STUDY ON EFFECTIVENESS OF LOCAL FLOOD WARNING AND EVACUATION SYSTEM (CASE STUDY: KAMPUNG PARIT KHALIL & KAMPUNG PARIT SRI PAYA)

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Abstract:
Flood warning is potentially a highly effective means of flood loss mitigation. Recent floods have suggested that flood warning systems are not performing to their full potential as a direct result of problems including poor community understanding of flood warning predictions, poor community response to warnings, and untimely delivery of warnings by responsible authorities. This paper presents the results of public survey assessment and Performance-Based Assessment (PBA) to evaluate the effectiveness of the local Flood Warning and Evacuation System (FWES) during the March 2004 flooding. The survey uses questionnaire and interviews to collect data. The questionnaires were distributed to the respondents from Kampung Parit Khalil and Kampung Parit Sri Paya with the head of the family as the focus group. Following the March 2004 flooding, the analysis reveals that the public were satisfied with the existing local FWES. However, PBA yields that the local FWES performance level is 20%, which is far below the 52% minimum performance level, and renders it ineffective. Suggestion to improve the effectiveness of local FWES include: issuing tiered warnings, use of Flood Intelligence Card, early message construction and raising flood awareness through community education. Hopefully, this study will be able to highlight the importance of an effective FWES and increase flood awareness and preparedness among the public as well as the responsible parties.

Keywords: Flood, Warning System, Evacuation, Flood Response, Performance-Based Assessment

1.0 INTRODUCTION

In Malaysia, major floods usually occur during the north-east monsoon i.e. from November till January due to continuous heavy rainfall. The largest flood on record occurred in 1926 and was followed by recurrence of severe floods as in 1931, 1947, 1954, 1957, 1967, 1971 and 1992. Flood victims are estimated as high as 2.7 millions. Large floods has caused loss of lives, damage to properties, public utilities, cultivation, and also caused hindrance to social and economic activities. Average annual flood damage is as high as RM100 millions.

For decades we have not coped well with floods. Part of the reason for this lies in the complex nature of floods and the varied responses to them. So, in order to somewhat cope with floods, the response must be integrated; collecting data, transmitting data, forecasting the flood, informing local officials, warning local residents, and taking protective action (including evacuation of residents).

1.1 Problem Statement

Local Flood Warning and Evacuation Systems (FWESs) are instituted and maintained at a local level. They consist of two parts: (1) the flood forecast system, and (2) the flood response system. In Malaysia, telemetric rainfall and river level stations are being used extensively than ever and recently, the government is capitalizing on new technological innovations such as the use of remote sensing in flood forecasting. The application of high-tech solutions can only reach the aim if the public responds positively to flood warnings and react appropriately before the arrival of the flood. So, an effective flood warning is crucial to achieve an optimal behavioral response from the public, thus, ensuring more lives and properties saved.

1.2 Objective of Study

The main objective of this study is to investigate the effectiveness of the Local Flood Warning and Evacuation System (FWES) in terms of disaster management and preparedness. The second objective is to identify the warning system and evacuation procedure used in the events of flood in Malaysia. Ayer Hitam was chosen as the study area. Recent flood events in Ayer Hitam occurred in March 2004. The third objective is to identify the problem/s that affects the effectiveness of the local FWES and finally to propose a method to improve the effectiveness of the local FWES.

1.3 Scope of Study

This thesis is focused on investigating the effectiveness of local FWES in terms of the flood warning in the response system and does not address the effectiveness of the flood forecasting system. The site chosen for this research are Kampung Parit Khalil and Kampung Parit Sri Paya.

The effectiveness of the local FWES was determined based on public survey and Performance-Based Assessment. Data for the PBA were collected using public survey.

2.0 METHODOLOGY

Research processes were divided into 3 stages which are, planning, sampling and data collection, and data analysis.

2.1 Planning

Several issues have been found arguable and a meeting with En. Hasran bin Haron from Department of Irrigation & Drainage, Batu Pahat was arranged to discuss the issues and the problems related. The meeting also meant to confirm the availability of data needed to fulfill the objectives of the study.

