apply and convenient for the user to send the information to alert people that the flood is coming. Several literature is concerned about factors of willing to pay (WTP) in flood insurance. The factors included income, education, price and so on. There are also many study focusing on flood insurance because the authors feel it is important as it can help in provide financial support in recovery stage.

Structural approach is the second highest flood mitigation knowledge covered by other researchers. Detention pond, dam, reservoir, recharge well, floating urbanization were studied in the articles. Structural mitigation cost is expensive and take a long time to finish the project but many of the authors believe structural mitigation method can reduce more damage and safer compare to non-structural method. Risk perception, awareness and preparedness also is an essential knowledge in flood mitigation. There are increasing number of literature study based on household awareness and their preparedness when flood occurs. The study indicates that if household received more information about flood, the risk perception and awareness is high.

The factors that influence flood mitigation is another knowledge of flood mitigation. The study highlighted household and organization have the ability to influence the flood mitigation plan. There are 3 articles study climate change. Climate change is the reason of flood mitigation. The climate change such as raining season will cause floodplain area flooding. The rest of knowledge including environmental impact assessment (EIA), evaluate the effectiveness of flood mitigation measure were not mention as much as other knowledge. This is the gap of flood mitigation knowledge. Future research can focus in this knowledge because this knowledge also important in flood mitigation.

**Table 3**
Analyse flood mitigation knowledge covered in article

| Author(s) | Non-structural | Structural | EIA | Climate change | Factors influence flood mitigation measure | Risk perception, Awareness, Household preparedness | Effectiveness of flood mitigation measure |
|---|---|---|---|---|---|---|---|
| Abbas et al. (2014) | X | | | | | | |
| 'Ainullotfi et al. (2014) | X | | | | | | |
| Alaghmand et al. (2010) | X | | | | | | |
| Ardeshir et al. (2013) | | X | | | | | |
| Atreya et al. (2015) | X | | | | | | |
| Babcicky et al. (2016) | | | | | | X | |
| Barbedo et al. (2014) | X | | | | | | |
| Brody et al. (2010) | | | | | X | | |
| Bubeck et al (2012) | | | | | X | X | |
| Bubeck et al. (2012) | | | | | | X | X |
| Chang et al. (2013) | X | | | | | | |
| Choi at al. (2010) | | X | | | | | |
| Cummings et al (2012) | X | | | | | | |
| Den at al. (2015) | | X | | | | | |
| Dey et al. (2011) | | X | | | | | |
| Gilbuena et al. (2013) | | | X | | | | |
| Heidari (2010) | | X | | | | | |
| Islam et al. (2016) | X | | | X | | | |
| Klongvessa et al. (2014) | | X | | X | | | |
| Kryžanowski et al. (2014) | | X | | | | | |
| Mohamad et al. (2013) | | X | | | | | |
| Musiake (2012) | X | | | | | | |
| Nicholson et al. (2012) | | X | | | | | |
| Nquot et al. (2014) | X | X | | | | | |
| Okon et al. (2015) | | | | X | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Olomoda (2012) | X | | | | | | |
| Osberghaus (2015) | | | | | | X | |
| Patel et al. (2013) | X | | | | | | |
| Petrolia et al. (2013) | | | | | | X | |
| Poussin et al. (2014) | | | | | X | | |
| Ramakrishnan et al. (2016) | X | | | | | | |
| Saher et al. (2014) | X | | | | | | |
| Seifert et al. (2013) | X | | | | | | |
| Shinde et al. (2014) | X | X | | | | | |
| Tunji et al. (2011) | | X | | | | | |
| Total | 16 | 12 | 1 | 3 | 3 | 5 | 1 |

**Classifying published journal by year**

**Table 4**
Number of survey studies from 2010-2016

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Total | 5 | 1 | 8 | 7 | 12 | 4 | 4 |

The total number of article published in the past 7 years have been analysed, as shown in Table 4. Based on Table 4, the number of article published from year 2010-2016 is not stable. The researcher identify year 2014 had the most published article which is 12 articles whilst year 2011 had the least number of article which is 1 only. In year 2014, non-structural method become the focused of authors. There are 6 articles knowledge of non-structural mitigation published on that year. According to Table 4, researcher found that flood insurance become popular start from 2014 because there are journals being published from 2014 until 2016. This indicates that people had realised the importance of flood insurance. Researcher believe there will be more and more journals relating to flood insurance being published in the future.

**Classifying articles by continents**

**Table 5**
Articles categorized according to continents

| Continents | Asia | Europe | American | Africa | Pacific |
|---|---|---|---|---|---|
| Number of articles | 18 | 9 | 5 | 2 | 1 |

The journals were analysed and listed in Table 5. All the article were categorised according to continents; Asia, Europe, American, Africa and Pacific. According to Table 5, majority of the studied were conducted in Asia (18). This is because many floods occur in Asia every year compare to other continents. Europe recorded (9) articles in this research. 3 research were done in Germany because of the river Rhine. Germany people pay attention on river Rhine to avoid overflow of water. Malaysia recorded (7) articles. Most of the research were done in Kelantan, Pahang and Johor as 3 of this states will receive annual flood every year due to monsoon season. However, that are not many research done in other continents for example American (5), Africa (2) and Pacific (1). There is 1 collaboration research done in Germany and Netherlands to investigate the flood insurance demand in that country.

## DISCUSSION AND CONCLUSION

In this paper, researcher investigate the knowledge of flood mitigation by analyse the selected articles published from 2010-2016. An examination of 35 articles used as a framework shows that flood mitigation knowledge can be grouped under 7 different research area as previously mentioned. The result shows that non-structural and structural mitigation is the most frequent knowledge covered by authors. In addition, there are many authors suggested technology as a prevention and mitigation tools. GIS and remote sensing can predict the coming flood and give an extra time to evacuate residence in flood area. However, flood insurance is another knowledge focused by authors. Insurance is a popular approach to fund flood disaster. Truth to say that insurance cannot reduce direct impact of flood but its helps a lot when comes to provide

financial support in recovery stage. When doing this research, researcher found that number of published articles every year is not consistent. Asia recorded most published articles, followed by Europe having 9 articles as most of the floods occur in Asia and Europe country. However, that are not many flood mitigation article done by other researcher in other continents. Thus, more research must be conduct in different region to get more understand of flood mitigation knowledge and methods used by other countries. More information can help future research to apply effective method to prevent flood.

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