Developing Malaysian community based flood warning initiatives through Activity Centered Design

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SUBMITTED IN TOTAL FULLFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF PROFESSIONAL DOCTORATE IN DESIGN
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SWINBURNE UNIVERSITY OF TECHNOLOGY
Signed Declaration

This thesis contains no material which has been accepted for any award of any other degree or diploma, except where due reference is made in the text of the thesis. To the best of my knowledge this thesis contains no material previously published or written by any other person, except where due reference is made in the text of the thesis.

Signed:

Date: 20 June 2011

Zulisman Maksom
Abstract
In recent years global warming and climate change, deriving from human activity, have become recognized as major contributors to the increased occurrence of natural disaster events worldwide. In Malaysia excessive rainfall in conjunction with deforestation and changes in agricultural practices has led to excessive flooding in many parts of the country over the past few decades, especially in the flat coastal agricultural regions. Current risk management, flood mitigation and early warning systems have been researched (both in Malaysia and internationally) in order to develop a design strategy that connects communities to a more comprehensive flood warning system. Specific research has been conducted for this study in the region of Seri Medan in Batu Pahat, Johor State, Malaysia, in order to discover the effectiveness of the current system and better plan its future development. The research undertaken mobilizes Activity Theory in order to establish the most effective and appropriate tools to use in designing communication systems for risk reduction in relation to floods in the Malaysian context.
Acknowledgements

I dedicate this research to all the flood victims in Malaysia with the hope that lives can be saved with a better implementation of future Flood Warning Systems. Thank you to Dr Keith Robertson for his continuous support and guidance. Thank you to Dr Gavin Melles as a Second Supervisor and Professor Per Mollerup for his professional advice on the design proposal. The most valuable and precious experience has been your inspiration and motivation that led to the completion of this research. Special thanks to my parents for their prayers and understanding and to all my friends who have been supportive.
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<th>Description</th>
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<td>ACD</td>
<td>Activity Centered Design</td>
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<tr>
<td>ACDT</td>
<td>Activity Centered Design Theory</td>
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<tr>
<td>AT</td>
<td>Activity Theory</td>
</tr>
<tr>
<td>CBFFWS</td>
<td>Community-based Flood Forecasting and Warning System</td>
</tr>
<tr>
<td>CFA</td>
<td>Country Fire Authority Victoria</td>
</tr>
<tr>
<td>DID</td>
<td>Department of Irrigation and Drainage</td>
</tr>
<tr>
<td>DSE</td>
<td>Department of Sustainability and Environment</td>
</tr>
<tr>
<td>EM-DAT</td>
<td>Emergency Database</td>
</tr>
<tr>
<td>FFW</td>
<td>Flood Forecasting and Warning Services</td>
</tr>
<tr>
<td>JKM</td>
<td>Jabatan Kebajikan Masyarakat</td>
</tr>
<tr>
<td>JMM</td>
<td>Jabatan Meteorologi Malaysia</td>
</tr>
<tr>
<td>MKN</td>
<td>Majlis Keselamatan Negara</td>
</tr>
<tr>
<td>MNTEWS</td>
<td>Malaysian National Tsunami Early Warning System</td>
</tr>
<tr>
<td>NSD</td>
<td>National Security Division</td>
</tr>
<tr>
<td>PSTN</td>
<td>Public Service Telephone Network</td>
</tr>
<tr>
<td>SCOT</td>
<td>Social Construction of Technology</td>
</tr>
<tr>
<td>TIDD</td>
<td>The International Disaster Database</td>
</tr>
<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
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1.0 Introduction

There has been an increase in natural disasters associated with global warming and climate change. Global warming is associated with human activities, particularly the use of fossil fuels and deforestation, which cause emissions of a large amount of ‘greenhouse’ gasses into the atmosphere, which in turn blanket the world surface keeping the environment warmer. This results in changes in climate with more frequent heat waves, a changed distribution and increase in rainfall, and increases in the frequency and intensity of many climate events (Houghton 2005). The International Disaster Database report shows that all natural disasters, such as avalanches/landslides, droughts, famines, earthquakes, windstorms, epidemics, volcanic eruptions and especially flooding have increased tremendously from 1900 to 2000 (Database 2008).

In Malaysia flooding is related to increasingly heavy and unpredictable monsoon seasons from the northeast and southwest that occur every year. These monsoons have been increasing in frequency and severity in recent decades (EM-DAT Emergency Events Database 2009). These erratic climate events are compounded by the gradual rise in sea level that exacerbates drainage problems in low lying estuarine environments so typical of the mangrove coasts of peninsular Malaysia. Environmental changes are now confirmed globally and by the highest levels of scientific authority, such as the Intergovernmental Panel on Climate Change (Bernstein et al. 2007).
Flooding has become one of the most rapidly growing types of natural disaster that has spread around the globe. Flooding takes many forms, from slow-onset riverine floods, rapid-onset flash floods, accumulation of rainwater in poorly drained environments and coastal floods caused by weather extremes such as cyclones (Few et al. 2004). These floods have caused a catastrophic loss of life and property and are an economic burden to both individuals and state infrastructure. Over the period from 1900-2007 floods have claimed the life of 335 million people across all continents and caused 35 billion US dollars in damages (Database 2007; EM-DAT Emergency Events Database 2008).

Predicting the occurrence and extent of natural disasters is difficult and predicates effective communication between diagnostic authorities and the affected populations. Each geographic region consists of different economies and populations, with unique flooding conditions in need of regionally appropriate solutions. Local populations need to be involved in public education programs that foster communal resilience and an intelligent response to local conditions. Research shows that educating the public is one of the most important areas in deciding whether a risk reduction program is effective or otherwise (Leonard, Johnston & Paton 2002).

A number of studies have already conducted into risk reduction in different areas of disaster management (Bildan 2003), flood mitigation (Chan 1997) and flood resilient societies (Beckman 2006). Beckman’s research into Vietnamese flooding shows how a more highly resilient society can be fostered by community based programs, which suggests that there is capacity in community and local organizations to ‘bounce back’ after a climate shock and potential adaptation to become more resilient in the future. The research also shows that stronger relationships between local government, local authorities and the community provide conditions for collective action which address the acute needs of the population.

Malaysia is one of many Asian countries where this type of natural disaster is occurring more frequently. Flooding is becoming more common and more threatening to life. Malaysia is affected by flood because of the heavy monsoonal and conventional rainfall, flat topography on both coasts of Peninsular Malaysia, heavy siltation of rivers and human activities (changed land use due to deforestation, agricultural practices and urbanization). These
have all contributed to increasing flood risk. Chan identifies rapid urbanization, deforestation and other environmental land uses that have altered the hydrology parameters of the country as changing flood characteristics (Chan 1997).

This study is concerned with the communication of risk reduction in relation to flood disaster in Malaysia. In this study Activity Centered Design theory has been mobilized as a research framework to identify the effectiveness of the Malaysian flood warning system as the issue is complex and involves various agencies. Activity Theory investigates the use of technologies as they relate to humans in order to investigate the possible range of action in conditions under which people are able to function. This includes the cultural and educational constraints of real people (Norman 2005). Thus the communications tools that have been developed in a design prototype work in tandem with the few existing systems and media that are already implemented or are available.

This study was commenced as an information design problem but further research and consideration has turned the project toward a service design problem with a stronger emphasis on systems of delivery. Information design is still relevant but no longer does it constitute the heart of the problems as they have emerged. It should be acknowledged that information design is a component mostly overlooked in Malaysian decision-making on disaster risk reduction warning systems. To date Malaysia has undertaken little research into developing effective information design tools for locations prone to natural disasters.

The most frequent forms of natural disasters in Malaysia are floods. From 1965 to 2007 floods have affected 1.15 million people and rank higher than other types of disasters. However prevention measures vary from one region to another (Database 2008).

Malaysia’s flood mitigation measures traditionally follow the well-trodden path of developed countries where they have initiated a largely structural program involving heavy engineering to control flooding, involving hefty investment. Chan, the leading Malaysian academic writer in this area, acknowledges that mechanical engineering driven approaches to flood mitigation seem not to be sufficient as flooding continues to increase in frequency and severity (Chan
Civil engineering solutions such as the building of dams, reservoirs, embankments, levees and artificial channels have become the norm in attempting to control floods. There are other more holistic solutions such as reforestation, better land management, more sustainable agricultural practices, ethical farming and systematic urban planning which can only be described as being under-developed in the Malaysian context.

1.1 Motivation for the study

The growing number of flood disaster occurrences and the increasing loss of life and property reported in *Natural Disaster Data Book 2005: An Analytical Overview March 2006* is one of the motivations for conducting this study.

Through the conduct of this research, it was also discovered that there was almost a complete disruption between the ‘systems' described by the meteorological authorities and the communities on the ground in the flood prone areas. In the Sri Medan region at least, the presence of flood warning infrastructure was found to be almost completely missing – suggesting that a bottom-up approach to build grass roots resilience was more likely to be effective than top-down hierarchies of responsibilities that are not operational for whatever reasons.

1.2 Problem statement

Problem

Natural disasters are devastating and costly to the nation. Various research initiatives have been undertaken to solve the problem from the perspectives of science, social science, engineering, politics and education. Research and initiatives in risk management, risk reduction, early warning systems, flood mitigation, preparedness and information dissemination are a challenge to each of these disciplines - all involve communication design to some extent. It is a common problem however, that each discipline tends to see the problem only from its own perspective and not holistically. Flood strategies need to be integrated into a systemic response.

There is no evidence that communication design is being studied or research undertaken for its contribution to risk reduction in natural disaster plans -
especially in a Malaysian context. There is also little evidence that communication design has been used to educate the affected public.

**Causes of the problem**

This study has tried to uncover the underlying systems set up in Malaysia to communicate disaster events. The main theoretical device we have mobilized to explore warning systems in Malaysia has been Activity Centered Design Theory. Towards these ends I undertook a regional case study of Seri Medan in South Western Peninsular Malaysia, conducted to investigate a typical rural community in a flood prone area. Activity Centered Design has exposed various weak links and broken connections in the existing system. In this study I have undertaken an information design audit, gaining a practical knowledge of the whole system, from forecast making to audience reception, literacy, language use and media utilization. This research seeks to explore the lines of communication between the authorities and those affected by the disaster.

Warning systems are complex and usually involve hundreds of people from climate and disaster experts to the rural dwellers, who become the public victims of climate mishap. Because of this complexity, communication systems should be developed simultaneously with the warning technology and delivery systems.

**Impact of the problem**

The number and extent of natural disasters have been steadily increasing from 1975 to 2006 (Figure 1). Despite this growth there has been no effective public intervention taken in the area of risk reduction. A better approach to communicating risk needs be taken. The current situation could be improved with vigilant monitoring, using information design in relation to local signage warnings of flood danger. Also by developing a continuous program of community education in relation to flood reactive behaviour and strategies to avoid risk and improve community survival.
1.3 Research objectives

The main goal of the study is to improve the current flood warning systems through communication design and develop visual communication tools for a model early warning system. Activity Centered Design theory has been used to identify stake holders and their place in the whole network and to help identify the most effective communication tools for the affected population.

In order to achieve this goal the study aims to achieve the following objectives:

i. To identify the media and visual elements that are likely to be most effective for communicating appropriate information and therefore reducing risk

ii. To design the models for communication tools

A warning system is not effective if it does not come with an ongoing monitoring and evaluation process. Ongoing management evaluation and improvement is needed to make sure that the system runs effectively and is effective in terms of actually communicating with its constituents. The current situation could be improved with vigilant monitoring using information design in relation to a continuous program of community education. User testing is crucial to this proper development but has not been undertaken in relation to this study. The research exposed preliminary stages, as yet underdeveloped,
that need to be established and activated before testing could provide adjustment to any communication strategy.

1.4 Research questions

Adoption of Activity Centered Design Theory as a comprehensive research framework puts visual communication into a social, physical and temporal context that helps this study to answer the following research questions:

i. How can design play a role in reducing risk by creating/developing awareness in relevant communities. This stage involves systems and media delivery.

ii. Which types of visual and communication tools are more effective in communicating risk reduction for natural disaster programs as applied in different media?

1.5 Scope of study

Activity Centered Design Theory has been adopted to develop better disaster communications strategies that are more fully contextualized. Three stages have been identified in the natural disaster process; pre-disaster, disaster and post-disaster events. The pre-disaster events are most significant where education, awareness and early warning systems are involved. Figure 2 in the disaster risk management process shows where awareness and risk reduction sit. Leonard et al (2002) states that an effective end-to-end early warning system must comprise five elements, which are (1) Early Warning System, (2) Planning, (3) Cooperation, Discussion and Communication, (4) Education and (5) Exercises (Leonard, Johnston & Paton 2002).
1. **Early Warning System:** This is the actual infrastructure and management system where implementation takes place. The system must be effective and deliver the early warning system, as planned in management strategies that have been set for the particular disaster event.

This study has investigated the current flood warning system’s effectiveness in Malaysia in order to assess how current practice takes place in an at-risk region. Research into the Sri Medan region shows that many of the communications links in the current system are either broken or not yet established, showing the local population to be dependent on the commercial television media for warnings, with no formal information delivery that targets direct communications or systems deliberately dedicated to flood safety strategies.

2. **Planning:** This stage involves a hierarchy of decision-making systems and communication tools that might be used in relation to flood warning. Planning would involve strategies for evacuation routes, procedures, resettlement and coordination between different organizations to streamline operations. In Malaysia, the Majlis Keselamatan Negara (MKN) is the body responsible to plan, coordinate and delegate the flood mitigation tasks to authorities such as the Department of Irrigation and Drainage (DID), Jabatan Meteorologi Malaysia (JMM), Jabatan Kebajikan Masyarakat (JKM) and local authority.
3. **Cooperation, Discussion and Communication:** This is where most of the activities that involve different stakeholders take place. Pre-planning and networked communication between different agencies and community representatives must be involved. At this stage monitoring of the key people in each of the affective agencies and affected communities is crucial as the turnover of these positions might be high and the risk of disconnection cannot be taken lightly as it involves the whole communication process. The coordination and clear communication between Majlis Keselamatan Negara (MKN) with other authority involved is crucial in the success at this stage. Each authority involved is given a specific task and role based on their expertise and areas of responsibility. This avoids miscommunication, task redundancy and mismanagement.

4. **Education:** Education is not a static process. In the context of warning system development, education must be ongoing, taking account of changing conditions, knowledge and populations. Education takes place both formally and informally. This is a stage where communication design will play a major role in developing effective communication delivery that can be understood and adhered to in the messages appropriate to communities of interest. The Malaysia Government especially the Kementerian Pelajaran Malaysia (KPM and the Kementerian Pelajaran Tinggi (KPT) need to play a significant role in promoting an awareness campaign at the primary, secondary and tertiary education level. At the same time, the local media need to be more frequent in providing information through various media as informal education that can be delivered to the masses.

5. **Exercises:** This stage cannot be neglected as it determines the effectiveness of the early warning systems. Continuous exercise by the stakeholders is crucial in sustaining the knowledge gained from the education stage and in testing the effectiveness of the systems. Scenario development and simulations that cover all levels, from management decision making and dissemination to real exercises conducted within affected environments, must be conducted to ensure that risk perception will improve. Majlis Keselamatan Negara (MKN) can play a significant role in coordinating proper exercises, which involve the authority, and the community to create more awareness on what action needs to be taken when flooding occurs. Periodical exercises will
help the authority involve the community to improve their knowledge in dealing with the flooding in the future.

The study focuses on developing effective visual communication for use in educating and warning the stakeholders on risk reduction in the natural pre-disaster event.

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<tbody>
<tr>
<td>Metropolitan Dept. Drainage and Irrigation Dept. Dept. of Environment Local Authority</td>
<td>Graphic Designer System Designer Software Developer Structural Engineer</td>
<td>Flood Affected Community Media and Communication Provider</td>
</tr>
</tbody>
</table>

**Domain Expert**

A domain expert or subject matter expert (SME) is a person with special knowledge or skills in a particular area. Domain experts are individuals who are both knowledgeable and extremely experienced within application domains.

The term can also refer to someone particularly familiar with a group, or its work habits, and can act as a usability evaluator.

**System Designer/Designers**

Is a person who designs the system and is expert in their domain derived from the input of the stakeholders. System Designer transfers the technical data or information from the expert to the end user by translating it into communication systems that can be understood.

<table>
<thead>
<tr>
<th>d. Supporting</th>
<th>e. Respondents</th>
</tr>
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<tbody>
<tr>
<td>Ministry of Social Affairs and Development Malaysian Royal Police Malaysian Royal Army Ministry of Health NGO’s</td>
<td>All the stakeholders</td>
</tr>
</tbody>
</table>

**Supporting**

Are people who are not domain expert specialist but will respond directly to the event. These people would receive an instruction from the Centre of Disaster Relief either at a National or District level depending on the disaster status.

**Respondent**

Is a person who will validate the data or design outcome. These are a people who will respond to the system development. These will involve all the stakeholders identified at different levels.

*Table 1: Stakeholders involved in a flood disaster in Malaysia*
This research studies the Seri Medan region and community where all relevant levels of information activity and dissemination are identified. Rural and urban populations differ in terms of education, age, race, culture and social interaction. This particular study focuses on a rural area with a more homogenous Malay community. Current visual systems have been examined. The mediums used in disseminating the communication for risk warning systems have been studied and analyzed to identify their functionality and effectiveness as communication tools.

As natural disasters are unavoidable, with particular geographic areas vulnerable to serial risk factors, effective communication is important and education and training is proposed as the platform through which to develop the communication tools. Each level of risk management involves different sets of stakeholders. Thus different levels of people would directly and indirectly be affected by the whole communication system.

Based on the Table 1 described above, the stakeholders involved in the flood disasters are identified.
1.6 Research framework

This study is conducted based on the following Activity Centered Design framework:

![Activity Centered Design Framework](image)

*Figure 4: Research Framework based on Activity Centered Design (Gay & Hembrooke H 2004)*

Activity Centered Design is a framework that is used to tabulate the inter relationship between each stakeholder involved in the development of the current flood warning systems. This framework provides a clear picture of the problems faced by the current system and its implementation. Further discussion of this framework is given in Chapter 3.