2.2 Sampling and Data Collection

The sampling process was carried out by selecting a proportion of the residents in the affected areas of March 2004 flooding to represent the whole population. They are selected randomly.

Table 2.1: Flooded Areas and Evacuation Centers

Evacuation Centers	Villages
Dewan Putra Ayer Hitam	Kg. Pt Khalil
Balai Raya Parit Sri Paya	Kg. Parit Sri Paya

2.3 Questionnaire

A set of 101 questionnaires was distributed among the residents in the flooded area. The questionnaires were divided into three (3) parts, which are:

i. **Part I**: Individual Background
This part will investigate the individual background such as, age, gender, race, and employments.

ii. **Part II**: March 2004 Flooding
This part contains inquiries about the March 2004 flooding. The questions are tailored to suit the information needed for the performance-based assessment.

iii. **Part III**: Public Opinions about the Local FWES
Ask about the contents of flood warnings, warning dissemination and response to warning. The public will be asked to express their satisfaction according to a Likert Scale.

2.4 Interviews

The primary target of these interviews is to obtain the data and information such as sufficient lead-time to take action, and criteria of an effective response, which will be used for the Performance-Based Assessment. Generally, the interviewees represent the parties involved in the District's Flood Operation Room and they are:

i. En. Md. Khairuzam bin Sahmin from DID, Batu Pahat
ii. ASP Abdul Karim Ahmad from Batu Pahat Police Headquarters
iii. En. Zam Zam Ismail from Batu Pahat District Office
iv. Village Headmens of Kg. Parit Khalid and Kg. Sri Paya

2.5 SPSS (Statistical Package for Social Science)

The data collected from the questionnaires and interviews were analyzed using SPSS software and then presented in the form of percentages, frequencies, tables, graphs or charts as appropriate.

2.6 Performance-Based Assessment

Performance-Based Assessment of flood warnings assumed that there are four principal factors, which contribute to an effective flood warning system:

i. Proportion of the population at risk which is warned with sufficient lead-time to take action **(R).**
ii. Proportion of residents available to respond to the warning **(PHA).**
iii. Proportion of households able to respond to the warning **(PRR).**
iv. Proportion of households who respond effectively **(PHE).**

An effective flood warning should have a minimum of 52 % performance level. This level of performance is based on the following percentage;

0.80 R x 0.80 PRA x 0.95 PHR x 0.70 PHE = 0.52

2.7 Relative Index Technique

Relative Index Technique will be used to analyze questions which are based on Likert Scale. It is used to determine the strength of support from the level of agreement on each statement in the questionnaire.

$$RI = \sum \frac{(1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5)}{5(n_1 + n_2 + n_3 + n_4 + n_5)}$$

where;
RI = Relative Index
n_1, n_2, n_3, n_4, n_5 = number of respondents

According to this formula, the RI value is measured from 0.2 to 1.0, where 0.2 represents the minimum support strength and 1.0 represents the maximum support strength (Holt et al. 1996). The factor with the highest support strength will be taken as the main factor.

3.0 ANALYSIS

The purposes of this analyses are to identify the factors affecting the effectiveness of local FWES and ultimately, to obtain the effectiveness level of the FWES in the study area.

3.1 Age and Gender

The questionnaires were distributed to the respondents in the study areas, and the focus group is the head of the family. As shown by the bar chart in Figure A, 76 % of the respondents are male and more than half of them belong to the age group of 36 to 55 years old. Female makes up the other 24 % of the respondents and most of them aged between 56 to 75 years old.

3.2 Races

The sampling process was carried out in two (2) villages within Ayer Hitam area, Kampung Parit Khalil and Kampung Parit Sri Paya. There are 56 families living in Kampung Parit Khalil and 45 families in Kampung Parit Sri Paya making a total of 101 questionnaires distributed. All of the respondents are Malays.

