AN SMS-BASED FLOOD WARNING SYSTEM FOR DEVELOPING COUNTRIES: THE CASE OF LAOS

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DECLARATION

I declare that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university. To the best of my knowledge and belief, this thesis does not contain any material published or written by another person except where due references are made within the thesis.

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ABSTRACT

National disasters such as floods are a worldwide phenomenon occurring frequently and lead to a huge loss of life and enormous economic cost. To minimise the impacts from floods, flood warning systems have been developed and applied around the globe. Developing countries were ranked at the top in the flood indices of the number of occurrences, people killed and affected, and economic damage.

A digital divide in communication technologies between developing and developed countries is still present. Mobile phone technologies are widely used in developing countries notably in the urban area but also the rural area, but there is a lack of Internet access. The availability of mobile phone technology in developing countries provides an opportunity of taking advantage for sharing flooding information that can be used as a part of flood warning systems.

The main purpose of this research was to investigate the feasibility of adopting SMS messages for a flood warning system in developing countries, the case study in Laos. In this study, a research model was developed, and surveys and a trial were conducted in the selected area in Laos. A closed question questionnaire was used to collect the required data and quantitative methods were used for data analysis.

Two preliminary surveys were conducted to evaluate the feasibility of adopting SMS messages for a flood warning system: the first survey with residents affected by annual floods in a selected area of Laos; and the second survey with flooding experts who worked or experienced with the current flood warning system. The findings of the surveys were used to compare perspectives of both residents and the flooding experts in relation to adopting and using SMS messages as part of a flood warning system in the case study area.

A research model (SMSTAM) was designed based on the Technology Acceptance Model (TAM) to test hypotheses to seek factors influencing the use of SMS messages in a flood warning system in the case study area. The data was collected randomly from 568 respondents, living in the case study area and those collected data were analysed based on statistical analysis including SPSS and AMOS for structural equation modelling.

A trial was carried out in which bulk SMS messages as real warnings which prepared and sent to residents, living in flood areas. The SMS messages for the trial were based on lessons learnt from previous studies such as appropriate message content, message size and message meaning. In this trial, the local language was used to send flood warnings to 116 residents simultaneously. Parameters analysed as part of the trial included transmission times, number of messages lost, message errors and awareness of residents to flood warnings.

Upon completing the trial, interviews were conducted to obtain feedback from those residents. The feedback assessed the appropriateness of the language of the warning and the response actions to the warning. The findings of the trial provided additional evidence and confirmed the findings from the surveys and the findings of the research model.

The findings from the two surveys, the research model test and the trial of the system confirmed that mobile phone technologies are widely available in the case study area in Laos in line with mobile phone penetration, as opposed to limited Internet access, as earlier expected. The findings of this study shows that beginning an SMS-based flood warning system in the case study area is currently unlikely to be successful due to low SMS usage resulting from the lack of local language installed in mobile phones and local language illiteracy of the residents. However, the study suggested that SMS-based flood warning through mobile phones has high potential, but installation of the local language on mobile phones ought to be encouraged and promoted.

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ABBREVIATIONS USED IN THESIS

1G	**First Generation of Mobile Phone Communication System**
2G	Second Generation of Mobile Phone Communication System
3G	Third Generation of Mobile Phone Communication System
4G	Fourth Generation of Mobile Phone Communication System
ACM	Association for Computing Machinery
ACMA	Australia Communications and Media Authority
ADRC	Asia Disaster Reduction Centre
AEM	Australian Emergency Manual
AGFI	Adjusted Goodness of Fit Index
AMOS	Analysis of Moment Structure
AVE	Average Variance Extracted
BTS	Base Transceiver Stations
CBS	Cell Broadcasting Service
CEO	Chief of Executive Officer
CFA	Confirmatory Factor Analysis
CFI	Incremental Index of Fit
CPU	Central Processing Unit
DMH	Department of Meteorology and Hydrology
EENA	European Emergency Number Association
EFA	Exploratory Factor Analysis
EM-DAT	The International Emergency Disaster Database
EWS	Early Warning System
G2C	Government to Consumers
GFI	Goodness of Fit Index
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GSMA	GSM Association
HYCOS	Hydrology Cycle Observation System
ICT	Information and Communications Technology
IPAWS	Integrated Public Alert and Warning System
ITU	International Technology Union
IU	Intentional of Use

IUCN	International Union for Conservation of Nature
KMO	Kaiser-Meyer-Olkin
LMB	Lower Mekong Basin
MAS	Mobile Alerting System
MIS	Management Information System
MRC	Mekong River Commission
NDMC	National Disaster Management Committee
NFI	Normed Fit Index
NGA	National Government Agencies
NGO	Non-Government Organisation
PC	Personal Computer
PCA	Principle Component Analysis
PDMC	Provincial Disaster Management Committee
PDU	Protocol Description Unit
PEN	Perceived Enjoyment
PEOU	Perceived Ease Of Use
PGFI	Parsimony Goodness-of-Fit Index
PNFI	Parsimonious Normed Fit Index
PRATIO	Parsimony Ratio
PU	Perceived of Usefulness
RAM	Random Access Memory
RMR	Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation
SARS	Severe Acute Respiratory Syndrome
SEM	Structure Equation Modelling
SIM	Subscriber Identity Module
SMS	Short Messaging Service
SMS FWAS	SMS Flood Warning Acceptance Model
SMSC	SMS Centre
SPSS	Software Package for Social Science
TAM	Technology Acceptance Model
TFWS	Total Flood Warning System
TLI	Tucker-Lewis Index

UN	United Nations
UNCEF	United Nations Children's Fund
UNDP	United Nation Development Programme
UNEP	United Nations for Environment Programme
UNESCAP	UN Economic and Social Commission for Asia and Pacific
UNESCO	UN Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNGAR	United Nations Global Assessment Report
UNISDR	United Nations Office for Disaster Risk Reduction
VDMC	Village Disaster Management Committee
WEA	Wireless Emergency Alert
WMO	World Metrology Organisation

CHAPTER I : INTRODUCTION

This chapter outlines the foundations of this dissertation. Section 1.1 presents the research background, Section 1.2 addresses research problems, Section 1.3 presents research justification, Section 1.4 introduces the research aim, the research objectives and research questions, Section 1.5 presents scope of study, Section 1.6 presents research methodology. The case study area and research significance are presented in Section 1.7 and Section 1.8 respectively, and finally the structure of the thesis is discussed in Section 1.9.

1.1 Research background

Natural disasters such as floods are a worldwide phenomenon; they are occurring more frequently and lead to devastating loss of life and huge property damage. In recent years, the number of natural disaster occurrences has noticeably increased, the results from natural disasters can result in loss of life and property and economic damages(Watson *et al.*, 2015). The United Nation Development Program report highlighted that globally the number of natural disaster has doubled since the 1980s, the cost of the damage and losses caused by disasters have been estimated at an average hundred billion dollars a year since the year 2000 (UN, 2006). According to the Asia Disaster Reduction Centre (ADRC) report: "Every year natural disasters increasingly occurred worldwide, killed tens of thousands of people, and damaged hundreds of billions dollars" (ADRC, 2014, p. 1).

Floods are natural disasters that occur due to heavy rain, storms, and cyclones and also result from human activities. Floods lead to extensive property damage, economic impact and loss of life. The ADRC reports pointed out that floods are dominant among all natural disasters in terms of occurrence, the number of people killed and affected, and economic damage (ADRC, 2013, 2014). The World Meteorological Organisation (WMO) states that precipitation pattern change and natural climate variability have led to a number of extreme floods around the world every year (WMO, 2015). A World Bank report also emphasised that floods are the most frequent among all natural disasters resulting increasing financial and economic damage significantly (World Bank, 2012).

As reported by ADRC (2013), Asia and developing countries were ranked the highest in all the indices of disaster occurrences (44.6%), the number of people killed and affected (84.6%) and amount of economic damage (49%). A study conducted by Alcántara-Ayala (2002) showed that developing countries were more damaged by floods than developed countries. By disaster type, floods are dominant in terms of occurrences, number of people killed and affected, and economic damage, representing 41.3%, 73.8% and 44.5% respectively (ADRC, 2014).

There is massive loss of life and enormous property damage in the Lower Mekong Basin countries of Cambodia, Laos, Thailand and Vietnam due to annual floods along the Mekong River and its tributaries(MRC, 2010, 2011a, 2011b, 2012). According to EM-DAT (2015), Laos (a case study for this research) is a developing country and is affected by a number of annual floods causing loss of life and property damage particularly in poor and remote areas. Laos has been ranked 6th in Asia by number of people killed per million population by flood in 2013.

Even though flood warning systems have been developed and implemented around the globe using different approaches and technologies, people living in the flood prone areas have continued to be affected by floods. Especially, developing countries have seen more harmful by flooding impacts compared to developed countries(Alcántara-Ayala, 2002).

The United Nations Global Assessment Reports on Disaster Risk Reduction (UNGAR) observed that in developing countries the mortality, the number of affected and economic loss associated with extensive natural disasters have been trending upwards (UNGAR, 2013, 2015). A recent United Nations report, conducted by Watson *et al.* (2015), mentioned that a large share of the economic losses from floods have been recorded in developed countries, while a major percentage of the deaths have occurred in developing countries. From these flood impacts, the issues of why developing countries have been affected by floods more than developed countries must be understood.

1.2 Research problems

1.2.1 Developing countries and floods.

Many studies have claimed that developing countries are more damaged by floods than developed countries due to limitations in flood warning systems, lack of appropriate technology adoption and bureaucratic inefficiency.

Limitations of flood warning systems are one of the main reasons why developing countries are vulnerable to floods. As stated by the UN (2006), in developing countries the warnings do not reach all the at risk areas due to underdeveloped information dissemination infrastructure and the ineffective warning systems. An evaluation study of existing early warning systems carried out by UNEP (2012) highlighted that in developing countries, some elements of the early warning process are not yet mature, particularly links and communication networks. In developing countries there were more losses and damages resulted in natural disasters such as floods than in developed countries due to limitations of the warning channels(Alcántara-Ayala, 2002)

Inappropriate technologies used in flood warning systems in developing countries. People living in the remote flood risk areas have lack of basic technology skills or may not even have access to the technologies used for flood warning notifications. According to the United Nation Framework Convention on Climate Change report, UNFCCC (2007), developing countries are the most vulnerable to flood impacts due to lack of appropriate technologies for flood warning systems. The global survey of warning system reported that in many developing countries, warning systems lack of basic capacities of equipment, skills and resources due to using inappropriate technologies, while some poorest countries do not have warning system at all(Basher, 2006; UN, 2006).

Bureaucracy is one of the main reasons for delays in flood warnings. The United Nations report also stated that in developing countries, the warning communication often failed as a result of a weak inter-personal and inter-agency relationship, including between early warning services and response units and other sectors(UNISDR, 2004a, 2004b). The United Nations report identified that warning services are limited in many developing countries because there is no formal institutional structure with requisite authority to issue warnings. The same report also emphasises that there is often a disconnection between key technical agencies and the authorities for effective exchange of technical information and hazard warnings (UN, 2006). As pointed out by UNEP (2012) in some developing countries there was disconnection between organisations responsible for issuing early warnings and the authorities in charge of responding to the warnings.

To bridge the gap between flood warning systems and authorities in charge of responding to the warnings, the system should use available, accessible and appropriate technologies. Grasso (2012) stated that an effective early warning system needs available communication systems to allow individuals to take timely action to reduce the risk and prepare for effective response. Another United Nations report argued that effectiveness of a flood warning system is associated with the use of an appropriate technology available in the country (UN, 2006).

1.2.2 Limitation of the flood warning system of the case study area

The case study area, The Lower Mekong Basin area of Laos, has experienced floods throughout its history. According to the International Disaster Database (EM-DAT), the Asia Disaster Centre (ADC), and Mekong River Commission (MRC), the case study area has been affected by a number of annual floods causing loss of life and property damage particularly in poor and remote areas (ADRC, 2014; EM-DAT, 2015; MRC, 2010).

Although a flood warning system has been available, it has limitations. To be precise, although the data centres receive real-time data from remote hydrological monitoring stations, there is no a real-time warning to alert the flood risk community. In the case of floods, the flood information is disseminated by public media through radio, television stations and newspapers. The real-time graphs of water level and rainfall are also available online(MRC, 2011b).

Annual flooding results in loss of life and property damage. According to the International Disaster Database (EM-DAT), the case study area was in the top 10 of the worst disasters in Asia by number of people killed per million populations and it was ranked at 6th place for floods in 2013.

1.3 Research justification

Mobile phone networks in developing countries have been developed widely in comparison to the Internet. As such, adoption of SMS messages for flood warning systems in developing countries is proposed for this study and is justified by the following reasons:

1.3.1 Mobile phone, fixed-line telephone and Internet users in developing countries

Despite Internet user penetration (number of Internet users per 100 inhabitants) continuously increasing since the 1990's, it has not grown as rapidly as mobile phone use in developed and developing countries. In 2014, globally the number of mobile phone subscribers worldwide is approaching the number of people on earth, this number has overtaken Internet penetration and fixed-line telephony users (ITU, 2014b). By the end 2014, mobile phone penetration worldwide reached 96 users per 100 inhabitants 121 for developed countries and 90 for developing countries, and this number has continued to increase. In contrast, in the same year only 40 users per 100 inhabitants for Internet penetration and 10 users per 100 inhabitants for fixed-line telephone penetration. The same report emphasised that the mobile phone is the most used ICT tool compared with other ICT tools such as Internet, fixed-line telephone and fixed broadband subscription (ITU, 2014b).

Other ITU reports also claimed that in many developing countries, even though there is limited Internet access, more than half of rural households have mobile phones. For instance, in some developing countries like Cambodia and Laos, by 2013 only around 5 and 10 per cent of their population used the Internet, whereas more than 134 and 68 per cent respectively of the population had mobile phones (ITU, 2014a).

1.3.2 SMS is popular in developing countries

In parallel with the rapid growth in mobile phone technologies and users, SMS services (such as interpersonal communication to government services) are becoming popular, not only in developed countries but also in developing countries. As reported by ITU (2013b), mobile phone users in the world represented 96% (6.8 billion mobile users out of 7.1 billion inhabitants), while the total active SMS users reached 5.9 billion worldwide, this mathematically indicates that almost 91% of the world's population could be reached by SMS (Ahonen & Moore, 2012a). In China alone, there were over 1.1 billion mobile subscribers, 760 million of them used SMS, and 897.3 billion text messages were sent during the year 2012. As stated by Portio Research (2013), around 8.3 trillion messages were sent in 2014 worldwide and SMS use will continue to increase. The International Telecommunication Union pointed out that continuous increases in mobile phone users is driving SMS use (ITU, 2010, 2014b).

The reasons why SMS services are popular are due to SMS technology features. SMS is easy to read, easy to write and easy to send for most people. Compared to the Internet, SMS is more readily available for every mobile user since SMS is one of the basic functions of a mobile device, which is typically within arm's reach anywhere and anytime. Technically, an SMS message is guaranteed to reach a receiver since the message is stored in the network until the destination mobile phone becomes available, so an SMS user can send or receive a message any time, whether the mobile device is on or is switched off (Susanto, 2012).

An SMS message is also concise. Because SMS text messages are usually limited to 160 characters, the message gets directly to the point, so people are more inclined to respond to the information included in the message. As stated by Ahonen (2012), an

SMS was read on average within 3 minutes compared to the email where the average was to read within 48 hours. Also, only 20% of emails were opened, compared to 97% of SMS text messages being opened and read.

In relationship to benefits, the SMS service has significantly reduced time and budget. Since a mobile phone is within user's arm reach, a message can be sent or received anytime and anywhere. In terms of budget, SMS is a low-cost service; the cost is based on a message sent/requested. For instance, in Laos sending an SMS within the same mobile phone network is 100 Kip (1.2c) per massage, and 250 Kip (3c) to other networks (Beeline Laos, 2014).

SMS has boomed in developing countries because of the availability of current mobile technology. Figure 1.1 shows a comparison of mobile subscriptions by technologies. Mobile network technology is dominated by 2G technology in developing countries with more than 60% usage. Although, there has been a relative reduction in its use with the rapid increase in the 3G network and the follow on 4G technology (ITU, 2014c).

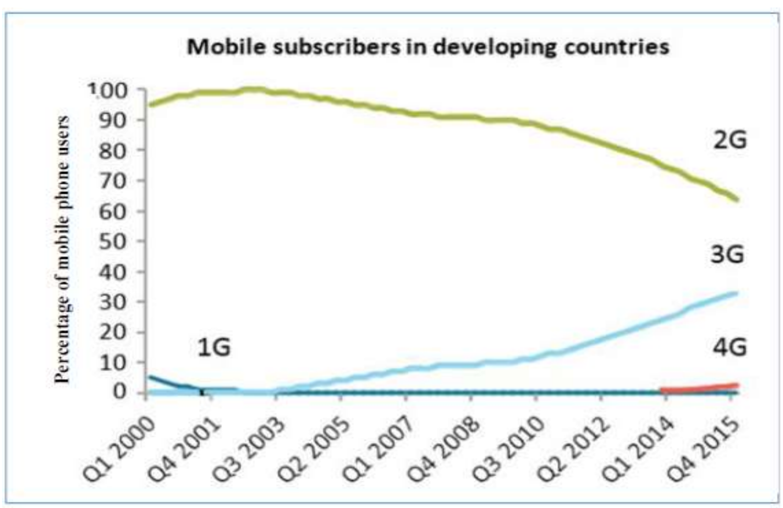


Figure 1. 1: The proportion of different mobile phones technologies

Standard mobile phones, as opposed to ‘smart’ mobile phones, are the norm in developing countries. As estimated by World Bank (2011), by the end of 2015 the standard mobile phone will still outnumber smartphones in developing countries (52% and 14% of the worldwide mobile phones respectively), while in developed countries that number stands at 16% and 18% of the world mobile phones respectively. This is reasonable since smartphone penetration (number of smartphone users per 100 inhabitants) is premised on the availability of mobile broadband while many developing countries are based on 2G networks. Qiang *et al.* (2011); World Bank (2011) also emphasised that standard mobile phones will continue to dominate over smartphones in the developing world, especially in rural areas.

Another reason for the popularity of SMS services is its compatibility. SMS messages are compatible with almost all mobile phones and network technologies. It does not matter whether the recipient has a smartphone or a bottom of the range entry level phone, they can each send/receive text messages to/from any mobile phone user. Also, SMS services can be used on 2G, 3G and 4G networks (Bhalla, 2010; Jamil *et al.*, 2008).

SMS-based services have experienced success in both developed and developing countries. For example, in Australia SMS’s are sent about vehicle registration renewals, reminders of doctor appointments and alerts about bushfire threats(eNotice, 2015). In the United Kingdom, people can register to receive automatic flood warnings via SMS, this service has been provided by the UK Environment Agency (UKEA, 2013). Local authorities in the Philippines and Indonesia have provided SMS services for getting feedback from their citizens

(Susanto, 2012). In Laos, people can apply for SMS job alerts and make advertisements through SMS messages (ETL Lao, 2014).

1.3.3 SMS advantages in developing countries

The choice of SMS as the flood warning system is borne out of a review revealing that SMS remains the most suitable disaster alert system in terms of its clarity, promptness, effectiveness and resilience to a disaster (Wattegama, 2007). A United Nation report emphasises that SMS has the capacity of reaching the majority of citizens living in the flood risk areas due to access to mobile phones, through which SMS's are delivered (UNESCAP, 2011).

In the light of the overwhelming population of mobile phone users of 90 per 100 inhabitants in developing countries in 2014 as highlighted by (ITU, 2014b), SMS would be a purposeful flood warning system to reach a larger percentage of people in flood risk areas of developing countries. The above reasons justify this study in investigating whether SMS message could be a good tool for a flood warning system in developing countries.

1.4 Research aims

The research aims to investigate the feasibility of adopting SMS messaging as a flood warning system to alert people in flood risk areas in developing countries, where mobile phone technologies are available, but there is a lack of Internet access. To fulfil the research aim, the major research objectives are:

- To review flooding impacts, the available flood warning systems, communication channels, and mobile phone technology development in developing countries.

- To conduct two surveys in the case study area to assess adoption an SMS messaging for flood warnings.
- To develop a research model to identify key predictors for adopting SMS messaging as a flood warning system in the case study area.
- To conduct the trial of the proposed system in the case study area to seek additional information to support the findings of the surveys and the research model.

To support these research objectives, the main questions to be answered are:

RQ1: What are the available flood warning systems worldwide and technologies used?

RQ2: What are the key elements motivating the adoption of SMS for a flood warning system in the case study area?

RQ3: What are the key predictors of adopting SMS messaging for a flood warning system in the case study area?

RQ4: What kind of flood warning system would be suitable in the case study area?

RQ5: Can SMS messaging via mobile phone be the best channel for flood warning systems in developing countries where mobile phone networks are available rather than the Internet?

1.5 Scope of the Study

The core theme of the thesis aims to investigate how people adopt the available technologies (SMS messages) for flood warning systems in developing countries where the mobile phone network infrastructure is more available than Internet access. This study does not relate to hydrological and environmental techniques, processes or any water-related science.

The SMS-based flood warning system for developing countries focuses on sending basic SMS messages via mobile phones to alert people living in flood risk areas using 2G, 3G and 4G networks. This study does not consider sending via other instant messaging over the Internet services such as Facebook and Twitter.

This study concentrates on disseminating flood warnings from the flood warning centre to reach the effected population in a timely manner. It does not consider other aspects for solving the flooding problem like a flood management strategy or flood relief.

The Lower Mekong Basin (LMB) in Laos is proposed as a research case study area in which mobile phone readiness and mobile network infrastructures are available. The research uses the existing mobile networks in the case study area for a trial of the proposed system to assess and analyse reliability of SMS transmission via mobile networks.

1.6 Research methodology

This section briefly introduces the research approach, data collection method, data analysis method, and data presentation used in this study.

A quantitative, multiple method research approach was used in this study (Chapter IV gives a detailed description of the research methodology). Initially surveys (field survey and online survey) were conducted in parallel in the flood risk area. In the surveys, the field survey targeted respondents were residents (preferably farmers), while the targeted respondents of the online survey were experts who work with the flood warning system of the case study area. The results of the two surveys were compared to evaluate the possibility of adoption of SMS in the case study area.

The research model was then developed and the hypotheses were proposed to seek the key factors influencing the use of SMS and the intent to adopt SMS for flood warning systems. Finally, the trial was carried out by sending bulk SMS messages to alert about floods as real warnings. The findings from the trial were intended to support the findings of the surveys.

Statistical techniques and tools including the SPSS with AMOS version 22 and Microsoft Excel spreadsheet, were used for this study. Combining and evaluating the results from the surveys, the research model and the trial, highlight the major findings in answering the research questions in this study.

1.7 The case study area

In order to gain in depth understanding about the real life context of flood disaster event, including what people experience from the flooding impacts and how people communicate before, during and after the disaster, a case study was adopted for this study. In order to meet the aim and the research objectives presented in Section 1.4, the case study area needed to be located in a flood risk area where vulnerable residents such as farmers are effected by annual floods. Chapter III describes details of the case study area selected for this study.

A case study area in Laos was chosen for this study because of its unique characteristics:

- Laos is a developing country
- In the case study area, there are annual floods and the floods cause loss of life and property damage (EM-DAT, 2015; MRC, 2011b).

- The Mekong River Commission (MRC), a flood warning organisation, is located in the case study area. The author received approval from the MRC to conduct the surveys in support of this study (as presented in Appendix 1).
- The existing flood warning system is limited in terms of a real-time delivery of flooding information to alert people in the flood prone areas (MRC, 2011b, 2013b).
- Mobile phone penetration in Laos is high, but Internet access is low (ITU, 2013a, 2013c, 2014b).

1.8 Research Significance

The answers to the research questions are to assist governments and flood warning authorities to examine the effectiveness of the current flood warning systems and the appropriateness of the technologies used. This is determined by evaluating accessibility, affordability and acceptance of adopted technologies. This study also enables government and the flood warning organisations to understand the most beneficial technologies to use for flood warning systems for a specific area. In particular, choosing technology that will be suitable and accepted by the residents in the affected areas.

Answering the research questions is crucial for the flood warning organisations to understand the important factors that lead to the acceptance of flood warning service for a specific flood prone area. Using available technology for flood warning systems in a flood area does not necessarily mean that the flood warning system is used by residents due to lack of technology skills or being unaffordable. Susanto (2012) stated that popularity of SMS does not guarantee that SMS-based e-government services are used by citizens.

This study contributes reflection and evaluation to governments and flood warning organisations of countries in which there is not yet a flood warning system. This will assist them to select technologies which may be accepted by the residents in flood prone areas. This research will guide to them to design and initiate effective flood warning systems by identifying technologies and systems which are suitable and acceptable by residents in a flood risk area.

This study contributes knowledge to the environment institutions, the government practitioners, forecasting and warning authorities and event researchers who are currently developing and intend to develop a flood warning system. This study also provides theoretical and practical contributions for future studies on adopting appropriate technology and its acceptance in flood risk communities.

1.9 Structure of the Thesis

This thesis comprises nine chapters which contain important research contributions. An overview of the structure of this thesis is presented in Figure 1.2, and the thesis is organized as described below:

Chapter I: Introduction

This chapter has focused on the problems in general and reviewed several broad issues of the research fundamentals namely, 1) research background; 2) research problems; 3) research justification; 4) the research aim, research objectives and research questions; 5) the scope of study; 6) research methodology; 7) the case study area; 8) research significance and structure of this thesis.

Chapter II: Literature Review

Chapter II reviews the recent studies and the leading reports on types of floods, existing flood warning systems, and available technologies for disaster warning systems. This chapter also explores mobile phone development and SMS services across the globe, the best practices for the adoption of SMS technology in various services, including SMS in business, in education and SMS for flood warning systems in developing countries. Finally, this chapter introduces technology acceptance models which guide the researcher to create a research model. This chapter contributes to the answer to the research question 1 (RQ1).