1.7 Significance of study

This study contributes to an undeveloped field of public education in Malaysia. It mediated the connection of expert warning systems with an affected population via a complex of administrative public authorities such as the Meteorological Department, police and local authorities.

i. The proposed communication tools from this study will help the public authorities to design and develop educational tools based on the research conducted in the study.

ii. By knowing the most appropriate visual communication mediums through the study a better targeted risk reduction program can be implemented.
iii. Authorities can help minimize the loss of life and assets during a disaster through mobilizing more effective communication tools and improving awareness if certain recommendations are implemented successfully.

iv. It is acknowledged that any proposed outcomes, applications or systems must be tested on potential at risk populations.

v. The Activity Centered Design (ACD) research framework is used to analyze the activity and mediating relationship between the subject, the object and the division of labour in the warning system.
2.0 Introduction

This chapter will begin with a review of the literature which discusses global warming effects and the frequency and density of natural disaster events, especially empirical studies on Malaysian natural disaster occurrences. The effectiveness of communication in risk reduction and awareness will also be addressed. The purpose of this review is to provide an understanding of the previous research in this area as well as providing a rationale for the choices of predictor variables in the present study.

2.1 Natural Disaster Phenomenon

“Disaster - a sudden accident or a natural catastrophe that causes great damage or loss of life. An event or fact leading to ruin or failure.”

A natural disaster is defined as a natural catastrophe that causes great damage or loss of life from natural phenomenon (Oxford 2008).
Global Warming and Natural Disasters
Countries around the world are concerned at the increasingly frequent occurrence of disasters. Most scientists think that the cause of climate related natural disasters is linked with global warming. Global warming issues caused by human activities have changed many factors in relation to the weather. (Houghton 2005). This does not mean that climate change policies have necessarily been forthcoming to match the dire predictions of the climate experts, but this indecision is more related to the national and international inability to decide on policy and actions rather than being about coping with increasing climate events.

In Peninsular Malaysia this has led to more flood disasters occurring in each area and state (Bernstein et al. 2007). These outcomes have also been exacerbated by deforestation for palm oil plantation monoculture (internationally one of the principal causes of human related climate change).

Characteristics/types of disaster in Asia
Floods, windstorms, earthquakes, landslides and epidemics occurred in Asia at a greater rate than other disasters in 2005. About 72% of the disasters in Asia consisted of windstorms and floods, followed by earthquakes (8%), epidemics (6%) and landslides (5%) (Natural Disaster Data Book 2005: An Analytical Overview March 2006).

Characteristic/types of disaster in the Americas
In 2005 in the Americas, which includes the countries of North and South America, floods and windstorms accounted for the vast majority (almost 84%) of natural disasters. In terms of human loss 98% of people killed in disasters in the Americas were killed by floods and windstorms. The research shows that economic damage sustained was mostly caused by windstorms (hurricane) (Natural Disaster Data Book 2005: An Analytical Overview March 2006).
Characteristics/types of disaster in Europe
The majority of disasters in 2005 were floods and extreme temperatures, accounting for 71% of all disasters. The majority of human losses were due to extreme temperatures (heat wave, 83%), followed by windstorms and floods. These disasters combined caused about 97% of total human losses in the region in 2005 (Natural Disaster Data Book 2005: An Analytical Overview March 2006).

Characteristics/types of disaster in Oceania
Disaster trends in Oceania are a bit different from other regions in 2005, as here the types of natural disasters strayed from other world regional patterns. The majority of disasters that occurred were windstorms and floods, accounting for 73% of the total. The remainder consisted of volcanic eruptions, earthquakes, and wild fires. The majority of human losses were due to wild fires (52%) followed by windstorms, earthquakes and floods. This is due to the wild fires in Australia and storms in the pacific island countries. (Natural Disaster Data Book 2005: An Analytical Overview March 2006)

2.2 Malaysian Natural Disasters
Malaysia is a country relatively safe from major natural disasters such as earthquakes and volcanic eruption, but the country was affected by the December 26, 2004 Tsunami that also struck Indonesia, Thailand, Sri Lanka and Bangladesh. (Accomplishments current activities and future requirements for disaster reduction in Malaysia 2003) In response the government installed the Malaysian National Tsunami Early Warning System with the installation of buoys in the Indian Ocean and South China Sea. (Malaysian National Tsunami Early Warning System (MNTEWS) 2009)

From time to time Malaysia is also affected by other disasters such as drought with high temperatures, due to the El-Nino phenomena, epidemic disasters (such as SARS, H1N1), landslides and the collapse of buildings as a result of landslides and also windstorms exacerbated by the La-Nina phenomena (Shaluf & Ahmadun 2006).

The Table 2 below shows different types of natural disaster that occurred in Malaysia from 1900-2009.
Peninsular Malaysia receives two monsoon seasons in a year, from the North East and South West Monsoons. They bring wet conditions, heavy rain and thunderstorms, which contribute to disasters such as flooding and landslides (Shaluf & Ahmadun 2006). The average annual rainfalls of 2,400mm for Peninsular Malaysia, 3,800mm for Sarawak and 2,600mm for Sabah, result in an abundant water supply that creates a water management problem (Flood and Drought Management in Malaysia 2007).
Flooding

Flooding is the most significant natural hazard in Malaysia in terms of population affected, frequency, extent, duration and socio-economic damage (Flood and Drought Management in Malaysia 2007). These phenomenon are illustrated by the data collected by the EM-DAT below that shows flooding to be increasing so that now more of the population is affected by flooding compared to other disasters. Other disasters include drought, epidemic, landslides, wave/surge, wild fire and wind storm (EM-DAT Emergency Events Database 2009).

| Summarized Table of Natural Disasters in Malaysia from 1965 to 2007 |
|-----------------|-----|-----|-------|-------|-----------------|-------|
|                 | # of Event | Killed | Injured | Homeless | Affected | Total Affected | Damage US$(000’s) |
| Drought         | 1   | 0   | 0      | 0       | 5,000    | 5,000           | 0       |
| avg per event   |     | 0   | 0      | 0       | 5,000    | 5,000           | 0       |
| Epidemic        | 11  | 462 | 0      | 0       | 10,363   | 10,363          | 0       |
| avg per event   |     | 42  | 0      | 0       | 942      | 942             | 0       |
| Flood           | 30  | 281 | 0      | 35,000  | 1,111,65 | 1,146,650       | 136,70  |
| avg per event   |     | 9   | 0      | 1,167   | 37,055   | 38,222          | 4,557   |
| Slides          | 4   | 152 | 35     | 250     | 0        | 285             | 0       |
| avg per event   |     | 38  | 9      | 63      | 0        | 71              | 0       |
| Wave / Surge    | 1   | 80  | 767    | 4,296   | 0        | 5,063           | 500,00  |
| avg per event   |     | 80  | 767    | 4,296   | 0        | 5,063           | 500,00  |
| Wild Fires      | 2   | 0   | 0      | 3,000   | 0        | 3,000           | 0       |
| avg per event   |     | 0   | 0      | 1,500   | 0        | 1,500           | 0       |
| Wind Storm      | 6   | 294 | 26     | 3,000   | 52,805   | 55,831          | 0       |
| avg per event   |     | 49  | 4      | 500     | 8,801    | 9,305           | 0       |

Table 3: EM-DAT database showing natural disaster in Malaysia from 1965 to 2007. The database recorded based on one of the criteria. 10 or more people reported killed, 100 people reported affected, a call for international assistance or declare of state of emergency.

One example of flooding that affected the southern part of Peninsular Malaysia with heavy rain, resulting in a flooding to Johor State, Melaka, Negeri Sembilan and Pahang, was recorded by the Meteorological Department in 2006. The satellite images (Figure 4) show that the region chosen as a research activity received heavy rain from 16 December to 20 December 2006 (Laporan Hujan Lebat Yang Mengakibatkan Banjir Di Negeri Johor, Melaka, Negeri Sembilan dan Pahang 2006). This example shows that in a short period of time this region received a tremendous amount of rain that resulted in both flash flooding and normal flooding.

At the peak of recent Johor floods around 110,000 people were evacuated and sheltered in relief centers with a death toll of 10 people (Flood and Drought Management in Malaysia 2007).

For the case study region, Seri Medan experienced its worst flooding in 2007 as a result of heavy monsoonal rainfall. Figure 4 below shows the region receiving heavy rain with thick clouds on radar images over a 24 hour period on the 4th December 2009,
Characteristics of the flooding

The characteristics of the flooding in the South East Asian region, including Malaysia, are the result of geographic and climate conditions. Peninsular Malaysia is flanked on each side by the vast Indian and Pacific Oceans, resulting in regular typhoons, storms and other extreme climate conditions. The region receives a seasonal exchange of moist air mass or wind called monsoons (Liongson 2003).

Flooding has been categorized into two types - Atmospheric and Geotechnical. Atmospheric examples can be frontal depression, thunderstorm, monsoon, tropical cyclones, snowmelt, ice jams and glacial lake outburst. Examples of geotechnical flooding are dam break, defense breach, tsunami or debris flow (Sene 2008). Bohari and Rashid define flooding and cyclones specifically as hydrological disasters (Bohari & Rashid 2001).
Based on Sene and Bohari and Rashid, the characteristics of flooding in Malaysia fall into the atmospheric type and specifically are hydrological disasters. This is mainly due to heavy monsoons where prolonged rainfall causes a range of river (rural and urban flash floods) flooding to occur. The research in this study however is concentrating on rural monsoonal flooding.

Malaysia faces two major atmospheric flood events, which are flash flooding and monsoon flood events. The monsoon flood, which occurs as a result of the heavy North East Monsoon season from November to March, covers a wider area. Flash floods occur mostly in urban areas, mainly due to the exacerbation of run-off due to urbanization, agriculture and other human activity (Hassan, Ghani & Abdullah 2006).

Below (Figure 5) is a map plotted by Hassan showing the area prone to flooding based on his research using GIS (Geographic Information Systems).

**Risk and Severity**

The flood disaster threat that Malaysia faces is an imminent event due to uncontrollable nature. The severity and frequency of occurrence of these floods can be linked to factors which are related to climate change, global
warming and human activity, as in many similar tropical countries (Houghton 2005).

Floods that occurred in 2006-2007 in Johor State were the most costly disaster in Malaysian history. The total cost of MYR1.5 billion was reported from these floods (Flood and Drought Management in Malaysia 2007). Reports from these recent events show the increase in flood frequency and magnitude, social economic disruption, public outcry, media coverage and the escalating government allocation of funds to mitigate them.

The data on the issue of climate change, resulting in the frequency of flood occurrences, has been discussed in Chapter 1. This chapter will concentrate on the human activity that contributes to the increase in flooding in general for Malaysia.

Deforestation in Malaysia has been reported by the United Nations as accelerating faster than in any other developing tropical country. The Food and Agriculture Organization of the United Nations reported that 80% of Peninsular Malaysian deforestation occurred for palm oil plantation establishment (Mabee & Saddler 2007).

Bradshaw et al. (2007) have conducted research into the effect of deforestation and whether it amplifies the flood risk and severity in the developing world. Their research shows that extracted measures of flood severity (flood duration, people killed and displaced, and total damage) showed some weak but detectable correlations to loss of natural forest cover.

Based on an arbitrary decrease in natural forest area of 10%, the model averaged predictions of flood frequency increases between 4% and 28% for the countries modeled. Using the same hypothetical decline in natural forest area the model resulted in a 4–8% increase in total flood duration. These correlations suggest that global-scale patterns in mean forest trends across countries are meaningful with respect to flood dynamics. Unabated loss of forests may increase or exacerbate the number of flood-related disasters, negatively impact millions of people and inflict trillions of dollars in damage to disadvantaged economies over the coming decades. This first global-scale empirical demonstration that forests are correlated with flood risk and severity
in developing countries reinforces the imperative for large-scale forest protection to protect human welfare and suggests that reforestation may help to reduce the frequency and severity of flood-related catastrophes (Bradshaw et al. 2007).

Flood risk is a function of physical flood-producing processes, which may be statistically measured as flood probability that may be altered by natural or human-induced environmental change. For example, large-scale land use change, such as extensive deforestation and conversion to palm oil plantations, may lead directly or indirectly to an increase in the probability of floods. Flood exposure is a measure of the human population and their habitation, land uses and investment located in flood zones that put them at risk from flooding (Chan 1997). The review indicates that deforestation does amplify the frequency and risk of flood disaster.

The case study region’s flood risk and severity is due to a few important factors. The observation from the case study revealed that the geographic location, the urbanization of the surrounding area and changing of socio-economic activity (especially clearing for palm oil plantations in the catchments) has led to the increased risk of flooding.

The low topography and the converging of the flooding of neighboring regions contribute to the severity of flooding in Seri Medan. This is described in detail in the Context and Setting section (Chapter 3).

The urbanization of surrounding areas has lead to widespread land clearance for roads, housing estates, business premises and manufacturing establishments that has lead to the loss of protective vegetation which can help delay run-off and erosion. The social economy of the people of Seri Medan has changed from rubber plantations to palm oil plantations, which has also contributed to the instability of the land as palm oil requires clean undergrowth conditions compared to rubber plantations which don’t.

Below is a series of photos that show the severity of the 2007 flood disaster in Seri Medan (Figure 6,7,8 and 9).
Developing Malaysian community based flood warning initiatives through Activity Centered Design

Figure 7: The Seri Medan River was flooded above bridge level when the 2007 flood occurred.

Figure 8: In 2007 the Seri Medan River has fully flooded. Water covers the river plain and surrounding areas.

Figure 9: The canal and the main road have become one waterway, 2007.
Malaysia is a safe country among the South East Asian Nations in terms of risk from many of the other major natural disasters such as earthquake, volcanic eruption and fire. The country is however vulnerable to increasing severity of flood disasters due to changing climatic conditions, illegal deforestation, excessive urbanization and changing land use.

The writer of this report was introduced to the research activity in the region of Seri Medan showing that development is moving quickly from purely farming to urban and industrial development with land use continuing to change. The flooding from catchments in surrounding regions also contributes to the severity of flooding in this region.

As flooding in this region is more imminent the villagers must adapt to the new and changing conditions with the help of the government and local authorities. Continuous education and proper warning systems are needed to help the community to be alert survive and minimize damage.
Developing Malaysian community based flood warning initiatives through Activity Centered Design

<table>
<thead>
<tr>
<th>Types of disaster</th>
<th>Frequency</th>
<th>Fatalities</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural disaster</td>
<td>19</td>
<td>1,460</td>
<td>821</td>
</tr>
<tr>
<td>(disaster that occur naturally due to environmental)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Man-made disaster</td>
<td>18</td>
<td>282</td>
<td>1,892</td>
</tr>
<tr>
<td>(disaster occur due to human environment)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsequent disaster</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(disaster occur due to both of the above at the same time)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Disaster frequency in Malaysia (Shaluf & Ahmadun 2006)

Although Malaysia is geographically outside the Pacific Rim of fire and is relatively free from any severe ravages and destruction caused by natural disasters such as earthquake, typhoon and volcanic eruptions, nevertheless the country (Table 4) is subject to monsoon floods, resultant landslides and severe haze episodes (Shaluf & Ahmadun 2006).

2.3 Hazard warning systems and effectiveness

Warning integration has not been improved for all hazards. Specifically, some improvement in prediction and forecast has been made at times of flood disaster because of the implementation of more advanced technologies, but warning system integration seems underdeveloped (Sorensen 2000). The Table 5 below shows the status of the Hazard Warning System development throughout the world in the last 20 years.

In Malaysia Flood Forecasting and Warning Services (FFW) are concentrated in the river basins where frequent flooding occurs (Policy and Mechanism of National Disaster Management and Relief 1994).
### hazard warning system and its integration (20 years)

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Prediction/forecast</th>
<th>Warning integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>Some improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Hurricane</td>
<td>Major improvement</td>
<td>Major improvement</td>
</tr>
<tr>
<td>Tornado</td>
<td>Some improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Drought</td>
<td>Not much improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Fire</td>
<td>Not much improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Avalanche</td>
<td>Not much improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Earthquake</td>
<td>Not much improvement</td>
<td>Major improvement</td>
</tr>
<tr>
<td>Volcano</td>
<td>Some improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Tsunami</td>
<td>Not much improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Landslide</td>
<td>Some improvement</td>
<td>Not much improvement</td>
</tr>
<tr>
<td>Nuclear power</td>
<td>Major improvement</td>
<td>Major improvement</td>
</tr>
<tr>
<td>Hazardous material/chemicals</td>
<td>Major improvement</td>
<td>Not much improvement</td>
</tr>
</tbody>
</table>

*Table 5: The availability of hazard warning systems and their integration for the past 20 years in most major parts of the world (Sorensen 2000)*

There are four types of flood forecasting and warning services mentioned in the policy, which are:

**Telemetry System**

The Telemetry System is a technology that allows data measurements to be made at a distance, usually using a wireless data transfer mechanism such as radio, hypersonic or infrared systems. It also encompasses data transferred over media such as a telephone or computer network, optical link, wireless or wired communication.

The Drainage and Irrigation Department is responsible for collecting and analyzing the data of rainfall and water level during the flood season. This data will be transmitted through VHF radio frequency, telephone or satellite. It is stated public policy that similar systems be implemented for another 10 river basins in between 1996-2000 but the Seri Medan region (chosen for this study) is not included at the point that the research undertaken for this thesis was conducted.

**Manual Flood Level Monitoring**

A total of 137 flood level monitoring stations have been set up at strategic locations across the country to monitor river levels on a real-time basis. When a water level exceeds the predetermined critical level the local observer shall transmit continuously the real-time water level information to the DID state office via the operation room at the district and state and federal offices.
Flood Warning Sirens
A total of 60 flood warning sirens, which automatically trigger once the flood level reaches its critical point, have been installed at strategic locations along certain rivers. However, no flood warning sirens have been found in the region chosen for this study.