3.3 Occupations

Government sector has the least number of respondents working in them, while, 66% of the respondents are farmers. The statistics is common as the study was carried out in rural areas where most of the residents have their own plantation or work in someone else's plantation. Refer Figure B for further result.

3.4 Analysis of Factors Affecting the Effectiveness of Flood Warning

The effectiveness of flood warning is crucially dependent on factors such as prior assessment, message dissemination, contents of warning messages, and public response.

3.4.1 Prior Assessment for Flood Warnings

Prior assessment to flood warnings includes forecast accuracy and forecast lead time.

3.4.1.1 Forecast Accuracy

During the March 2004 flooding, the study areas were badly affected due to torrential rainfall exceeding 290mm for more than 8 hours and inundation from Sembrong River coupled with water overflow from highlands. Refer Figure C for designated critical level at warning station. Table A shows the Alert, Warning and Danger Level of Sembrong River and the date and time when the first flood warning was issued.

The survey result shows that 74 % of the samples in the study area were not given any warning prior to the event. The first official warning was issued on 9/3/2004 at 10.00 am, the following day after the flood impact.

3.4.1.2 Forecast Lead Time

According to interviews with officers from DID Batu Pahat and Police Headquarters, if the local FWES can provides at least 30 minutes of lead time, lives will be saved. But in order to take loss-reducing action, people would need at least one hour of lead time. Therefore, it is concluded that the sufficient lead time to take action is above one hour.

In the March 2004 event, the official warnings were disseminated after the flood impact, thus, the term 'lead time' in this analysis refers to the time after the first official warning reached the public to the point before evacuation. The pie chart in Figure D describes the results of the lead time. 1 to 6 hours is the optimum lead time to take action as it provide enough time to act effectively and not too long a time until people lost their sense of urgency.

3.4.2 Dissemination of Flood Warnings

A couple of factors must be considered when choosing the best channel to disseminate warnings.

3.4.2.1 Source Credibility

Warnings that came from village headmen have the highest confidence level above all the others sources because people tend to trust someone they personally know. Furthermore, village headmen are persons chosen to lead the residents through a democratic election process. In other words, they are naturally entrusted to give advice and lead the people living under their jurisdiction area. Refer Figure E and Table B for result.

3.4.2.2 Channel Redundancy

Survey indicates that 80% of the respondents felt 'Confident' upon the truth of the warning, and, most of them heard it from two sources, while, respondents who felt 'Very Confident' heard the warnings from three to four sources. This shows that people will be more likely to believe the warning if they heard it from more than one sources because it is in peoples' psychological nature to deny the danger of unexpected threat and rely on group opinion to interpret the threat. The case is termed as "normalcy bias". The utilization of mass media and multiple channels increase the chance of the warnings to be heard in a wider coverage area, thus ensuring a higher level of confidence that would help negate the effects of "normalcy bias". However, as described by the chart in Figure F, too many sources of warning may decreased their confidence level since the overabundance of information would probably leads to confusion.

3.4.3 Contents of Warning Message

All of the respondents gave a positive answer when asked whether or not they understood the warnings. But, upon further inquiries it was found that 30 % of them still do not clearly understood the contents of the warnings.

They understood the essence of the warning, which is to warn them of impending flood, but they neglected the details of the message, which is the important part or a warning as it is design to further assist them in making important decisions such as; appropriate actions to protect life and properties, where to move, the safest route to the nearest evacuation center, etc.

3.4.4 Public Response to Flood Warnings

Figure G reveals that 21% of the respondents act ineffectively in response to the warnings. 61% of the residents responded very effectively during the flood. This percentage is quite high considering that most of them did not receive any warnings prior to the arrival of the flood. The statistics in the next section of this analysis will prove that factors such as previous flood experience contribute to the effectiveness of their response.

3.4.4.1 Age

When alerted, age is one of the factors that affect the effectiveness of an individual response. Refer Figure H for results. People from the 36-55 years are usually in possession of higher physical and mental strength compared to the elders in the group of 56-75 years old. Furthermore, they were motivated to act very effectively since most of them have small children to protect, while, many of the elders only have themselves to care for. However, the elderly can respond as well as other groups, if family support is available.