Chapter III: The Case Study Area

This chapter describes an overview of the case study area, where the surveys were conducted and where the trial of the proposed system was carried out. This chapter then gives reasons for choosing this case study approach. A general description is provided of the case study area characteristics: a country profile and topography, type of floods, the existing flood warning system, flood management plan and ICT development. The existing flood warning system is reviewed and limitations in it identified. This chapter also contributes to the answers to the research question 1 (RQ1).

Chapter IV: **Research Methodology**

Chapter IV deals with research methodology for this study, an explanation of why a case study has been chosen for the research, followed by an introduction to the research design, data collection process and data analysis techniques. Finally, the ethical consideration for this research is included in this chapter.

Chapter V: The Surveys

This chapter presents two surveys, the paper-based field survey and the online survey. The paper-based survey was used to evaluate the resident's views about being ready to use an SMS-based flood warning system in the case study area. The online survey included the views of the flooding experts who worked in the flood warning systems of the case study area. The online survey assessed technical perspectives related to the possibility of using an SMS-based flood warning system in the case study area. Chapter V compares and discusses the results from both surveys and answers research question 2 (RQ2).

Chapter VI: **Model Development and Testing**

This chapter proposes a research model and tests the hypotheses of the research model. The chapter covers how the research model was developed, including questionnaire, research constructs, hypotheses development and explanation of how to inferentially analyse the collected data. Finally, this chapter presents findings by applying exploratory factors analysis (EFA), confirmatory factor analysis (CFA), validating the construct measures, estimating a model-it and reporting the results of the hypotheses tests. This chapter answers to the research question 3 (RQ3).

Chapter VII: Trial of the Proposed System

This chapter describes and presents the process of the trial including introducing locations, software and hardware used for the trial, mobile phone providers, types of handsets, and explaining how data was collected and analysed. This chapter presents the results of the trial, followed by drawing conclusions and addressing limitations of the trial. This chapter answers research questions 4 and 5 (RQ4 and RQ5).

Chapter VIII: General Discussion

This chapter discusses the results of this research by describing and discussing the descriptive analysis of the surveys from Chapter V, inferential analysis of the research model and testing of the hypotheses from Chapter VI, and the descriptive analysis of the trial of the proposed system from Chapter VII.

Chapter IX: Conclusion and Future Work

Finally, Chapter IX briefly summarizes outcomes of all chapters including whether this study achieved the research aims and objectives and answered the research questions or not. Then the theoretical and practical contribution of the study is presented. Finally, limitations and future work directions are outlined.

Research Structure

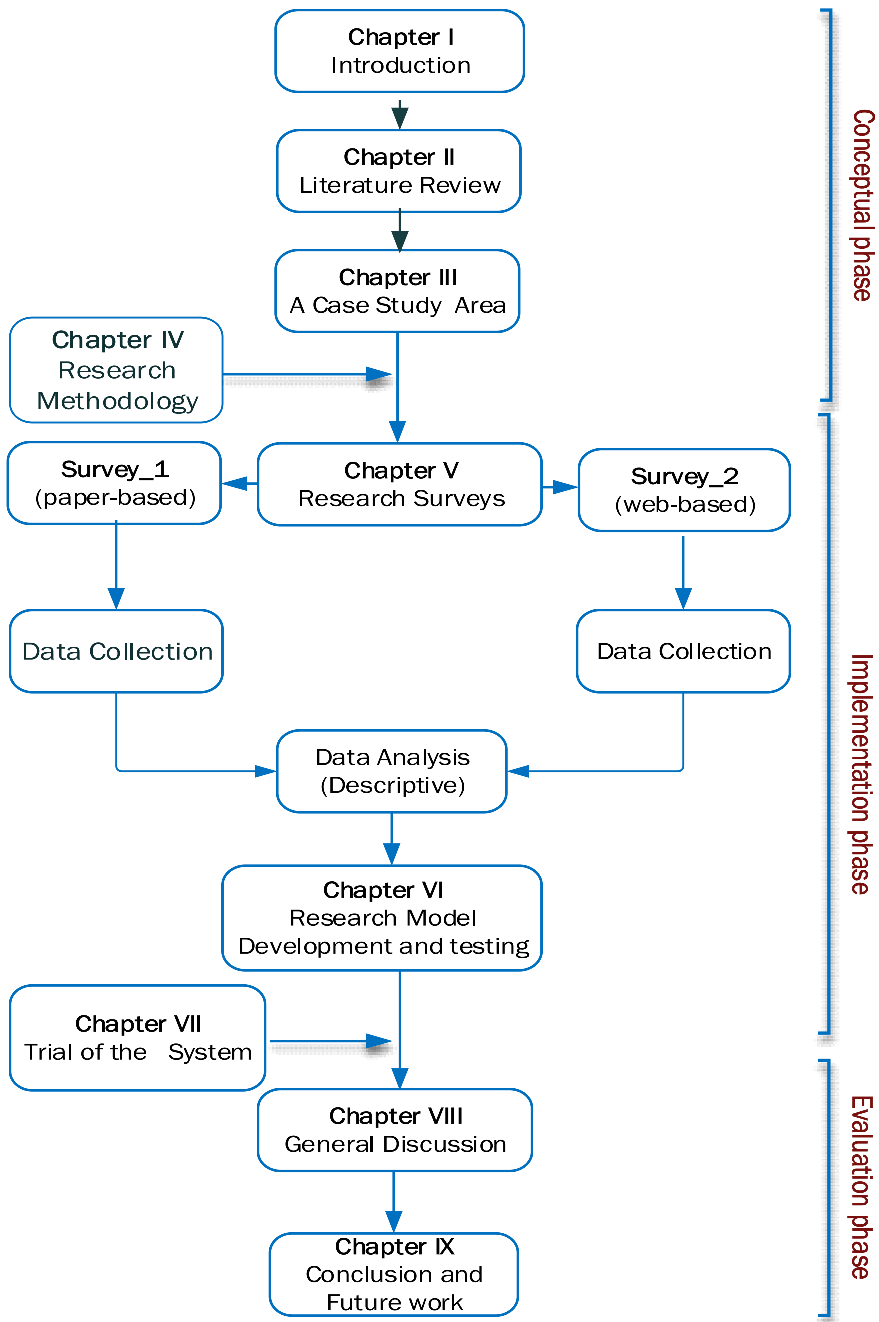


Figure 1. 2: Map of the dissertation

CHAPTER II : LITERATURE REVIEW

This chapter reviews the literature related to types of floods, flood warning systems, and available technologies for disaster warning systems. This chapter also explores mobile phone development and SMS services cross the globe, and the best practices for adoption of SMS technology in various services in developing countries. Finally, this chapter introduces technology acceptance models which guide the researcher to create a research model to test hypotheses for this research. The literature reviewed appeared in the leading reports and journals such as the United Nations reports, the World Bank reports, the ITU reports, the Mekong River Commission reports, the International journal of Future computer and communication, International journal of innovation, management and technology, and online databases including Google Scholar, Science Direct, IEEE Explore, ACM Digital Library and ProQuest.

2.1 Types of floods

There are several definitions and classifications for floods in the relevant literature. Flooding is defined as *"temporary covering by water of land not normally covered by water"* as a result of heavy rainfall (Barredo, 2007, p. 125). Floods are usually classified into three main types: a river flood, a flash flood and a coastal flood(Maddox, 2014).

2.1.1 River floods

River floods are a slow rise of water level and water spilling over river banks. River floods are generally the result of water from heavy rains caused by monsoons, hurricanes, tropical storms or snow melts upstream exceeding the capacity of rivers and their tributaries. River floods are usually the combination of several factors and time of the year in a given region, i.e., weather, soil conditions, measures for flood protection and land use(Barredo, 2007).

In Europe, this type of flood can be related to season: in summer/autumn, a river flood occurs from high rain fall, while in winter/spring it is triggered by rainfall and can be partly connected with snow and ice melt. In tropical climate countries, like in the Mekong River Basin, river floods result from intense rains and tropical storms. River floods can also occur if the free flow of a river is temporarily blocked by natural obstructions or human activities. River floods can lead to major losses of livestock, damage to crops and extensive damage to infrastructure. This may also result in isolation of the communities and loss of lives(MRC, 2011b).

2.1.2 Flash floods

Flash floods are brought about by the convective precipitation of large volumes of water from heavy rain, intense thunderstorms or water suddenly released from an upstream storage where the drainage system is insufficient to cope with the flow. Flash floods may occur after the collapse of a human structure such as a dam or a reservoir. Among the factors that contribute to this type of flood are rainfall intensity, rainfall duration, surface conditions and topography. Flash floods occur usually less than six hours after heavy rain and they lead to the greatest threat to loss of life(BOM, 2015; MRC, 2012).

2.1.3 Coastal floods

Coast floods are extreme tidal conditions including high tides, storm surges and tsunamis. Coast floods are generally caused by windstorms, including hurricanes, cyclones and typhoons. Strong winds and low atmosphere pressure combined with high tides cause sea level to rise above normal, forcing sea water inland and producing flooding. These floods also result from tsunamis which are caused by earthquakes and by high tides causing water in a river to back up resulting in a flood. Examples of coastal floods those due to the cyclone that hit the Philippines in 2013, and the coastal foods resulting from tsunamis that hit Indonesia and Japan in 2004 and 2012 respectively(Hubbard, 2012; Jonkman & Vrijling, 2008).

To minimise the loss of lives, damage to properties and to mitigate the impact on affected communities, a number of countries and organisations have initiated and have been improving flood warning systems as can be seen in the next section.

2.2 Flood Occurrence and impacts

A flood is a natural hazard that occurs due to heavy rain, cyclones and rain storms and leads to extensive property damage and loss of life for people living in flood prone areas. Table 2.1 shows that 361 natural disasters occurred worldwide in 2013, killing 23,583 people and affecting over 99.9 million people. The estimated amount of economic damage came close to US$119 billion (ADRC, 2014; EM-DAT, 2015). As shown in the Table 2.1, floods were dominant among all natural disasters in terms of occurrence (41.3%), the number of people killed (41.7%), the number of people affected (32.1%), and economic damage (44.5%).

Table 2. 1: The impacts of Natural Disasters in 2013 (ADRC, 2014)

Disaster Type	*Impact*							
	Occurrence (share in %)		Killed (share in %)		Affected (share in %)		Damage (US$ million) (share in %)	
Drought	12	(3.3%)		(0.0%)	11,223,522	(11.2%)	2,547	(2.1%)
Earthquake	28	(7.8%)	1,120	(4.8%)	7,031,162	(7.0%)	9,075	(7.6%)
Epidemic	25	(6.9%)	922	(3.9%)	93,438	(0.1%)		(0.0%)
Extreme temperature	17	(4.7%)	2,142	(9.1%)	270,016	(0.3%)	1,000	(0.8%)
Flood	149	(41.3%)	9,823	(41.7%)	32,050,807	(32.1%)	53,175	(44.5%)
Mass movement	12	(3.3%)	281	(1.2%)	1,033	(0.0%)	8	(0.0%)
Storm	105	(29.1%)	9,215	(39.1%)	49,124,353	(49.2%)	52,492	(44.0%)
Volcano	3	(0.8%)		(0.0%)	105,106	(0.1%)		(0.0%)
Wildfire	10	(2.8%)	35	(0.1%)	8,831	(0.0%)	1,072	(0.9%)
Total	361	(100.0%)	23,538	(100.0%)	99,908,268	(100.0%)	119,369	(100.0%)

Developing countries seem to be more vulnerable to flood impacts than developed countries. Examples of flooding in both developing and developed countries include the following cases:

The 2010 Pakistan floods began in late July 2010, as a result of heavy monsoon rain; the floods resulted in more than 2000 deaths and directly affected 20 million people via property destruction worth U$40 billion (Webster *et al.*, 2011). During 2013 the Philippines suffered heavy floods caused by Typhoon Haiyan as a result of the flood and storm more than 6,201 people died, 14 million people were effected and total economic impact was $U13 billion. In 2010, massive floods affected the Lower Mekong Basin countries of Cambodia, Laos, Thailand and Vietnam. In this flood, 98 people were killed, 5 million people were affected and the total property damage was U$1.2 billon(MRC, 2010, 2012).

A number of floods hit Australia during the years 2011 and 2015 across Queensland, New South Wales and Victoria. In 2011, floods forced the evacuation of thousands of people from towns and cities, damage was in excess of $A15 billion, over 200,000 people were affected and 35 people died (Brecht, 2011). In 2012 significant flooding, due to Hurricane Sandy, hit New York and New Jersey in the USA. The preliminary damage estimates were near U$50 billion, 8.5 million people were affected and there were about 100 directly related deaths (Blake *et al.*, 2013; Roux, 2012). An extreme flood in central Europe during June 2013, due to heavy rain, swept through Germany, the Czech Republic, Austria, Slovakia and Hungary. Thousands of people were evacuated from their homes in flood prone areas. The total cost of the damage was about €12 billion and at least 25 deaths were reported(Grams *et al.*, 2014).

It is worth pointing out that developing countries have been more vulnerable to flooding impact than developed countries. The International Disaster Database, EM-DAT (2015) showed that Asia ranked top in all the indices of flooding occurrences, and developing countries ranked top in the number of people killed and affected, and economic damage between 2010 and 2015.

Even though flood warning systems have been developed and implemented worldwide, people are still affected by annual floods in developing countries. Thus, flood warning systems are reviewed in the next section.

2.3 Flood Warning Systems

2.3.1 Concept of a flood warning system

According to previous studies and governmental reports, flood warnings are defined in various ways. The European Emergency Number Association defined a public warning as a capability to bring to the immediate attention of all people who might be directly impacted following the predicted danger so that they can take action to mitigate the impact of this incident (EENA, 2012). Wattegama (2007), defines a warning as a communication of information about a hazard of threat to population at risk in order for them to take appropriate action to mitigate any potentially negative impacts. A flood warning is the information provided in advance of floods that may occur in the near future, it must reach the users without any delay and with sufficient lead time to permit response actions to take place (Rahman *et al.*, 2013). The report of UNEP (2012) states that early warning is the provision of timely and effective information through identified institutions that allows individuals exposed to hazard to take action to avoid or reduce the risk and prepare for effective response.

According to the Australia Emergency Manuals Series, the purpose of a flood warning is to provide an advise on possible flooding so people can take action to minimise its negative impacts (AEM, 2009). The United Nations for Disaster Risk Reduction describes an early flood warning system as being composed of three main elements, *detecting and forecasting* (identifying extreme events to formulate warnings), *disseminating* warning information (alerting people) and *responding* (taking action to mitigate the impact of floods). The flood warning system also must be comprehensible and accessible and deliver clear and concise messages to all users (UNISDR, 2004a).

The Mekong River Commission report framed the flood warning system as a process of data collection, flood forecast and dissemination. The data collection includes data measurement and data transmission, flood forecast combines data analysis and creation of a flood forecast, and dissemination is the issuance of flood information to people in an affected area. The same report also describes the flood warning system having three threshold stages of warning: no warning, preparation, and severe flood (MRC, 2010, 2011b).

Early warning can save lives and property but cannot prevent all damages. Several countries have significantly reduced death by developing an effective early warning system. For example, the Bangladesh cyclone early warning system allows people to evacuate to safe shelter hours before the cyclone makes landfall, reducing death. Specifically in the 2007 cyclone there were 3,000 deaths compared to 300,000 deaths due to the cyclone in 1970, even though the two cyclones had similar characteristics(Pearson, 2012; Rogers & Tsirkunov, 2011).

The notion of "effective flood warning system" has been addressed by reports from many International organisations. The World Bank report stated that an effective system needs to have a well-integrated system of data collection, monitoring and information dissemination, while the Untitled Nations report claimed that taking action in response to floods is the main activity for a flood warning (UNISDR, 2015; World Bank, 2012)

A number of different types of flood warning systems could contribute to minimising the impact of floods across the globe, but effectiveness depends on countries, regions, management and policies as mentioned in the next section.

2.3.2 Worldwide Flood Warning Systems

Historically, floods have destroyed lives and damaged property around the globe. Developing countries have been harmed by floods more than developed countries (Peduzzi *et al.*, 2009; UNISDR, 2009). A number of flood warning systems are increasingly considered to be an integral component of preparedness, warning and mitigation for people in the risk areas, some warning systems are more effective than others, and existing ones are still in need of improvement(Pearson, 2012). The following section contains descriptions of implications and use of public warning systems for natural disasters in developed and developing countries.

2.3.2.1 In developed countries

Since 2005, Australia has deployed a flood warning system called "*the total flood warning system (TFWS)*"(Studdert, 2009). The concept of the TFWS includes monitoring and prediction, interpretation, message construction, communication, protective behaviour and review as it can be seen in Figure 2.1

- *Monitoring and prediction:* detecting flooding and predicting flood status during flood
- *Interpretation:* identifying in advance the impact of the prediction on communities at risk
- *Message construction:* devising the content of the message which will warn people of impending flooding
- *Communication:* disseminating warning information in a timely manner to people in the risk areas
- *Response:* generating appropriate and timely actions from the threatened community and from the agencies involved
- *Review:* Examining the various aspects of the system with a view to improving its performance.

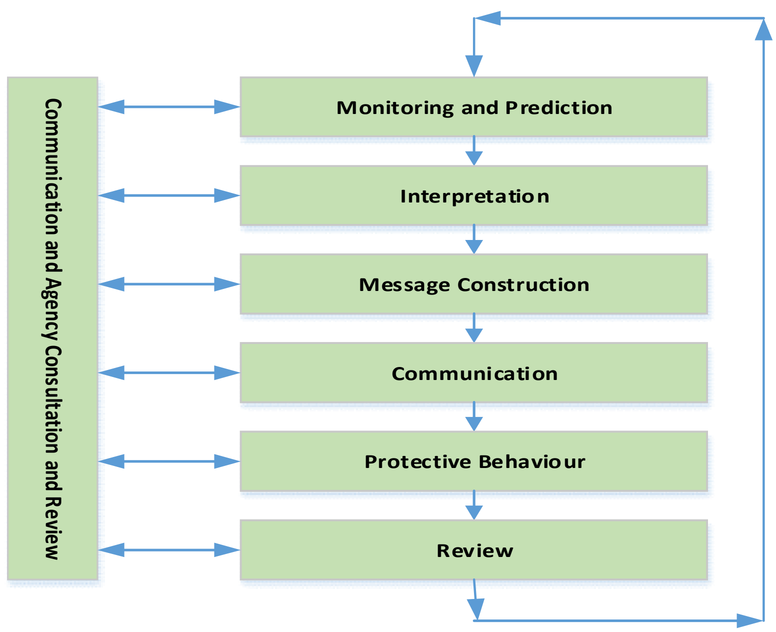


Figure 2. 1: The components of the total flood warning system (Studdert, 2009)

This system used a range of techniques and technologies. For example, "communication" has general and specific targeted audiences. The general warnings are disseminated to whole communities by broadcast media such as radio, television station and Internet, while specific warnings are used for alerting households or individuals in the flood effected area by means of telephone, mobile phones, SMS, two-way radio and door knocking.

Figure 2.2 illustrates general and specific warnings from quick to slow dissemination. For the total flood warning system to work effectively, the components must all be present and integrated rather than operating in isolation from each other. The specific warnings serve to reinforce and confirm the general warnings (Barry, 2008).

More quickly disseminated	**General warning**	**Specific warning**
↓ More slowly disseminated	***Radio message:*** Break-in community announcements or interviews with flood warning forecasting or emergency service staff. ***Television:*** Messages run across the screen during new or ad breaks. ***Scheduled news bulletin:*** many take longer to go to air. **The internet**(websites) ***Notice boards:*** Community or tourist information boards in town centres ***Newspaper:*** local or regional	***Telephone:*** Voice mail and automated mass dialling with tape or digitally-recorded messages intended to be heard by numerous households simultaneously. ***Facsimile:*** Especially for businesses and institutions ***Computer links:*** emails ***Two-way radio:*** packet radio ***Loud hailers:*** public address system or sirens, either mobile(on police or fire vehicles) or fixed in one place ***Doorknocking***

Figure 2. 2: General and specific communication modes(Studdert, 2009).

Other developed countries like Norway, Sweden, Japan, Chile and the United States have been using a wide range of methods and technologies for their warning systems to alert the public about natural hazard threats such as floods, tsunamis and hurricane. Norway has implemented a public warning for natural disasters in combination with sirens, fixed phone and mobile phones. The system is based on electronic sirens delivering a warning to citizens simultaneously, SMS alerts to mobile phones used by national authorities and fixed phone alerts used in local areas(UMS, 2014). A similar system has been used by Sweden where the system consists of around 4,500 sirens (EENA, 2012)

The leading Japanese mobile phone operator, the NTT Docomo, has offered their cell broadcast service since 2007. The service is called "the Earthquake and Tsunami Warning System" (ETWS) which can deliver a warning for impending earthquakes and/or tsunamis to mobile devices within four seconds(Docomo, 2012). However, users on the NTT Docomo network are provided with a handset that has a specific configuration menu that allows them to choose whether to receive earthquake and/or tsunami warnings or not. The menu also allows users to select the volume and duration of the ringtone dedicated to an emergency message (JMA, 2013).

In 2010, after suffering from one of the worst earthquakes in Chile, the Chilean government decided to deploy an adequate emergency alert and notification system. The system is a multi-channel alert and notification system using *cell broadcast* technology and expanded in the future through notification over TV, radio, siren and Internet(One2many, 2012).

The United States operates the Integrated Public Alert and Warning System (IPAWS) sending an alert about natural hazards to the public(FEMA, 2012). The system allows a single emergency alert message to be delivered to multiple communication systems as shown in Figure 2.3. The integrated system has been considered to be effective, reliable, flexible and comprehensive in alerting people in case of emergency. Messages are originated by the alerting authorities (federal, state or local level) using a range of national and local alert systems which receive weather data via the Internet. The messages go to the IPAWS servers that gather the messages and authenticate them, the messages are then transmitted to the public through multiple paths: the Emergency Alert, Wireless Emergency Alert (WEA), Internet Service, National Oceanic and Atmosphere Administration, and state and local alerting systems(Lucero, 2013).

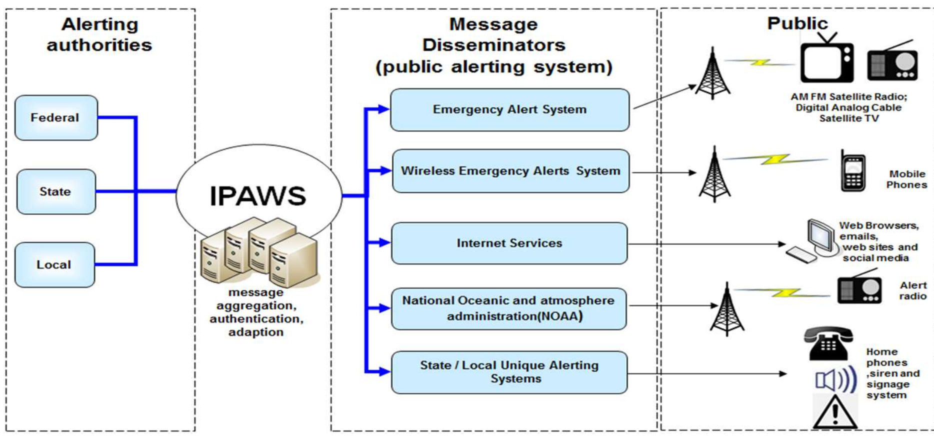


Figure 2. 3: The IPAWS Architecture in the United States (Lucero, 2013)

2.3.2.2 In developing countries

Developing countries have adopted flood warning systems to warn their citizens living in flood prone areas by using various methods and techniques.

In China, flood forecasting and warning systems have been implemented by setting up hydrological stations nationwide, including rainfall and water level stations. The data is transmitted via mobile phone networks, two-way radios, and satellite to the central government every hour. Hydrological models and geographic information system (GIS) software are used for flood forecasting. Flood warnings are issued through the broadcast media to the public, and via telephone and SMS messages to flood control offices, including country, town and village levels. The system allows users to make inquiries of the database, and presents data in web-based GIS format with visual alert information, but the system does not have real-time warnings to people in a flood risk areas (Ma, 2010; Yoshiaki & Jonh, 2012).

Because of its geographic location, the Philippines is exposed to a variety of hazards such as annual typhoons and floods. Before disseminating a flood warning to the public, hydrological data (rainfall, water level and water flow) are collected at regular intervals and sent to the central forecasting offices through radio communication, telephone and email for analysis and to prepare the flood bulletins. The national and local broadcast media is the most direct channel through which a warning reaches the public. People in the community often use their indigenous knowledge to determine whether their places will be affected by hazards or not (Garcia, 2007).

Bangladesh is a flood-prone country and extreme floods inundate more than half of the country almost every year. In the existing early flood warning system the hydrological data (rainfall and water level) for forecasting are received from the radar stations to the Flood Forecasting and Warning Centre and combined with the data from the gauge reader staff (through mobile phone calls). A decline in data quality has been found, which impacts on the data accuracy for the flood forecasts. Disseminating flood information in Bangladesh to the public is through broadcast media, websites and the local dissemination points using mobile phones (DANIDA, 2006). A recent study shows that Bangladeshis living in the flood-prone areas are receiving little information about floods through the existing warning dissemination media like TV, radio and newspapers, and the majority of them get flood information from local authorities and words of mouth from their neighbours (Rahman *et al.*, 2012). Another study conducted by Rahman *et al.* (2013) pointed out that radio, TV and SMS are the preferred means respectively for early flood warning system in Bangladesh, but the SMS-based warning needs to be in the local language.

South Africa suffers from annual floods. As part of the early warning system for flood forecasting and issuing warnings, real time data are transmitted from three sources (observation stations, radar and satellite) to the weather service centre. The received data is processed at the centre using effective flood forecasting models to produce flood forecasts. In the case of a flood, the information is distributed to communities at risk through mass media (radio, TVs and newspapers) and through the disaster management centre by emails, faxes, Internet, emergency telephone calls and SMS messages. Moreover, communities can access the forecast information and flood status from the monitoring website (Poolman, 2012).