Flood Warning Board
Flood Warning Boards have been installed in flood-prone areas in the major river basins, but Seri Medan is not included as it is classified as a sub-basin region. Levels marked on these warning boards are correlated to the level at observation points upstream. The residents of the villages are able to access for themselves the impending flood situation in their area based on the real-time upstream river and forecast levels shown on the warning boards. But earlier observation from the field research activity shows that these boards are not available to all flood-prone areas.

Current systems that have been implemented by Malaysia for flood forecasting and warning include 233 telemetric rainfall stations, 190 telemetric water level stations, 256 manual stick gauges, 84 flood warning boards, 217 flood warning sirens, and real-time forecasting and warning systems in nine river basins (Total Disaster Risk Management-Good Practice 2005).

The quick dissemination of information is important for a well-developed early warning system for an emergency. The style and content of a message can have a dramatic effect on public response. Sorensen (2000) stated that there are five specific topics that are important to include in assembling the actual content of a public warning message system: the nature, location, guidance, time, and resources needed to properly assess the hazard or risk. According to Sorensen, the style aspects that are important to include are message specificity, consistency, accuracy, certainty, and clarity (Sorensen 2000).

The flood warning systems and devices mentioned above reflect the official policy of the Malaysian Natural Disaster Directive that has been stated in recent policy (Policy and Mechanism of National Disaster Management and...
Whether or not they are consistent across the board is fairly arbitrary. In the Seri Medan area for instance only the river gauges were present. There was no evidence of warning boards or signage systems that existed to warn the villagers.

It is important to maintain how the information needs to be disseminated from every level shown in Figure 2 (Page 8). Community involvement is important as it will help each individual to better understand the warning procedures involved and to take precautionary measures if needed. The models showed that consistent and continuous information dissemination is important at every level when developing an early warning system (Leonard, Johnston & Paton 2002).

In recent years the focus of the international community in relation to disaster or emergency management has shifted from the development of disaster response capabilities to the need to strengthen risk reduction and control mechanisms and policies, with a particular interest in the design and implementation of better early warning systems as a major social and governmental response to the threat of disasters.

The emphasis on early warning systems has turned attention and funding to the current capabilities and developments in science and technology and unfortunately distracted us from the central issue of addressing the real needs of the communities and people at risk. Hall suggests that the development of the early warning systems must not be governed by the science and the technology but be developed instead by the risk management agency itself (Hall 2007).

The role of communities in disaster reduction is increasingly being recognized. Communities are knowledgeable about their own environment and possess strong coping capabilities. Involving communities in the whole process of hazard identification, vulnerability and capacity assessment, could lead to a much more holistic risk reduction program, developed and implemented to ensure that problems are addressed by appropriate interventions. The community can be the main actor and beneficiary in the risk reduction and development process (Bildan 2003). Excellent examples of pro-active communities can be seen in the highly successful Australian prevention and
management programs developed by Landcare and the Country Fire Authority in Victoria Australia. Landcare is a community led re-forestation program initiated by the ACF and the Farmers Federation. The Country Fire Authority (CFA) runs a community education program by volunteers, funded by the state government to help the Fire Service Department in dealing with fire prevention, fire disasters and related events.

<table>
<thead>
<tr>
<th>Components of the Risk Communication Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Primary types of risk communication aims</td>
</tr>
<tr>
<td>• Advancing/changing knowledge and attitudes regarding risks</td>
</tr>
<tr>
<td>• Modifying risk-related behavior of exposed people</td>
</tr>
<tr>
<td>• Promoting community participation in hazard mitigation</td>
</tr>
<tr>
<td>• Developing disaster preparedness and emergency management</td>
</tr>
<tr>
<td>2. Communication means and channels</td>
</tr>
<tr>
<td>• Brochures etc. distributed by institutions/agencies</td>
</tr>
<tr>
<td>• Product information, machine operating instruction, etc</td>
</tr>
<tr>
<td>• Education video/film, computer products</td>
</tr>
<tr>
<td>• Info presented via broadcasting, TV, newspapers, journals</td>
</tr>
<tr>
<td>• Personal presentations meeting, drills etc)</td>
</tr>
<tr>
<td>3. Situations In which risk communications occurs</td>
</tr>
<tr>
<td>• Information/preparedness campaigns by authorities/agencies</td>
</tr>
<tr>
<td>• Tests, exercises, safety training courses</td>
</tr>
<tr>
<td>• Emergency info and warnings for exposed people</td>
</tr>
<tr>
<td>• Evacuation</td>
</tr>
<tr>
<td>• Public hearings, conference etc</td>
</tr>
<tr>
<td>• Counseling contacts, medical advice</td>
</tr>
<tr>
<td>• Judicial proceedings</td>
</tr>
<tr>
<td>4. Target audiences and actors</td>
</tr>
<tr>
<td>• Risk-exposed people</td>
</tr>
<tr>
<td>• The general public</td>
</tr>
<tr>
<td>• Industry/manufacturer/companies</td>
</tr>
<tr>
<td>• Administrative/regulatory authorities</td>
</tr>
<tr>
<td>• Scientific institutions</td>
</tr>
<tr>
<td>• Journalist/media</td>
</tr>
</tbody>
</table>

Table 6: Components of the Risk Communication Process (Rohrmann 1998)

Rohrmann (1998) stated that risk communication research is more important when it comprises interdisciplinary fields of hazard perception, risk information, behavior change strategies and interactive problem-solving approaches. He stressed that psychology can be seen as the core discipline. He also warns that risk communication is a rather general term and that there is no established and coherent definition of the field, confirming that the various tasks related to risk communication have three primary goals: to advance knowledge, to influence individual behavior and to deal with risk problems on a communal level.
In order to understand the communication process for hazard communication, Rohrmann suggests that the relevant components (Table 6) need to be identified.

The component of risk in the Risk Communication Process needs to be considered when dealing with risk management. The aim of the process is to identify what advanced or changing knowledge and attitudes regarding risks need to be pursued and does the process also involve modifying the risk related behaviour of the exposed community. It also needs to promote community participation in hazard mitigation and at the same time develop emergency management and preparedness.

The Risk Communication Process also involves how to deliver the information through the most suitable and most effective channels. Brochures, for example, manuals, educational videos, advertorials or even drills need to be considered based on their suitability.

A clearly defined evaluation of the situation in which risk communication occurs needs to be made. Information campaigns by authorities, exercises and drills, evacuation plan and process, public hearing and feedback, counseling, medical assistance and juridical proceedings have to be put in place and ready to be mobilized when needed.

The target audiences or the affected community need to be clearly identified as each of them carries different needs. The risk exposed community, the general public, companies, regulatory authorities, and media will be affected differently and play a different role in determining the success of the risk component.

2.4 Flood Forecasting and Warning Services in Malaysia

As in many other countries in the world where flooding occurs frequently, Malaysia has been developing early warning systems since the early 1970s and continuing to better implement the systems and meet international standards.
The government has set up a special committee and mechanism through standing orders on Flood Relief Machinery issued by the National Security Division (BKN) under the Prime Minister’s Department. (*Policy and Mechanism of National Disaster Management and Relief 1994*). With the enforcement of the National Security Council’s Directive 20, all flood disasters are to be handled under this directive and consequently The Committee of Natural Disaster Relief was dissolved.

The Meteorological Department (MMS) is the agency responsible for providing the information and the warning occurrences relating to the weather phenomenon to the general public through the mass media or other government agencies directly involved in flood or disaster mitigation. (*Policy and Mechanism of National Disaster Management and Relief 1994*)

A Central Forecasting Office has been established in the Meteorological Headquarters to monitor closely the weather and sea conditions over the Malaysian region, where special emphasis has been given to heavy rainfall, strong winds and heavy rainfalls associated with tropical storms.

Meanwhile the role of the Department of Irrigation and Drainage (DID) is to establish flood control measures. This involves the establishment of the Permanent Flood Control Commission to implement flood control measures in order to reduce the flood occurrences and to minimize flood damage.

Previously the department was also responsible for coordinating the flood mitigation process in the federal, state and district levels before that role was taken over by the National Disaster Management and Relief Committee in 1997.

In addition the Department of Irrigation and Drainage (DID) is also responsible for the implementation of structural flood mitigation measures, provision of flood forecasting and warning services to river basins experiencing frequent floods.

As stated in the Mechanism of Disaster and Relief Management Directive, the Department of Irrigation and Drainage (DID) has been designated with the task of implementing the structural flood mitigation works where a flood
mitigation plan has been developed for 17 major river basins and 27 towns. In this plan various structural and non-structural measures have been proposed and partially implemented. (Policy and Mechanism of National Disaster Management and Relief 1994)

In the case of the Sri Medan region there is no significant structural flood mitigation plan that has been implemented besides the installation of water level gauges and the nomination of a flood relief centre. There is no sign of a community based flood-warning plan or signage that informs the community of pending floods.

The department has been concentrating on improving the river channels, building flood levees, ring bunds, by-pass flood ways, use of mining pools for flood attenuation and construction of flood retention dams to regulate flood flows. So far minimal attention has been put on the social aspect of communications between the community affected and information on the danger of the flood itself.

The Department of Irrigation and Drainage also provides the Flood Forecasting and Warning Services (FFW). These services are telemetry systems, manual flood level monitoring, flood warning sirens and flood warning boards. But in the case of the Seri Medan region, there are no flood warning sirens and flood warning boards available that can inform the villagers about the pending flood.

**Detection**

As there are various agencies involved in the early warning systems, the illustration below (Figure 10) would help to identify how the early flood warning systems have been implemented in Malaysia.

It shows the different agencies, their level of responsibility and their involvement in the early warning systems workflow. The current model (Figure 10) shows how information and data were gathered, collected and processed by the respective departments before being disseminated to the mass media or other departments involved.
The whole process showing how the current early warning system works can be identified based on the model (Figure 10) below.

**Malaysia current Early Warning System Model**

![Diagram of current Early Warning System for flood in Malaysia](image)

*Figure 11: The current Early Warning System for flood in Malaysia (Policy and Mechanism of National Disaster Management and Relief 1994).*

The illustration shows that the flowchart of the current early warning systems work in a similar way to most early warning systems from other countries. However, in the current Malaysian model there is a concentration on the basic flow but a neglect of the society and communication design aspects at the lowest levels of communication, where warnings need to be disseminated to the flood victims or villagers. Both Malaysian departments use aspects of mass media and physically installed warning tools (such as sirens and warning boards), however, as the Batu Pahat research discovered, their implementation is far from complete and comprehensive, leaving whole communities exposed to the elements.
Malaysia, as with other countries, uses similar and standard instrumentation networks for flood warning and forecasting. As stated by Sene (2008) flood warning and forecasting systems usually rely on a network of meteorological, river and/or coastal instruments that have been put in place. He also stated that monitoring networks could also serve a range of purposes in addition to flood warning and forecasting, such as water resources monitoring, marine forecasting and climate change monitoring.

Flood warning can be divided into detection, thresholds and dissemination, where real time measurements of meteorological and river or coastal conditions are used to guide operational decision making. This implementation system is applicable to Malaysia.

**Meteorological Conditions**

This is a well-established method that has been used by most of the countries in the world including Malaysia where specific locations are used for observing the meteorological parameters. The implementation of this method in Malaysia has been acknowledged (*Policy and Mechanism of National Disaster Management and Relief 1994)*.

These instruments take the form of rain gauges, cups or ultrasonic anemometers (wind speed), wind vanes (wind directions), radiometers, hygrometers and neutron or capacitance probes and have been installed in major locations, including the Seri Medan region. These instruments are not meant for the villagers to understand or take into consideration. They are instead meant to be read by experts and interpreted for the local inhabitants.

**Media Disseminations**

In Malaysia the data of the telemetry systems is used in a similar way to other countries and as endorsed by the World Meteorological Organization. There are different types of telemetry systems in use in the Malaysian context such as telephone lines (PSTN), radio and satellite. Each system has its own advantages and limitations as shown in the table below from Sene:
### Strength and weaknesses in telemetry system

<table>
<thead>
<tr>
<th>Method</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone, broadband, local wireless, Ethernet</td>
<td>Uses an existing network</td>
<td>May incur connection and usage charges</td>
</tr>
<tr>
<td></td>
<td>Simple to setup and operate</td>
<td>Require reliable public network landline and exchanges can be damaged by flooding and high winds if it is not design to avoid these problem</td>
</tr>
<tr>
<td>Cell phone</td>
<td>Uses an existing network</td>
<td>May incur connection and usage charges</td>
</tr>
<tr>
<td></td>
<td>Simple to setup and operate</td>
<td>Possible data drop-outs in heavy rainfall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network can be affected by power cuts during flood events</td>
</tr>
<tr>
<td>Radio</td>
<td>Probably no connection charges other than radio license fees once the networks is established</td>
<td>User needs to establish and maintain the network (equipment and transmission)</td>
</tr>
<tr>
<td></td>
<td>User retains full control of the network</td>
<td>Line of sight required for transmission possibly requiring repeater stations, or limiting the range for coastal applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May be affected by interference</td>
</tr>
<tr>
<td>Satellite</td>
<td>Instruments can be installed anywhere visible to the satellite</td>
<td>May incur data transmission charges</td>
</tr>
<tr>
<td></td>
<td>No requirement to establish a network</td>
<td>Possibly no suitable satellite visible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transmission may be restricted to the time of overpass or transmission time slots determined by the operator</td>
</tr>
<tr>
<td>Meteor burst</td>
<td>No requirement to establish a network</td>
<td>Relatively high power transmitter required</td>
</tr>
<tr>
<td></td>
<td>Signal can be transmitted over a long ranges</td>
<td>Possible delays whilst waiting for suitable transmission conditions</td>
</tr>
</tbody>
</table>

Table 7: Examples of strength and weaknesses and possible limitations in telemetry methods (Sene 2008).

From Table 7 above, it is evident that highly technological equipment may have limitations that would give only partial or unreliable coverage or even incorrect information resulting in erroneous warning information being disseminated. Sometimes a more conventional form of communication such as using a siren should be put in place so that the population at risk can be continuously warned and prepared by being provided with enough information on how to deal with conditions.
Information Availability Relating to Flooding

There are few media tools used in disseminating the warning system data to the people in the affected area. However the Meteorological Department and The Department of Irrigation and Drainage do provide information relating to flood development.

Guidelines for flood preparedness can be found on The Department of Irrigation and Drainage websites. These guidelines state what action needs to be taken prior, during and after flood occurrence. This sub chapter will discuss what information and warning types are available and what strengths and weaknesses current systems of communication possess.

Early warning systems for floods in Malaysia (as stated earlier in this chapter) are based on the most common standard used by other countries and validated by the World Meteorological Organization (WMO) under the WMO Flood Forecasting Initiative. But the implementation of the flood warning systems also differ from country to country to suit their level of economic and social development.

The Early Warning Systems of Malaysia contain the necessary levels of Detection, Thresholds, Dissemination, Response, Recovery and Review. But it is also important to recognize that each level of effectiveness would depend on how each category is designed and implemented. The overall systems are generally effective from the technological point of view and the comprehensiveness of the system would meet international standards, however there are weaknesses at particular levels that have been exposed by the research in this study. This will be discussed further in Chapter 4. (Analysis)

Weather Forecast and Warning through Media

Media such as television and radio are the main mediums that usually deliver information regarding weather conditions. The weather forecasting information is based on the data received from the Meteorological Department.
Below (Figure 11) is an example of how the weather forecasting is usually broadcast. It informs the viewers as to what they should expect from current weather conditions. This is a typical form of weather forecasting on television media in Malaysia (*Buletin Utama* 2010).

![Weather Forecast](image)

*Figure 12: Screen shot of weather forecast broadcast from one of the local television channel in the prime news. ([www.tv3.com.my](http://www.tv3.com.my))*

The screenshot shows the limitations of the information presented. The forecast is too general and does not contain any detailed forecast within the region. In addition the advertisement distracts from the crucial information (ie. weather details) as it takes up so much screen space, its bright colours fight for attention and it submerges the morning (pagi) and afternoon (petang) weather details within it. Overall this weather forecast does not provide any information that would benefit the viewer, as it does not contain any forecasting details let alone flood warning details.

The broadcasting agency together with the government authority needs to think seriously about providing the viewer with accurate and complete forecasting as television is the most popular mass communication medium in the village. Weather forecasting should be presented in a way that catches attention and takes the viewer and their local weather conditions seriously. Additionally it needs to be aired more frequently as the Malaysian weather conditions can change dramatically.
Forecasting and Warning through Websites

Information relating to flooding is available from Two (2) different websites, which are; The Meteorological Department Website (*Portal Rasmi Jabatan Meteorologi Malaysia 2010*) (Figure 12), and the Department of Irrigation and Drainage’s Infobajir (*Infobanjir 2010*) (Figure 13).

*Figure 13: Malaysian Meteorological Department Website shows the weather forecast (www.met.gov.my)*

*Figure 14: Infobanjir from Department of Irrigation and Drainage website shows the information about flooding. (http://infobanjir.water.gov.my)*

Both of these websites show the weather forecast but the Infobanjir from the Department of Irrigation and Drainage shows information solely in relation to flooding, while the Meteorological Department shows information relating to general weather, world weather and also flooding. The interviews conducted...
in this study revealed that most of the affected communities were unaware of the existence of both websites. This is due to such factors as Internet service unavailability, the level of computer literacy among the community and also the lack of promotion of these websites.

Furthermore from the analysis gathered through the researcher’s observation both of the websites lack interaction and user interface friendliness. Information is too general and sometimes does not provide any benefit to the particular location of the user.

It is crucial to develop websites that contain information, which benefit the users. Information relating to basic survival in dealing with flooding, emergency numbers, a list of relief centres, action guides on how to react to flooding etc. would add great value to the websites. So it is not only providing the users with flood warning information but also encouraging and teaching the users actions relating to dealing with flooding. In the long term this would benefit the users and their community as the websites would become a continuous learning resource that leads to a resilient society.