3.4.4.2 Previous Flood Experience

In the March 2004 flooding, 79 % of the sample responded effectively (refer to Figure I) although, most of them did not receive any warnings prior to the event. Their effective response was due to the fact that, they knew from previous experience, what should and should not be done in the event of a flood. It shows that the more people become experience with flood, the more they will rely on informal warnings and environmental cues to interpret a threat. The crosstabulation in Table C also proves that previous experience of damaging flood is likely to improve response.

3.4.4.3 Normalcy-Bias

As expected, the results of the research indicate that people take steps to confirm the flood threat. The result yields that 68% of the respondents have 'normalcy-bias' in their response. These people reported that they spoke with neighbors, friends and relatives about the flood and the evacuation warning. A few of them also sought confirmation about the flood threat and about courses of action recommended by the authorities and the village headmen. The act of seeking confirmation before acting was a waste of precious time and could endanger them if the other signals, such as the action of neighbors and weathers contradicted the official warnings. 'Normalcy-Bias also reduced the effectiveness of their response. Refer Table D for result.

3.5 Evacuation

The designated evacuation center for the residents of Kg Parit Khalil was Dewan Putra Air Hitam while residents of Kg. Parit Sri Paya were ordered to move to Parit Sri Paya Community Hall. The random sample survey confirmed that 53% of the respondents left their homes. A further 47% respondent had stayed at home although they were specifically ordered to evacuate. Almost half of the survey respondents who did not evacuate believed that they were not under threat, 39% respondents believed that they lived in the higher parts of the village; therefore they would not be affected. A few respondents expressed concerns about the security of their homes. Refer Figure J for source of information about evacuation centers.

3.6 Public Opinion

Table E simplify the results of the public opinion on which medium best be used for warnings dissemination. The respondents agree that their village headmen followed by special siren would be the best modes to alert the residents. They also agree that the information such as stated in Table F were incorporated in the warning. The survey also reveals majority of the respondents agree that the responsible authorities have carried out an effective task during the rescue and evacuation process. Generally, it can be concluded that the public were satisfied with the existing local FWES. Refer Figure K for further result.

3.7 Performance-Based Assessment

The performance level for the local FWES during the March 2004 flooding is,

0.26 (R) x 0.97(PHA) x 0.99 (PRR) x 0.79 (PHE) = **20%**

Refer to Table G for value of element (R), Table H for (PHA), Table I for (PRR) and Figure G for (PHE). According to Smith and Ward (1998), an effective flood warning scheme should have a minimum of 52% performance level. Therefore on this basis, the local FWES for the March 2004 flooding is considered **ineffective.**

4.0 DISCUSSION

Flood warnings often don't work well and too frequently fail completely - and this despite great effort by the responsible authorities. Other social attributes that could cause failure are:

i. Some people are not risk averse; hence warnings are understood but ignored or even taken as a challenge.
ii. Other priorities may interfere with immediate response to warning messages

iii. Other signals, such as the actions of neighbors or weather, may contradict the official warning - people may seek confirmation before acting.
iv. Some people have an aversion to following authority and may ignore official advice

5.0 CONCLUSIONS

Flood warning is potentially a highly effective means of flood loss mitigation. Past experience has shown that warnings have the capacity to enhance public safety and reduce flood damages, by allowing persons adequate time to evacuate and to lift or remove belongings. Recent floods of March 2004 have supported this, but have suggested that flood warning systems are **not performing to their full potential**.

The study has found that **problems** including poor community understanding of flood warning predictions, poor community response to warnings, and untimely delivery of warnings by responsible authorities **reduced flood warning effectiveness**.

Suggestion to improve the effectiveness of local FWES include; issuing tiered warnings, use of Flood Intelligence Card, early message construction and raising flood awareness through community education.

Finally it is crucial to stress a need for a **review** of system performance after an event. Predictive models need to be re-examined, as do message-construction and dissemination procedures. System review should also be undertaken as technology and environmental circumstances change.

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