The Mekong River passes through Laos which is affected by annual floods during the monsoon season. The flood warning systems in the country are operated by the Department of Meteorology and Hydrology (DMH) and the Mekong River Commission, MRC (MRC, 2013b). To collect data to support the systems, the data centres receive real-time data at 15-minute intervals from the monitoring stations along the Mekong River and its mainstream tributaries via the Global System for Mobile communication (GSM) networks (MRC, 2011b). For flood forecasting, the data is processed and prepared bulletins are issued twice a day during the monsoon season. For real-time monitoring, the real-time graphs of water level and rainfall are created and published online(MRC, 2013b). In the case of floods the flood information is mainly disseminated by public media through radio, television stations and newspapers. The DMH also shares the flood information with the Disaster Management Committee (DMC), including national, provincial and district committees to act as a first contact point for the warnings as illustrated in Figure 2.4.

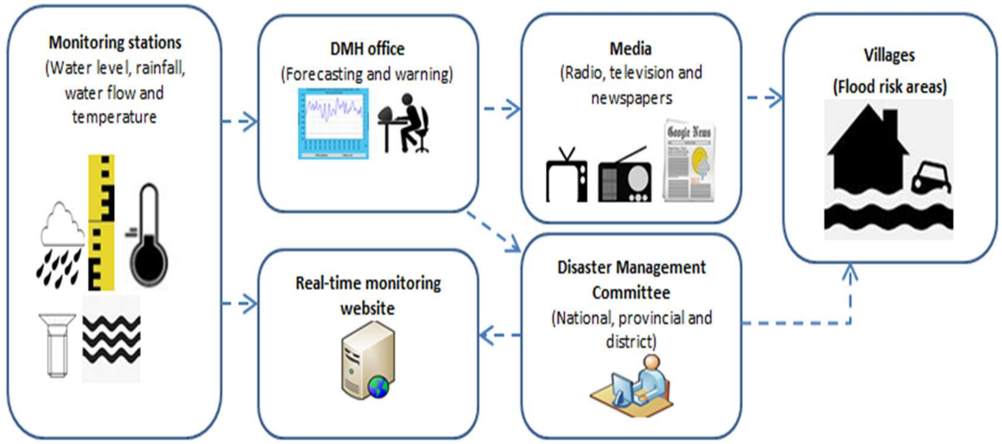


Figure 2.4: Flood warning systems in Laos (Garcia, 2007; MRC, 2011b).

With the aim of preventing loss of life from disasters such as the case of the 2004 Tsunami in the Indian Ocean, the Indian government developed an alert system which could disseminate warning messages to people in specific areas in their local languages. The system, called Geneva Natural Disaster Information System (GNDIS), is a joint project between the Geneva Software Technologies and India authorities. The system is a multi-lingual cell broadcast service that is capable of sending text alerts in the event of an emergency through mobile phones in over 100 languages including English and all regional languages of India. The system was basically designed to disseminate warnings in the case of a tsunami within 30 seconds, but the system could also be used to warn of other types of emergencies such as floods, cyclones or epidemics. However, the user needs to equip and configure their devices with a subscriber identity module (SIM) that is compatible with GNDIS (Aloudat & Michael, 2011; Kamal, 2015).

In brief, in developing countries flood warning systems are mostly based on mass media (radio and television stations) and newspapers, while in developed countries flood warning systems are integrated and distribute emergency warnings to people in the risk areas through multiple channels.

2.4 Technologies used for disaster warning systems

This section reviews a wide range of communication technologies used in natural disaster warnings and potential technologies to be used. These technologies include radio and television, amateur radio and sirens, Internet and emails, instant messaging, telephones, SMS messaging and cell broadcasting.

2.4.1 Radio and Television

Radio and television are traditional electronic media that have been broadcasting worldwide for many decades. These media convey information to people around the world. Today radio and television play an important role in transmitting information across cultures and countries. For warning about a national disaster, radio and television can be used to spread a warning more quickly to a broad population than other communication technologies such as the Internet or mobile phones. For example, in Australia, radio and television are popular to warn the public about bushfire and flood threats (Studdert, 2009). In Bangladesh, radio can reduce the potential death toll of cyclones due to it being easily understandable with language-appropriate warnings. In the Lower Mekong Basin countries like Laos, the radio and television is a main medium of communication for weather reports and flood warning (MRC, 2011b, 2013b). Drawbacks of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off (Wattegama, 2007).

2.4.2 Amateur radio and Sirens

Amateur radio or *ham radio* can be used to warn to people in a community during disaster in the event that traditional communication infrastructure breaks down. In such a situation, amateur radio operators transmit emergency message on voice mode to people in the affected areas.

Sirens are an effective warning system for outdoor use especially in areas with special warning needs such as dams, chemical plants, and populated coastal areas such as beaches in the case of tsunami warnings. Sirens can be used in a scalable way from one siren to whole areas and are also able to make spoken announcements (Wattegama, 2007).

2.4.3 Internet and Email

The Internet, including emails, can play a role in disaster warning, but its effectiveness depends on the Internet's penetration and access within the community of the risk area. Reports (ITU, 2013a, 2014a; UNISDR, 2009; Wattegama, 2007), suggest that while the Internet can play a prominent role in developed countries, where almost all homes and offices have an Internet connection, this is not the case in developing countries. The ITU report emphasises that in many developing countries, less than 5 percent of the population use the Internet and even those who are users do not use it on a regular basis.

Although instant messaging (SMS on Internet) like Facebook or Twitter has been popular in recent years, mobile Internet penetration is low in developing countries with just 21 percent of mobile internet use in developing countries by the end 2014. The United Nation report on ICT for disaster management highlighted that significant obstacles impeding widespread Internet usage in developing countries were economic, cultural, linguistic and administrative constraints (ITU, 2014a;

Wattegama, 2007). With this situation in developing countries, it is difficult to expect Internet, emails and instant messages to be suitable for flood warning.

2.4.4 Instant messaging

Greater smartphone penetration allows for potentially more use of instant messaging. Instant messaging (IM) is a communication technology used for text-based communication between two or more participations over the Internet. In other words, IM is an SMS on the Internet like Facebook Messenger, WhatsApp and Twitter.

It is worth noting that, in recent years, increasing use of smartphones has driven SMS-like instant messaging. According to an ITU report, written by Soto (2014), the most popular instant messaging services today include Facebook, WhatsApp, Skype, Viber and Line. According to the same report, in the first quarter of 2014 the number of active users of Facebook and WhatsApp reached 680 and 500 million users respectively, and this number is increasing. The study by Church and Oliveira (2013), indicates that IM applications have features attractive to smartphone users. For instance, WhatsApp is a cross-platform instant messaging application allowing smartphone users to communicate regardless of their brand of phone. It enables users to send and receive text messages, images, video, audio and location-based information in real-time to individuals and groups. WhatsApp also provides delivery notification, highlighting when a message is sent and when it is delivered to the recipient device. However, all IM applications require a mobile internet connection to function, and both parties must have the proprietary software installed on their mobile phones. Figure 2.5 shows the top instant message applications with their available features and active users.

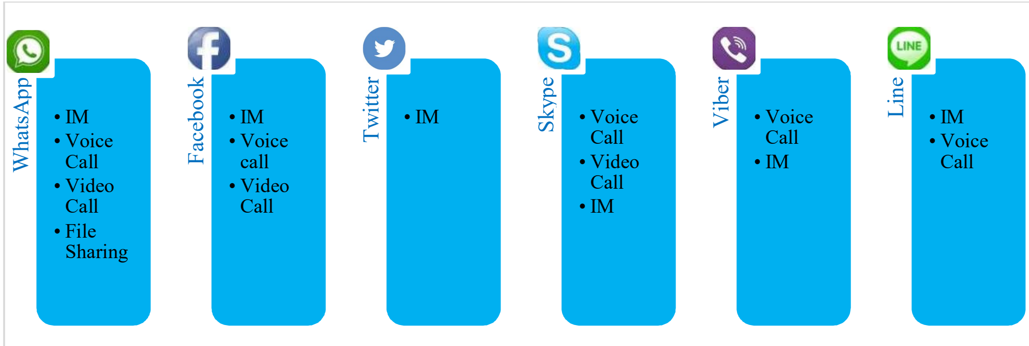


Figure 2.5: The top instant message applications

Increases in the number of IM subscribers results in the question about the impact of IM on traditional SMS services. Portio Research has identified that worldwide SMS traffic reached 8.3 trillion messages by end of 2014 and will continue to increase until reaching a peak in 2015, after which it will start declining. IM message service has overtaken the SMS service in North America, Europe and the Asia Pacific region (Whitfield, 2014).

The growth in use of IM applications is dependent on a number of factors: 3G penetration, smartphone ownership and price sensitivity (Portio Research, 2013; Soto, 2014; Whitfield, 2014). Another survey reports that the key driver behind the decline in SMS use is smartphone penetration increase which leads to users shifting away from SMS to IM application (Facebook, WhatsApp). For example, SMS traffic has declined since 2012 in the United States, Canada, some EU countries, Japan and Korea.

As reported by the ITU, by end of 2014, globally mobile broadband (3G or 4G) penetration reached 32 users per 100 inhabitants, 84 users per 100 inhabitants in developed countries and only 21 users per 100 inhabitants in developing countries (ITU, 2014b). Low penetration of mobile broadband in developing countries can result in lower usage of IM applications. Surprisingly, Japan is home to IM application *Line* and South Korea is home to *Kakao Talk,* both countries are huge IM players, yet SMS usage in Japan and Korea is still high.

2.4.5 Telephones

Telephones including landline and mobile phones can play an important role in warning communities about the impending danger of a disaster, where telephone technology is available (e.g. coverage of mobile phone network). A report conducted by ICT for Disaster Mitigation and Preparedness claimed that in a small coastal village timely telephone call warnings about the impending Indian Ocean tsunami in 2004 saved the village's entire population of 3,600 inhabitant, as well as those of three neighbouring villages (Subramanian, 2005; Wattegama, 2007). However, there is a possible disadvantage to using telephones for disaster warnings due to the congestion that may occur immediately before and during a disaster, resulting in phone calls in that vital period not being completed.

2.4.6 Cell broadcasting

Cell Broadcast (CB) is a message service of point to multipoint broadcast. It is a one way communication system sending to all mobile handsets in the specific area. It is similar to radio broadcasting (Sillem & Wiersma, 2006). Several studies and reports such as (GSMA, 2013; One2many, 2012; Sillem & Wiersma, 2006) emphasised that CB technology works on a one-to-many basis so that one message can be sent to many millions of devices instantly. The CB always reaches all handsets even during peak periods (busy time) because of its own dedicated channel, meaning the CB messages are always guaranteed to reach all handsets within a few seconds.

However, cell broadcast hasn't been widely adopted, although it has garnered interest from many governments across the world for emergency alerts services like

EU-Alert (Europe), WEA (USA), National Message (Israel), LAT-Alert (Chile) and the Earthquake Tsunami Warning System (Japan) (GSMA, 2013).

Others claim that CB technology has been available for a long time but hasn't been adopted for services similar to SMS. They stated that the CB messages cannot be received in the case of a mobile phone that is switched off and the CB broadcaster has no way of knowing who receives the messages (Clothier, 2005; One2many, 2012).

Sillem and Wiersma (2006), pointed out that CB's lack of use is due to its one way communication. If a phone switches off or is out of a coverage area, the CB message will not be received by a mobile phone user at a later time. Another drawback of CB is its activation; each mobile phone needs to be activated in order to receive the CB messages. According to the pilot study, conducted by Sillem and Wiersma (2006), they claimed that activation of a mobile phone to the cell broadcast channel is one of the main issues for users adopting this technology. Table 2.2 provides a comparison between characteristics of SMS service and CB services for a flood warning system.

Table 2. 2: Characteristic of SMS and CBS (Aloudat & Michael, 2011; GSMA, 2013)

Characteristics	Short Message Service (SMS)	Cell Broadcast Service (CBS)
Transmission Type	Messages sent point-to-point	Messages sent point to areas
Message Size	140-160 characters. Maximum of 5 messages can be concatenated	93 characters. Maximum of 15 concatenated pages
Message Type	Messages will be sent only to all registered numbers	Messages can be sent to all numbers or a specific area
Congestion and Delay	Messages may be delayed or lost during a disaster due to network congestion	Congestion unlikely as CBS are sent on dedicated channels. Almost no delay except if received in poor coverage areas
Security	A messages can be spoofed from other phones	Good. Safeguards prevent an outsider sending messages
Reception	Message is received once the mobile is switched on	No reception if the mobile is switched on after broadcasting
Handset Compatibility	All handsets support SMS	Compatible on most handsets except few legacy devices, but may require manual configuration
Delivery Confirmation	A sender can request delivery confirmation	No confirmation of delivery
Transmission Capacity	Depends on network infrastructure. Usually the SMS warning system has the capacity to send 300 messages per second	20 seconds to 2 minutes to all mobile phones within the activated broadcasting channel

2.4.7 SMS messaging

In an SMS service a message is sent point-to-point to a specific predefined set of phone numbers and can be made in different options such as point to point (phone to phone) and point to group (bulk SMS).

SMS is a feature of the Global System for Mobile (GSM), or 2G, communication networks. It is a text messaging service that allows a mobile phone user to exchange short text messages between mobile devices over the mobile networks with Pull SMS and Push SMS services. In store and forward systems, messages are not sent directly to the receiving mobile phone but routed through a number of network nodes whether a device is in or out of range, the messages are stored in the network until delivery at the next opportunity (Fitzgerald *et al.*, 2010).

The SMS service is well known and is popular around the world since the 2G generation (GSM) was first launched in 1992. SMS use can be seen from interpersonal chats for daily life to e-government services (G2C) such as emergency alerts. SMS is used worldwide because of its readiness, basic functions and ease of use. According to GSMA (2013), SMS is familiar to most mobile users worldwide since it is readily available. As stated earlier, by 2013, mobile phone users reached 96%, while the active SMS users were 91% of the world population (ITU, 2013b). Similar research conducted by Portio Research (2013) indicated that more than 8 trillion messages were sent worldwide in 2013, the number of text messages reached to around 8.3 trillion in 2014, and this worldwide SMS traffic will continue to increase in 2015.

Several studies, conducted by ACMA (2014); Grzywacz and Demerouti (2013), report that an SMS message is compatible with almost all mobile phones and network technologies. It does not matter whether the recipient has a smartphone or basic phone, they can send/receive text messages to/from any mobile phone user, and SMS service can work with 2G, 3G, 4G networks and beyond (5G). Others authors, such as Susanto (2012); Susanto and Goodwin (2006) claimed that SMS is one of the basic functions of a mobile device. They also indicated that SMS is easy to read, easy to write and easy to send for most people, even those uneducated.

Table 2.3: Comparison of communication channels (Wattegama, 2007)

Channel	Benefits	Challenges
Radio and Television	Widespread	Takes time to get the warning Limited use at night
Amateur/Community radio	Excellent for poor, rural and remote communities	Not widespread People lose interest if used only in the case of disaster
Sirens	Can be used at night Good in rural areas	Maintenance of the system Cannot disseminate in detailed messages
Internet/Emails	Interactive Multiple sources can be checked for accuracy of information	Not widespread
Telephone (fixed and mobile)	Messages delivered quickly	Problems of authenticity Does not reach non-users Congestion
SMS	Quick Messages can be sent to group	Congestion Does not reach non-users Local language problems
Cell broadcasting	No congestions	Does not reach non-users Local language problems

Table 2.3 shows advantages and disadvantages of different communication technology used in flood warning systems around the world. Despite the disadvantages of SMS services shown in Table 2.2 and Table 2.3, many studies claimed that SMS messages are still a popular technology for people. For example, the European Emergency Number Association (EENA) stated that although criticizing features of SMS due to its congestion in the network and lack of geo-targeting message, many networks of today can cope with these drawbacks. This will make SMS a solid, reliable and efficient means of reaching citizens during matters of urgency (EENA, 2012). Another study concludes that SMS is still considered a more reliable, privacy preserving technology for mobile communication (Church & Oliveira, 2013).

2.5 Mobile phone development

Since the 1970's, the mobile phone communication system has been developed and deployed around the world from the First-Generation to the generation of today, including 1G, 2G, 3G and 4G.

1G, "First-Generation", refers to the first generation of mobile phone communication systems. The 1G was based on the analogue system which transmitted only voice information between radio towers. However, 1G had low capacity, unreliable handoff, poor voice link and no security (Mudit, 2010).

2G, "Second-Generation", uses Global System for Mobile (GSM) Communication and was first used in the early 1990's including GSM850/900 and GSM1800/1900. GSM provides digital voice and data services, and improves transmission quality, system capacity and coverage. The short message service (SMS) is a feature of GSM and was first used from this 2G generation as shown in Figure 2.6.

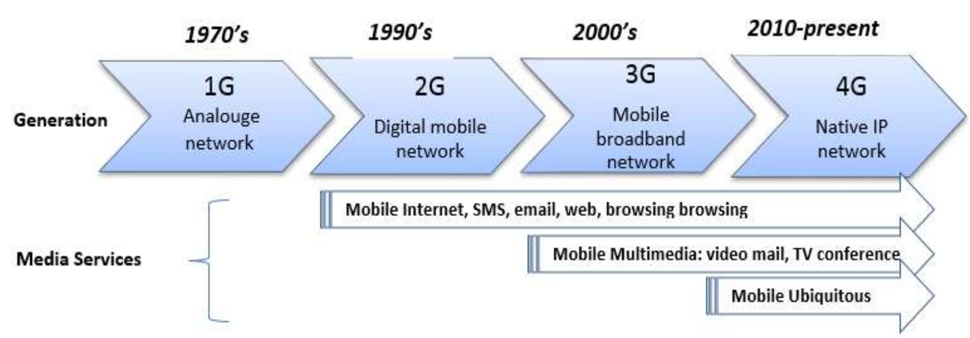


Figure 2. 6: Generations of mobile phone network (Toshio & Tomoyuki, 2005)

3G, "Third-Generation", services are known as Universal Mobile Telecommunications Services (UMTS) were launched in 2001 and provide a variety of advanced multimedia services and high speed internet access. The 3G system is compatible with the 2G technologies such as SMS messages services over GSM (Toshio & Tomoyuki, 2005).

4G, “Fourth-Generation”, was launched in 2010 and is known as the mobile generation with more advanced technology and features. It is basically the extension of the 3G technology with more bandwidth and services offering high quality streaming multimedia over end to end Internet protocol (Mudit, 2010).

Among the four network generations, GSM or 2G is the most successful family of mobile phone standards worldwide and is still used today, particularly in developing countries. These standard technologies (1G, 2G, 3G & 4G) of mobile networks have been used in different proportions worldwide. In Figure 2.7, the mobile market share of GSM (2G) still dominates other generation technologies. In the first quarter of 2014 GSM service was used by over 4.4 billion subscribers representing 65% of the total mobile phone users worldwide, followed by the 3G network with 25% (1.7 billion subscribers) and 4G is used for just 10% (4G America, 2014).

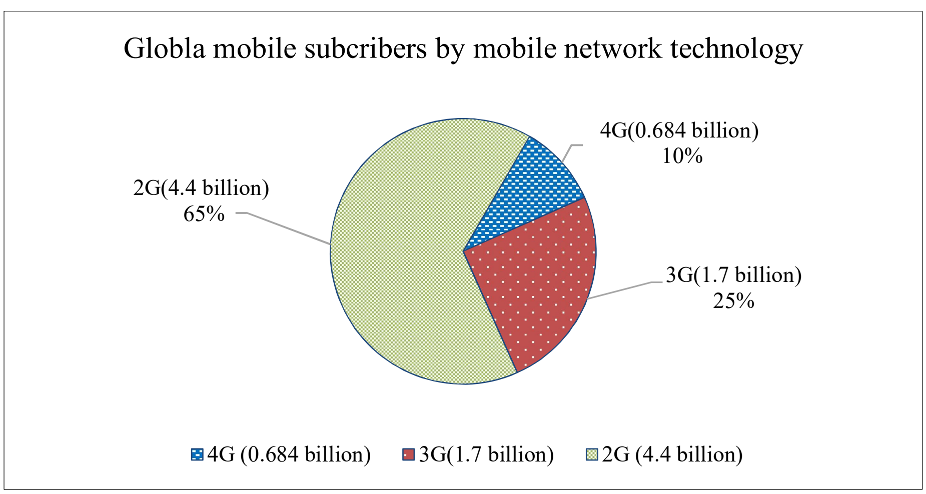


Figure 2.7: Mobile phone network share by technology (4G America, 2014)

The decline in fixed-telephone subscriptions over the past decades was accompanied by strong growth in mobile phone subscriptions. According to figures reported from ITU (2014a), by the end of 2014 the number of mobile phone subscribers (7 billion) had almost reached the number of people on Earth (7.1 billion). In other words, at the end of 2014, mobile phone penetration rates stood at 96% globally: 121% in developed countries; and 90% in developing countries; as shown at Figure 2.8.

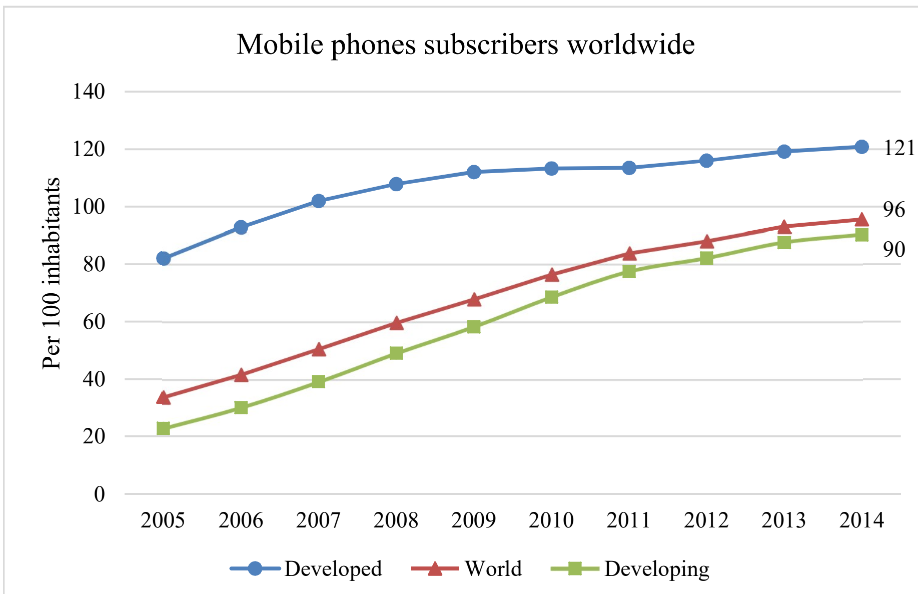


Figure 2.8: Mobile subscribers worldwide(ITU, 2014b)

For developing countries, mobile phone technology adoption is more advanced than other telecommunication technologies like the Internet and fixed phones. According to the ITU (2013a), the percentage of mobile phone usage in developing countries reached 89.4%, compared to Internet access and fixed phones of just 30% and 11% respectively, as shown in Figure 2.9.

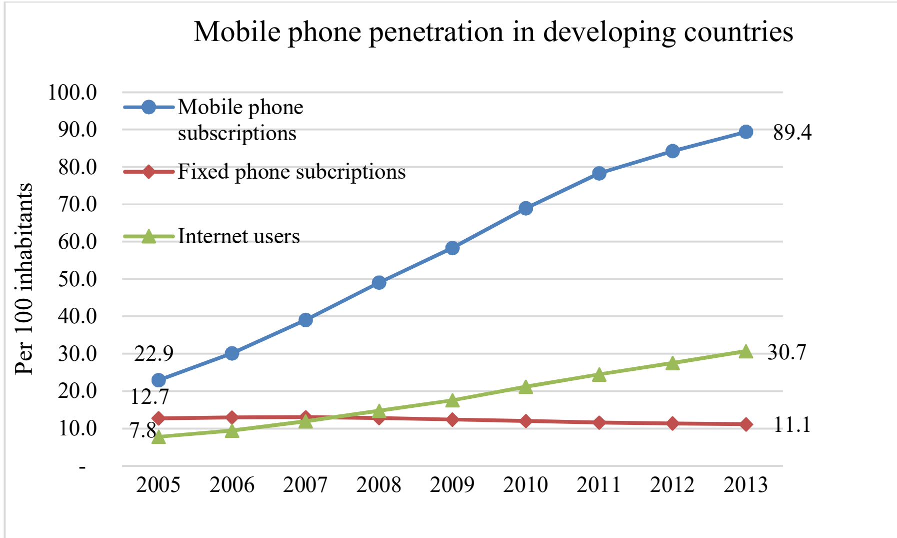


Figure 2. 9:Mobile phone penetration in developing countries (ITU, 2013a).

According to the report by ITU (2014c), developing countries are home to more than three quarters (78%) of all mobile phone subscriptions worldwide (5.4 billion). The continuing increase in subscriptions is occurring mostly in Africa and Asia-Pacific region, where penetration reached 69 and 89 subscribers per 100 inhabitants respectively (ITU, 2014b).The above numbers suggest that global mobile phone users almost reach the world's population. Increasing mobile phone penetration in developing countries can be assumed to drive increasing use of SMS services, which are reviewed in the next section.

2.6 SMS services

SMS services have been initiated and accepted by many organisations and governmental institutions worldwide. SMS services cover a wide range of applications from interpersonal communication to provision of government services. This section introduces the applications of SMS services including SMS-based notification, SMS-based e-government, SMS-based business and SMS-based natural disaster warning.

An *SMS notification* is a Push Mode SMS service in that a number of mobile devices receive the notification (SMS messages) that is pushed from a mobile phone network. Such messages are initiated by a mobile phone user or institution and sent to multiple recipients (Riley *et al.*, 2011). Susanto (2012) pointed out that even if a phone is switched off or is out of signal range, the notification messages will reach mobile subscribers when their mobile phone is on. For instance, receiving a missed call notification or an advertising message from many mobile phone operators are basic examples of an SMS-based notification.

An example use of SMS notification is an anti-truancy SMS messaging system deployed in schools in Czech Republic and the Philippines (Carić *et al.*, 2005; Mojares *et al.*, 2013; Shyam *et al.*). Other SMS notifications called *"eNotice"*, which is deployed by the South Australian government, reminds car owners of an upcoming vehicle registration renewal. This system allows the registered drivers to receive an email or SMS reminder message 7 days and 1 day before the registration is due to expire (eNotice, 2015). In many hospitals and healthcare centres, patients can receive an appointment reminder via SMS on their mobile phones, the patients can subsequently choose to respond to the reminder by confirming, rescheduling or cancelling the appointment(Car *et al.*, 2008; Downer *et al.*, 2005).