2.5 Visual Analysis and Design Effectiveness

Little is known about how visual displays of risk affect perceived risk, decision-making processes and ultimately behavior. Visual displays might be presented independently, or in combination with numerical data, or shown as narrative translations – as in animations. Accumulated data shows that a significant proportion of people have difficulty grasping and recognizing statistical or numerical data. Visual displays have desirable properties that can enhance the understanding of statistics (Michaels & Headley 2004).

Lipkus and Hollands (1999) use the following recommendations for future research (1) conduct research linking graphical perception in risk perception (2) determine effects of preference for and experience with display on risk (3) establish how graphs affect perceived severity and risk (4) establish how risk characteristics interact with visual displays to affect risk perception (5) determine the range of probabilities conveyed most effectively (6) determine which visuals are most effective to communicate risk uncertainty.
Research consistently indicates that in direct comparisons of word-only and word-plus symbol signs the latter performed better. Reaction time is faster, understanding is more rapid, legibility distance is greater and recall is more accurate. In addition visual symbols are language free, so consequently they can be read by a wider audience, including the illiterate, non-English (or local language) speaking people, people with low vision and also viewers with cognitive impairments (Olgyay 2003).

As Tufte (1990) said, even though we are navigating through three-dimensional space our information is still caught up with a two dimensional surface. As such he outlines various design strategies that can sharpen the information resolution by increasing the number of dimensions that can be represented on a plane surface.

Writers and document designers do not always reflect sufficiently, or at all, on the profile of their audience, and quite obviously this can then lead to problems in the effectiveness of the documents they produce.

Writers, editors, experts and colleagues from the institution on behalf of whom the document is being designed should therefore be also part of the design process as well as the audience for whom the design is being developed. User centeredness in design would preach that both the sender and the receiver take co-responsibility for the effectiveness of the document (Stadler & Land 2007).

The effectiveness of communication about risk has to be about the actual outcomes of the tools and that sufficient information, dissemination and reception is taking place in the defined target group as a precondition for effectiveness (Rohrmann 1998).

Thus Rohrmann suggested that the evaluation for risk communication effectiveness must consider aspects of the evaluation as on Table 8.
Table 8: Criteria for Risk Communication Effectiveness (Rohrmann 1998)

Rohrmann (1998) agreed that different risk communication tasks require different approaches, however from the social-psychologists point of view that he represents he suggests a careful review of current procedures, Rohrmann maps and observes barriers, critical principles and recommendations for communicating risk issues and information strategies. Table 9 is a list of proposals by Rohrmann for effective information/communication design.

Design has been discussed as a process where designing information requires holistic thinking. Rohrmann suggested that we need to look at the culture, which is the whole context in which information has a role to design information, and need to ask, “What purposes does information serve in a culture? How can it serve in the culture better? What new purposes can the information fulfill? And what should the information be like in order to fulfill those purposes?” (Karabeg 2003).

Table 8 shows the goal-related criteria between content evaluation, process evaluation, outcome evaluation and procedural criteria when evaluating the risk communication effectiveness and where this information can be obtained. Content evaluations, which consist of correct and complete information, and
comprehensive understanding of ethical issues are best gathered from the risk communication agency (A) and the risk expert or risk communication expert (E) and also the participant for the latter (R).

Issues such as difficulties in running the program, the inclusion of the relevant societal group and feedback are processes that can be managed by the risk communication agency (A) and risk expert (E).

The outcome of the evaluation such as degree of information distribution, increased or improved problem awareness and the reduction of accidents can be gathered and feedback obtained from the risk Expert (E) and the participant (R).

The Procedural Criteria such as financial planning and training, flexibility and adaptability of the evaluation aspect can be gathered from the risk communication agency (A) and risk expert (E) as they are the ones who control and hold the policy which is involved in planning and implementing the systems.

<table>
<thead>
<tr>
<th>No</th>
<th>Suggestion on designing hazard information/communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ensure valid understanding of how people process and evaluate hazard information</td>
</tr>
<tr>
<td>2</td>
<td>Focus risk communication on behavior change rather than mere knowledge advancement</td>
</tr>
<tr>
<td>3</td>
<td>Check materials/device for comprehensibility, credibility, feasibility and capacity to motivate</td>
</tr>
<tr>
<td>4</td>
<td>Acknowledge apathy/inertia and information overload when designing preparedness requirements</td>
</tr>
<tr>
<td>5</td>
<td>Adapt material to core characteristics of specified target groups (including ethnicity issues)</td>
</tr>
<tr>
<td>6</td>
<td>Provide interactive communication and pathways for information requests and confirmation</td>
</tr>
<tr>
<td>7</td>
<td>Strengthen personal involvement and responsibility</td>
</tr>
</tbody>
</table>

Table 9: Suggestion for Designing Hazard Information/Communication (Rohrmann 1998)

Rohrmann also reiterated that modern culture needs new ways of informing because culture is changing from traditional to modern, the epistemology has
changed from naïve to symbolic and the information changes from printing press to Internet and multimedia.

**Summary**

The literature review covers most aspects of research on global warming, natural disasters and how they affect the world, types of natural disasters, flooding and its severity, characteristics of flooding in different continents, Malaysian flooding, warning systems currently available and risk perception of the victims.

The literature shows that early warning systems, as they have been developed, currently only include aspects of technological advancement and engineering. The social aspects of flooding (where communication design would be most active) appear to be little discussed or utilized. These reviews show there is a gap in the systems and that such research would become valuable to the improvement of future warning systems development.

The literature review also provides evidence that there are weaknesses in current flood warning systems implementation in Malaysia, where some aspects such as community involvement, communication design and continuous education regarding flooding are not undertaken as part of the development of an effective warning system.
3.0 Introduction

This chapter is divided into two sections - Activity Design Theory and the context and setting of the study. Activity Design Theory is used to provide structure to the research framework. Interviews, observation, field visits and image and data gathering were the methods used to provide research information in the regional case study, which in the case of this thesis provides a real world context for the research problem. The case study research was conducted in the Seri Medan region of Batu Pahat District in Johor State. It is acknowledged that the findings of this study should not be seen as being typical or definitive for all Malaysian regions, however it was necessary to test the effectiveness of the current flood warning systems in a flood affected area. Research conducted for a Professional Doctorate is necessarily restricted by a limited scope of scale and resources. If this research was to be taken further to apply to a truly national system then further research into the diverse flood affected regions of Malaysia would be a necessary starting point.

3.1 Activity Centered Design Theory as an embodying methodology

Activity Theory emerged from the work of the Russian semiotician and psychologist Lev Semenovich Vygotsky, who argued against artificial separation between mind and behaviour and between mind and society.
Instead, Vygotsky proposed the unity of perception, speech, and action. He concentrated on the centrality of mediating devices, such as language and other symbols or tools in the development of mind and thought, where the emphasis focused on meaning through action, the connection between the individual and the social, the role of mediating tools that provide the core around which activity theory developed.

Activity Theory is used to develop the most appropriate research methods to expose the relationship between human interaction and design activity in relation to Malaysian flood warning systems. In Activity Theory the objective is to better understand the behaviour and relevant characteristics of individuals and how these social entities interact with the technologies they use in the activities of their daily life (Kaptelinin & Nardi 2006).

This research has adopted the structure of the Activity Theory Diagram (Figure 14) to analyze the activities and mediating relationships between the subject (the community affected by the flooding), the object, (the current flood warning system) and the division of labour (both the authorities involved in the flood warning system and the community) which overall encompass all of the key stakeholders. Rules indicate government laws, organizations and policies developed around flood warning and the related chains of command.

Based on Engestrom’s model (Gay & Hembrooke 2004), activity systems in this study consist of people, artifacts, an object, socio cultural rules and roles where the hierarchical authority structure and development of the early warning systems are defined. The composition of the activity systems encompass a broad sweep of activity, actions and operations in relation to flood warning in Malaysia from the diagnosis of the meteorologist to the inundated rural population. The hierarchical structure of actions and the identification of the different components of an activity system that exist in the development of the early warning systems provide helpful guideposts for articulating and examining the complexity of the context. Multilayered activity theory identifies the many actions involved in an activity and structurally places these actions in relation to each other (Gay & Hembrooke 2004).
Activity Centered Design Framework

Application of Engestrom’s activity analysis to communication and learning

Figure 15: Engestrom’s diagram of activity analysis to communication and learning

Activity Theory is used in this study to evaluate the multiple dimensions of human engagement within the Malaysian flood warning systems. The diagram framework configures those dimensions and processes into a coherent activity. Engestrom’s activity analysis (originally developed to analyze communication and learning) has been adapted specifically for this study.

From Figure 15 the research uncovered a disturbance/disconnection in the current early warning systems implementation. The framework shows that the communication and relationships between stakeholders are often disconnected in the currently implemented systems. Disconnections imply a lack of functionality and reveal that system participants are operating under false assumptions if they are operating as if the linkages are complete.
Activity Theory Framework for Flood Disaster Warning Systems

Activity Theory Framework for Flood Warning System

Figure 16: The activity diagram adapted to accommodate the Malaysian Early Warning System implementation

The theory has helped the researcher to frame the complex nature of warning systems development and identify which areas in the systems create problems that lead to inefficiency. Figure 15 above shows that a disturbance/disconnection clearly exists between the current tools used in the flood warning systems and the flood affected community. These disturbances in systems implementation identify where system delivery has broken down.

In developing more effective systems the relationship between each individual involved is mediated by the tools that are used to achieve certain objectives of the proposed systems development (Gay & Hembrooke 2004). This framework has enabled the research to identify the relationship between the tools used, systems and rules developed to support them and the people involved, All of these things impact on the currently implemented system.

The Activity Theory model used by the researcher also enables the identification of engagement between human stakeholders with the tools currently implemented that mediate action. Understanding the cultural, physical and social phenomena of the current situation is a foundation for understanding activity systems. In Activity Theory objects must be seen and
understood operating in the space of the real world, what Gay and Hembrooke call the 'orienting space'. Acting on an object is the orienting space of the action as described by Gay and Hembrooke (Gay & Hembrooke 2004).

This study is primarily conducted through design discipline, however Activity Centered Design, with the use of Activity Theory Analysis (Figure 15) was used to develop the research strategy to position all the inter-related issues involved in investigating a complex subject, including all the levels of involvement by government authorities and the stakeholders. Each of the levels and elements identified were studied to provide comprehensive insights and to progress the research.

Different levels of stakeholders were identified according to particular professional and social roles, responsibilities, qualifications and cultural beliefs. The hierarchy of actions and the identification of the different components of an activity system provide helpful guideposts for articulating and examining the complexity of the content (Gay & Hembrooke 2004).

3.2 An Ecological Perspective

Activity Theory is described as having an ecological perspective. Ecology recognizes the complexity and interconnectedness of systems and as well acknowledges that human systems must be managed and studied over time in order to gain an accurate perspective on their function and comprehensiveness. An ecological perspective is necessary to assess the need for stability and the need for change in the system.

Gay and Hambrooke (2004) have stated that systems do not exist in a vacuum but rather are situated in a broader context of networks of interacting systems. They further elaborate that component systems within ecological systems are characterized by progressive interactions, mutual accommodation and extinction throughout the life of the system, where these interactions are dynamic processes in and of themselves.

The Diagram (Figure 16) below shows the temporal interconnection between the activity in the context of its 'situatedness'. It shows that mutual accommodations among system elements shape the relationships among the
components, all of which are interdependent. Thus any change in any part of the system will automatically alter and affect the related systems.

![Diagram of Temporal Interconnections and "situatedness" of an activity](adapted from Boer, Can Baalen, & Kimer, 2002) Gay and Hembrooke (2004)

The research frameworks concentrate on a three level ecological perspective as illustrated in Figure 16. The defining levels are identified as Malaysia in general as the macro level, state or regional as a meso level and villages as a micro level. This research on early warning systems looks at the overall macro implementation (which covers the Malaysian perspective) and goes down to the independent activities by the villagers at the micro level. This helps the researcher to identify the interaction and interdependence issues relating to the effectiveness of the current warning systems and their future enhancement.

The macro level in relation to Malaysia refers to the larger national social contexts in which early warning systems have been developed in the past, at present and in the future. The investigation and research explored the belief systems, resources, lifestyles and opportunity integrated in the current systems and how they affect it’s functioning.

In relation to the Malaysian flood warning systems the meso level refers to the regional or state level authorities, which are in turn dependent upon both national and local settings (Gay & Hembrooke 2004). The research defines the micro level as the village level, where the individual or community
functions in its immediate, local environment. This level of research is of course crucial to any user centered understanding of systems as the individual or community understanding of the warning systems is the ultimate test of their effectiveness and viability.

3.3 Understanding perspective: Social construction of Technology

As the study progresses into design development understanding the process of how social interaction plays a large role in design development is crucial. The SCOT (Social Construction of Technology) model used to consider the many social perspectives that surround the development of design or technology (which evolved out of studies of the sociology of scientific knowledge and the history of technology) examines the branches of technology that coexist to meet the needs of social groups.

Gay and Hembrooke (2004) stated that Activity Theory (Social Construction Of Technology) emphasizes multiple social perspectives, social construction and the use of tools in specified contexts that help to achieve the goal of designing appropriate and successful artifacts. Bijker et al., borrowing from the sociology of knowledge argued that social groups that constitute the social environment play a critical role in defining and solving the problems that arise during the development of integrated systems (Bijker, Hughes & Pinch 1990).

The SCOT (Social Construction of Technology) model encourages the designer to consider the interactions, ambiguities and complexities within and between various groups that are defining and developing digital or conventional technological environments. These multiple social perspectives that surround the growth of new technologies help develop a more holistic approach, which contrasts with standard practices in technological development (Gay & Hembrooke 2004).

In this study the SCOT (Social Construction of Technology) model is used to help the researcher identify the interactions involved between the stakeholders and the ambiguities that exist in the current early warning systems and to understand the complex issues that surround the development of the early warning systems. Issues such as the variance of literacy within the population, the social distribution of media use and the nature of cultural
beliefs and practices. The establishment of expert driven systems was once seen as a sufficient model of design development but increasingly designers are proactively addressing the particular needs and challenges of their intended users. Ultimately, different versions of design and media delivery must be considered and resolved, resulting in better community consensus and better communication overall.

In the SCOT model, a framework of interpretive flexibility addresses various notions that are held by each relevant social group. The main SCOT concepts are relevant social groups, interpretative flexibility, closure and evaluation.

**Relevant Social Groups**

Relevant social groups can be defined as having members who share a set of meanings attached to specific artifacts. Different social groups can derive very different meanings from a single technology. Thus meanings or interpretation of use create an expectation that leads to alteration in the design of the artifact and to the acceptance of one version over another. Social groups can differ not only in terms of experience, technical expertise and goals but also in their ability to influence the final project (Gay & Hembrooke 2004).

In this study the involvement of various social groups with different levels of hierarchy are important to the development of this project as their experiences, technical expertise and goals are different, and change the way design is developed. The expert level expertise has goals which suppose a particular system of operation and which might be quite different to the experience of flood victims trapped in a remote social setting. Early warning systems need to work and function effectively for both groups.

**Interpretive flexibility**

In this study, where activity centered design has provided the organizing principles, it is the involvement of groups in the flood warning systems communication and collaboration processes that will help bridge the gap between actual users’ needs and the design developed to serve them. The data gathered from the interviews with both experts and rural villagers is used to decipher the different interpretations, ideas, understandings and expectations that will help in the design process.
As design is an ongoing process of interpretation and reshaping, the designer benefits from working in tandem with the end users and other groups during the development stages.

**Closure**

Closure is a process whereby some sort of consensus in finalizing the process to reach an agreement is made through the design of systems and solutions. Stakeholders at all levels need consultation as to the nature of the problem and the success of delivery. To achieve closure the systems developed must take into account the various interpretations gathered in the research and investigation process. The concept of closure occurs when a consensus emerges, that a kind of truth has been winnowed from the various interpretations and so the problem moves towards resolution (Bijker, Huges & Pinch 1990).

In this research the proposed design solutions have come from a consensus between the different levels of stakeholders and various issues relating to local communities in relation to their experience of flood warning systems implementation.

The expectation of closure in relation to the design solutions that have been developed in the prototypes related to this research, incorporate feedback and perspectives received from all the stakeholders involved. The proposed outcomes presented in this study must of course be tested on users in order to develop confidence that the system established is workable and properly understood at all levels of operation.

**Evaluation**

Activity Centered Design and user-centered methods often adopt a circular, iterative process in which evaluation is a critical component of a design; a process of build, evaluate, analyze and redesign (Gay & Hembrooke 2004). After several design iterations it is expected that the design will incorporate perspectives from each group or be specifically tailored to meet particular needs.
In this research study evaluation is used throughout the research process. Identifying the gaps, disturbances and weaknesses of current early warning systems provides an insight into current system effectiveness. Evaluation is also used to identify the adaptation of technology in understanding the risk perception of the villagers and in discovering the thoughts of all the stakeholders in regards to the current warning systems.

Additionally, evaluation is important in Activity Centered Design in determining the future uses of the technology or systems, the needs of each stakeholder involved and in identifying any problems that the users and the designer might not be aware of.

The information gathered about stakeholders in this study has been collected through interviews and observation.

3.4 Contexts and Setting

The research investigation conducted was to enable the researcher to physically examine the current situation in one particular region in relation to the currently implemented early warning systems. This sort of observation and data gathering was necessary for any objective understanding of the actual situation and to be able to move towards a more accurate assessment of the situation. The purpose of the investigation was to qualitatively identify any issues relating to the risk perceptions and actions taken by the affected villagers when the flooding occurs. It was also intended to more fully identify the environmental cause, analyze the geographic location and the current warning systems implemented in the particular region to ascertain the extent that these factors impacted on the villagers and influenced the effectiveness of the current warning systems. Identifying and analyzing the above factors would help to qualify the actual causes of the existing problems and to find solutions (Gerring 2006).

The region chosen for the investigation was Kampung Seri Medan in a Batu Pahat Region in Johor State, Malaysia. It was opened by Tuan Haji Yusof from Indonesia in 1912 and was called Sri Ramonia. This village has been prone to flooding for many years since the early 1960s due to its geographic location and the lack of effective water canals. All the flooding that occurs in
Seri Medan is the result of overflow water from the nearby regions of Caah and Bekok and when Seri Medan is flooded it also affects its southern neighboring region, Parit Sulong. Starting in 1985 the government established an initiative to help this region deal with flooding by developing canals and setting up a water monitoring system to ease the flood severity with the hope that it would prevent the flooding from occurring. (*Policy and Mechanism of National Disaster Management and Relief* 1994). This effort has not eliminated flooding as other contributing factors still exist (Chan, 1997). Seri Medan is located in the North East of Batu Pahat District at 1 degree 59’ 0” North and 102 degree 56’ 0” East, as shown in Figure 17.

![Figure 18: Seri Medan location on the map is identified with the red marker.](image)

The research investigation was conducted along the main road Jalan Parit Warijo and the surrounding village that is connected to the main road. Seri Medan region is accessed by the main road, Jalan Parit Sulong, which is the only entrance and exit to the village. Sungai Seri Medan runs across the region from the north east part (Bekok and Caah) and meets Sungai Simpang Kiri (Parit Sulong) before it meets Sungai Batu Pahat. The region is surrounded by a hilly terrain and the North South Highway runs across the northern part of the region.

This region continually faces severe flooding as loss of property, crops, and belongings testify. So it is important to study and observe to find the causes
and problems that exist. Photos below show the severe conditions facing the region in the 2007 flooding disaster. Past experience tells us that villagers have not been given sufficient warning to act so the current early warning system’s effectiveness is in question.

The big flood in 2007 brought tremendous stress to the Seri Medan community as most of the road was cut off. The water level of the main river rose overnight, brought along sediment and mud, cutting a few roads leading to outlying villages and so prevented the community from taking remedial action.

This region’s population mainly consists of Malay ethnic groups whose main economic activity is farming and also working in industries such as manufacturing.

**Research Investigation**

As the research developed within the structures of Activity Theory a research investigation based on the Seri Medan region of southern Peninsular Malaysia was designed to fit the parameters of the framework (Gay & Hembrooke 2004). Interviews were conducted for three main categories: the main stakeholders, who were the villagers (and the flood victims); the experts who were from both the Meteorology Department and the Department of Drainage and Irrigation; plus the Local Authority and the Malaysia Security Council. Various levels of expertise and authority are represented within these groups. Observational research was also conducted during a visit to the region. The research investigation was conducted over a three month period in 2009.

**Villager’s Interviews**

Interviews were conducted randomly among the villagers aged between 20-60 years with no preference toward gender. The villagers interviewed were arranged by the head of village and interviewed in different days and times based on their availability. Respondents were 65.7% male and 32.8% female.

The sampling ratio of the population is 1:50. This ratio was used to represent the actual numbers of the village populations. Each village chosen was represented by the same number of respondents.
Conducting the interviews
The interviews were conducted with the help of the head of the village, where a few people were contacted and interviewed anonymously. The interview was based on a set of 10 questions and the respondents were interviewed verbally. It was decided to conduct interviews verbally due to an expected proportion of older residents with low literacy levels. All the answers were recorded on hard-copy questionnaires. Each of the interviews lasted from 15-20 minutes. A sample interview question is attached. (Appendix 2 and 3)

Observations
Observations of the region were conducted to visually and physically identify any assumptions that had been made in the preliminary research with regard to the presence and efficiency of any early warning systems, system implementation and also the effect of human development and geographical conditions that may be evident. Findings from the observations can be found in chapter 4.0

Expert Interviews
Interviews with experts were conducted to gain insights, knowledge, ideas, perceptions and understandings from the professional stakeholders involved in relation to the current early warning systems, their implementation, their effectiveness or weaknesses and future plans. Interviews with different levels of experts were conducted using the same method. Certain questions asked were similar in meaning to those on the villagers’ questionnaire so as to identify any similarity and difference in their answers.

The questionnaire developed for the experts is attached. (Appendix 3). The findings from the interviews can be found in chapter 4.0
Summary

Activity Centered Design Theory is a research framework that provides a template for research methods chosen to accomplish this research activity. This theory helped in mapping the complexity of the topic and also provided an understanding of the effectiveness of the current warning systems. Activity Centered Design Theory also helped to identify the turbulence that exists in the current systems. This methodology minimizes any error or any overlooked issues that may arise as it gives a clear universally applicable framework for research content and structure. Activity Centered Design Theory illustrates above all the centrality of design to the whole warning system process as it provides basic organizing principles that link the diverse levels of contribution and affect to the warning system process.
4.0 Introduction

This chapter has been divided into two sections that are Field Research Data Analysis and Comparative Analysis. The Field Research Data Analysis section describes and analyzes the data gathered from the field research conducted mainly in Sri Medan. This data is presented through charts and elaborated through discussion.

The Comparative Analysis sections analyze what other countries have done around the issue of warning systems. This study was conducted in Victoria, Australia which has by chance, over the life of this study, been developing its response to bush fire warning systems (Teague, McLeod & Pascoe 2010).

I also sourced an interesting Philippines community based flood warning system that provides a strong contrast to the Australian initiatives. The Philippines study may be much closer in its focus to rural Malaysia, but like Australia concentrates on building community initiative in terms of response strategies. (Hernando 2007)
4.1 Field Research Data Analysis

Results from the interviews show some difference between age cohorts but much less difference according to gender. Most of the villagers gave similar answers to questions such as what media they use or see in relation to awareness of the flood disaster occurrences. Up to 60 years of age most contributors identified television, radio and newspapers as their main source of information in roughly equal proportions. Only in the over 60 cohort did newspapers disappear as a source of regular information and television dominated as a source of news and weather. It was found that only a small fraction of the sample received information regarding flood occurrences from television and radio and they are from both genders in the age range of 60 and above. Research suggests this might be due to the low levels of literacy of this particular group. This group tended to get their flood warning information from television and radio only. The Chart (Figure 18) representing Question No. 1 is shown below:

![Chart showing adoption of different media in gathering information about flood occurrences by different age groups and gender.](image-url)

*Figure 19: The chart shows the adoption of different media in gathering information about flood occurrences by different age groups and gender.*
Meanwhile Question No. 2 of the interview reveals a most important finding that most of the respondents were only aware that the television advertisements exist and were unaware that other media forms (such as the Internet) were informative on conditions in their area. All the respondents were aware that the television campaign about flooding exists in some form – most acknowledged that standard weather forecasts were their main source of weather information.

None of the respondents had seen any form of publication being distributed to them pertaining to flood awareness. According to respondents the only information available is through television and word of mouth.

Question No. 3 pertains to respondents main concerns about flooding and shows that almost all respondents stated that loss of property and life were their main concerns. This is significant evidence that flooding affects their daily lives. A slight variation in loss of property is detected for female respondents in the age range of 31-40 years, where their main concern was more about loss of life. This is presumably because at this age most of the female respondents are married with children and culturally their family is their paramount concern. Figure 19.

![The main concern when flooding occurs](image)

Figure 20: The chart shows that loss of property and life is the main concern when flooding occurs.
There is a significant variant among the respondents about whether they are prepared to leave and vacate their home when flooding occurs. The group most prepared to vacate their homes were males between the ages of 20-30 and 40-60. Females between 20-40 were considerably more reluctant to vacate their house and belongings. Both genders over 60 would prefer to stay. Figure 20.

![Figure 20: The significant variant in intention to leave the house and belongings when flooding occurs](image)

When questioned about what type of loss they encountered most of the respondents agreed that loss of their house was the loss everyone had felt most strongly, while loss of crops ranked as the second and third type of loss endured. Figure 21.
Figure 22: Type of loss that has been encountered by the respondents shows that house, farming and crops is the biggest lost they experienced in flooding.

Most of the respondents are aware of the existence of the Flood Relief Centre in their village. Almost 95% of the respondents are aware that they have to evacuate their home and move to the relief centre while the rest are unaware of the existence of the Flood Relief Centre. The evidence shows that most of them are aware of the relief centre as the same place has been used previously and the continuous experience of flooding has developed this cognitive memory.

Most of the respondents also believe that the information regarding flooding is easily understood. This is due to the fact that most of the information is disseminated by visual and audio means through television and radio. A small number of respondents found that the information is not easily understood due to the technical language used and presumably the limited vocabulary of these respondents.

Throughout the interview the sample shows that most of the respondents agreed that they receive most of the information about flooding through three main media, which are television, radio and newspapers (Figure 22). Respondents asserted that there was no formal warning given of the flooding before the flooding occurred.
Figure 23: The chart shows that all respondents agreed that they receive or learn about flood information through television, radio and newspaper.

There is almost equally divided opinion when it comes to the question as to whether they have sufficient time to take action in relation to flooding. 56% believe that they do not receive sufficient warning to act when a flood occurs.

Figure 23.

Figure 24: Perception about sufficient warning of a pending flood is divided almost equally, where 56% believe that they do not have sufficient time to take action.

Figure 24.
The last question provides insight into whether the respondents have access to mobile technology and what features of it they use most. In this case the respondents were asked whether they own a mobile phone and how they use it. This question is significant in helping determine the degree of mobile technology adaptation. Its use among the villagers should be considered as a future media solution in this research. Figure 24.

![Mobile phone ownership chart]

*Figure 25: The chart shows that most of the respondents own a mobile phone. It shows that the penetration of the ubiquitous technology is widely accepted.*

The results indicate that using a mobile phone for making a call or sending a text message are equally important. The data also shows that the younger generation use text messaging more than the older generation. Thus it shows that the adaptation of technology is not equally shared or applied in the same way across the community.

Observation was the key method used to identify, analyze and evaluate the existing situation in this flood-prone region. It provides a clear insight into what systems are in place regarding flood warning. The observation revealed that the geographic location of Seri Medan is prone to flooding as it is located in the middle of two major watercourses. Seri Medan flooding is caused by the overflow of water from neighboring regions such as Caah and Bekok. This region is close to where the dam has been built and to the source of the river that crosses Seri Medan. When the monsoon season arrives the amount of water from rainfall cannot be contained by the river and the dam. Thus the
water overflows, flooding the Caah and Bekok regions and then moving down to Sri Medan and Parit Sulong.

The map (Figure 25) below shows the Seri Medan region (Marked A) and its neighbouring areas and indicates how the process of flooding starts. Each of the colour zones represents a region that will be flooded during the monsoon season, and how they affect each other is also indicated.

![Map showing how Seri Medan is affected by flooding from neighboring regions.](image)

As the observation continued, it revealed that there is no indication of any type of physical warning system in place that directly connects to the villagers. There are no sirens, information or signboards existing along the roads to warn the villagers in the event of flooding. The continuous education that is part of hazard warning community development (as described by Leonard) seems to be inactive, in Seri Medan at least, and there is no indication of any effort to put it in place (Leonard, Johnston & Paton 2002).

Interviews with experts from the Meteorological Department, the Department of Drainage and Irrigation (DID), the National Security Council (MKN), the Local Council and the Health Department all show that they hold different
understandings and perceptions regarding the effectiveness of early warning system implementation. Most of the experts believe that the current systems are effective but they also believe that they can be further improved.

The Meteorological Department expert indicated that the severity of the floods in the region depends on the monsoon at that time and usually is different from year to year. He indicated that the most severe recent flooding happened in 2007, when the level of water was above 1.5 meters high. The EM-DATA indicates that the severity of flood disasters worldwide is increasing each year (EM-DAT Emergency Events Database 2008; International Disaster Database 2006).

The National Security Council (MKN) personnel also indicated that this region is facing flooding every year as it is geographically located in a low valley surrounded by a few low hills. So it is prone to flooding. The spokesperson for MKN also agreed that the severity of the flooding in this region is based on how much rain it gets when the monsoon comes. Malaysia is also affected by two major climate extremes, which are El Nino and La Nina. The Meteorological Department reported the frequency of the occurrence of La Nina as much less than that of El Nino. The years of occurrence of La Nina are listed below: Table 10.

<table>
<thead>
<tr>
<th>Heavy Rain Season in Malaysia caused by La Nina</th>
</tr>
</thead>
</table>

Table 10: The years that La Nina brought heavy rainfall to Malaysia (source: (Frequency of occurrence of El Nino/La Nina 2009))

The Meteorological Department indicated that flood affected villagers are informed through websites, television and radio and by local authorities about a pending flood. The respondents said that the Meteorological Department websites and Infobajir website from the Department of Drainage and Irrigation exist and that they provide information about flooding.

Most of the experts acknowledged that logistical information, such as evacuation procedure, are not in place for the villagers to consume. Although existing within their organizations this information has not been translated into physical tools such as brochures or pamphlets that can be distributed to the
affected villages as part of the ongoing campaign. This research aims to identify the gaps that exist in the current systems between the villagers and the organizations involved. Information and communication design have been researched to identify the best and most appropriate tools to deliver the information that might help to bring alive the current warning systems and make them more effective.

Most of the experts stated that different methods have been used to disseminate information in recent flood disasters, such as media broadcasting, information on websites, person to person, and through village leaders, but they also explained that there is no information disseminated through mobile technology or printed material such as brochures or pamphlets and signage.

### 4.2 Integration of theory and field research findings

From the case study conducted the preliminary theory and assumptions indicate that there is an information design issue facing the current early warning systems implementation around Seri Medan. Also, information gathered from experts shows a slight variant in flood perception, it’s occurrences and it’s severity. Generally experts in the Meteorology Department and Department of Irrigation and Drainage believe that they are part of a systematic structure that can effectively report weather occurrences. However, simultaneously from the other end of the hierarchy, in the flood-prone villages, the effective dissemination of warning information is almost non-existent.

In relation to information dissemination the experts and the villagers contradict each other. The villagers stated that information relating to flooding could only be reached through television and radio. Villagers did not acknowledge accessing information from websites, even though from the expert point of view this is their main point of delivery. Internet access is either not widely available for the villagers or simply not accessed for information. This method of disseminating information is, currently at least, inadequate. Internet access could be promoted as part of the educational campaign that clearly needs to be introduced in relation to flood warning.
The preliminary assumption of the non-existence of physical forms of information, such as brochures and pamphlets, was also found to be true. The experts indicated that there is no such medium available, which can be used by villagers as ongoing alert information. Thus the lack of these physical forms of information hinder the effectiveness of flood awareness and the development of strategic community action, which are significant attributes of any effective warning system.

Further observation found that the region lacked physical warning systems, such as sirens and signboards to help alert the villagers to flood events. There is no indication of any real-time water level or rain gauges that can disseminate this information to the villagers. The experts also agreed that the region does not have those facilities.

4.3 Comparative Analysis

Comparative analysis was conducted to better understand what other countries have done to address climate related early warning systems. Both the Country Fire Authority’s strategy, developed in 2010 through the State Government of Victoria (The 2009 Victorian Bushfires Royal Commission), and the Philippines Community Based Flood Warning Initiative, have been compared with Malaysia's current Early Warning System implementation in order to look at their effectiveness and differences.

The 2009 Victorian Bushfires Royal Commission has been most influential in developing a strategy for how the Victorian Government deals with future bush fires in the state. The Royal Commission has been setup to investigate why the current systems failed to respond in the Black Saturday 2009 fires in Victoria when 173 lives and a vast number of properties were lost to fire. Clearly government and community run systems fell short in this catastrophic event. Systems of prevention and evacuation policies were major themes explored by the Bushfires Royal Commission (Teague, McLeod & Pascoe 2009).

The reports identified how the authorities and residents responded to the February 7th, 2009 fires. Confusion and conflicting opinion seemed to dominate the community response to what were clearly exceptional
circumstances and the Commission’s brief was to improve strategic response structures to cope with future events. Decisions made by people in positions of responsibility and those in harms way failed to protect the safety of the community. The commission examined the current policies, systems and structures needed to ensure all the related organizations and individuals were well informed to make effective decisions to protect life and minimize loss.

The findings of the report show that the stay or go policy failed to allow for variations in fire severity and the commission recommended that the state needed to make further changes in the current policy. The Commission acknowledged that every fire must be dealt with differently and thus develop flexible and more proactive approaches to community safety, with different advice, support and responses needed from the fire agencies. The Commission decided that in the event of a fire the fire agencies should focus their mindset in providing information and attending to community safety rather than fire suppression if the first effort to contain the fire failed.

The stay or go policy assumed that individuals had a fire plan and knew what response was needed when the bush fire appeared. Most victims however did not have a comprehensive plan and furthermore it was discovered that a one size fits all policy was inappropriate on that day of massive catastrophe.

In addition the warnings that had been given to the people at risk is now understood as having been too narrow. It only directed the people to enact their fire plans rather than give more specific directions or advice. This lead most of the people to take a wait and see action rather than evacuate.

With the entire problem identified the commission recommended that a change in future policy was needed, with 67 specific recommendations. The commission suggested that the current policy be retained but that it be improved in a number of areas as listed below: Table 11.
<table>
<thead>
<tr>
<th>No.</th>
<th>Royal Commission of Victorian Bush Fire Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Covering the full range of fires – with particular recognition of the heightened risk associated with the most ferocious fires on the worst of days</td>
</tr>
<tr>
<td>2</td>
<td>Strengthening warnings and improving their timeliness and dissemination</td>
</tr>
<tr>
<td>3</td>
<td>Providing more practical and realistic options such as community refuges, bushfire shelters and evacuation – including assisted evacuation of vulnerable people</td>
</tr>
<tr>
<td>4</td>
<td>Improving the quality and availability of advice on fire behaviour and house dependability and clearly conveying the message that among risks of staying to defend are death and serious injury</td>
</tr>
</tbody>
</table>

Table 11: Royal Commission of Victorian Bush Fire recommendation for current policy enhancement. (Teague, McLeod & Pascoe 2009)

From the Royal Commission report the Victorian Government has revised its approach to finding the solutions to future bushfire warnings. The new technology of fire warning systems since then has been tested and implemented for future use. The Victorian Government has now endorsed the Emergency Services Communication Strategy Framework to improve communication and has developed the ‘One Source One Message’ tool to affect an integrated and simultaneous bushfire warning to different sources, such as Country Fire Authority Victoria (CFA) and Department of Sustainability and Environment (DSE) websites, Victorian Bushfire Information Line and the media.