A number of countries are initiating SMS functionality in *SMS-based* e-*government services* which provide government information and public services to citizens, businesses and government employees and organisations. The Philippines takes advantage of the fact that many Filipinos own mobile phones with the country garnering a reputation as the “SMS Capital of the World”. As of December 2012, a number of National Government Agencies have SMS facilities to augment traditional public services (ICTO, 2009). The US emergency text alert is a free public service notifying US citizens of an emergency situation by text message(Sampson 2012). In Switzerland, customers of wireless operator Swisscom Mobile (Swisscom-mobile.com) can send an SMS to find the location of their nearest doctor or hospital(Arnet, 2002). For this SMS service, mobile users need only send a text message to a designed short code (key word), the service locates the position of the mobile user and sends back the nearest names and address. In the UK, SMS messages are used for travel information. London’s underground and express airport trains provide free SMS to mobile phone users in the event of delay or cancelation(Lyons, 2006).

During the 2014 election in Libya, an SMS-based voter registration system was developed and implemented. More than 1.5 million people registered using that system, providing Libyan voters with unprecedented access to the democratic process. The system managed over 6 million text messages without incident (Aljazeera, 2014).

There have been a number of businesses promoting their products and services via SMS messages to encourage interaction with users. In particular, many countries have access to SMS banking services. For example, Bangladesh allows their citizens can request their account balance via SMS, and can also sign up to receive automatic salary notification(M. S. Jamil & Mousumi, 2008). Similarly, SMS banking alerts are also implemented by the Bank of America, which offers SMS alerts to their customers so that they can get information about important activity in their checking, saving and credit card accounts(Lamar *et al.*, 2008). Australia’s leading banks

(NAB, ANZ and Commonwealth Bank) offer SMS service for their customers to remind them when credit card payments are due, and of fund transfers and account balances(Flood *et al.*, 2013). In Singapore, SMS-based check-in is available for all Singapore Airline and codeshare flights from most cities in its global network. Passengers can check in and confirm their seat allocation by sending an SMS to the airline mobile number(SMS Check-in, 2015).

SMS-based disaster warning services have been adopted in many countries, both developed and developing countries and is used to warn of tsunami, bushfire and flood. Since 2009, the Australian Government (Country Fire Authority) have sent emergency warnings to citizens of Victoria and New South Wales via SMS to warn them about extreme weather condition and risk of bushfire(Brown *et al.*, 2010). Since 2011 the Queensland Government has sent SMS messages to alert the public about severe floods(Holmes *et al.*, 2012). In the United Kingdom, SMS-based warnings are provided by the Environment Agency. People who register with "Floodline Warning Direct Service" receive an automatic warning by SMS, telephone and email (UKEA, 2013). In the United States of America, the Integrated Public Alert and Warning System allows a single alert message to be delivered over many communication mediums including to mobile phones via SMS (Lucero, 2013). In 2014, the Indian Meteorological Department launched an SMS-based cyclone warning system, the system provides alerts to a wide range of users including disaster managers, targeted users and the general public. The system has resulted in a significant reduction in loss of life and property (Mohan, 2014).

Since the extraordinary tsunami events in the Indian Ocean in 2004 and the Pacific coast of Japan in 2011, SMS-based tsunami warning systems have been introduced and are available to users who subscribe to receive the warnings. For instance, the new SMS-based tsunami warning system launched in India in 2015 will have the ability to send SMS messages immediately to all mobile phones in designated locations where a disaster will strike (Cowan, 2014). In Indonesia, an SMS tsunami early warning with timely service has been deployed for Bali's hotels, one of Indonesia's major tourism destinations (BHA, 2015).

In 2003, the Government of Hong Kong sent SMS messages to allay SARS (Severe Acute Respiratory Syndrome) fears to nearly six million people, but there was network overload resulting in some people receiving the message after six hours and others never receiving it at all (Aloudat *et al.*, 2007; Perron, 2003).

Starting in 2007, Singapore deployed an early warning system as a part of the "lightning risk alert system". Singapore as a country has one of the highest rates of lightning activity in the world with almost 187 days of lightning a year. The system basically tracks and monitors predefined geographic locations of lightning activity. If there is a high possibility for lightning activity in a specific area, the system will initiate warning messages to schools in the targeted areas. A school principal will receive an SMS message that includes information such as a beginning time and duration of that high lightning risk, messages are also sent if the warning is cancelled. The initiative is controlled by the National Environment Agency and the Ministry of Education of Singapore (Aloudat *et al.*, 2007).

A recent and effective SMS-based service was the use of SMS messages to combat an Ebola outbreak in West Africa(Tracey *et al.*, 2015). The SMS alerts were been sent by "the International Red Cross" to remind the people of Sierra Leone showing symptoms of Ebola to seek early advice, avoid physical contact with others, and cooperate with community health workers(Pore *et al.*, 2015). In addition, people could also text back to ask basic questions about Ebola and receive automated responses with information ranging from treatment options to tips for cleaning and medical assistance. In the same vein, Senegal's Ministry of Health, cooperating with the World Health Organisation (WTO), sent 4 million SMS messages to the public, warning of the dangers of Ebola and how to prevent it (Guerena, 2014; WTO, 2014).

These examples of SMS services suggest that mobile phones and SMS are viable mass communication tools. The United Nations report (UNESCAP, 2011) identified mobile phones as one of the best means for dissemination of disaster alerts, replacing radio and television as the best communication channel for reaching communities in disaster areas. The communities can be warned about risks using the common alerting protocol, short message service (SMS).

2.7 Technology Acceptance Model

To answer research question 3 (RQ3), it is worth reviewing technology acceptance models (TAM) in order to create a research model and test hypotheses seeking factors influencing the adoption of an SMS messaging system for flood warning in the case study area. Hence, this section introduces concepts of TAM and its components.

TAM was originally proposed by Davis *et al.* (1989) based on the Theory of Reasoned Action (TRA) and aimed at developing a model for explaining a user's acceptance of computers at work. Later it has been used to study user acceptance of mobile service, mobile internet, and social media (Kaasinen, 2005; D. Lee & Lehto, 2013; W. Lee *et al.*, 2000; Shin, 2007). According to Davis *et al.* (1989), TAM has been extended and tested by many researchers. Studies on information systems (Davis, 1985; Venkatesh & Davis, 2000), used TAM to explain and predict determinants of user acceptance of a wide range of end-user technologies and if the users will actually adopt a system to use in their job. TAM and its extensions are described below.

2.7.1 Technology Acceptance Model 1(TAM 1)

The original TAM or TAM1 was designed specifically to explain computer user's behaviour within the organisational context. Davis *et al.* (1989), pointed out that two particular beliefs, perceived usefulness (PU) and perceived ease of use (PEOU), are main factors in explaining user attitude, intention and their actual use. The external variables affect the attitude toward using and the intention to use via the two beliefs, PU and PEOU (Figure 2.10).

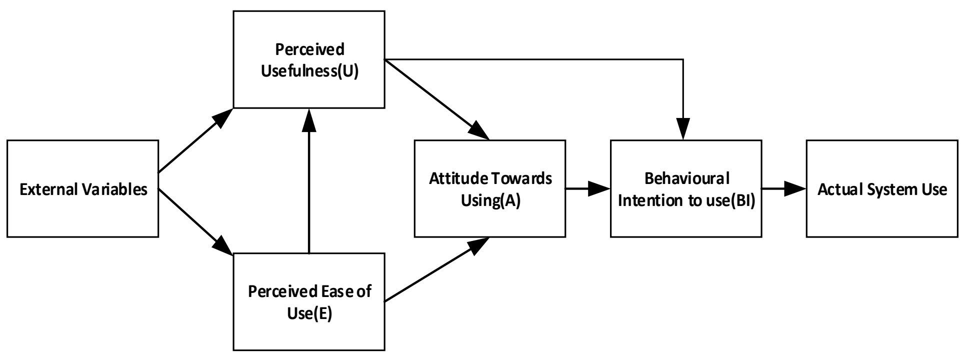


Figure 2.10: The original technology acceptance model

Venkatesh and Davis (2000) found out that "attitude towards using" has little impact in mediating the perceived usefulness and ease of use to intention to use, as a result of which, "attitude towards using" was removed from the original TAM (Davis *et al.*, 1989).

The modified TAM posits that *Perceived Ease of Use* and *Perceived Usefulness* affect the *Intention to Use*, which directly affects *Usage* and *Perceived Ease of Use* also affects *Perceived Usefulness* (Figure 2.11). For TAM, two main beliefs are strong determinants: *Perceived Usefulness* is defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance, and *Perceived Ease of Use* is defined as the degree to which the prospective user expects the targeted system to be free of effort or is easy to use (Davis *et al.*, 1989).

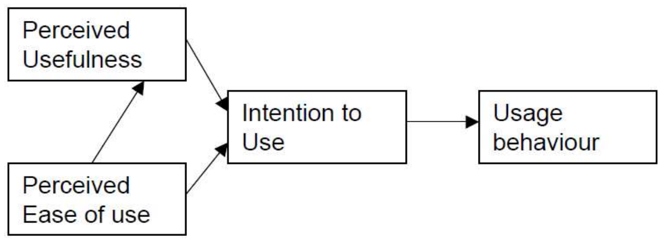


Figure 2.11: Technology acceptance model, TAM (Davis *et al.*, 1989).

2.7.2 Technology Acceptance Model 2 (TAM2)

In order to address the concerns by Davis *et al.* (1992) regarding the external variables toward perceived ease of use and perceived usefulness, Venkatesh and Davis (2000) have enhanced the TAM model to TAM2, which provides a detailed account of the key forces underlying judgement of perceived usefulness (Figure 2.12). TAM2 reflects the impact of both social influence processes (image, subjective norm, experience and voluntariness) and cognitive instrumental process (job relevance, output quality, result demonstrability), and perceived ease of use significantly influenced user acceptance.

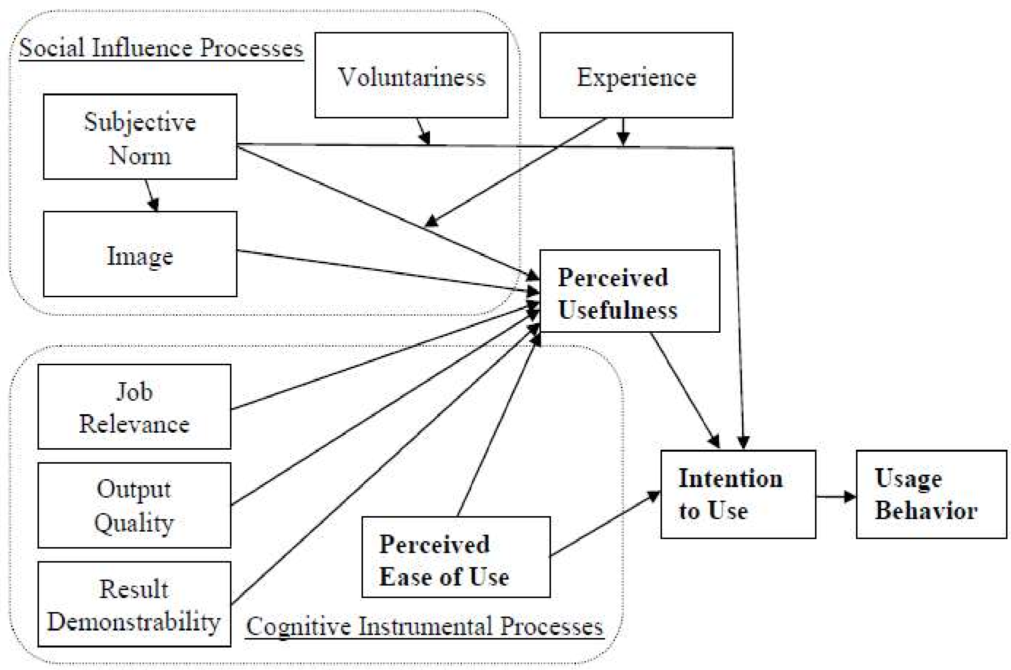


Figure 2.12: Technology Acceptance Model 2 (Venkatesh & Davis, 2000)

2.7.3 Technology Acceptance Model 3 (TAM3)

The Technical Acceptance Model 3 (TAM3) is an integrated model of the determinants of perceived usefulness and ease of use (Venkatesh & Bala, 2008). TAM3 combines TAM2 with the anchor and adjustment determents of perceived ease of use computer, self-efficacy, computer anxiety, computer playfulness and the perception of external control. Ease of use is perceived as enjoyment and objective usability as show in Figure 2.13.

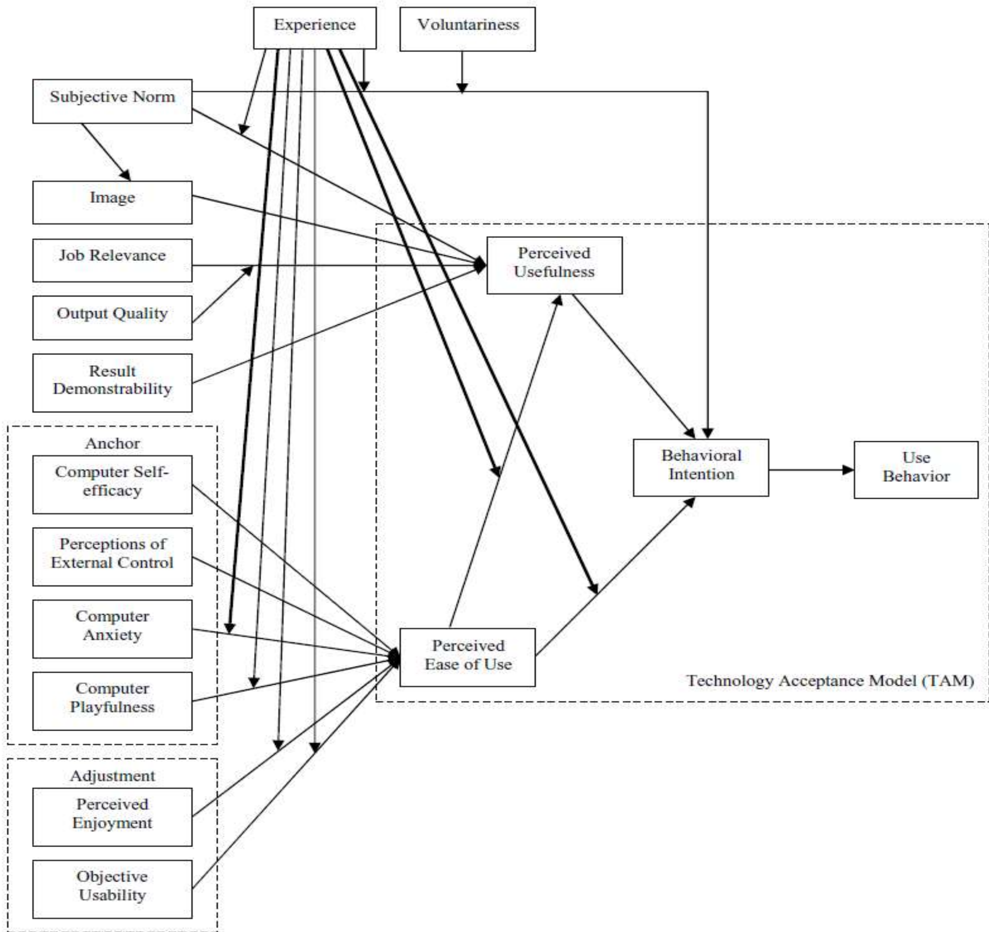


Figure 2.13: Technology Acceptance Model 3 (Venkatesh & Bala, 2008)

TAM3 comprises of three new relationships which were not measured earlier: firstly the effect of experience on the relationship between computer anxiety and perceived ease of use; secondly, the effect of experience on the relationship between perceived ease of use and perceived usefulness; and, thirdly, the effect of experience on the relationship between ease of use and behavioural intention.

2.7.4 Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh *et al.* (2003), have proposed a unified view for the user acceptance model. They have combined the original TAM with seven other user acceptance research approaches and called the result the Unified Theory of Acceptance and Use of

Technology (UTAUT). UTAUT is a model aimed at explaining the relationship between usage and intention (Venkatesh *et al.*, 2003). There are four main variables in the model: performance expectancy, effort expectancy, social influence and facilitating condition. The first three variables are direct determinants of behavioural intention, and facilitating conditions is a direct determinant of use behaviour. There are also four moderators in the UTAUT model: gender, age, experience and voluntariness (Figure 2.14).

UTAUT is a much more recent model than TAM and considered to be an extension of TAM. For this model, performance expectancy replaces the *Perceived Usefulness* in the original TAM and Effort expectancy replaces *Perceived Ease of Use*, Social influence and Facilitating conditions have been adopted from other research approaches (Bagozzi, 2007).

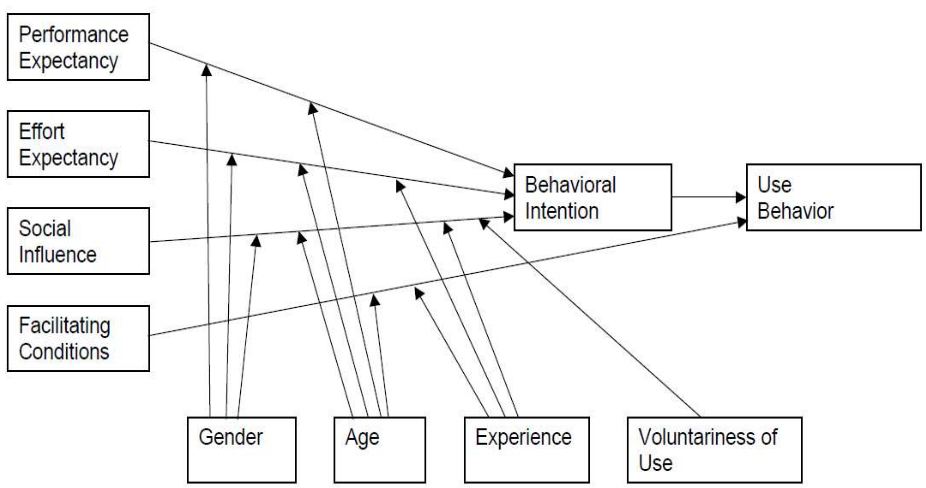


Figure 2.14: UTAUT(Venkatesh *et al.*, 2003)

2.7.5 Extended Technology Acceptance Model

In order to address the individual motivation toward website acceptance, Van der Heijden (2003) expanded the constructs of TAM with the construct of perceived enjoyment and perceived attractiveness. Figure 2.15 shows the construct of this extended TAM. Perceived enjoyment is proposed to have direct effect on both attitude toward using and intention to use. Additionally, perceived enjoyment is also assumed to be influenced by perceived ease of use.

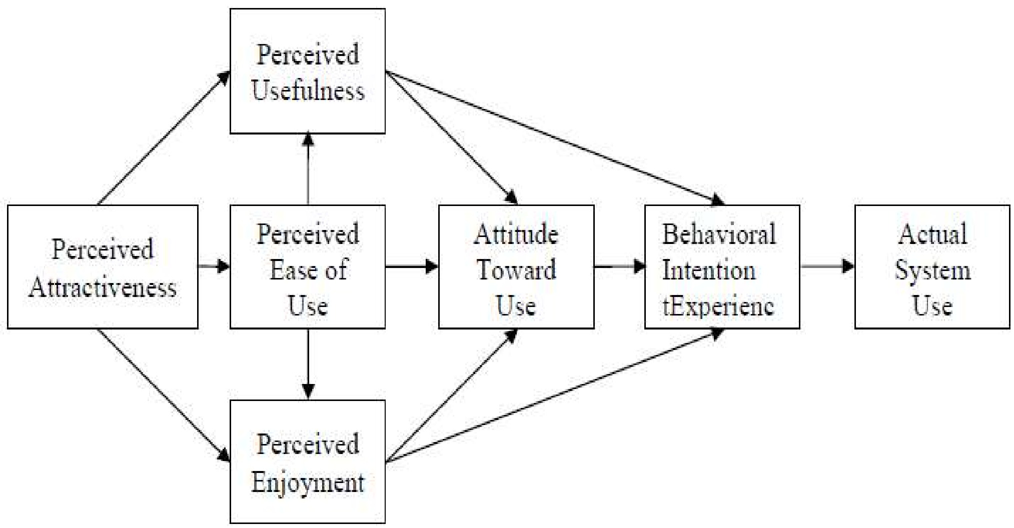


Figure 2.15: Extended Technology Acceptance Model (Van der Heijden, 2003)

2.7.6 User Acceptance of Mobile Alerting System (MAS)

The MAS was adopted from TAM and extended by Haataja *et al.* (2011). The mobile alerting system or MAS was defined to be a system used for presenting time critical emergency information to recipients who had a mobile phone. MAS was extended with three main TAM constructs (perceived usefulness, perceived ease of use and intention to use) and two extended constructs (perceived trust and perceived financial cost) as shown in Figure 2.16. Perceived trust is defined as an individual's belief in the application and the system, while perceived financial cost relates to the ability to pay for the service or for the system.

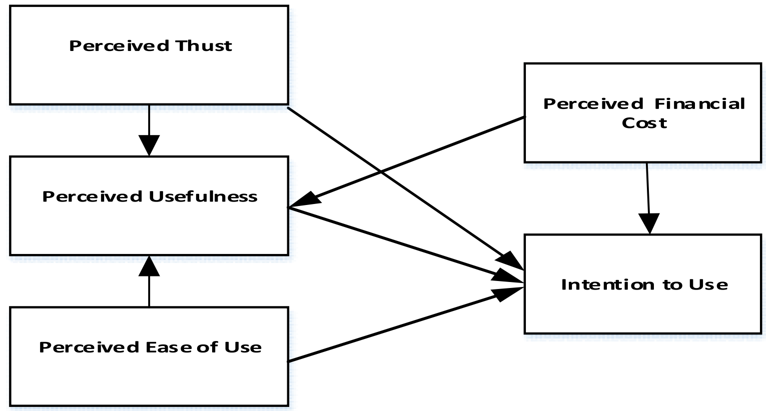


Figure 2.16: User Acceptance of Mobile Alerting System by Haataja *et al.* (2011).

In this study, constructs of the TAMs and the extended TAM model by Van der Heijden (2003) as presented in Figure 2.15 will be chosen to formulate a research model. Particularly, *Perceived usefulness, Perceived ease of use, Perceived of Enjoyment, Attitude toward Use and Intention to Use* will be selected. Selection of these constructs and TAM models for the research model is based on previous studies as stated by Davis *et al.* (1989) that *Perceived usefulness* and *Perceived Ease of Use* are strong determinants for the TAM and the extended TAM. For the construct of *Perceived Enjoyment*, a system perceived to be easy to use will be conceived as more fun to use, leading to a stronger linkage between perceived fun and attitude toward use (Bruner & Kumar, 2005).

2.8 Chapter review

This chapter has reviewed types of floods, existing flood warning systems and available technologies used in the disaster warning systems. This chapter also explored mobile phone development and SMS services cross the globe, the best practices of adoption of SMS technology in various services. Finally, this chapter introduces technology acceptance models.

The review shows that in developing countries flood warning systems are mostly based on traditional mass media, radio and television stations, newspapers and websites. In developed countries, flood warning systems have been integrated and distribute flood information and warn of an emergency publicly through multiple channels. The available technology channels include amateur radio, sirens, internet, telephone, cell broadcasting, SMS messages and instant messaging (e.g. messaging on Facebook).

For developing countries, cutting edge technology such as mobile networks has been more available and accessible in comparison to the Internet. Compared to cell broadcasting and instant messaging (WhatsApp or Facebook), the SMS service has advantages thanks to its readiness, ease of use, low cost, capability, and store and forward features. Moreover, due to limitations of flood warning systems, developing countries are more vulnerable to damage by floods compared with developed countries. Constructs of the TAM models were identified to formulate a research model in Chapter VI; this includes *Perceived Usefulness, Perceived Ease of Use, Perceived of Enjoyment, Attitude toward Use and Intention to Use.*

The next chapter, Chapter III, introduces the case study area, Laos where the two surveys and the trial of the SMS service were conducted. Chapter III includes an overview of the topology of the area, a description of the current flood warning system, mobile phone and SMS service availability, and reasons for choosing a case study area for this research.

CHAPTER III : THE CASE STUDY AREA, LAOS

The purpose of this chapter is to provide an overview of the case study area in Laos where the two surveys were conducted and the trial of the proposed system was carried out. In light of the existing literature on the case study area, this chapter reviews a profile of Laos, including demography, topography, flood situation, flood warning system, flood management in Laos and ICT development. Finally, this chapter describes the reasons the case study area was chosen for this study.

3.1 Demography

The latest census identified that in 2014 Laos has 6.8 million inhabitants living in its 18 provinces, 141 districts and 10,552 villages with most people (63%) still living in rural areas. Laos is one of the least developed countries, the estimated per capital income in 2014 was just US$1,674, but poverty is lower in cities than in the villages of the rural areas (UNDP, 2015). Laos is one of the world's most ethnically diverse countries with 49 ethnic groups and different spoken languages (Sengthong, 2008).

Laotian is the official language in Laos. According to the population census in 2005, the literacy rate was 72.7%, but the rate was higher in urban areas (89%) and lowest in rural areas (54%) and varied amongst ages with younger ages having a higher literacy rate. For example, literacy among people aged 15 to 24 reached 84% in 2005. The literacy rate also differed considerably among the ethnic groups (Sengthong, 2008; UN, 2012).

French is spoken widely in Laos. Most of the people who speak French are older. The younger generations are studying French in schools, but the young ones are more interested in speaking and practising English due to a boom in tourism (Enfield, 2006).

3.2 ICT development in Laos

Laos is one of the developing countries with the strongest mobile phone growth in the Asia-Pacific region. Mobile phone penetration in Laos was 64% in 2012 and by the end of 2013 it reached to 68 users per 100 inhabitants. However, according to the Business Monitor International (BMI), by the end of 2017, the Laos 'mobile phone penetration rate will have reached 169 users per 100 inhabitants, about 11.5 million subscribers' (BMI, 2013).