The Community-based Flood Forecasting and Warning System (CBFFWS) in the Philippines was an initiative setup by the Pampanga River Basin Flood Forecasting and Warning Centre for the community that was affected by floods within a small watershed or sub-basin, generally not covered by the automated Flood Forecasting and Warning System (FFWS) (Hernando 2007).

This is a local community based operational flood forecasting system, a warning that helps them in mitigating the effects of flooding in their area. The system is a non-structural flood mitigation plan that is very simple in it’s design and operation. What makes this system holistic is its ability to enhance and activate the social and moral responsibility of the community, its leaders and the local government unit through the direct and active participation of community members.
The system is set up to protect life and property by achieving and maintaining a high-level of community preparedness through timely flood information and warnings. The true essence of a community-based system is community empowerment, where the community is encouraged to protect and prepare for themselves and so build their resilience.

The system consists of simple sets of monitoring instruments, rain gauges and rain markers. Volunteers are equipped with dedicated radio communication sets or cellular phones for data exchange and transmission to transmit the warning to their community. The initial weather forecast from the national meteorological office is the main source of information, together with the observation of localized weather systems.

The benefit of community based forecasting and warning systems is to provide the community’s disaster response personnel with advanced flood information that can be readily translated to community response actions. Flood information is linked to direct action, flood preparedness strategies and evacuation activities if necessary. Below (Table 12) is an example of the warning levels, conditions and community activities:
### Philippines Community-Based Flood Warning System Code

<table>
<thead>
<tr>
<th>Warning Level</th>
<th>Example of conditions (anyone of the following)</th>
<th>Possible community activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Warning Level 1</strong>&lt;br&gt;Flood is possible in the next 24 hours; suggest community awareness</td>
<td>Public Storm Warning Signal (PSWS) No. 1 is raised&lt;br&gt;• When river stage reached the alert level at a water level monitoring station&lt;br&gt;• When rainfall observed at an upstream station reached about 100mm in 18 to 24 hours or less</td>
<td>Strengthening house posts; charging of reserve batteries; stocking food supplies to last for at least 3 days. And so forth&lt;br&gt;(These are activities that are not wasted even if floods do not occur)</td>
</tr>
<tr>
<td><strong>Warning Level 2</strong>&lt;br&gt;Flood is threatening; suggest community preparedness</td>
<td>PSWS No. 2 is raised:&lt;br&gt;• When river stage reached alarm level at a water level monitoring station and&lt;br&gt;• When rainfall observed at upstream station reached 100mm in 12 hours or less and continuous rains observed in all stations</td>
<td>Raising flood-sensitive things above possible flood levels inside the house; gather farm animals to a safe place, and so forth&lt;br&gt;(These are activities that may take some time to accomplish)</td>
</tr>
<tr>
<td><strong>Warning Level 3</strong>&lt;br&gt;Flood is expected to occur; suggest evacuation of areas to be affected</td>
<td>PSWS No. 3 is raised;&lt;br&gt;• When river stage reached critical level at a water level monitoring station;&lt;br&gt;• When the rate of rise at the water level monitoring station from level 1 to level 2 is attained in 30 minutes or less;&lt;br&gt;• When rainfall observed at the upstream station reached about 100mm in 9 hours or less and continuous rains observed in all stations</td>
<td>Evacuate immediately to safer grounds</td>
</tr>
</tbody>
</table>

*Table 12: Example of the warning levels, conditions and community activities (Hernando 2007)*

From the comparison of the Australian and Philippines Governments comes varied and different approaches in dealing with warning systems, but there are similarities in terms of policy where the community plays a role in the effectiveness of the warning systems and their activation.

The analysis shows that the authorities from both Australia and the Philippines believe that the community needs to be empowered by getting involved in the systems and also the ongoing education relating to the disasters.

Both the Australian and Philippine systems show the need to make allowances for local needs and circumstances and for situations to be regularly evaluated, managed and improved. The Victorian Government
implementation of technology shows the financial capabilities to invest in a more advanced technology as part of the systems, while the Philippines Government approach shows how more can be done through self-empowerment at minimal cost. Both systems work for the benefit of the community.

As Malaysia approaches her target as a developed nation in 2020, it would be beneficial for the government to take this approach as part of its future warning systems implementation, encouraging a more holistic approach. Implementation of new technology in conjunction with community empowerment should both be part of a more holistic community-based approach.

4.4 Statement of major problem

After the completion of the case study the following major problems were identified:

i. The information provided to the effected community is not sufficient as a continuous provision and updating of knowledge is required to help them take proper action within appropriate time frames.

ii. The lack of wider coverage by a variety of media in disseminating the information has resulted in limited penetration of the community.

iii. The information implemented by the early warning systems is fragmented, resulting in an inefficient system for the region.

iv. Lack of community education

As a result the early warning system implementation in this region appears to be inadequate and does not provide effective solutions. The generation and evaluation of solutions in relation to this problem are discussed in Chapter 5.
Summary

The case study conducted has successfully provided vital information about the implementation of the current warning systems to the region of Seri Medan. It casts light on the effectiveness and weakness of the current systems. The research activities reveal that there is a fragmented approach in information dissemination to the effected villagers, meaning that some vital information is not easily available. Information in printed and physical forms (such as pamphlets, brochures, warning boards, and sirens) are not available. These could help affected villagers to act more autonomously and appropriately in the event of flooding.

From the comparative analysis the study found that both the adaptation of proper technology and the involvement of the affected community, with the support from the authorities, are crucial in the activation of effective warning systems. The Australian bush fire initiative to revamp the way the warning systems were implemented by introducing a various communication design solutions, such as developing communications tools in a form of pamphlet, brochure, TV campaign, signage systems etc., helped the community to be alert and understand better how the whole early warning systems works.

The community involvement in the Philippines flood warning systems, where the community is proactively involved in early warning systems implementation, has resulted in a more aware, effective, resilient community. It shows that by doing this the community learns about and better understands flooding when it occurs.

The combination of technology, communication design, community education and involvement offer the best solutions to enhance the current Flood Warning System in Malaysia.
5 Design Development

5.0 Introduction

This chapter introduces the design proposal and design solutions stimulated by the research findings described in earlier chapters. The research has been used to expose the extent of and weaknesses in the current systems and to propose the most logical and necessary solutions through utilizing activity centered design theory.

The research shows that design has never been included as an integral part of the development of the current flood warning systems in Seri Medan in particular and in Malaysia generally. The evidence clearly shows that so far flood warning and mitigation has largely been seen as an engineering and environmental problem with little emphasis on communication and community development.

It is my hope that this research project demonstrates that design has shifted from being a discipline with mainly aesthetic purposes to having a more central role in the application of many other related disciplines. Design has a social responsibility to educate and teach the society about relevant procedures and practices. In this study design plays a major contribution in delivering effective strategies for warning systems. Design is used to deliver clear and precise information and communication to the community by
translating what is often complex information into simple and easily understood ‘chunks’ through relevant delivery systems.

Flood warning systems have recently seen massive change and development. Different continents, regions and countries deploy different ways of conducting flood warning systems, based on past practice, economic scale, climate and local needs thrown up by local weather events. Interestingly these various warning systems have usually developed similar fundamental models – mostly with more development at the community level than I found in regional Malaysia.

The research findings show that the current Malaysian warning systems lack two key components. These both affect communication design in relation to the development of a universally understood warning system and the building of responsible and pro-active community participation through developing ongoing risk preparedness education. The lack of effective communication tools have led to devastating outcomes in the community when risks are not communicated. A proper warning code that educates and alerts the community seems nowhere to be found, so a risk reduction strategy in the community is under-developed. Media, which plays an integral role in delivering accurate and timely warnings, is under exploited in delivery of warnings. Weather forecasts and flood warnings have only ever been delivered informally through the conventional media – mainly television and radio news broadcasts. So a flood warning does not reach the community as a clear and targeted message.

So far, the meteorological authority has neglected the importance of continuous, ongoing community education, either formally or informally, in regard to warnings. Even school children have not been formally taught about flood risk, nor has this occurred at a community level. Thus awareness of the level of the danger of flooding among the community in any given situation is underdeveloped and this puts the affected communities at risk. Communication materials such as brochures, websites, posters, action guides and signage are either inadequate or do not exist.

This chapter will introduce a design proposal as a solution to the above problems. It proposes components that the authority can use to increase the effectiveness of the current systems.
5.1 Design Tools Proposal

Based on the research findings the design solutions and their most appropriate mediums of delivery were developed. A tree matrix graphic was used to list all possible tools and mediums that can be critically justified in relation to its role and effectiveness. It is also useful to identify and isolate any tools that are not meeting the criteria. Issues such as feasibility, effectiveness and cost were considered in finalizing the design solutions.

The matrix graphic below (Figure 26) shows various tools and mediums and their significance in the design proposal. It shows that some of the most advanced technologies are not necessarily the most effective way to deliver warnings – at least to a rural population.
Figure 27:Diagramming the Flood Warning Systems Solutions
One of the roles of this study is to highlight the importance of design in warning systems development in Malaysia. Through my research I have tried to expose fundamental aspects of the communication task of warning systems and what they mean to the community and the other stakeholders. A better understanding of the chain of information that leads to risk perception awareness is one of the key elements in this design proposal.

The design development in this study is concentrated on a few key areas. These are:

5.2 Warning code development
5.3 Warning sign iconography development
5.4 Printed educational materials design development
5.5 Media campaign development

The development of a proper warning code is considered crucial as the first step. This is due currently to the lack of a proper warning code that specially targets flooding. A warning code is information to be used under the strict guidelines of an authority to be communicated to an affected community. This code helps them to analyze the level of risk and what actions need to be taken in pending floods. Developing a proper warning code is crucial as the first stage.

Once the warning code has been developed it needs to be transformed into informative and effective tools that were identified earlier. The signage or signboard of the warning code needs to be designed and manufactured in a most effective way. This process will be elaborated further in this chapter.

To continuously promote this newly developed warning code and signage a set of new educational materials delivered in the form of printed material and broadcast media are needed to support the new design. The purpose of these media platforms is to bring awareness to the community of the new design implementations and inform them about risk perception and actions they might take in regard to flooding to lessen its harm and impact. This design development is covered in this chapter.

The mass electronic media have long been the best places to deliver information to the community. One of the roles of this research was to discover
which media already play a significant role in the community in delivering information and entertainment. Television is most likely the most popular medium to deliver new warning codes and related social policy. The development of a series of advertorial materials can help to increase awareness in the community regarding the floods and the best ways of reacting to them.

5.2 Warning Code

Developing a warning code was based on a study of how warning systems are constructed and communicated in other cultures. Of course my starting point was to investigate what codes had been developed in the current Malaysian system but I also looked around the world for other examples of best practice. A study was conducted through collecting various examples from different countries and agencies in order to better understand how each country perceives and uses its codes (Figure 27). Most countries, including third world countries such as the Philippines, acknowledge that a community building educational development phase is integral to the successful development of any warning system program.

<table>
<thead>
<tr>
<th>(a). UK Flood Signage</th>
<th>(b). Cardiff Flood Signage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(c). Philippines Flood signage</th>
<th>(d). Arizona Flood Signage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 28: Various examples from different country showing flood warning sign
The Meteorological Department of Malaysia currently uses color-coding to communicate some aspects of risk. An example of their use of color-coding is currently found in the Meteorological Department of Malaysia website. This color code does not specifically represent the flood warning codes but rather is used as an internal gauge to indicate the risk level of any disasters. Figure 28.

<table>
<thead>
<tr>
<th>Warning Level</th>
<th>Physical Criteria</th>
<th>Likely Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Possible monsoon in within 24-48 hours</td>
<td>Flooding in a low lying areas and river-bank</td>
</tr>
<tr>
<td></td>
<td>Moderate monsoon rain should happen within a few hours</td>
<td>Roof could be blown off by the wind</td>
</tr>
<tr>
<td>Orange</td>
<td>Low pressure systems/and tropical cyclone of 50-60km/h with moderate to heavy rain developing or;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windstorms with 50-60km/h (trees shaking) with drizzle to moderate rain lasting up to 2 hours</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>Heavy monsoon rain widespread likely to happen within few hours or;</td>
<td>Flooding in a low lying areas and river-bank</td>
</tr>
<tr>
<td></td>
<td>Tropical cyclone with a wind at least 60km/h with moderate to heavy rain or;</td>
<td>Heavy flooding. Currents could be of danger to kids who play near large drainage systems or riverbanks</td>
</tr>
<tr>
<td></td>
<td>Heavy wind with a speed of 60km/h (could cause structural damage) with moderate to heavy rain lasting up to 2 hours</td>
<td>Roof could be blown off by wind</td>
</tr>
</tbody>
</table>

Figure 29: Generic Warning Code use by the Malaysian Meteorological Department to measure the risk level of disaster (Portal Rasmi Jabatan Meteorologi Malaysia 2010)

The early design sketches are developed from various examples gathered internationally. Colour-codes have been explored in various shades from warm to cool colour palettes using a colour wheel. It is crucial to identify the most correct colour representation for the new design. Colour has both technical and cultural meaning and needs to be sensitive to both international usage and specific cultural difference. Such examination and outcomes need to be tested by users on the ground to test their own perceptions. Unfortunately this level of testing was seen as being outside the capacity of this study.

The second stage in the development of the warning code is to identify the risk levels that the code should carry that can be implemented and used effectively by stakeholders. By developing a clear and simple code of risk level information a new standard of warning code can be deployed through different types of communications tools such as signage systems, printed materials and
Developing Malaysian community-based flood warning initiatives through Activity Centered Design

the broadcast media. Synchronized dissemination of information should lead to a more effective warning system.

In comparison, Australian bushfire (Fire Ready 2010) preparation uses 5 levels of risk perception in developing the bushfire warning codes, while the United Kingdom uses 3 levels of risk in relation to floods. The illustration below shows the Australian bushfire and United Kingdom flood warning codes. The similarity between both codes is that they have the same common risk perception with just a slight difference in terms of how it has been designed and used. The Australian system uses colour coding to represent the risk level while the United Kingdom flood uses an icon with the same background to represent the risk.

Fire danger intensity and water levels are two different elements that cannot be similarly depicted. Fire or heat usually is easy to measure with a colour tone to represent cool, warm or hot while water level is more easily identified by looking at its level relative to its surroundings. The illustration below (Figure 29) shows different ways of representing two different elements but with a similar level of risk.

Figure 30: United Kingdom Flood Warning Code (Left) and Australian Bush Fire Warning Code (Right)
The warning code development in this study was most heavily influenced by the example from the United Kingdom. This study adopted an even simpler symbolism to enable the design development to be understood by the user. Risk level has been simplified and written in a simple, easy to understand statement.

Below (Figure 30) is a preliminary design arranged to illustrate how the risk level symbolism has been developed. In the initial design stages symbols depicting levels of risk through signs and colour were developed and intensively discussed and critiqued with both my principal supervisor, Dr Keith Robertson, and Professor Per Mollerup, an internationally renowned authority on signs and information design. Through discussion of my prototypes it was decided that simplicity is the key to the best solutions in disseminating any new type of information to a user.

Figure 31: Early warning code development using colour coding to identify level of risk
Some ideas (Figure 31) are proposed and analyzed throughout the warning code development. Colour-coordination, sign-components and textual information were critiqued and analyzed to test feasibility and effectiveness. Below are various warning code developments.

(a). Warning code development in combination of plain text and color code

(b). Warning code development with a combination of plain text, color code background and the position of iconography

Figure 32: Various design development for Warning Code

Below (Figure 32) is the final risk level information that was considered the most appropriate to be implemented. Time is of the essence and it is crucial that actions are simply understood and reactions to warnings should be
instinctively taken. Warning system communication should be easily understood and well rehearsed at a community level.

![Warning Code Design](image)

**Figure 33: Final stage of Warning Code design that will be use in conjunction with the Iconographic Sign**

### 5.3 Warning Sign Iconography Development

The preliminary design ideas are to explore the design elements that can be used in the development of flood warnings. Issues such as signs, forms, lines, and colours are being explored to test for functionality. The social issues of culture and belief have also been considered.

The study involved a comparison of the various elements that usually exist when developing an iconography of flooding. Elements such as human shapes, houses, waters, trees are being tested and explored. All elements have been compared and analyzed through each design iteration.

Issues such as localization are taken into account to make sure the design outcome can be universally understood in a Malaysian context. Of course this stage too should be user tested in Malaysia before any warning program is implemented. Interestingly we chose to virtually eliminate any more culturally specific iconography in the name of simplicity.
The designs below show the preliminary concepts that utilize a range of design elements. House icons, human pictographs, water, waves and various elements were put into the preliminary design phases to create a communication with cultural impact and to test the feasibility, functionality and effectiveness of the final design. This stage is crucial, but would not be finalized until it was tested against the reactions of the users.

Below (Figure 33 and Figure 34) are a range of design developments of the Iconography designed to create impact and convey clear communication.

**Figure 34: Multi elements have been created to analyze the impact on the iconography development. A combination of colour, icon and numerical figures are analyzed to investigate the information dissemination effectiveness.**
SIGN DEVELOPMENT

Figure 35: Investigating the impact of common icons often used in flood warning development. This investigation tests the impact of what information might be understood by the user.

The main concern from the early concept (Figure 33 and Figure 34) was the complexity of the design. The concern was that the more complex the design the more time seems to be required to understand the message. Signs require a high level of efficiency and simplicity in order to be digested. This process led to our having to judge whether this design is actually very efficient and easily understood by the users.