Meanwhile the number of 3G customers in Laos is still low. As estimated by the BMI, the number of 3G subscribers was around 350,000 at the end 2012 and reached around 595,000 users at the end of 2013, a figure that was only 5.5% of the total number of mobile users in Laos. However, 3G use is trending and is upwards expected to reach 1.2 million users by 2017, at which point 3G will represent an 18.2% penetration rate (BMI, 2013)

According to an ITU statistical report, the fixed-line telephone in Laos is continuously growing, albeit in small numbers. The report stated that there were 450,000 fixed-line subscribers in Laos at the end of 2012, representing 6% of the population; this number reached 701,712 users at the end of 2013, a penetration rate of 10%. Due to the popularity of mobile phone services as network coverage and quality improves, the fixed-line market will become increasingly challenging (ITU, 2015).

The Internet market in Laos has experienced a moderate growth since 2008 due to demand for Internet services, particularly from the younger population and foreign visitors. The ITU reports that there was around 10 internet users per 100 inhabitants in 2012, this figure increased and reached 12.5 users per 100 inhabitants in 2013, representing a 2% increase. BMI (2013) has estimated that in the year 2017, the number of internet users in Laos will increase to 1.3 million users, representing 19 users per 100 inhabitants.

Table 3.1: ICT development in Laos (BMI, 2013; ITU, 2015)

Subscribers by technology	**2012**	**2013**	**2017f**
Mobile users			
No. of mobile phone subscribers (**'000**)	4,300	4,613	11,500
No. of 3G phone subscribers (**'000**)	350	595	1,200
No. of mobile phone subscribers per **100** inhabitants	64.5	68.4	169
Fixed-Line users			
No. of main fixed lines in service (**'000**)	450	701.7	N/A
No. of main fixed lines/100 inhabitants	6	10	N/A
Internet users			
No. of internet users (**'000**)	711	853	1,300
No. of internet users/100 inhabitants	10.75	12.5	19
No. of broadband internet subscribers (**'000**)	68	84	281
No. of broadband internet subscribers/100 inhabitants	0.5	0.6	4.1

In summary, Table 3.1 illustrates that mobile phone technology is the most available followed by fixed line telephones and then the Internet. Due to the increasing number in mobile phone users, the adoption of SMS messages for a flood warning system in Laos is likely to be effective.

3.3 Topography of Laos

Laos is located in South-Eastern Asia and is a landlocked country sharing borders with China and Myanmar in the North, Vietnam in the East, Thailand in the West and Cambodia in the South. Mountain ranges and plateaus cover approximately 70% (236,800 km^2) of the country(UNDP, 2015).

The Mekong River is one of the world's great rivers; it flows for almost 4,400 km from its source in Tibet through China, Myanmar, Laos, Thailand, Cambodia and Vietnam, draining a basin area of 809,500 square kilometres. It traverses Laos from North to South a distance of more then1,000 km; Laos provides 35% of its basin, and a number of tributaries join the Mekong river in Laos as shown in Figure 3.1 (MRC, 2011b).

The geographic location of Laos is in the Lower Mekong Basin (LMB) and, along with the flat topographic nature of the terrain along the Mekong River and its tributaries; it is extremely vulnerable to floods in the Middle and South. Laos is located at the heart of the LMB, which is on the floodway flowing from the Upper Mekong Basin of Myanmar (2%) and China (16%), and joined with 35% of the LMB in Laos. Moreover, water volume in Cambodia, Thailand and Vietnam covering 18%, 18% and 11% of the LMB respectively, could block water flow from the upstream. This makes Laos a vulnerable area for annual floods.

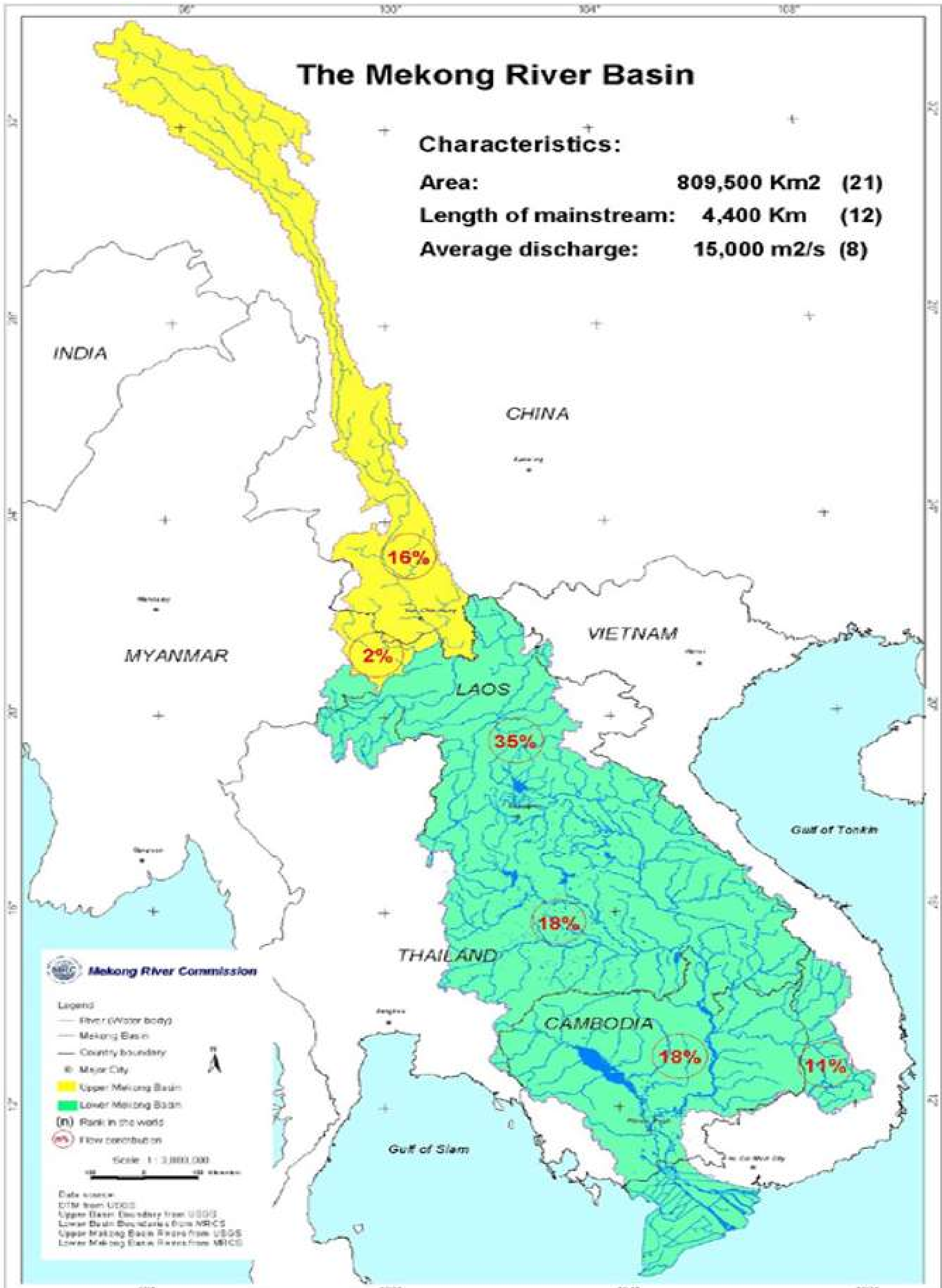


Figure 3.1: The Mekong River Basin (MRC, 2011b)

The climate of Laos is tropical monsoonal and as a consequence Laos catches a huge rainfall which compounds flooding. The average rainfall is from 1,311mm to 1,645mm per annum in the Northern provinces. Provinces in the Mekong river valleys receive rainfall between 1,824mm and 3,211mm per annum. The long duration of heavy rainfall which occurs over about five months, from June to October, creates local floods in flood prone areas. The annual rainfall in Laos is shown in Figure 3.2.

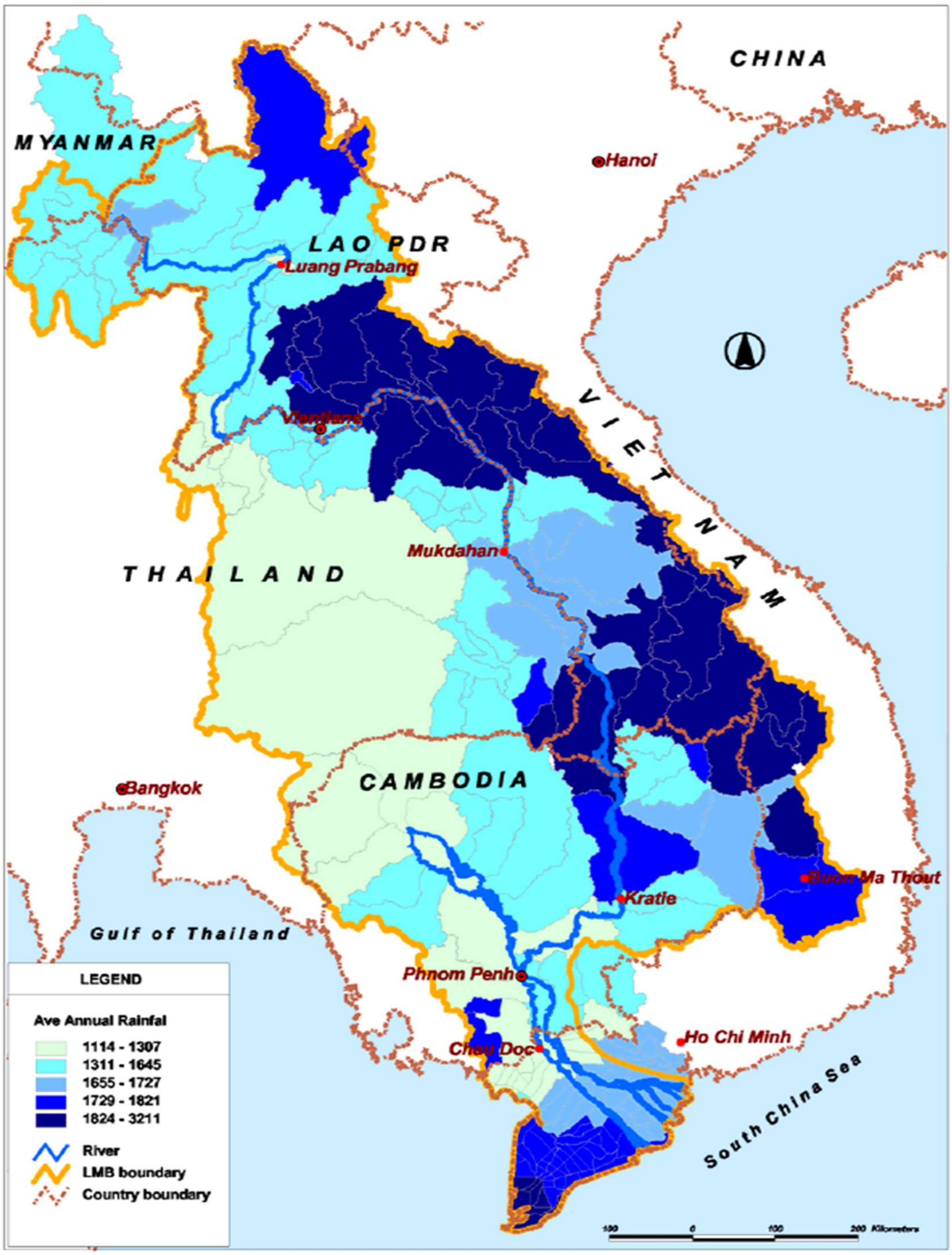


Figure 3.2: Average annual rainfall in Laos

3.4 Floods in Laos

Flooding is a recurrent natural phenomenon occurring every year in Laos. Destructive severe floods are one of the main barriers to economic development; many parts of the country are often subjected to flooding along both the Mekong River and its main tributaries due to heavy rain during the monsoon season. In Laos there are six important flooding prone areas located in the central and southern provinces, five along the Mekong River and the other on a Mekong tributary. There are two major types of floods experienced, river floods and flash floods.

River floods in Laos are characterized by a slow rise in water level and gradual inundation of large areas through water spilling over river banks. This is caused by excessive rainfall and/or tropical storms for several days or even weeks over large areas of the river catchments during the rainy season. Another important feature of this type of flood in Laos is that, the ground becomes fully saturated, thus exceeding the soil's capacity for water absorption, and producing an increased overland flow and runoff. In addition, due to Laos having a number of rivers (Mekong tributaries) flowing into each other and the main Mekong river, frequent river floods occur along the Mekong River and its tributaries, due to intense rain over large areas(Mekong-HYCOS, 2008; MRC, 2011b; Phonevilay, 2006).

Flash floods in Laos are characterised by a fast rise and fall of water level in the rivers resulting from heavy rain and tropical storms. This type of flood generally occurs in the hilly areas due to heavy rainfall over small areas within a short period of time. It can also occur on flood plains along the river as a result of heavy rainfall over a large area of river basin. The flash floods can occur any time of the day or night and happen within a few hours after heavy rain (Barredo, 2007; MRC, 2010, 2011b; Son & Bakker, 2011).

3.5 Impacts of floods in Laos

Laos has experienced floods throughout its history. According to the International Disaster Database (EM-DAT), the Asia Disaster Centre (ADC), and Mekong River Commission (MRC), Laos has been affected by a number of annual floods causing loss of life and property damage in particular in poor and remote areas (ADRC, 2014; EM-DAT, 2015; MRC, 2010). Table 3.2 shows that Laos has been affected by a number of floods since 1966.

Table 3.2: Flood history in Laos since 1966 (EM-DAT, 2015)

Year	Disaster type	Occurrence	No. of people deaths	No. of people affected	Total damage ('000 $)
1966	Flood	1	300	72,000	15,300
1968	Flood	1	2	9,600	1,280
1971	Flood	1	14	115,000	200
1978	Flood	1	31	459,000	N/A
1984	Flood	1	14	2,000	N/A
1991	Flood	1	N/A	332,000	N/A
1991	Storm	1	N/A	38,315	150
1992	Flood	1	10	150	21,828
1992	Storm	1	22	268,877	3,650
1993	Storm	1	8	120	302,151
1994	Flood	1	N/A	190,000	N/A
1995	Flood	2	N/A	591,400	N/A
1996	Flood	1	30	420,000	N/A
2000	Flood	1	15	450,000	1,000
2001	Flood	1	N/A	453,000	N/A
2002	Flood	1	2	150,000	N/A
2008	Flood	1	6	204,190	N/A
2009	Storm	1	16	128,887	100,000
2011	Flood	2	48	467,000	N/A
2013	Flood	2	23	574,253	121,000
Total:		**23**	**541**	**4,925,792**	**566,559**

Since about 70% of Laos is covered by mountain ranges and most of the population lives and depends largely on agricultural activities in the rural areas, flooding is a major annual disaster resulting an extensive damage and loss of lives of vulnerable people as shown by the following cases(MRC, 2010). As reported by MRC (2011b), the 2008 extreme flood occurred along the Mekong River and affected 32,610 households, 4 people died and total damage was more than US$56 million. The 2009 flash flood caused by a typhoon hit the South of the country; 180,000 people were directly affected, there were 28 deaths and the direct economic loss was estimated at US$58 million. During the 2010 flash flood, more than 80,000 people were affected, 7 died and the total property damage was more than US$20 million. In the 2013 flash flood, about 350,000 people were affected with 20 deaths and the property damage was estimated to be more than US$60 million (MRC, 2010, 2011a, 2012, 2013a).

According to the International Disaster Database (EM-DAT), Laos is in the top 10 of the worst disasters in Asia by number of people killed per million populations and Laos was ranked in 6th place for the flood by the disaster type in 2013 as shown in Table 3.3.

Table 3.3: The worst disasters in Asia by number of people killed (ADRC, 2014)

No	Disaster Type	Country	Date	No people killed per million	No of killed	Population
1	Storm	Philippines	8/11/2013	82.58	7,986	96,706,764
2	Flood	Cambodia	24/09/2013	13.45	200	14,864,646
3	Epidemic	Laos	--/01/2013	11.59	77	6,645,827
4	Flood	India	12/06/2013	4.9	6,054	1,236,686,732
5	Flood	Nepal	10/07/2013	4.33	119	27,474,377
6	**Flood**	**Laos**	**--/06/2013**	**3.01**	**20**	**6,645,827**
7	Flood	Sri Lanka	8/06/2013	2.85	58	20,328,000
8	Flood	Nepal	25/05/2013	2.77	76	27,474,377
9	Extreme temperature	Japan	--/05/2013	2.65	338	127,561,489
10	Flood	Sri Lanka	8/01/2013	2.56	52	20,328,000

A severe flood in 2008 and flash floods from storms in 2009 revived concern among the government offices and Mekong River Commission to seek measures for a lasting solution to the country's recurrent flood problems. As a result, a flood warning system was formulated and sponsored by the Mekong River Commission in collaboration with the Lao government, the Department of Hydrology and Meteorology (Mekong-HYCOS, 2008).

3.6 Flood management in Laos

The government of Laos established the National Disaster Management Committee (NDMC) in 1999 as a top-down approach for managing collaboration between focal points of each level as shown in Figure 3.4. The main role of the NDMC is to be responsible for coordination of monitoring, prevention, and response activities for national disasters with local administrations, including provincial Disaster Management Committee (PDMC), District Disaster Management Committee

(DDMC) and Village Disaster Management Committee (VDMC) as shown in Figure 3.3 (CFE_DMHA, 2014; Goodyear, 2011).

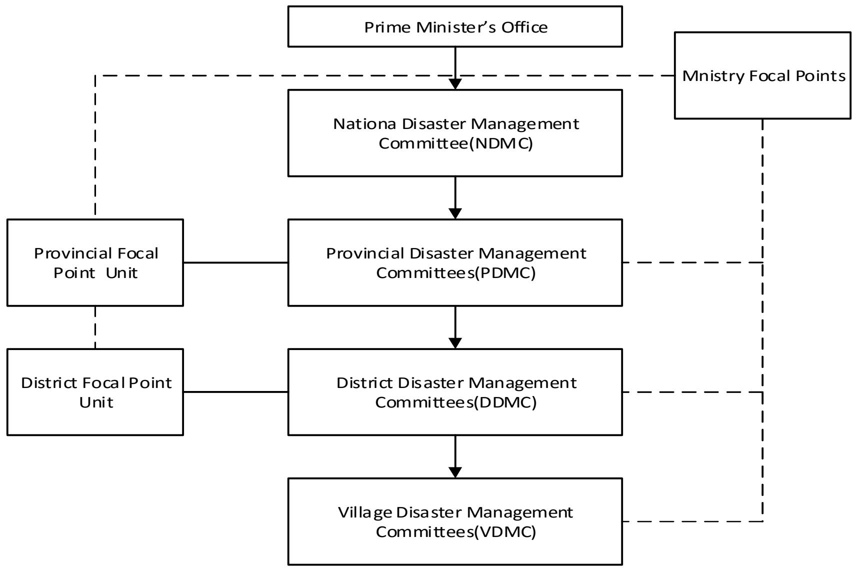


Figure 3.3: National Disaster Management in Laos (CFE_DMHA, 2014)

At the national level, the NDMC is responsible for planning policies, obtaining statistics on disaster victims, requesting assistance, mobilizing resources and funding, public education, directing disaster relief operations, preparedness, and response and interagency coordination between international and non-government agencies and assisting provincial and district committees (PDMC and DDMC).

The PDMC responsibilities are directed at strengthening disaster preparedness at the provincial level and supporting national priorities and guidelines. The PDMC also monitors hazards and disaster threats and emerging disaster prone areas together with the impact on the vulnerable population.

The DDMC receives hazard information of specific areas at the district level from the PDMC. The main tasks of the DDMC are to coordinate with the government agencies, NGOs, communities and private sector for prevention and mitigation of disasters.

The VDMC prepare the plans and procedures for disaster management for their locations, identify and map hazards and conduct the risk and vulnerability analysis. To respond to a warning, the head of each village gets flood information from DDMC and use a public address system. The household heads are called to the meeting to discuss activities in preparation for an incoming flood.

3.7 The Current Flood warning system and its limitations

The flood warning system in Laos is operated by the Department of Meteorology and Hydrology (DMH) and the Mekong River Commission (MRC). The MRC has four member countries (Cambodia, Laos, Thailand and Vietnam). The system is called the Mekong Hydrological Cycle Observation System (Mekong-HYCOS) which is currently composed of 49 hydrological stations along the Mekong River and its main tributaries in the Lower Mekong Basin, twelve of those hydrological stations are located in Laos as presented in Figure 3.4 (Mekong-HYCOS, 2008).

The hydrological stations are designed to collect and transmit real-time hydrological data (water level, precipitation and temperature) via the mobile phone network at 15-minute intervals from the remote hydrological stations. The data is transmitted from the hydrological stations to the data centre at the MRC headquarter via the GSM networks of each country. If the data cannot be sent, it is stored in the data loggers and sent in the next 15-minute sending interval.

For flood forecasting, the data is processed and bulletins prepared and issued twice a day during the monsoon season (June-October), the real-time graphs of water level and rainfall are created and published on the real-time monitoring website (MRC, 2013b). In the case of a flood being detected, the flood information is mainly disseminated to the public through radio, television stations, and newspapers and online through websites.

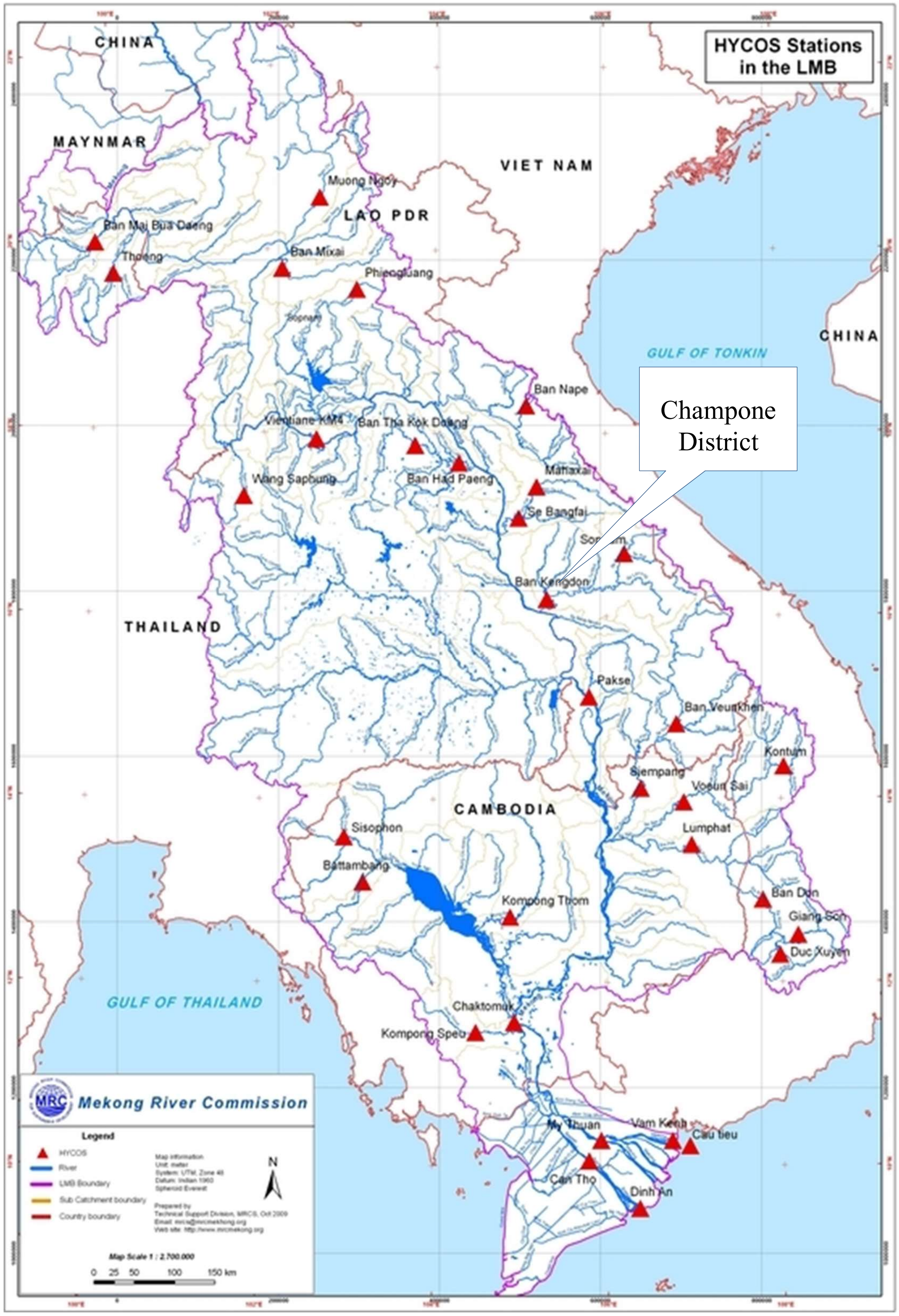


Figure 3.4: The hydrological stations in the LMB (Mekong-HYCOS, 2008).

Even through the system has online real-time graphs of flood warnings, this kind of warning is for those who have necessary technology and skills, which people living in flood risk areas may not have.

Based on characteristics of the current flood warning system mentioned above, the system could be effective for river floods (slow water flow), but it has limitations for warnings in the case of flash floods. To cope with flash floods, warnings need to reach the vulnerable communities in a timely manner. According to the MRC report, despite the fact that the current Mekong forecasting and early warning systems have continued to play a crucial role in providing warning to people in the MRB, improvement of the current flood warning system is required and should be a prioritised activity (MRC, 2011b).

3.8 Case study area

In order to meet the research objectives and research questions (as presented in Section 1.4), a case study area was required for this study.

For information of above sections in this chapter, Laos is one of vulnerable developing countries to annual floods due to its topography, heavy rainfall during monsoons and limitations of flood warning. Moreover, vulnerability of Laos to annual floods because it is located in heart of Lower Mekong Basin where Mekong river travels from North to South and it is on the floodway flowing from the upper basins.

Therefore, the district of *Champhone* locating in the south of Laos, as shown in Figure 3.4, was chosen as the case study area for this study. Champhone district has 20,000 inhabitants living in 40 villages with most people because of its additional unique characteristics (EM-DAT, 2015; IUCN, 2011; MRC, 2011b; Sopha & Sharp, 2013):

- District of Champhone is located in remote area, where the mobile network access and usage exceeds that of the Internet.
- Heavy rainfall during monsoon season creates severe annual floods for Champhone district.
- Champhone district is traversed by the Xe Champhone River flowing to the Mekong River, and it is vulnerable to floods during monsoon seasons.
- Annual floods are common and sensitive for residents of Champhone district due to unavoidable property damages.

3.9 Chapter review

This chapter provides a profile of the case study area (Laos) including demography, topology, flood characteristics, impacts of floods, the existing flood warning system, flood management plan and ICT development.

This chapter indicates that Laos is vulnerable to annual floods due to its topology and heavy rainfall during monsoons. The case study area has been affected by annual floods that have caused loss of life and huge property damage. The current flood warning system was prioritised to be improved due to its limitations. Mobile phone technologies and networks are more available and accessible than other communication means such as fixed line telephones and the Internet.

Champhone district in the southern part of Laos was selected as the case study area because it is located in a remote area where annual floods are common and mobile phone networks are available more so than the Internet.

The next chapter introduces the framework of the research methodology, including how the research was designed, methods of data collection and analysis and how the data is to be presented.

CHAPTER IV : RESEARCH METHODOLOGY

This chapter deals with research approaches for this study, how this study was conducted, data analysed and results presented. The methodology includes research design, method of data collection and analysis. Finally, the ethical issues are included in this chapter.

4.1 Introduction

In this study, a multi-method research approach and a case study has been applied. Quantitative data was collected from two surveys (field survey and online survey) and from a trial of the flood warning system developed. The surveys were conducted concurrently in the case study area using closed questionnaires and the collected data were analysed descriptively and inferentially. The trial of the system was carried out sequentially and its results were compared and confirmed with the results of the two surveys.

Research methodology has been defined by many researchers as the procedural framework within which the research is conducted. Remenyi *et al.* (1998), defined a research methodology as the use of specific methods to: 1) Gather adequate and representative evidence of a phenomena; 2) Develop appropriate ways to analyse the collected data; 3) Demonstrate the validity or reasonableness of any findings or conclusion.

Research methodology has been linked to popular terms of “multi-method research” and “mixed method research”. As McKendrick (1999); Morse (2003) noted, multi-method research allows for in-depth understanding into a particular case. Tashakkori and Teddlie (2003), pointed out that mixed method research involves a process of data collection or analysis of quantitative and/or qualitative data in a single study concurrently or sequentially.

A case study approach was selected for this study that focuses on adoption of mobile phone technology in flood prone areas to minimise flood impact. To be more precise, to what degree can vulnerable people such as farmers, who live in flood prone areas, adopt available SMS technology to alert them about flood information in order to reduce and/or avoid flood impact. This study does not consider techniques for reducing/avoiding the physical attributes of the actual floods. The next three sections introduce research design, data collection techniques and data analysis methods and process.

4.2 Research design

4.2.1 Research steps

The procedural research of this study comprises three main phases: conceptual, implementation and evaluation phases as illustrated in Figure 1.2 in Chapter I.

- **The conceptual phase:**

The conceptual phase is the starting point of the research journey, it involves the research background, research problems, identifying research aims and objectives and the method to be used in the conduct of the research.

Remenyi *et al.* (1998) stated that the primary drivers of research approaches includes: (1) the *research topic*; (2) the *research problem;* and (3) the *research specific question.* Ellis and Levy (2009) described the research process as starting with following: (1) the *problems* driving the research; (2) the *body of knowledge*; and (3) the *nature of the data.*

The conceptual phase of this research includes *research introduction* (Chapter I), *literature review* (Chapter II), *introduction of a case study area* (Chapter III) and this Chapter IV, *the research methodology*.

- **Implementation phase:**

This phase involves the research surveys. It concludes the process of data collection, data analysis and data presentation. Covered in this phase is how data can be collected, what methods should be used to analyse the data and how the data can be presented. The implementation phase of this study includes the *two research surveys* (the field survey and the online survey in Chapter V), *the research model development and testing* (Chapter VI) and *Trial of the proposed system* (Chapter VII).

- **Evaluation Phase**

This phase is the final stage of the research project. It involves discussion of research findings from the two surveys and the trial of the proposed system and draws conclusions. The discussion in Chapter VIII includes evaluation of whether the research has answered the research questions or not, while research limitations and future work are included in the concluding chapter (Chapter IX).

4.2.2 Qualitative and Quantitative Paradigms

Research methods can be broadly categorised as *quantitative* or *qualitative* (Lee & Hubona, 2009; Venkatesh *et al.*, 2013). *Quantitative* research methods are characterised by the collection of information that can be analysed numerically, the results from quantitative methods typically are presented using statistical techniques, tables and graphs (Marshall, 1996).

The *quantitative* method explains phenomena by collecting numerical data that are analysed using mathematically based methods with particular statistical tools (Aliaga & Gunderson, 1998; Yin, 2003, 2009). On the other hand, *qualitative* methods of research provide added value in identifying and exploring intangible factors such as cultural expectation, gender roles, ethnic and religious implications and individual feelings. *Qualitative* methods also explore relationships and perceptions held by affected persons and communities (WFP, 2009).

Differences between qualitative and quantitative methods are that qualitative methods are usually applied where the research issue is less clear and the questions to the respondents are likely to result in complex and inconclusive answers. By contrast, quantitative methods are appropriately applied where the research issue is clearly defend and the questions asked of respondents lead to concise answers (Brannen, 1992). With qualitative methods, the researcher is involved as an instrument, bringing their own cultural values and assumptions, while quantitative methods are much less flexible where the tool is predetermined and technologically tuned (Brannen, 1992; McCracken, 1988). Philip (1998) stated the difference between qualitative and quantitative methods as being subjectivity and objectivity respectively.

Sale *et al.* (2002) concluded that as the two paradigms do not study the same phenomena, qualitative and quantitative methods cannot be mixed for cross validation purposes, but they agreed that they can be combined for complementary purposes. However, Brannen (1992) has identified that qualitative and quantitative methods can differ and overlap in logical terms.

A number of researchers have used multiple methods for their study in order to obtain knowledge about different aspects of a phenomenon under study. Mingers (2001) argued that *multiple method* approaches help to gain complete answers and increase the robustness of understanding. Tashakkori and Teddlie (2003) identified two types of multiple methods research, *mixed method research* and *multi-method research*.

4.2.3 Mixed methods research

Mixed method research employs multiple methods of data collection and analysis in line with methodical combination of qualitative and quantitative research methods, either concurrently (independent of each other) or sequentially (findings from one approach are followed up by the other), to understand a phenomenon of interest. For example, Chang (2006) conducted a mixed method study to compare perceptions of the same phenomenon of interest to two different types of participants. Terrell (2012) stated that mixed method research can provide an investigator with many design choices with involve a range of sequential and concurrent strategies using combination of quantitative and qualitative data collection, then finally the results were compared. Creswell (2003) explained that mixed method involves the collection of both qualitative (open-ended) and quantitative (closed-ended) data in response to research questions or hypotheses.

However, as pointed out by Creswell and Plano Clark (2007), conducting mixed method research is not easy. It is challenging because such research is perceived as requiring more work, financial resources and more time.

4.2.4 Multi-method research

In *multi-method* research, researchers employ two or more research methods for a single worldview, but use only one type of method, qualitative or quantitative. (Azorin & Cameron, 2010). For example, Sun and Zhang (2006) conducted multi-method research using two different quantitative methods (a field study and an experiment) to understand the causal relationships between enjoyment and perceived ease of use in the context of Information System adoption. Creswell (2003) stated that the multi-method approach refers to the use of multiple methods, typically quantitative or qualitative, in conducting research.

There have been several debates regarding the superiority of one or the other of the two major paradigms stemming from positivist and constructivist orientations (Datta, 1994). Howe (1988) argued that qualitative and quantitative research paradigms cannot and should not be mixed due to the incompatibility of the paradigms underlying the methods. However, others have pointed out that qualitative and quantitative methods are compatible. Bryman and Bell (2007) stated that research methods are independent of assumptions, so the research can use single or multiple paradigms.

In a review of research methods from 1,784 journal articles, Cameron and Azorin (2010) found that quantitative studies dominated (76%), followed by mixed method studies (14%) and qualitative studies (10%). Grimmer and Hanson (2009) undertook a similar study of 398 articles in five countries and found that most of the authors used quantitative research methods for their studies, followed by qualitative and mixed research methods as shown in Table 4.1

Table 4.1: The research methods used by authors (Grimmer & Hanson, 2009)

Countries	**Quantitative**	**Qualitative**	**Mixed**
United States	86.67%	5.33%	8.00%
Canada	85.71%	10.71%	3.57%
China	72.06%	10.29%	17.65%
Australia	52.00%	34.00%	14.00%
United Kingdom	45.20%	33.33%	21.47%
Average	**68.33%**	**18.74%**	**12.94%**

4.2.5 The case study approach

A case study has been defined by researchers from different perspectives. Yin (2009) defined a case study as an empirical inquiry that investigates the case or cases addressing the "*how*" and "*why*" questions concerning the phenomenon of interest. According to Yin (2009), a case study can be used to *explain, describe* or *explore* events or phenomena in the everyday contexts in which they occur. Yin (2003) also notes that the case study approach allows the investigators to retain the holistic and meaningful characteristics of real-life events. According to Yin, the need to use a case study approach arises whenever an empirical inquiry must examine a contemporary phenomenon in its real life context, especially when the boundaries between the phenomenon and its contexts are not clearly evident.

Majchrzac (1984) pointed out that a case study is advantageous in many respects as they are usually quick, cost-efficient and allow room for impressionistic analysis of a situation. Chetty (1996) explains that the case study method of research is a rigorous methodology that allows decision making processes and causality to be studied. It is suitable for answering *when, why*, and *how* questions about a set of events.

Despite these advantages, a case study has received criticism. Yin (1984) discussed three types of argument against a case study research. First, case study is often accuses of lack rigour. Second, a case study provides very little basic for scientific generation since they use a small number of subjects. Third, a case study is difficult to conduct because it needs massive amount of documentation and use period of time(Darke *et al.*, 1998).

In summary, a case study approach has been chosen for this study because:

- Case study research is used to understand an in-depth real-life context.
- The case study approach captures realistic evidence from respondents.
- The multi-method approach can be used in a case study method approach.
- The case study is cost effective because respondents can be identified within a community.
- For the case study method, honest answers can be obtained from the affected residents.

4.2.6 Research method approach

In this study, the research method approach supplied by Creswell and Plano Clark (2007) was chosen. It is multi-method research using quantitative methods for data collection and data analysis within a single study. Furthermore, this study also adopted from the research approach of Sun and Zhang (2006) who used two, concurrent quantitative methods for studying a single issue (a field study and an experiment). Figure 4.1 shows the process of data collection and data analysis used in this study. Firstly, the two surveys were concurrently conducted: the online survey is a web-based questionnaire targeted at the flooding experts working in the current flood warning systems. The field survey was a paper-based questionnaire involving data collection from residents who live in the flood risk areas and who have been affected by floods. Then, quantitative data analysis was carried out and results from the two surveys were compared. The purpose of conducting the two surveys was a preliminary evaluation of the adoption of SMS for a flood warning system in the case study area.

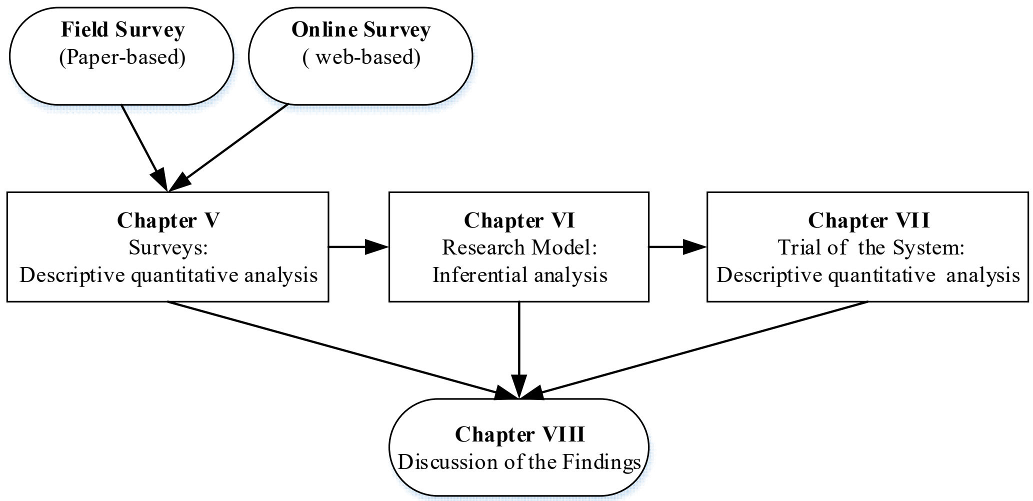


Figure 4. 1: The Research method approach

Secondly, a research model was developed to test the hypotheses. The research model aimed to seek factors influencing adoption of SMS for a flood warning system in the case study area.

Thirdly, a trial of the proposed system was conducted after completing the surveys and the research model testing. The findings of the trial were intended to check and confirm findings from the field and online surveys. Finally, this study discuses all findings from Chapters V, VI and VII.

In summary, the research approach of this study is quantitative multi-method using three sources of data collection: the field survey, the online survey and the trial of the system. The data analysis includes three parts: descriptive data analysis (Chapter V), the research model testing (Chapter VI) and descriptive data analysis of the system trial (Chapter VII).

4.2.7 Reasons of selecting the research method

The multi-method approach, quantitative method and a case study were used for this research. As stated by (Azorin & Cameron, 2010), the multi-method research employs two or more research methods for a single worldview. In this study, the combination of results from the two surveys, research model and the trial of the system provides key findings for this study.

Quantitative methods were chosen for this study because of the nature of this research. The research aim is a preliminary investigation of an SMS-based flood warning system for developing countries where mobile phone technologies have been widely developed in comparison to the Internet. Thus, the research mainly focused on penetration of mobile phones, proportion of SMS use, reliability of mobile phone infrastructure in flood prone areas and the feasibility of adopting SMS for issuing flood warnings.

In addition, due to limited time and budget for this study, a close-ended questionnaire (quantitative Likert-scale) is suitable for the surveys since such a questionnaire approach is inexpensive, saves time and can engage a requisite number of participants.

Furthermore, quantitative approaches have dominated published articles in leading countries like the United States of America, the United Kingdom, China, Australia and Canada(Azorin & Cameron, 2010; Grimmer & Hanson, 2009). For all the above reasons, the multiple, quantitative methods were used for this study.

A case study approach was applied in this study for understanding the real-life context and to capture realistic evidence from respondents. The case study used a questionnaire, which is cost effective, because respondents can be gathered from a local community.

4.2.8 Questionnaire design

A questionnaire is a key tool for gathering information from respondents to contribute to a study's findings. An effective questionnaire is dependent on the questions asked and so question design is an important process for a survey. As stated by McLafferty (2003), before embarking on survey based research it is important to have a clear understand of the research objective and the key questions to be addressed (McLafferty, 2003). Fowler and Cosenza (2009) also pointed out that question design was one of the most important means of collecting data.

In this study, there are two types of questionnaire: the first questionnaire is for the field survey (Appendix 2) and the second questionnaire is for the online survey (Appendix 3). Close-ended questions were used for both types of questionnaire and the quantitative method approach was used for data collection and analysis.

The two survey questionnaires contained similar questions in order to compare findings from the two surveys. The similar questions include literacy level of residents living in the flood risk areas, available technologies, use of technologies and use of SMS messages in the case study area. The field survey questionnaire had additional questions that were based on a basic TAM model containing the main determinants of the TAM, *perceived usefulness, perceived ease of use, perceived enjoyment, attitude toward use* and *intention to use*. The additional questions were to develop a research model and test hypotheses for seeking factors influencing adoption of SMS messages for flood warnings in the case study area.

The questionnaire for the field survey was translated into the local language (Laotian) so that it could be understood by the researcher's assistants and participants in the case study (Appendix 4).

The questionnaires for both surveys used a 5-point *Likert* scale for user satisfaction and user agreement (e.g. 1 = strong disagree, 5 = strong agree and 1= strongly unsatisfied and 5 = strongly satisfied). The 5-point Likert scale was chosen for this study because it was determined to be suitable for local people as a result of pilot tests (detail is presented in Sections 5.2.1.1 and 5.2.2.1). Osteras *et al.* (2008) claimed that the 5-point Likert scale questionnaire has better data quality in terms of internal consistency and missing data effects. In order to encourage respondents to answer all questions honestly and not to skip questions, both questionnaires excluded *sensitive* questions and were *confidential* and *anonymous*.

4.2.9 Sampling design

Sampling is a very important issue in research as the respondents chosen have a significant impact on the research finding. The sample is a subset of population to whom the questionnaire is administered(McLafferty, 2003).

Sampling of the targeted respondents means selecting a group of people in a manner that maximises the researcher's ability to answer research questions (Tashakkori & Teddlie, 2009). Thus sampling can be one of four subtypes:

- Random Sampling
- Stratified Sampling
- Cluster Sampling

- Multistage Sampling

In random sampling, every member of the population of interest has an equal and independent chance of being chosen. Thus, a random sampling approach was administered for this study to avoid bias in selecting respondents.

In order to find a size of the sample, the formula of Cochran (1977) method outlined in Kotrlik and Higgins (2001) was used in this study. The formula is shown as follows

$$n_0 = \frac{t^2 \times p \times (1-p)}{d^2} \qquad \text{(Equation 1)}$$

Where

- $\boldsymbol{n_0}$ is the minimum estimated sample size
- ***t*** is the value of the *t*-distribution corresponding to the chosen alpha level for 0.5, it is 1.96
- ***p*** is the estimate of population proportion, when *p* is unknown the best to set it at 0.5(Kotrlik & Higgins, 2001)
- ***d*** is the margin of error using 5% or 0.05 as recommended by Bartlett (1954)

If n0 is greater than 5% of overall population, then

$$n_1 = \frac{n_0}{1+n_0/N} \qquad \text{(Equation 2)}$$

Where

- $\mathbf{n_1}$ is adjusted minimum estimated sample size
- ***N*** is total population size

In this study, three types of sample size need to be identified for, including for field survey, online survey and trial of system and are discussed at next section 4.3.

4.3 Data Collection

This research includes data collections from the field survey, the online survey and the trial of the system using quantitative methods. The field survey data collection was obtained from the questionnaire administered to residents living in the flood prone areas of the case study area. The online survey asked questions of flooding experts who work in the current flood warning systems of the study case area. The third data collection was gained from an application as part of the trial system.

As stated by Kitchenhan and Pfleeger (2002); Knapp and Kirk (2003), there are two methods of delivery for survey based data collection. The first is a *supervised survey*, where the researcher is present as respondents answer questions. The second is *unsupervised surveys*, which involves user self-selecting to be part of an already distributed survey.

This research used both approaches: the field survey used the *supervised method* as the researcher and researcher's assistants read the questions to the respondents on the questionnaire forms and noted the respondent's answers. The *unsupervised method* was used for the online survey in which the respondents can manage the survey process themselves. The data collection of the trial was through an application known as an SMS gateway. This data was recorded in a database.

One criticism of unsupervised surveys is that the participants can actually misread or misunderstand questions (Kitchenhan & Pfleeger, 2002). Another identified issue is that users may not answer survey question completely honestly (Knapp & Kirk, 2003).

4.3.1 Field Survey

The field survey was a *supervised survey*, where the researcher and the researcher's assistants presented the questions and recorded answers as respondents provided them. If respondents had the ability complete the survey on their own, they were allowed to do so in consultation and supervision of the researcher or researcher's assistant in case there were any unclear questions.

The goal of this survey was to obtain information regarding the adoption of SMS for a flood warning system in the case study area. Information sought included basic education level, technological ability and attitude toward using mobile phone technology. To avoid missing data as much as possible, a pre-test and training for the assistants were conducted before doing the survey.

4.3.1.1 Targeted respondents and sampling selection

The targeted population of the field survey was people living in flood risk areas, particularly *farmers,* who were the most vulnerable group in such areas.

As stated in section 3.8, flooding areas of Champhone district with population of 20,000 inhabitants living in 40 villages, was chosen for this study. Out of 40 villages, five(5) villages whose population of around 8400 inhabitants were selected to perform the field survey because those villages are located in high flood risk areas of wetland in the case study area(IUCN, 2011; Sopha & Sharp, 2013).

Based on "Equation 1" and "Equation 2" from section 4.2.9, the estimated minimum sample size for total population of 8400 inhabitants is 368. However (Salkind, 1997) recommended that if a study uses surveys or questionnaires, oversampling need to be increased 40-50% of minimum estimated sample because to avoid uncooperative subjects. Thus, in this study sampling size of field survey was 580.

4.3.1.2 Conducting questionnaire survey and data recording.

Due to time constraints, the researcher decided to hire field assistants to help with the field survey, so three field assistants were recruited, trained and employed. The researcher chose these assistants because of their background and flooding experience, one of them was a graduate from the National University of Laos, who specialised in rural development, and the other two were from local flood prone areas, and had graduated from secondary school and had experience related to floods.

The researcher trained the field assistants regarding the research objectives and particularly how to fill in the questionnaire while avoiding errors and missing questions. After arriving in the flood risk areas of the case study area, the researcher had to contact the head of each village to ask for permission by submitting "a Letter of Introduction" (Appendix 5). The head of village replied with a letter of consent (Appendix 6) which was translated into the local language for presenting to participants before asking them to answer the questionnaire.

At the end of each day, the researcher and the field assistants checked and edited each questionnaire. If any confusion arose, it was resolved by discussion. After the researcher went through some completed questionnaire with assistants and felt confident about the assistants' capability to fill in the questionnaire, they were allowed to work independently. Mobile phones were used to communicate between the researcher and the assistants.

Local influential people such as heads of villages, school teachers, and business people were contacted and asked for their help in conducting the survey. Once the survey work was completed, all questionnaires were stored in a secure place. The data was recorded from questionnaire into spreadsheets by the researcher and an assistant. The collected data were stored and backed up in the researcher's computer and the hard drives.

4.3.2 Online Survey

The online survey was a web-based questionnaire provided using the survey tool Gizmo. The *unsupervised method* was used for the online survey in which the respondents can undertake the survey process by them. To avoid incomplete surveys, a pilot test was conducted before launching the main survey.

4.3.2.1 Targeted Respondents and sampling selection

The targeted respondents for the online survey were the flooding experts who work in the current flood warning systems of the case study area from the Mekong River Commission (MRC) and the Department of Hydrology and Meteorology (DMH) in Laos. Those respondents included flood forecasters, flooding modellers, hydrologists, meteorologists, and water-related specialists. Based on documents from the MRC (2015), the reasons of choosing these targeted respondents are as follows:

- They are dealing with the current flood warning systems
- They know the real situation about floods and mobile phone technology availability in local communities.
- They have a high level of education and have mobile phone technology skills
- They have experience using mobile phone and SMS features

Before recruiting participants from the MRC and the DMH, the Letter of Introduction and the approval letter were sent by the researcher to the two organisations. The researcher including names and email addresses received the details of 33 participants from the organisations. Due to a small targeted population and based on formulas of sampling equations in section 4.2.9; sample size for online survey was 33.

4.3.2.2 The online survey launch and data recording

The survey was released by sending the survey link to the email addresses of the targeted respondents (flooding experts) with two months allowed for completion from May to June 2013 with reminder emails to the recruited respondents during this period of time.

Once the survey was closed, the data was imported into Microsoft Excel and safely stored in the University's backup drive and the researcher's personal computer and external drives.

4.3.3 The trial of the system

The third survey involved the trial of the system, sending SMS messages containing flood warning messages to people in the study case area. The objectives of the trial are:

- To evaluate reliability of an SMS service in terms of sending time, delay time and lost messages.
- To evaluate SMS message content and local language availability on mobile devices.
- To assess the actions of people living in the flood risk areas in case of a severe flood.
- To confirm the findings from this trial with the results of the surveys.

To avoid misunderstanding of the flood warnings of this trial amongst the population, the researcher cooperated with governmental institutions, The

Department of Meteorology and Hydrology of Laos and the Mekong River Commission Secretariat.

4.3.3.1 Targeted respondents and sampling selection

The targeted respondents for the trial were the selected mobile phone users living in the five selected villages of high flood risk area in Champhone district. Specifically, 150 mobile phone users (30 mobile phone users per a village) were selected randomly. Based on sampling formulas of section 4.2.9, the minimum sample size of the trial is 109, but sample size of this trial was increased to 120, because increase in sample size is needed as recommended by Salkind (1997).

The required data to be collected from the targeted respondents included mobile phone numbers, the type of mobile phone (basic phone or smart phone), mobile phone providers and brands of mobile phones. All the required data were entered into a database via the application interface. To protect the privacy of the participants, their names were excluded.

4.3.3.2 Structured messages

According to the Austrian Emergency Manual, AEM (2009), an emergency warning message need to be clear, comprehensible and avoid confusing the targeted audience. For this trial, a message of up to 140 characters was prepared in the local language (Lao language). The message was constructed to be as simple and understandable as possible, and to be persuasive so that residents who received the warning would act in response to the warning as quickly as possible. The message includes specific time of the flood, how to evacuate and a hot line for contact.

4.3.3.3 Conducting the trial and data recording.

The trial was conducted for one hour since this timeframe was sufficient for warn about a flash flood in the case study area. The trial was sent in two stages, the first stage was the warning of the severe flood, followed by the second stage which explained and confirmed that the warning was a trial. For both sent messages, the application recorded variables, including transmission time, delayed messages and lost messages or messages containing errors. The recorded variables were exported into CSV files and saved for analysis.