Many of these symbols (eg. Person, house, tree and water level) indicate duplicated signs and run the risk of confusing the response of the reader (eg. How deep is half a house compared to the depth of half a person? We decided that ultimately a clearer communication could be established by using just one single symbol (water level), a simple figure to give order (order – 1,2,3) and a very limited use of design elements (colour). As the design would be restricted to a limited space the hierarchy of the information must be clearly implemented so that no confusion existed. In this design the information needs to be read first.

Below (Figure 35) is a comparison of a similar iconography design for the same purpose but with a different approach which leads to different ways of interpreting it.
Design iterations

From preliminary design concepts the development has gone through several design iterations where changes have been made based on discussions between myself, the main supervisor and Prof Per Mollerup. There are several issues that have been considered, which are:

i. Colour coding in the early implementation might not be necessary as it might not benefit a disability user such as a colourblind sufferer. Research shows that 1 out of 12 people have some sort of colour vision problems.

ii. Too many elements distract from the main message, which distracts from the functional operation of the sign.

iii. Simple, clean design creates the most direct message where time is crucial for community action.

The early design proposal identifies the level of colour-coding that most precisely communicates this particular issue. Thus the colour-coding implementation is used throughout the initial concept.

The illustration below shows the initial concept that shows how the colours are coordinated to show the different level of risk. This colour coding concept,
which been adapted by many places in various ways (such as Australia’s Victorian Bush Fire warning system), follows the logic of colour coordination and can work and be understood easily.

### SIGN DEVELOPMENT

![Colour coordination stages](image)

*Figure 37: Colour coordination stages shows that colour gives various interpretations of the overall design and meaning to the icon.*

The initial design concept (Figure 36) involved the investigation and testing of ideas using colour coordinates and shapes to find the clearest and most uncomplicated way of delivering the information to users. When critiquing the designs reproduced above, Professor Mollerup raised the following issues:

1. The complexity of the designs can make them unnecessarily confusing.
2. Too many signs need to be digested by the users.
3. Colour coordination might not work at all times especially for people with vision disability.
4. Simple information is preferable as it offers a less interpretive process. The faster and easier the information is to digest the more effective it can be.

The design development moved through a process of simplification where design elements have been reduced to a minimum. Duplication of information was removed, fonts were stylized, the levels of risk were reduced from 5 levels...
to only 3 to reduce confusion, colour coordination was simplified to just two colours, which are light blue to represent the level of water and black for the numbered levels of risk. This gives a cleaner, uncluttered design that suits the purpose and objective of delivering just in time information to the users.

The final iconography is shown below (Figure 37). (Note: facsimile versions of these publications are inserted in Appendix 4.1)

![Figure 38: Final Iconography that will be used throughout the campaign.](image-url)
5.4 Printed Materials Design Development

Choosing the right media in this research project is seen as another crucial aspect of the delivery of the message. Research of other cultures (in this case in the Philippines) in relation to flood warnings indicated that community opinion needed to be engaged in order to affect better informed reactive behavior to future flood events. Printed materials provide a more personalized medium of information delivery. Communities that are not well prepared for the pending flood tend to have slow responses and poorly coordinated actions.

For these reasons this research proposes a community education campaign. Printed material, including an action guide, brochure for survival kit, posters, signage systems and warning code flyers, were developed to support the introduction of the new warning code system.

Preliminary Design

The whole concept of the design is to introduce the elements of the warning code system and its iconography. This should lead to better integration of the design solutions.

The preliminary designs used in the primary printed materials are show below (Figure 38, Figure 39, and Figure 40). The Action Guide, Survival Kit Brochure and Warning Code Pamphlet were developed as the initial educational communications. The function of these materials is to provide simple and easily understood information relating to flooding. When the time of disaster occurs communities should be able to prepare themselves and understand what actions need to be taken in relation to preparation for evacuation of homes and safe retreat to a community centre if necessary. These printed materials provide all needed information.
Figure 39: Action Guide, Survival Kit Brochure, and Warning Code Pamphlet – Preliminary idea 1

Figure 40: Action Guide, Survival Kit Brochure, and Warning Code Pamphlet – Preliminary idea 2
The brochures are the most personal and portable information vehicles developed for the community education program. Posters developed take a more direct approach to the community as a whole where a real photo of flooding has been presented. The design development has concentrated on the arrangement of information based on a hierarchy. The warning code, the images and the information slowly evolved over several design iterations. Below are the earlier design concepts that lead to the final poster design. (Figure 41, Figure 42 and Figure 43)
STAY OR EVACUATE?

In some emergencies the safest action is to stay inside. But in other emergencies it can be safer to leave the building or evacuate an entire area.

Act before it too late!

Figure 42: Preliminary posters design with earlier 4 level warning codes integrated with earlier color-coding
In some emergencies the safest action is to stay inside. But in other emergencies it can be safer to leave the building or evacuate an entire area.

Act before it’s too late!

Figure 43: Poster design development with new iconography icon integrated with color-coding
STAY OR EVACUATE?

In some emergencies the safest action is to stay inside. But in other emergencies it can be safer to leave the building or evacuate an entire area.

Act before it’s too late!

Figure 44: Poster development with 3 level warning code and color-coding integration
**Final Printed Materials Design**

The final printed materials design derived from a series of design iterations made after critiques were taken into consideration. The final design is more aligned with the simplicity of the overall concept to provide less cluttered information, avoid repetition, and be easy to understand and be effective.

These designs (Figure 44) should help the reader to extract the information faster as most of the information is straightforward. Below is the final design for Action Guide, Survival Kit Brochure and Warning Code Pamphlet. (Note: facsimile versions of these publications are inserted in Appendix 4.3, 4.4, 4.5 and 4.6

**ACTION GUIDE: FRONT AND BACK (MAGNETIC AND NORMAL PRINT)**

![Action Guide Front and Back Design](image)

*Figure 45: Final design for Action guide Front and Back*

The design emphasis is on basic essential information needed in case of flooding. The front design provides the information needed when flooding happens and on the back is the warning code, which provides information on flood risk level.
The warning code brochure (Figure 45) is a two-fold design with important information, which includes the emergency number and also the interpretation of the warning code.

The next design (Figure 46) is the pamphlet on basic survival preparation in case of emergency. This pamphlet provides information on how people need to be prepared with basic survival kits. It also provides information on what action needs to be taken when flooding occurs and what needs to be done before evacuating the property.

All the designs emphasize simplicity and easy to understand concepts, which are crucial in delivering a precise message that can be easily understood. This is necessary as it helps the information to be disseminated faster and give a stronger impact to the user.
**Figure 47: Final design of pamphlet on basic survival kit and action that needs to be taken when flooding occurs.**
POSTER DESIGN

STAY OR EVACUATE?

1 ALERT  2 PREPARE  3 EVACUATE

In some emergencies the safest action is to stay inside. But in other emergencies it can be safer to leave the building or evacuate an entire area.

Act before it’s too late!

Figure 48: Final design for posters integrated with the final iconography and warning code
WRNING CODE: STICKERS, PLAQUE AND SIGNBOARD

Flood Warning System

Level 3
EVACUATE
Heavy rain continues and waters have risen above human height. If not escaped make your way to the stable high point on the roof top if necessary. Await rescue.

Level 2
PREPARE
Heavy rain continues and waters have risen. Prepare to evacuate low lying homes. Secure valuables, emergency supplies, dependant family, pets and evacuate to local community shelter.

Level 1
ALERT
Heavy rain has commenced with waters rising. Secure loose equipment outside. Pack valuables and emergency clothing. Print exit route and method of travel. Stay alert to rising waters.

Figure 49: Final design warning code that can be printed or developed as a reflective signage systems to be placed in strategic locations

The final warning code designs could be applied as stickers, plaques or even signboards, depending on their location and suitability. For example the stickers of this code can be distributed and placed on the notice boards. The signage of the code could also be positioned at or near the flood prone area to provide awareness to the community on flooding and its levels of risk.

The final signage systems (Figure 49) will be developed on both reflective signage and in digital form. The reflective signage will be placed in a flood prone area as stand-alone signage. The solar powered digital signage will provide an alternative to conventional reflective signage. Its advantage is that it can be seen with greater clarity and be seen at a greater distance. With its blinking function it provides more impact to the users.
5.5 Television Campaign Development

In Malaysia television has been a major communication medium since its introduction in the 1960s. Television is popular across the population, especially in rural areas where it delivers news, entertainment, education, advertising and advertorials. It is also the main medium that disseminates weather and flood forecasts and also warnings. The research findings show that the community in the region still considered that television as the main media through which they might receive weather related information.

The social obligations of the broadcasting provider (whether it be government funded or private) are to deliver accurate information to the viewer, including broadcasting of any warnings for disasters, such as flooding. At the same time it must provide effective and timely information so the affected community can take action.
Safety warnings can really only be made through the authority of public agencies, so it must always be their initiative that triggers the issuing of alerts. It could also be argued that it is the public duty of the authorities to prepare and educate the public in flood safety awareness so that their response to flooding is both quick and rational. The role of the public broadcaster can only ever be that of a conduit rather than that of an initiator of information.

The development of the television campaign is based on the following factors:

i. Most important is that this campaign is an introduction to a new warning system that is about to be implemented.

ii. It will be necessary to educate the community over the long term with constant airing and audience testing to guarantee successful transmission and awareness.

iii. It must give awareness of the danger of flooding and the appropriate actions that must be taken when it occurs.

**Conceptual Design**

The preliminary design explores the possibility of introducing a simple yet effective television campaign that gives the community an awareness of how flooding can endanger their life and belongings. The campaign consists of a sequence of 3 info-commercials. The first campaign is to introduce the signs used in the new warning code and to provide and understanding of the new warning code implementation.

Below is an example of an early concept of the introduction campaign. (Figure 50, Figure 51 Figure 52 and Figure 53)
The early design (Figure 50) shows the use of iconography integrated into a simple design. The main function here is to introduce the community to the new system and its relation to flood conditions and to what actions need to be taken by the individual and the community.

The inclusion of colour-coding is tested to evaluate its effectiveness and whether it contributes to information dissemination. The critique on this design was that colour-coding has only a small effect on the main message of the campaign and it might not be so important to an effective design.

The next conceptual design (Figure 51) was developed to bring home the message of flooding, through real images of lives threatened in a more explicit way. Instead of using computer-generated imagery, real video news footage of a flooding scenario, combined with the flood warning icon, was considered. This type of representation works in giving real impact to the audience about the danger of flooding in their own lives. The only problem with this concept was the positioning of the warning icon before the campaign ended.
The diagonal position of the icon to represent the level of risk does not provide extra impact to the whole campaign. Thus it has been changed in the final design.

The inclusion of a real flooding scenario (Figure 52) with computer-generated imagery has been conceptualized to ‘make real’ the otherwise abstract depiction of water levels as used in the computer generated warning iconography. This design concept somehow works but the lack of additional information on the design such as text elements might create confusion for the audience. Thus additional text, (alert, prepare, evacuate) was added in the final design.

Figure 52: A television campaign using a real situation of flooding explicitly to emphasizes the seriousness of the message.

Figure 53: A combination of real photograph with computer generated imagery.
The next design (Figure 53) uses computer-generated imagery. A set of human stick figures is used to represent humans instead of real people. This is actually to address questions of privacy, which might arise if a real photograph was to be used. But the issue of how culturally appropriate the human stick figures were has led to this idea being cancelled.

Figure 54: A computer generated imagery of a cartoon like family is also analyzed to give an idea of whether a total abstraction is more effective than photography.

The proposed design has gone through a series of changes based on the critiques and comments from the supervisors and other professional advice. This process has lead to final design solutions that provide the most effective television campaign, leading to better information dissemination and awareness to the viewer. Three designs have been chosen as part of the television campaign that serve various purposes, which are; to provide an understanding of a new warning code that has been introduced, to provide a real awareness of the danger of the flooding and to warn the affected community regarding the pending flood and its danger to life and belongings.

Below are the final designs chosen: (Note: facsimile versions of these publications are inserted in Appendix 4.8, 4.9 and 4.10)

The first television campaign (Figure 54) objective is to introduce the audience to the implementation of the new warning signs for flooding. The campaign is very simple, fully computer generated, so as to give simple and clear information to the audience. The two main elements (the number and the water level) are used to give an unequivocal understanding of water level. The
marker indicator on the left of the screen gives a metric value in meters of the water level to complete the information presented.

**TELEVISION CAMPAIGN 1**

![Television Campaign 1](image)

*Figure 55: The first series of 3 television campaigns that are going to be aired to introduce the new warning sign.*

The second television campaign (Figure 55) will be aired after the initial flood warning iconography is established. This campaign emphasizes the real scenario of what happens when flooding occurs. The combination of computer generated and real life scenarios are used to generate a continuity of the first campaign, where emphasis is on the new warning sign implementation. The second part of the campaign shows a video of a typical village house to create more of an impact on what damage flooding can cause.
Figure 56: A combination of computer generated and real life footage is used to emphasize the new warning sign campaign.

The third television campaign (Figure 56) uses a real scenario that will provide a dramatic impact to the audience through real life situations they can easily identify with. The main objective of this third television campaign is to link the warning signs to real life and death conditions as portrayed, because the real graphics are more intense.

Figure 57: Television campaign which is going to be used to emphasize the danger of flooding to individuals, property or family.
Summary

The design development has sought to bring to life the main findings of this research through activity centered design. The stages of the design process undertaken provide an insight into what design might contribute to the development of early warning systems in general and for flooding in particular.

Design has opened up a whole new set of solutions to what is at present an incomplete and disconnected system and tried to relate its warnings to end-users. Through design a complex warning information system has been simplified and disseminated using tools that the users are familiar with and already have access to, such as visual signage, printed material and also media broadcasts.

The design process contributed to an understanding that simple design is more appropriate for this type of use where information needs to be disseminated, understood and absorbed very fast and effectively. By the very nature of this subject it must be fast, efficient and unequivocal.

This chapter is only a design proposal. It has not incorporated user testing and this would be imperative before these designs were finalized. User testing has not been conducted due to the time constraints and scale of research possible in a PhD. This research could be further expanded in the future in another context where concentration on design testing can take place.

This chapter has opened up an opportunity for research to expand beyond the horizon of what design has traditionally encompassed. However the design discipline is expanding and when linked to social theory (such as activity theory) can point to other aspects of design (such as systems design), which expose, for instance, the omission of community education in the current Malaysian flood warning strategy.
6.0 Recommendations and Conclusion

Overall the research that has been undertaken has shown considerable insight into the warning systems that already exists and what might exist. The aim of this research is to investigate the effectiveness of flood warning systems through communication design research by using Activity Centered Design Theory as an organizing methodology. The goal of this research is to improve the current flood warning system through communication design and develop visual communication and community education tools for disaster risk reduction.

To complete this research a few phases of research have been conducted to inform the research topic and expose any research gap. Then preliminary research investigations were explored through a literature review, choosing research methodologies (interviews, observation and field studies) and proposing communication media and messages also based on the research findings. User testing still needs to be undertaken before the implementation of any such program. User testing of the design proposal and prototype is essential before any major public interest campaign such as this would be proceeded with. User testing was originally part of this study plan but when it was discovered how underdeveloped the flood warning systems were in Malaysia the scope of this study was enlarged to take in public education and consequently the public consulting phase was abandoned.
Identifying the research topic and research gaps has been a challenging process as it has forced this study to take a more holistic approach, resulting in a proposal encompassing a much wider field of complexity. The scope of this research topic, including identifying research gaps, has concentrated on natural rural flooding, but there are other flooding types (such as flash flooding) that are different in nature and require a separate research process.

The preliminary research investigation through the literature review reveals that most of the research in the field of natural rural flooding was conducted in multidisciplinary scholarly fields such as engineering, social science, medical, geology and meteorology, but in the Malaysian context there is virtually no acknowledgement of communication design in the whole process. In a public interest area such as this it is necessary to bring together a wide range of public institutions and functionary bodies. It is a tremendous challenge to prove and argue that there is design research that has been successful in helping solve some of the issues under study. This is why this study adopted Activity Centered Design Theory, which has been used as a research methodology to embody and interconnect the whole research process.

Warning systems are necessarily complex by nature, bringing together areas as diverse as meteorology, media distribution, design and broadcast of information about the physical threats and changes to vulnerable living environments. For these reasons activity theory has played a most significant role in aiding the understanding of the whole process, the complex relationships that exist, the stakeholders involved, the potential victims, the rules and policy that are (or are not) in place and the relationships between all of these factors. This combined with the research investigation itself, where interviews of the stakeholders, observation and field studies helped to solve complex issues in the development of Malaysian flood warning systems.

The research analysis and resultant findings show that an ongoing warning system is very complex in nature and requires constant evaluation and management to maintain ongoing effectiveness. The primary finding shows that in the development of flood warning systems in Malaysia a design component, especially communication design, has been neglected as part of the early warning systems model. Thus it creates a disturbance in the overall
flow and interconnectivity of the whole systems, especially the flow between the systems and the end users, which in this case are the flood-affected villagers. The systems perform well at the top level where the data is first gathered, processed and disseminated, but it becomes fragmented and ineffective when it reaches the end user as the complex data is not converted into directions for actions that can be readily understood by the potential flood victims. Through this research however, I believe the primary problems with the current system have been identified and through using activity theory I have been able to make recommendations that would enhance the effectiveness of the current systems.

**Recommendation**

The research findings from this study give insight into future development of a range of warning systems, not only in relation to floods. Perhaps the most important insight is that design should be an integral part of any warning system development as it as crucial to any successfully implemented component in an early warning system. Communication design is like a bridge and mediator that connects and communicates any complex information to the end user. It transforms complex data to a set of tools that can be understood by the end user and so improves the effectiveness of the overall system.

Activity Centered Design Theory used in this research proved to be an essential component as it became an effective research framework methodology that will help any future research related to complex issues like this.

The final essential component of any Flood Warning System Model is continuous ongoing education in relation to affected populations. Continuous learning leading to more proactive behavior from all the stakeholders is crucial to enhance the effectiveness of the current warning systems. Continuous learning provides a more resilient community more able to take the initiative in their local area. Support tools such as the television campaigns, new warning signage systems and printed materials are essential to achieving better informed communities.