4.3.3.4 Post-trial interview

After the trial, feedback from the mobile phone recipients was obtained via mobile calls. The aim of the post-trial interview was to obtain additional information relating to the content of the warning and action taken in response to the flood.

Ten (10) participants were area was selected targeted respondent of the post-trial interview from five villages of the case study area. Five (5) of them were heads of the villages because they are focal points of disaster management committee which get flooding information from the high committee levels and inform to villagers(details are discussed in section 3.6).

The interview was conducted after two hours of launching the trial because mobile phone users should have received the trial warning message. The feedback questions in the local language and English are presented in Appendix 7.

4.4 Data Analysis

There are three sources of collected data to be analysed:

- Data from the online survey
- Data from the field survey
- Data from the trial of the system

There were three stages of data analysis: data analysis 1 and data analysis 3 were descriptive analyses using Microsoft Excel spreadsheet and the Statistical Software Package for Social Science (SPSS) version 22. Data analysis 2 was inferential analysis using data from the field survey. SPSS version 22 and AMOS (Analysis of Moment Structure) were used to test the hypotheses of the structural equation modelling of the research model. The data analysis flow of this study is shown in Figure 4.2.

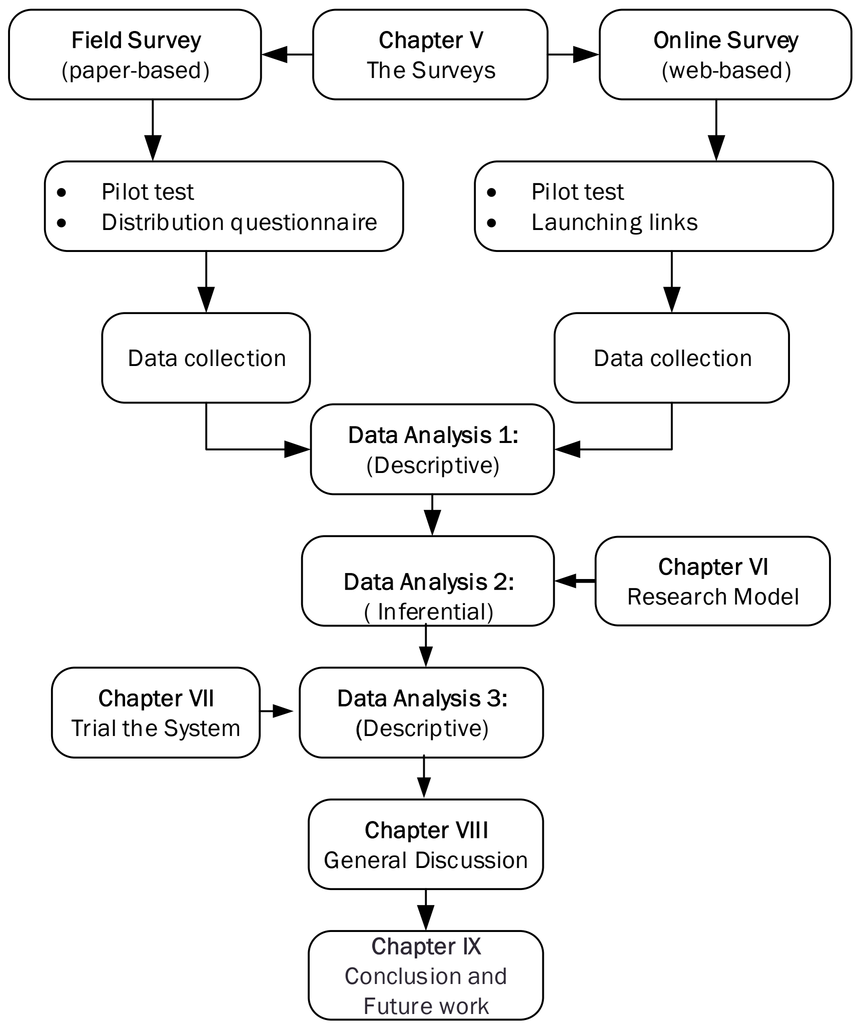


Figure 4. 2: The research data analysis

4.4.1 Data analysis 1: Descriptive analysis

As Williams (2015) states, descriptive statistics are used to describe, or summarise, data in ways that are meaningful and useful. He also emphasised descriptive statistics as being at the heart of all quantitative analysis.

"Data analysis 1" compared the collected data from the online survey and the field survey. To be specific, this data analysis was to assess opinions of two groups of respondents including literacy level, technology reliability, mobile phone penetration, SMS use and readiness of adopting SMS in a flood warning system.

4.4.2 Data analysis 2: Inferential analysis

Data analysis 2 used the collected data from the field survey to formulate a research model to test the hypotheses. The purpose of the inferential analysis was to seek factors influencing adopting SMS messages for flood warnings in the case study area. The factors were chosen for this study since they are main determinants of technology adoption(Davis, 1985; Davis *et al.*, 1989; Venkatesh *et al.*, 2003). The factors include *Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Intention to Use* and *Perceived Enjoyment* (the details are described in Chapter 6).

As highlighted by Goodfriend (2015), inferential statistics is a way of analysing data that allows the researcher to make conclusions about whether a hypothesis was supported by the research results.

To enhance the model fit, an exploratory factor analysis (EFA) was used to examine validity between the items and constructs. An internal consistency analysis for the Cronbach's alpha value was also conducted.

Confirmatory factor analysis (CFA) was performed to check the model fit indices such as Chi-square (χ^2), Goodness-of-Fit Index (GFI), Tucker Lewis Fit Index (TLI), comparative fit index (CFI) and root mean square error of approximation (RMSEA), so that the indices would pass an acceptable level before estimating the research model.

Finally, the hypotheses were tested for the relationships between factors of the research model by reporting a standardized coefficient beta (β), a weight of significance (p) and a coefficient of determination (R^2).

4.4.3 Data analysis 3: Descriptive analysis

Data analysis of the trial aims to identify additional evidence to support the findings from data analysis 1 and data analysis 2. Data analysis 3 evaluates warning message contents, reliability of mobile phone network and SMS transmission time. In particular, this data analysis is to answer research questions 5 (RQ5) which stated that *"Can an SMS messaging via mobile phones be the best channel for a flood warning system in developing countries where mobile phone networks are more available rather than the Internet ?"*

4.5 Ethical issues

This study was conducted following Flinders University regulations. Prior to conducting the surveys, the research project was approved by the Social and Behavioural Research Ethics Committee of Flinders University (Project No: 5954). The research project was also approved by the Mekong River Commission (MRC) to allow its staff to participate in the online survey.

For the paper-based questionnaire, before asking questions, each of the respondents was informed of the objectives of the study and provided with a consent form and the letter of approval from the head of village. For this field survey, respondents were aged over 18 years old have a right to decide whether or not to participate in the survey and they also were free to withdraw at any stage of the interviewing process.

For the online survey, the letter of approval from their organisation (MRC) was attached in the emails containing the link to the online survey. The participants in the online survey were free to stop filling in the questionnaire.

4.6 Chapter review

This chapter introduced the research methodology, including research design, data collection process, data analysis techniques and addressed the ethical issues. In this study, the quantitative multi-method research approach was used to collect and analyse the data. The case study approach was also used in this study.

There were three sources of data collection: the field survey, the online survey and trial of the system. The field survey data was obtained from residents living in the flood prone areas of the case study area. The online data collection was gained from the flooding experts who work in the current flood systems of the case study area. The third data collection occurred from within the trial of the system.

There were also three phases of data analyses: the first data analysis is descriptive analysis which compared the findings from the field survey and the online survey. The second data analysis is inferential data analysis, which developed the research model using the data from the field survey. The third data analysis is descriptive analysis obtained from the trial of the system. The combination of the three analyses results were a key finding for this study.

The next chapter, Chapter V, introduces the surveys, the online survey and the field survey. The findings of the two surveys are compared and discussed.

CHAPTER V : THE SURVEYS

This chapter introduces the survey locations, followed by the processes of the two surveys and data analysis. Finally, the findings are discussed and compared results of two groups of respondents.

5.1 Location of the survey

It was important for the location of these surveys to have special flood characteristics of vulnerability, harmfulness and being unpreventable. Vulnerable residents in flood risk areas undoubtedly should be the targeted population for this research because they can fully explain issues as they are the group of people who have been effected by severe floods.

Champhone district was selected for this study, the reasons for which are described in Chapter III. It is located in about 65 km from the main towns of *Savannakhet* province, and it has 40 villages with a population of around 20,000 people. The majority of people living in the study area are engaged of agricultural activities (IUCN, 2011).

Floods in Champhone district are influenced by flows in many rivers in the upstream catchment causing high water levels in the Xe Champhone River which subsequently spills over its banks. Often floods occur when rainfall is intense, and drainage is congested due to high water level

Champhone District is located in southern Laos and is characterised by high rainfall and wetlands. *Xe Champhone* River traverses the district, annual floods are common, and the scale of the floods vary between years (Figure 3.4)

5.2 The surveys

The two surveys conducted were the field survey and the online survey. The field survey collected the data from 569 respondents who lived in the case study area, while the online survey collected data from 24 flooding experts who worked with the flood warning systems of the case study area.

The results from the two surveys compared perspectives of residents and flooding experts for each of the questions. The significant findings from the two surveys are considered to be a key preliminary finding for motivating the adoption of SMS for flood warning systems in developing countries.

5.2.1 The field survey

The field survey was conducted in the selected case study area. The targeted respondents were residents living in the flood risk areas of the case study location. The residents were vulnerable and have limited knowledge and technology skills.

5.2.1.1 Survey pilot test

The survey was tested before conducting the main survey in order to find out if the questions in the questionnaire were suitable, acceptable and understandable by the mainly farmers in the case study area. Fifteen (15) questionnaires with a 7-point Likert scale were completed for the pilot test in five villages in flood risk areas of the case study area. As such, fifteen people were invited to participate in the survey test. Testers and the researcher assistants found difficulties and misunderstandings regarding to the 7-point scale options. Hence, the questionnaire was modified to use a 5-point Likert scale and some changes were made regarding instructions and the meaning of questions. The final version of the questionnaire for the field survey in English is presented in Appendix 2.

5.2.1.2 Conducting the survey

The field survey was conducted in the case study area of Laos from March to May 2013, covering a period of two months. This survey was a *supervised survey,* where the researcher and the researcher's assistants presented questions, and then respondents answer accordingly. The purpose of presenting questions to the respondents, rather than letting them undertake it themselves, was that this method saved time and reduced confusion arising from the questions, which minimised missing data. The targeted population of the field survey were residents affected by recent floods, particularly *farmers*, who are a group particularly vulnerable to floods. In this survey, 580 respondents aged over 18 years old were selected randomly from the village populations in the flood-prone areas.

5.2.1.3 Demographic profile.

The target population of the field survey was farmers who lived in the flood risk areas. A large proportion of missing data in 11 questionnaires (3.9%) was found to be due to incomplete questions and withdrawal of participants during interviews. The remaining 569 respondents were considered to be the population for this study.

Table 5.1 shows the demographic profile of respondents for the field survey. More than half of the respondents (54.66%) were male and the majority of respondents were in the age range 21 to 60. A smaller group of respondents were elders aged 60 or above and also a younger age group were between 18 and 20 years old, representing around 9% each. The majority of the respondents were farmers (63.27%) who were vulnerable to flood and who were the primary targeted respondents. The second largest category was employees who worked for government and private sectors such as teachers and traders working in a private company (18.28%). Businesspersons and students made up 7.91% and 6.33% of the participants respectively. The smallest percentage of respondents was unspecified (other), at just 4.22%.

Table 5.1: Respondent profile of the field survey (N=569)

Categories	Respondents	Percentage (%)
Gender		
Male	311	54.66
Female	258	43.06
Ages		
18-20	53	9.30
21-30	122	21.40
31-40	131	23.00
41-50	127	22.30
51-60	80	14.10
Above 60	56	9.80
Profession		
Businesspersons	45	7.91
Employees(govt./private)	104	18.28
Farmers	360	63.27
Students	36	6.33
Other	24	4.22
Total respondents	**N=569**	

The farmers were expected to give good evidence for this study by giving honest answers based on their previous real life experience of flood impact. The untargeted respondents like businesspersons, employees and students were taken into account as a limitation of this study, which is addressed in Chapter IX.

5.2.2 Online survey

The online survey was conducted to get the opinions from flooding experts, who work in the flood warning system in the case study area. The flood experts had knowledge of flood warning systems, high education, communication technology skills and they also were familiar with the local community in the flood risk areas.

5.2.2.1 The online pilot test

The 7-point Likert scale of online questionnaire was also modified into a 5-point Likert scale in order to match the field survey since it was intended that the online survey be compared with the results of the field survey.

Prior to releasing the main survey, the pilot test was conducted to evaluate the following points:

- The wording of each question.
- Contents and meaning of questions
- Instructions for the whole questionnaire and each question
- Question layout, user friendliness, look and feel.

Five (5) colleagues of the researcher who met the targeted respondent criteria were invited to participate in the survey testing. Four accepted the invitation and three completed the actual survey with feedback. The feedback mentioned spelling, unclear instructions and meaning of some questions. The online survey questionnaire was modified and adjusted according to the comments of the pilot testers. The final online questionnaire is presented in Appendix 3.

Since the pilot testers met the targeted criteria and worked in targeted authorities, their responses provided a practical guide to the expected results once the survey was made available online.

5.2.2.2 Launch of the online survey

The online survey ran for two months from May to Jun 2013. The targeted respondents of the online survey were flood experts who worked in the current flood warning systems. This online survey used a self-administered approach, where respondents freely filled in the forms and submitted at any time during the time the online survey was available. It was reasonable to assume that the targeted respondents had technological skills since the MRC has long encourage educated people with English competence and technology skills to join their team (MRC, 2015).

For this survey, an online software tool (the Gizmo survey) was used, with URL http://www.surveygizmo.com/s3/1127502/SMS-Flood-warning-System. The reason for using this tool is that it was free and the data could be exported to CSV files.

5.2.2.3 Demographic profile

The target population of the online survey was flooding experts (33) who worked in the flooding forecasting systems. A large proportion of missing data in 9 questionnaires was found to be due to incomplete questions and withdrawal of participants during interviews. The remaining 24 respondents were considered to be the population for this study for further data analysis.

Table 5.2 shows the actual respondent profile of the online survey, categorised by gender, age and profession. Males dominated accounting for 87.50% of responses. In terms of age, the majority of the respondents were 41 to 50 years old (50%), followed by respondents aged between 51-60 and 31-40, representing 29.17% and 20.83% respectively.

By profession, the majority of them were the hydrologists (33.33%), followed by flood forecasters and environment specialist (20.83% each). Smaller occupations were flood modeller and meteorologist at 12.5% each.

Table 5.2: Respondent profile of the online survey (N=24)

Categories	Respondents	Percentage (%)
Gender		
Male	21	87.50
Female	3	12.50
Ages		
18-20	0	0.00
21-30	0	0.00
31-40	5	20.83
41-50	12	50.00
51-60	7	29.17
Above 60	0	0.00
Profession		
Hydrologist	8	33.33
Flood forecaster	5	20.83
Environment specialist	5	20.83
Flooding modeller	3	12.50
Meteorologist	3	12.50
Total respondents	**N=24**	

It is important to stress that respondents participating in the online survey were working in professions related to flood warning and that they had knowledge and skills about flood disasters and warnings (MRC, 2015).

5.3 Analysis and Results

This section presents compares and discusses descriptively the survey findings from the two groups of respondents. The findings include literacy level, reliability of mobile phone network, mobile phone penetration, SMS use and resident's opinion of adoption of SMS for flood warnings.

5.3.1 Literacy level

Questions asking the respondents whether they have a basic knowledge of the local language and/or English were to assess their capabilities in those languages. Respondents who understand local languages or English can use SMS messages easily. As stated in Section 5.3.2, flooding experts had a high level of education with reasonable levels of capability in local languages and English, so only respondents living in the flood risk areas have been assessed for their competence of knowing their local language (Lao) and the basics of English.

Table 5.3 indicates the literacy level of respondents from the flood risk areas who can read and write their own native language (Laotian) by profession. Most respondents can read and write their own language (28.1% at a fair level, 13.2% good and 34.4% very good). However, farmers were the majority of respondents who cannot read and write their own language, representing 10.2% for do not know at all, 14.1% at a poor level and 39% who can read and write at a fair level and above (27.2% fair, 9.7% good and 2.1% very good).

Table 5.3: Level of local language (Laotian) among the respondents

Employment		Can read and write native language(Laotian)					Total
		Cannot	Poor	Fair	Good	Very good	
Employees (govt./private)	Count	0	0	0	5	99	104
	% of Total	0.0%	0.0%	0.0%	0.9%	17.4%	18.3%
Business persons	Count	0	0	2	8	35	45
	% of Total	0.0%	0.0%	0.4%	1.4%	6.2%	7.9%
Farmers	Count	58	80	155	55	12	360
	% of Total	10.2%	14.1%	27.2%	9.7%	2.1%	63.3%
Students	Count	0	0	0	0	36	36
	% of Total	0.0%	0.0%	0.0%	0.0%	6.3%	6.3%
Others	Count	0	0	3	7	14	24
	% of Total	0.0%	0.0%	0.5%	1.2%	2.5%	4.2%
Total	**Count**	**58**	**80**	**160**	**75**	**196**	**569**
	% of Total	**10.2%**	**14.1%**	**28.1%**	**13.2%**	**34.4%**	**100.0%**

Table 5.4 illustrates the English ability for the respondents surveyed in the flood risk areas; it was quite low compared to ability in the native language. More than half of the respondents (51.1%) did not know the basics of English, including 49.7% of the farmers who could not understand English at all.

Table 5.4: Level of English for respondents

Employment		Can understand basic English					Total
		Cannot	Poor	Fair	Good	Very good	
Employees (govt./ private)	Count	0	1	11	36	56	104
	% of Total	0.0%	0.2%	1.9%	6.3%	9.8%	18.3%
Business persons	Count	2	1	12	16	14	45
	% of Total	0.4%	0.2%	2.1%	2.8%	2.5%	7.9%
Farmers	Count	283	53	11	10	3	360
	% of Total	49.7%	9.3%	1.9%	1.8%	0.5%	63.3%
Students	Count	0	0	2	11	23	36
	% of Total	0.0%	0.0%	.4%	1.9%	4.0%	6.3%
Others	Count	6	4	8	4	2	24
	% of Total	1.1%	0.7%	1.4%	0.7%	0.4%	4.2%
Total	**Count**	**291**	**59**	**44**	**77**	**98**	**569**
	% of Total	**51.1%**	**10.4 %**	**7.7%**	**13.5%**	**17.2%**	**100.0%**

Knowledge of the local and English languages leads to easier use of SMS messages because sending a message or reading an incoming message requires at least the basic knowledge of the local language. Table 5.3 and 5.4 indicate that the targeted respondents (farmers) had batter knowledge of their local language compared to English, 39% and 3.2% respectively, at fair levels and above. Hence, it is suggested that an SMS-based flood warning system would need to use the local language for warning messages so that the residents living in flood prone areas have the greatest chance of understanding them.

5.3.2 Mobile phone penetration in the flood risk area

Questions to find out the percentage of mobile phone users in flood prone areas were asked of both residents and flooding experts. The residents who live in flood prone areas were questioned whether they have mobile phones or not, while the flooding experts was asked whether or not they agree that the residents living in flood areas have their own mobile phones. The aim of this question was to find out the availability of mobile phones in the case study area. The more mobile phone users the greater possibility of adopting SMS technology in the area.

Table 5.5 shows that 96.8% of residents have their own mobile phones, 3.2% of total respondents across farmers, students and businesspersons don’t have mobile phones, representing 2.6%, 0.4% and 0.2% respectively. Surprisingly, 95.8% of farmers had their own mobile phones. For the respondents who don’t have their own mobile phones, they indicated that they used to have their own mobile phones and/or they currently share the mobile phones with their family members.

Table 5.5: Mobile phone penetration in the flood risk areas by profession

Profession		Resident has a mobile phone		Total
		Don't have mobile phone	Have my own mobile phone	
Employees (govt./private)	Count	0	104	104
	% within Profession	0.0%	100.0%	100.0%
	% of Total	0.0%	18.3%	18.3%
Business persons	Count	1	44	45
	% within Profession	2.2%	97.8%	100.0%
	% of Total	0.2%	7.7%	7.9%
Farmers	Count	15	345	360
	%within Profession	**4.2%**	**95.8%**	**100.0%**
	% of Total	2.6%	60.6%	63.3%
Students	Count	2	34	36
	% within Profession	5.6%	94.4%	100.0%
	% of Total	0.4%	6.0%	6.3%
Others	Count	0	24	24
	% within Profession	0.0%	100.0%	100.0%
	% of Total	0.0%	4.2%	4.2%
Total	Count	18	551	569
	% within Profession	3.2%	96.8%	100.0%
	% of Total	**3.2%**	**96.8%**	**100.0%**

In order to confirm mobile phone ownership among the residents, the flooding experts were asked whether the residents have mobile phones or not.

Table 5. 6: Mobile phone penetration responded by to the experts.

Level of Agreement	Frequency	Percent
Strong disagree	1	4.1%
Disagree	3	12.5%
Neither disagree or agree	9	37.5%
Agree	8	33.3%
Strong agree	3	12.5%
Total	**24**	**100.00%**

Table 5.6 illustrates the mobile phone penetration in the flood risk area as answered by the flooding experts. Around 45.8% believed that residents have mobile phones

(33.3% agreement and 12.5% strong agreements), while 37.5% of them were not sure and 16.6% of flooding experts disagreed.

From Table 5.5 and 5.6, it can be seen that mobile phone penetration in the case study area is relatively high. 96.8% of residents had mobile phones; specifically 95.8 % of farmers in the case study had their own mobile phones. This level of ownership implies that it is possible to adopt SMS messages to alert farmers about a severe flood.

5.3.3 Mobile phone coverage in the flood risk areas

The two groups of respondents (residents and flooding experts) were asked whether or not the mobile phone signal is reliable in the flood-prone areas. The reason for asking this question is to determine if mobile phone coverage is available or not in flood risk areas.

Figure 5.1 shows that both groups of participants considered mobile phone coverage to be very satisfactory. A total of 42% and 23% of respondents in the flood risk areas believed that mobile phone coverage in their areas is reliable and very reliable respectively. Although, 33% of respondents believed that mobile signals in their areas, was neither unreliable nor reliable (neutral), only 2% of them were not happy with the mobile signal.

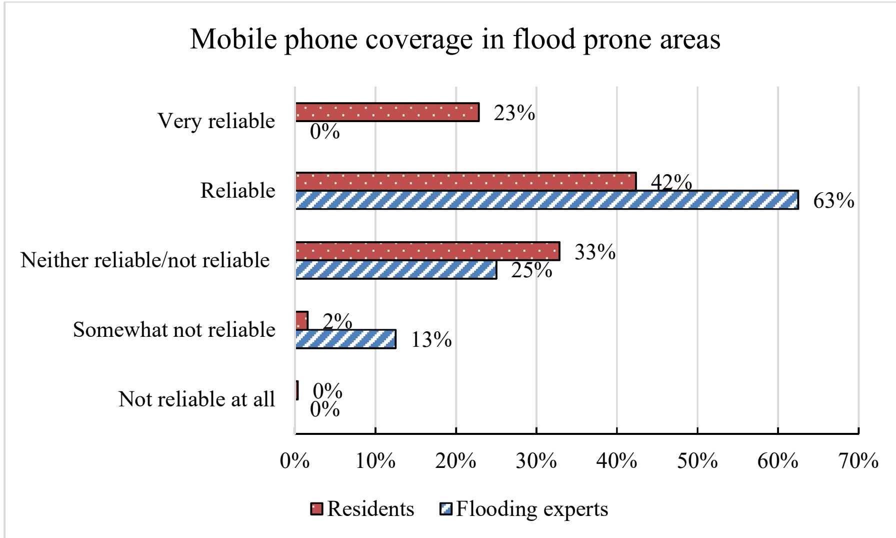


Figure 5.1: Mobile phone coverage in the flood risk area

It was important to ask the flooding experts for their opinions about the reliability of mobile phone coverage in flood risk areas. The flooding experts are likely to know mobile phone coverage in the communities because they normally use mobile phones during field trips or visiting their hydrological stations (MRC, 2011b). Their opinions of the mobile phone coverage was reliable (63%), followed by neutral response (25%), but just 13% of them asserted that mobile phone coverage is somewhat unreliable.

A comparison of the results from the two groups of respondents, Figure 5.1, shows that more than half of both groups believed that mobile phone coverage in flood risk areas was reliable. Therefore, it is evident that an SMS-based flood warning system is likely to reach the majority of mobile phone recipients located in the flood risk areas.

5.3.4 Residents can afford using mobile phones

This section presents results of answers to questions regarding affordability (monthly top up) of mobile phones. It is important to ask residents whether they can afford a mobile phone or not. The answers to this question indicate affordability of using the technology in daily life.

A majority of the respondents(58%) in the flood-prone areas felt that they can neither afford nor cannot afford mobile phones, with 37% of them saying they can afford using mobile phones (25% for can afford and 12% for always can afford respectively) and just 5% believed that they somewhat cannot afford (Figure 5.2).

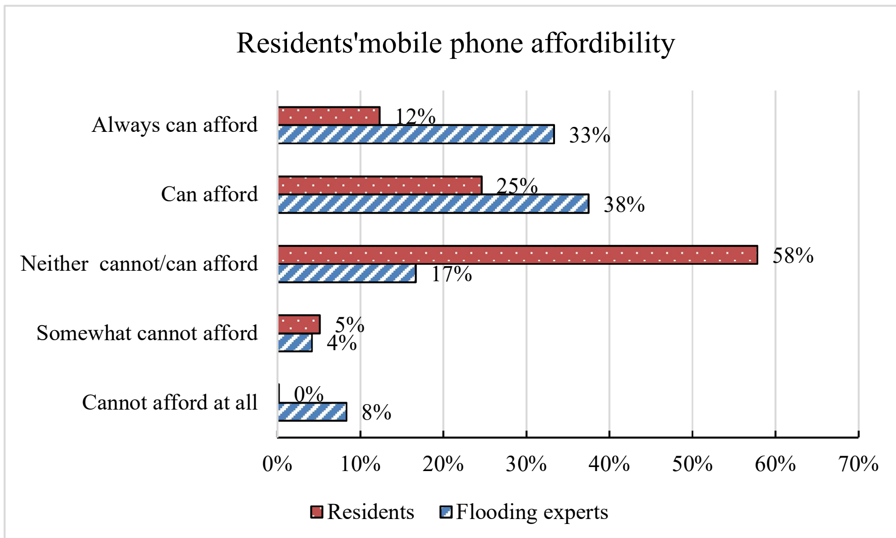


Figure 5. 2: Affordability of using mobile phones in flood risk area

About 38% of the respondents of the flooding experts have given their opinion that residents in the flood risk areas can afford mobile phone top up and 33% of them indicated that they can always afford it. 16% of flood experts said that residents neither can nor cannot afford, while 4% and 8% of them said they cannot afford and cannot afford at all respectively.