Proactive behavior needs to be nurtured among the community and other stakeholders by involving them in the early warning systems development,
such as participating in the evacuation exercises, handling the monitoring equipment and also participating in local decision-making.

Figure 58: The proposed Warning System Model

The inclusion of an activated community in the whole warning system, combined with good communication design tools and early warning systems models would eventually help to improve the performance of the system as a whole. The community should be continuously taught through on-going programs, such as an awareness development campaign, through suitable media to get stakeholders involved enough to manage their own micro warning systems delivery and by participating in and operating certain tools themselves. This will lead to better understanding of how the warning systems work in their region and improve their awareness of any risk that may occur. Education programs and system fine-tuning are never finished and must be understood and supported by the government as an on-going process that needs constant evaluation and tweaking. (Figure 57)

Government and local authorities should take account of the Philippines Community Based Warning Systems (Hernando 2007) as a model that starts on a small scale. Choosing a region that is willing to participate in the development of community based warning systems is a positive start with the
introduction of the model. In order for such initiatives to take off it is necessary to first have the commitment of key stakeholders, from government departmental representatives to members of vulnerable communities. The involvement of villagers empowers them to become more responsible for their own safety and wellbeing. The Philippines Community Based Warning System demonstrates how governments might manage limited resources more effectively.

Information relating to warning systems should be centralized and made available to different levels of users. Providing centralized information through known government authorities and creating an awareness of its existence through the media should help it reach its targeted audience. This is so to avoid any message fragmentation and differing interpretations of information being disseminated to the users. Information must be clear and designed in a way that it is quickly and unequivocally understood by a diverse population, literate and illiterate, able and disabled.

The research findings in this study will be offered to the various authorities involved as a guideline for future development of the current systems to help them in creating a better and more effective flood warning system. The findings can be a reference for future research undertakings in related areas of study.

The National Security Council (MKN), Jabatan Meterologi (JM), Jabatan Perairan dan Saliran (JPS), and Jabatan Kerja Raya (JKR) will be the authorities that will benefit from this research finding. Each of the authorities can collaborate in developing an effective flood warning system in the future. Information regarding flooding can be centralized to avoid information overlapping, which in the past has resulted in confusion, fragmentation and issues of accuracy.

**Further Research**
This research investigates just a small portion of the issues that might be developed in the future within a bigger picture in regard to warning systems. This research can be diversified to other areas that require the development of warning systems, such as urban flash flooding, bush-fires, tsunamis and even man made disasters.
In this particular research issues such as user testing design have not been covered due to the limitation of the timeframe that the researcher faced. Thus the design proposal and development of the design proposal can only be presented as an idea that the authorities can develop. This design proposal needs further research, such as user testing for its effectiveness in the real environment and testing its compatibility to the current warning system model. Various design elements (eg. Colours, signs, languages and symbols) can be further tested to find out what cultural and local factors will have on the whole design effectiveness.

Technology and media keep changing so developing different warning system solutions in different media, such as mobile technology need to be under constant revision. Delivering communication design in different forms of media will expand the possibility of technical adaptation and its feasibility.

Overall the research process has been successful in identifying the research gaps and showing that the system might be repaired and extended through activity theory. Research investigation addressed the issues effectively through some simple data gathering and analysis. Understanding how activity theory works in the real world has born the most fruit in terms of exposing weaknesses in the current warning system and where it might need repair and improvement.

The research has given some insight into how climate change disasters occur and what destruction they create that affects the daily life of the people in Malaysia. It also gives valuable insights into the issues of flooding, flood warning systems and related reactive behaviours. Through climate change natural disasters are occurring with greater frequency and severity and the whole world needs to collectively work together to do their part. To reduce pollution, to minimize negative affects created by urbanization and to practice more ethical crop cultivation. Furthermore to better manage irrigation systems, forestry, land planning, and the education of the populations relating to all the above. And to address these issues through properly designed tools and programs in which communication design plays a central part.
The diagram (Figure 58) below shows the list of the levels of action needed to develop a truly comprehensive warning system.

**The Flood Warning System Development Guidelines**

- **TOOLS:** Designing and developing the right tools that deliver the complex information. A warning sign system that is easily recognizable. Providing educational kits relating to flooding that can be accessed and understood by the community. Advertising or television campaign that promotes the warning systems not only in the flooding season.

- **SUBJECT:** Flood-affected communities need to be proactive to support the community-based warning system initiative and local strategies.

- **OBJECT:** Current and future flood warning system development or enhancement must take account of user requirements.

- **RULES:** Procedures and policies need constant evaluation and revision to be effective.

- **DIVISION OF LABOUR:** Government and related agencies need to collaborate to make fast decisions and to avoid overlapping tasks.

- **COMMUNITY:** The community must be included in the warning system development and operation in order to create more resilient and sustainable society able to defend or protect themselves against flooding. They are also the best repositories of local knowledge.

*Figure 59: Actions needed to develop a truly comprehensive warning system*

As the proverb says prevention is better than cure and it would be better to prevent these problems from starting rather than waiting for problems to happen when it is too late to attend to them.
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Appendices

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From: "Keith Wilkins" <KWilkins@groupwise.swin.edu.au> To: "Keith Robertson" <KRobertson@groupwise.swin.edu.au> Subject: SUHREC Project 2008/154 Ethics Clearance Date: Tuesday, December 23, 2008 4:49 PM

To: Dr Keith Robertson/Mr Zulisman Maksom, Design [bcc Mr Maksom]

Dear Keith and Zulisman

SUHREC Project 2008/154 Visual Communication as an Agent for Risk Reduction Effectiveness: Case Study Based on a Malaysian Region "Batu Pahat" Dr Keith Robertson, Design; Mr Zulisman Maksom, Dr Gavin Melles Approved Duration: 01/01/2009 To 01/01/2010

I refer to the ethical review of the above project protocol undertaken on behalf of Swinburne's Human Research Ethics Committee (SUHREC) by a SUHREC Subcommittee (SHESC1). Your responses to the review, as emailed yesterday with attachments, were put to a delegate of the Subcommittee for consideration. I also acknowledge receipt of Malay translations of the consent instruments emailed today.

I am pleased to advise that, as submitted to date, the project has approval to proceed in line with standard on-going ethics clearance conditions here outlined.

- All human research activity undertaken under Swinburne auspices must conform to Swinburne and external regulatory standards, including the National Statement on Ethical Conduct in Human Research and with respect to secure data use, retention and disposal.

- The named Swinburne Chief Investigator/Supervisor remains responsible for any personnel appointed to or associated with the project being made aware of ethics clearance conditions, including research and consent procedures or instruments approved. Any change in chief investigator/supervisor requires timely notification and SUHREC endorsement.

- The above project has been approved as submitted for ethical review by or on behalf of SUHREC. Amendments to approved procedures or instruments ordinarily require prior ethical appraisal/ clearance. SUHREC must be notified immediately or as soon as possible thereafter of (a) any serious or unexpected adverse effects on participants and any redress measures; (b) proposed changes in protocols; and (c) unforeseen events which might affect continued ethical acceptability of the project. - At a minimum, an annual report on the progress of the project is required as well as at the conclusion (or abandonment) of the project.

- A duly authorised external or internal audit of the project may be undertaken at any time. Please contact me if you have any queries about on-going ethics clearance. The SUHREC project number should be quoted in communication. Best wishes for the project.

Yours sincerely
Keith Wilkins Secretary, SHESC1

*******************************************
Keith Wilkins Research Ethics Officer Swinburne Research (H68) Swinburne University of Technology P O Box 218 HAWTHORN VIC 3122 Tel +61 3 9214 5218 Fax +61 3 9214 5267

Appendix 1
Ethics Clearance Consent
Appendix 2
Questionnaire for Villagers

Villager or Flood Victim

<table>
<thead>
<tr>
<th>Gender:</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>20-30</td>
<td>31-40</td>
</tr>
</tbody>
</table>

1. Do you ever come across any flood disaster awareness information on one of these media:
   a. Television
   b. Radio
   c. Brochure and Pamphlet
   d. Newspaper
   e. SMS
   f. Warning board
   g. Other_____________________

Which of the above seem most effective to you?
________________________________________________________
________________________________________________________
________________________________________________________

1. Are you aware of any flood warning or awareness material/signs/publications/websites etc. available in your area?
   a. Warning Board
   b. Poster, brochure, pamphlet
   c. TV Advertisement
   d. Web site related to flood
   e. Other______________________

If Yes, does this information seem effective to you? Yes No

2. What is the main concern when flooding occurs? Circle the selection
   a. Loss of property
   b. Loss of life
   c. Loss of communication/disruption
   d. Other___________________________________

3. Have you had to vacate and leave the house and belonging when flood occurs? Yes No

4. Have you had loss of
   a. house? Yes No
   b. farming? Yes No
   c. Crops? Yes No
   d. Life? Yes No
5. Are you aware of the existence of the Flood Relief Centre and its location?  
Yes No

6. Have you found information about flooding easy to understand? Yes No  
If No, give a reason why it is not easy to understand
_____________________________________________________
_____________________________________________________
_____________________________________________________

7. How do you receive information about flooding? List in order of importance  
1._________________________________________________
2._________________________________________________
3._________________________________________________
4._________________________________________________
5._________________________________________________

8. Do you get sufficient warning of a pending flood, enough for you to take effective action?  
Yes No  
If No stated the reason____________________________________

10. Do you own a mobile phone?  
Yes No  
If Yes, what primarily you use it for?  
a. Make/receive a call Yes No  
b. Send a text messages Yes No
Appendix 3
Questionnaire for Experts

Department of Meteorology

<table>
<thead>
<tr>
<th>Position:</th>
<th>Department:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td></td>
</tr>
</tbody>
</table>

1. How many flood occurrences has your region experienced over the past 5 years?

2. Is the frequency and severity of flooding worsening?

3. How is the flood-affected villager informed about a pending flood?

4. Is information about flood occurrences available? At what level eg. national, administrative, regional, local etc.
   a. National  Yes  No
   b. State     Yes  No
   c. District  Yes  No
   d. Administrative  Yes  No
   e. Other ______________________________

5. What kind of information about floods is available?
   a. evacuation procedure  Yes  No
   b. flood relief centre/escape centre  Yes  No
   c. emergency contact number to call  Yes  No
   d. flood severity and the level of water  Yes  No
   e. Other ______________________________

6. In recent floods what methods/communication tools have been used to disseminate information to the local population?
   a. media broadcasting  Yes  No
   b. websites  Yes  No
   c. mobile phone  Yes  No
   d. person to person  Yes  No
   e. village leader  Yes  No
   f. distribution of pamphlet, brochure or warning notice  Yes  No
   g. Other ______________________________
Local Authority: Local Council, Local Police, Fire Brigade, Health Department, MKN

<table>
<thead>
<tr>
<th>Position:</th>
<th>Department:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Title:</td>
<td></td>
</tr>
</tbody>
</table>

1. What is the role of the department in flood related disaster?

2. How many flood occurrences has your region experienced over the past 5 years?

3. Is the frequency and severity of flooding worsening?

4. How is the flood-affected villager informed about a pending flood?

5. What kind of action is taken when flooding occurs?

6. Does your department get sufficient warning of a pending flood, enough for you to take effective action?

7. What kind of information about floods is available?
   a. evacuation procedure Yes No
   b. flood relief centre/escape centre Yes No
   c. emergency contact number to call Yes No
   d. flood severity and the level of water Yes No
   e. Other _____________________________

Which of the above is the most effective? ______________________

8. In recent floods what methods/communication tools have been used to disseminate information to the local population?
   a. media broadcasting Yes No
   b. websites Yes No
   c. mobile phone Yes No
   d. person to person Yes No
   e. village leader Yes No
   f. distribution of pamphlet, brochure or warning notice Yes No
   g. Other _____________________________

Which of the above is the most effective? ______________________
Department of Drainage and Irrigation

<table>
<thead>
<tr>
<th>Position:</th>
<th>Department:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td></td>
</tr>
</tbody>
</table>

1. What is the role of the department in flood related disaster?

2. What kind of action is taken by the department when flooding occurs?

3. Does your department get sufficient warning of a pending flood, enough for you to take effective action?

4. Is information about flood occurrences available? At what level eg. national, administrative, regional, local etc.
   a. National
   b. State
   c. District
   d. Administrative

5. What kind of information about floods is available?
   a. evacuation procedure
   b. flood relief centre/escape centre
   c. emergency contact number to call
   d. flood severity and the level of water
   e. Other ______________________________

6. In recent floods what methods/communication tools have been used to disseminate information to the local population?
   a. media broadcasting
   b. websites
   c. mobile phone
   d. person to person
   e. village leader
   f. distribution of pamphlet, brochure or warning notice
   g. Other ______________________________
Appendix 4

Flood Warning System Communication Plan

This section of Appendix 5 is a Flood Warning System Communication Plan which consists of the items below:

- Communication Objective
- Target Audience
- Communication Tools
- Timing and Frequency
- Responsibility
- Communication quality

- Communication Objective
  1. To actively develop and support the continuous improvement of the flood warning system through communication design by shared understanding through effective communication.
  2. To engage the Malaysia flood warning stakeholders who are responsible to develop the communication design tool to actively participate in communication design implementation of the tools.
  3. To provide stakeholders with information needed for developing effective communication design tools for flood warning systems
  4. To develop a guideline for the Malaysian Flood Warning authority to use proper communication design as a primary tool in educating the community regarding the flooding.

- Target Audience
  The main types of audience/stakeholders for Malaysian Flood Warning Systems are:
  1. Majlis Keselamatan Negara (MKN)
  2. Department of Irrigation and Drainage (DID)
  3. Jabatan Meteorologi Malaysia (JMM)
  4. Communication Design Experts
  5. Government agencies
  6. Local Governments
  7. Community Representatives (Head Villagers etc)
  8. Community

- Communication Tools
  The communication tool presented is an example of many alternatives in communication design that can be developed. In this appendix a number of design proposals have been proposed which are:

  1. Iconography
  2. Flood Warning Code
  3. Signage
  4. Educational Kit (Action Guide)
  5. Educational Kit (Survival Kit Brochure)
  6. Educational Kit (Warning Code Pamphlet)
  7. Educational Kit (Poster)
  8. Television Campaign 1, 2 and 3
• **Timing and Frequencies**
The communication tools that have been develop need to be constantly updated and disseminated through printed materials and broadcasting media. The television campaign needs to be aired in prime time everyday and more frequently when the monsoon season occurs. Brochures and other printed materials need to be always available for consumption and be located at the all-strategic places such as schools, community halls and through mails.

• **Responsibilities**
The preparation of communication design material is conducted and monitored by the Majlis Keselamatan Negara (MKN) working closely with the Communication Design Expert. Jabatan Meteorologi (JMM) and Department of Irrigation and Drainage (DID) will provide the analysis and interpretation of data gathered to be used in the development of the Communication tools with input from other experts from the flood warning fields such as academics and researchers.

Datelines for preparing the materials need to be coordinated between the Majlis Keselamatan Negara and Communication Design Expert at an advanced stage.

The main tasks will be:
1. Majlis Keselamatan Negara (MKN) and the Communication Design Expert will decide when and what type of communication tools will be used.
2. Transcribing and analyzing the data and information regarding the flooding will be conducted with collaboration from various agencies such as Jabatan Kebajikan Masyarakat (JKM), Local Authorities, Department of Irrigation and Drainage (DID) and Jabatan Meteorologi (JMM)
3. The Communication Design Expert will draft the tools and present these to stakeholders involved to ensure clear and concise messages will get through.
4. Setting up a one-stop centre with which stakeholders can communicate to answer any queries.
5. The local authorities, communities, schools, and media will be responsible for disseminating the communication tools that have been develop.

• **Communication Quality**
The communication tools that have been developed must show a clear, consistency and appeal to the community to attract their awareness. Using simple language and graphic representation will help in disseminating the information faster. The information presented in the communication tools must convey strong messages about the danger of flooding and the danger it represents to life and property.

Below is a proposed communication tools that needs to be developed for Flood Warning Systems in Malaysia
Appendix 4.1
Iconography Design
Flood Warning System

**Alert**
- Level 1
  - Heavy rain has commenced with waters rising. Secure loose equipment outside. Pack up and prepare for possible evacuation.

**Prepare**
- Level 2
  - Heavy rain continues and waters have risen. Prepare to evacuate low lying homes. Secure family pets and evacuate to local community shelters. Emergency supplies and dependent needs must be prepared for evacuation.

**Evacuate**
- Level 3
  - Emergency. A wall is necessary. Abandon home. Take your way to the nearest high point - on the road above human height. No escape needed. Make heavy rain continues and waters have risen.
Appendix 4.3
Educational Kit
(Action Guide)
Appendix 4.4
Educational Kit
(Survival Kit Brochure Front and back)
Developing Malaysian community-based flood warning initiatives through Activity Centered Design

Appendix 4.5

Educational Kit
(Survival Kit Brochure Inside)

What action need to be taken BEFORE flood?

1. Alert
2. Prepare
3. Evacuate

What action need to be taken DURING flood?

- Leave your home
- Ask your family members to leave the most vulnerable places in the house
- Continue taking care of your children
- Avoid using phone, television, or radio
- Keep all your emergency supplies easily accessible
- Be aware of local emergency numbers or contact them
- Keep all your emergency supplies easily accessible
- Continue taking care of your children
- Avoid using phone, television, or radio

What action need to be taken AFTER flood?

- Listen to emergency statements
- Return only after being advised to do so
- Avoid using phone, television, or radio
- Be aware of local emergency numbers or contact them
- Keep all your emergency supplies easily accessible
- Continue taking care of your children
- Avoid using phone, television, or radio
Appendix 4.6
Educational Kit
(Warning Code Pamphlet)
STAY OR EVACUATE?

In some emergencies the safest action is to stay inside. But in other emergencies it can be safer to leave the building or evacuate an entire area.

Act before it’s too late!
Television Campaign 1
Television Campaign 2

1. Alert

2. Prepare

3. Evacuate
Appendix 4.10

Television Campaign 3