Table 5.7 shows that the majority of farmers (62.5%) answered that that they can neither afford nor cannot afford mobile phones, only around 32.5% of them said they can afford it and 5% of them believed that they cannot afford.

Table 5. 7: Resident affordability of use mobile phones

Profession		Do resident can afford to use mobile phone?					Total
		Not affordable at all	Somewhat not affordable	Neither affordable /not affordable	Affordable	Very affordable	
Employees (govt./ private)	Count	0	5	55	29	15	104
	% within Profession	0.0%	4.8%	52.9%	27.9%	14.4%	100.0%
	% of Total	0.0%	0.9%	9.7%	5.1%	2.6%	18.3%
Business person	Count	0	0	9	19	17	45
	% within Profession	0.0%	0.0%	20.0%	42.2%	37.8%	100.0%
	% of Total	0.0%	0.0%	1.6%	3.3%	3.0%	7.9%
Farmers	Count	0	18	225	83	34	360
	% within Profession	**0.0%**	**5.0%**	**62.5%**	**23.1%**	**9.4%**	**100.0%**
	% of Total	0.0%	3.2%	39.5%	14.6%	6.0%	63.3%
Students	Count	1	4	25	3	3	36
	% within Profession	2.8%	11.1%	69.4%	8.3%	8.3%	100.0%
	% of Total	0.2%	0.7%	4.4%	0.5%	0.5%	6.3%
Others	Count	0	2	15	6	1	24
	% within Profession	0.0%	8.3%	62.5%	25.0%	4.2%	100.0%
	% of Total	0.0%	0.4%	2.6%	1.1%	0.2%	4.2%
Total	Count	1	29	329	140	70	569
	% within Profession	0.2%	5.1%	57.8%	24.6%	12.3%	100.0%
	% of Total	**0.2%**	**5.1%**	**57.8%**	**24.6%**	**12.3%**	100.0%

It is important to note that the neutral responses of the residents was high compared to the answers of the flooding experts (58% against 17%) and 62.5% of farmers. It is interesting to find out reasons why the residents including farmers sometimes can afford or cannot afford a mobile phone.

5.3.5 Residents always switch on mobile phones

Since it is preferable that residents have their mobile phones switched on at all times, questions were asked about this. The residents were asked if they have their mobile phone switched on at all times or only sometimes.

The majority (67%) of respondents answered that they often have their mobile phone switched on (21% often and 46% always), while 30% of them replied that they neither turned them on nor off (neutral answers). Only 2% and 1% of them believed that they sometimes and rarely switched on their mobile phones (Figure 5.3).

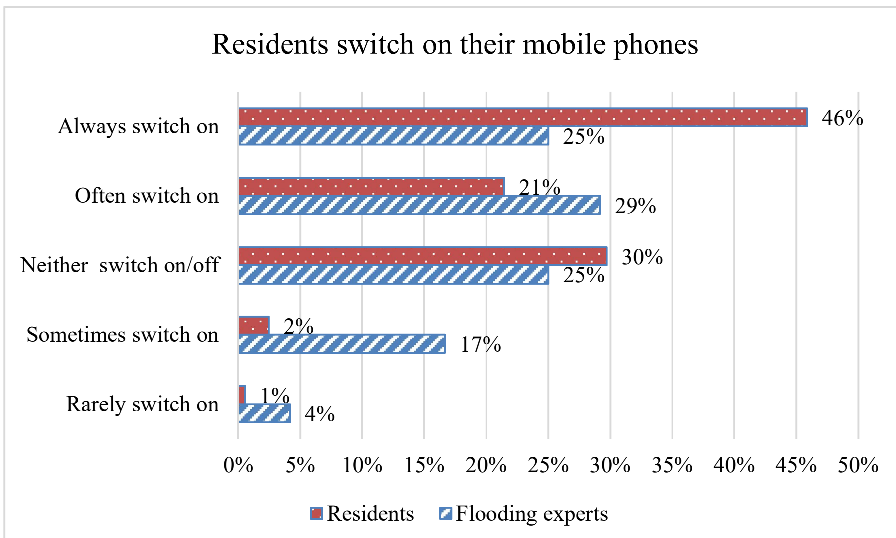


Figure 5. 3: Residents switched on their mobile phone

Similarly, 54% of the flooding experts agreed that the residents switched their mobile phones on (25% for often and 29% always switch on respectively), followed by 25% were for neutral opinions, whereas 17% and 4% of them believed that the residents sometimes and rarely turn on their mobile phones.

Table 5. 8: Residents switch on mobile phones

Profession		Do residents switch on their mobile phone? Rarely switch on	Sometimes switch on	Neither switch on/off	Often switch on	Always switch on	Total
Employees govt./priv.	Count	0	6	18	27	53	104
	% within Profession	0.0%	5.8%	17.3%	26.0%	51.0%	100.0%
	% of Total	0.0%	1.1%	3.2%	4.7%	9.3%	18.3%
Business persons	Count	0	2	2	15	26	45
	% within Profession	0.0%	4.4%	4.4%	33.3%	57.8%	100.0%
	% of Total	0.0%	0.4%	0.4%	2.6%	4.6%	7.9%
Farmers	Count	3	5	132	69	151	360
	% within Profession	**0.8%**	**1.4%**	**36.7%**	**19.2%**	**41.9%**	**100.0%**
	% of Total	0.5%	0.9%	23.2%	12.1%	26.5%	63.3%
Students	Count	0	0	14	9	13	36
	% within Profession	0.0%	0.0%	38.9%	25.0%	36.1%	100.0%
	% of Total	0.0%	0.0%	2.5%	1.6%	2.3%	6.3%
Others	Count	0	1	3	2	18	24
	% within Profession	0.0%	4.2%	12.5%	8.3%	75.0%	100.0%
	% of Total	0.0%	0.2%	0.5%	0.4%	3.2%	4.2%
Total	Count	3	14	169	122	261	569
	% within Profession	0.5%	2.5%	29.7%	21.4%	45.9%	100.0%
	% of Total	**0.5%**	**2.5%**	**29.7%**	**21.4%**	**45.9%**	**100.0%**

Table 5.8 also shows that 61.1%of famers often switched on their mobile phones (19.2% for often and 41.9% for always), followed by 36.7% of them neither switched on nor off. A few of them rarely and sometimes switched their mobile phones on (0.8% and 1.4% respectively).

In summary, the majority of both groups of respondents (64% residents and 54% flooding experts) said that the residents living in flood risk areas often switch on their mobile phones, specifically 61.1% of farmers often switched them on. There was a relatively high percentage of both respondent groups that gave neutral answers (30% and 25%) and 36.7% of farmers also answered the neutral option.This issue needs to be investigated.

5.3.6 Residents carry their mobile phones

The purpose of this question is to check if residents in flood risk areas carry their mobile phone or not while working. In order to receive a warning about floods via mobile phones the residents should carry their mobile phone with them.

Figure 5.4 shows that there were similar patterns in answering this question for residents and flooding experts. Specifically, 63% of the residents carry their mobile phone at work (22% often carry and 41% always carry), followed by 34% for neither carry or not carry. Only 3% and 1% of them felt that they sometimes and rarely carry their mobile phones.

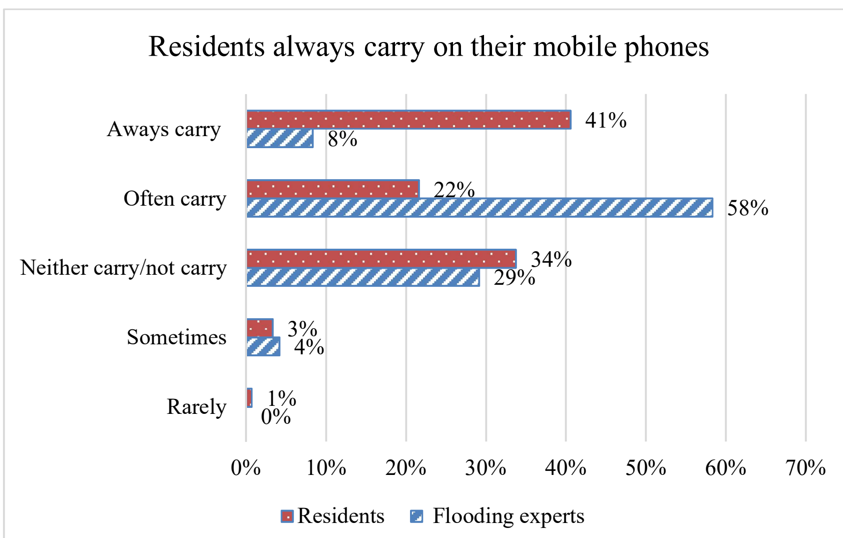


Figure 5.4: Residents carry their mobile phones

66% of the flooding experts believed that residents carry their mobile phones during work (58% often carry and 8% always carry), followed by 29% of them saying that residents neither carry nor not carry and only 4% of the flood experts said that the residents sometimes carry their mobile phones.

Table 5. 9: Residents carry mobile phones for work

Profession		Do residents carry their mobile phones?					Total
		Rarely switch on	Sometimes switch on	Neither switch on/off	Often switch on	Always switch on	
Employees (govt./private)	Count	0	6	24	30	44	104
	% within Profession	0.0%	5.8%	23.1%	28.8%	42.3%	100.0%
	% of Total	0.0%	1.1%	4.2%	5.3%	7.7%	18.3%
Business persons	Count	0	0	2	10	33	45
	% within Profession	0.0%	0.0%	4.4%	22.2%	73.3%	100.0%
	% of Total	0.0%	0.0%	.4%	1.8%	5.8%	7.9%
Farmers	Count	3	13	145	72	127	360
	% within Profession	**0.8%**	**3.6%**	**40.3%**	**20.0%**	**35.3%**	**100.0%**
	% of Total	0.5%	2.3%	25.5%	12.7%	22.3%	63.3%
Students	Count	0	0	15	6	15	36
	% within Profession	0.0%	0.0%	41.7%	16.7%	41.7%	100.0%
	% of Total	0.0%	0.0%	2.6%	1.1%	2.6%	6.3%
Others	Count	1	0	6	5	12	24
	% within Profession	4.2%	0.0%	25.0%	20.8%	50.0%	100.0%
	% of Total	0.2%	0.0%	1.1%	.9%	2.1%	4.2%
Total	Count	4	19	192	123	231	569
	% within Profession	0.7%	3.3%	33.7%	21.6%	40.6%	100.0%
	% of Total	**0.7%**	**3.3%**	**33.7%**	**21.6%**	**40.6%**	**100.0%**

Table 5.9 indicates majority of residents carried on their mobile phones for work. 55.3% of farmers carry their mobile phones (20% for often and 35.3% for always carry), followed by 40.3% of them answered that they neither carried nor did not carried. There were few of them rarely and sometimes carried mobile phones (0.8% and 3.6% respectively).

To sum up, the majority of residents carry their mobile phone at work. The flooding experts also confirmed that the residents carry their mobile phone to work, although there was a small percentage of both respondents that said that residents only sometimes carry their mobile phone to work, between 3% and 4%.This research indicates that the majority of residents carry their mobile phones during work, but 40.3% of farmers neither carried and did not carried their mobile phones. The issue also needs to be investigated.

5.3.7 Residents in flood risk areas use SMS

Both residents and flooding experts were asked whether residents living in the flood prone areas use SMS. This question was to evaluate the proportion of residents using SMS.

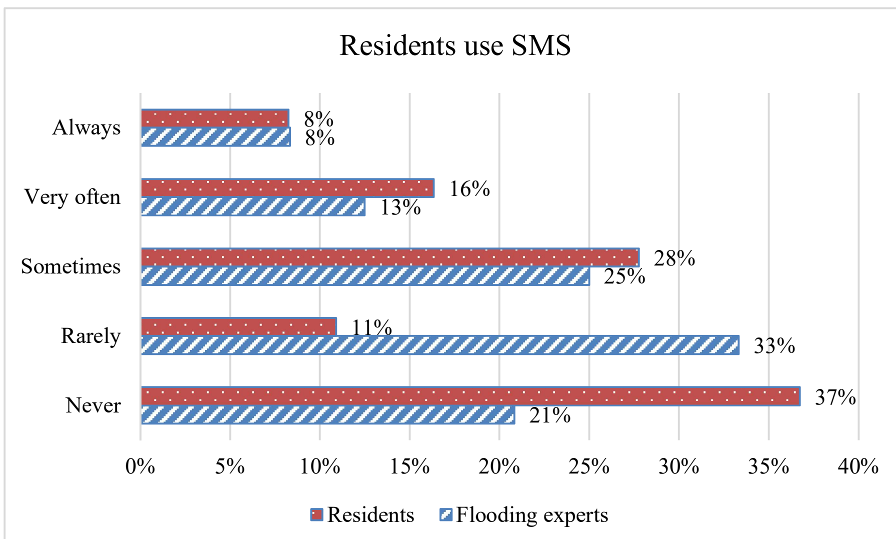


Figure 5.5: SMS used by residents

Figure 5.5 compares the data collected from residents and the opinion of the flooding experts. For the residents, 37% of them never have used SMS, followed by 11% and 28% answered that they used SMS rarely and sometimes respectively. Only 24% of them used SMS very often and always (16% and 8% for often and always used respectively). For this question, 54% of the flooding experts believed that the residents never use or rarely use (21% and 33% for never and rarely used). 25%

believed that the residents sometimes use SMS, with only 21% of them (13% often and 8% always used) thought the residents often used SMS.

Table 5.10 shows that 56.1% of farmers who never used SMS, followed by 22.2% of them used sometimes and 16.7% of them rarely use SMS. Only 5% of them used SMS messages regularly (2.8% of usually and 2.2% of always). Table 5.10 also shows that around 43.9% of the farmers seem to have knowledge of use SMS (16.7% for rarely use, 22.2% for sometimes use, 2.8% for usually use and 2.2% for always use).

Table 5. 10: SMS used by profession

Profession		Do residents use SMS?					Total
		Never	Rarely	Sometimes	Usually	Always	
Employees (govt./private)	Count	1	0	37	56	10	104
	% within Profession	1.0%	0.0%	35.6%	53.8%	9.6%	100.0%
	% of Total	0.2%	0.0%	6.5%	9.8%	1.8%	18.3%
Business persons	Count	1	0	17	16	11	45
	% within Profession	2.2%	0.0%	37.8%	35.6%	24.4%	100.0%
	% of Total	0.2%	0.0%	3.0%	2.8%	1.9%	7.9%
Farmers	Count	202	60	80	10	8	360
	% within Profession	**56.1%**	**16.7%**	**22.2%**	**2.8%**	**2.2%**	**100.0%**
	% of Total	35.5%	10.5%	14.1%	1.8%	1.4%	63.3%
Students	Count	0	2	10	9	15	36
	% within Profession	0.0%	5.6%	27.8%	25.0%	41.7%	100.0%
	% of Total	0.0%	0.4%	1.8%	1.6%	2.6%	6.3%
Others	Count	5	0	14	2	3	24
	% within Profession	20.8%	0.0%	58.3%	8.3%	12.5%	100.0%
	% of Total	0.9%	0.0%	2.5%	0.4%	0.5%	4.2%
Total	Count	209	62	158	93	47	569
	% within Profession	36.7%	10.9%	27.8%	16.3%	8.3%	100.0%
	% of Total	**36.7%**	**10.9%**	**27.8%**	**16.3%**	**8.3%**	**100.0%**

In summary, Figure 5.5 indicates that both the residents and the flooding experts believed that the residents in flood risk areas are unlikely to use SMS in their daily life. Table 5.10 shows that there was a very small number of farmers who used SMS regularly, albeit 43.9% of them used to use SMS.

It is interesting to note that even though residents have their own mobile phones, there might be some barriers that prevent the residents from using SMS. As a result, it was deemed necessary to identify factors influencing the use of SMS among residents in flood prone areas by developing and testing a research model (Chapter VI) and by interviewing residents after a trial of the proposed system (Chapter VII).

5.3.8 Effectiveness of the current flood warning system

The current flood warning system was evaluated for effectiveness by asking both residents and flooding experts, if it is effective. The aim of this question was to check if the residents are happy with the current system (e.g. timely receipt of a flood warning). The flooding experts were asked to assess what they technically think about the current flood warning system.

Figure 5.6 shows that 41% of the residents thought that the current flood warning system is effective (13% for very effective and 28% for effective), whereas 59% of the flooding experts believed that the flood warning system is effective (46% of effective and 13% for very effective).

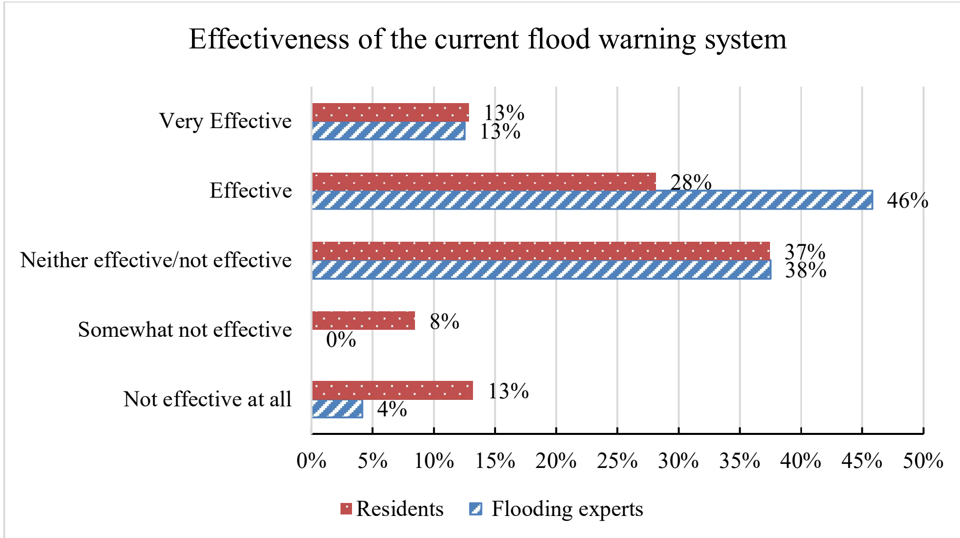


Figure 5.6: Effectiveness of the current flood warning system

It must be recognised that around 37% and 38% of both residents and flooding experts said that the current flood warning system is neither effective nor ineffective. In addition, 13% of residents thought that the current flood warning system is not effective at all, while 4% of flooding experts also believed the same.

Table 5.11 illustrates that 37.2% of farmers believed that the current flood warning system is effective, 40.6% of them were not sure about its effectiveness(neutral answer), but 13.9% of them answered that it was not effective at all and 8.3% of them answered with somewhat no effective.

Table 5. 11: Effectiveness of the current flood warning system

Profession		Do resident think the current flood warning system is effective?					Total
		Not effective at all	Somewhat no effective	Neither ineffective /effective	Effective	Very Effective	
Employees (govt./ private)	Count	17	6	32	32	17	104
	% within Profession	16.3%	5.8%	30.8%	30.8%	16.3%	100.0%
	% of Total	3.0%	1.1%	5.6%	5.6%	3.0%	18.3%
Business persons	Count	6	2	12	16	9	45
	% within Profession	13.3%	4.4%	26.7%	35.6%	20.0%	100.0%
	% of Total	1.1%	0.4%	2.1%	2.8%	1.6%	7.9%
Farmers	Count	50	30	146	95	39	360
	% within Profession	**13.9%**	**8.3%**	**40.6%**	**26.4%**	**10.8%**	**100.0%**
	% of Total	8.8%	5.3%	25.7%	16.7%	6.9%	63.3%
Students	Count	4	2	12	12	6	36
	% within Profession	11.1%	5.6%	33.3%	33.3%	16.7%	100.0%
	% of Total	0.7%	0.4%	2.1%	2.1%	1.1%	6.3%
Others	Count	2	5	8	6	3	24
	% within Profession	8.3%	20.8%	33.3%	25.0%	12.5%	100.0%
	% of Total	0.4%	0.9%	1.4%	1.1%	0.5%	4.2%
Total	Count	79	45	210	161	74	569
	% within Profession	13.9%	7.9%	36.9%	28.3%	13.0%	100.0%
	% of Total	**13.9%**	**7.9%**	**36.9%**	**28.3%**	**13.0%**	**100.0%**

It would be strongly desirable to know why the farmers were not happy with the current flood warning system (22.2%), while only 4% of flooding experts believed the same.

5.3.9 Readiness to adopt an SMS-based flood warning system

The residents and the flooding experts were asked for their opinions whether or not there was a possibility of adoption of SMS in flood warning system in the case study area. Both the residents and the flooding experts gave similar opinions that there was a high possibility of adopting SMS messages for flood warning in the case study area. Figure 5.7 illustrates that 83% of residents had a highly favourable opinion of using an SMS-based flood system, 51% with possible and 32% with high possible, followed by 13% who thought it was neither impossible nor possible, and only 2% of the residents disagreed with SMS adoption.

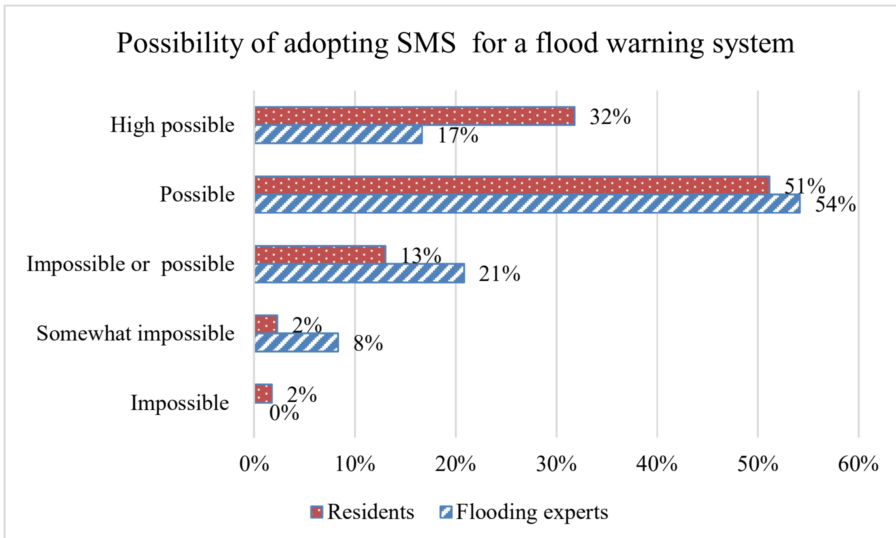


Figure 5.7: Adoption of an SMS-based flood warning system

More than half (54%) of the flooding experts agreed with it being possible to apply SMS as a flood warning system for people in the flood risk areas in the case study, and 17% indicated that it is highly possible to use this proposed system, followed by 21% who answered with a neutral opinion and just 8% who believed it was somewhat impossible.

Similarly, Table 5.12 reveals that 84.2% of farmers were ready to use SMS for a flood waring in their areas, followed by 13.3% of them gave their opinions that it neither possible nor impossible, only 2.5% for impossible.

Table 5. 12: Readiness of use of SMS-based flood warning

Profession		Are residents ready to use an SMS-based flood warning?					Total
		Impossible	Somewhat impossible	Neither possible/ impossible	Possible	High possible	
Employees (govt./private)	Count	0	5	19	44	36	104
	% within Profession	0.0%	4.8%	18.3%	42.3%	34.6%	100.0%
	% of Total	0.0%	0.9%	3.3%	7.7%	6.3%	18.3%
Business persons	Count	0	0	1	14	30	45
	% within Profession	0.0%	0.0%	2.2%	31.1%	66.7%	100.0%
	% of Total	0.0%	0.0%	0.2%	2.5%	5.3%	7.9%
Farmers	Count	1	8	48	202	101	360
	% within Profession	**0.3%**	**2.2%**	**13.3%**	**56.1%**	**28.1%**	100.0%
	% of Total	0.2%	1.4%	8.4%	35.5%	17.8%	63.3%
Students	Count	0	0	3	25	8	36
	% within Profession	0.0%	0.0%	8.3%	69.4%	22.2%	100.0%
	% of Total	0.0%	0.0%	0.5%	4.4%	1.4%	6.3%
Others	Count	0	0	4	13	7	24
	% within Profession	0.0%	0.0%	16.7%	54.2%	29.2%	100.0%
	% of Total	0.0%	0.0%	0.7%	2.3%	1.2%	4.2%
Total	Count	1	13	75	298	182	569
	% within Profession	0.2%	2.3%	13.2%	52.4%	32.0%	100.0%
	% of Total	**0.2%**	**2.3%**	**13.2%**	**52.4%**	**32.0%**	**100.0%**

To sum up, both flooding experts and residents responded that it was highly possible to use SMS for flood warnings in the case study area (71 % and 83% possible or highly possible). It is interesting to note that 84.2% of farmers in the case study area are ready to adopt SMS messages for a flood warning system, even though there was a small number of the use SMS among them.

5.3.10 Phone calls or SMS

Residents were asked for their preference of a flood warning, between receiving SMS messages or phone calls from a flooding authority in a case of a severe flood. Figure 5.8 illustrates that receiving a phone call is the first choice: 79% of the residents in flood risk area chose phone calls (41% and 38 % with high priority and essential respectively), whereas 32% of the residents preferred the warning via SMS (28% and 4% with high priority and essential levels respectively).

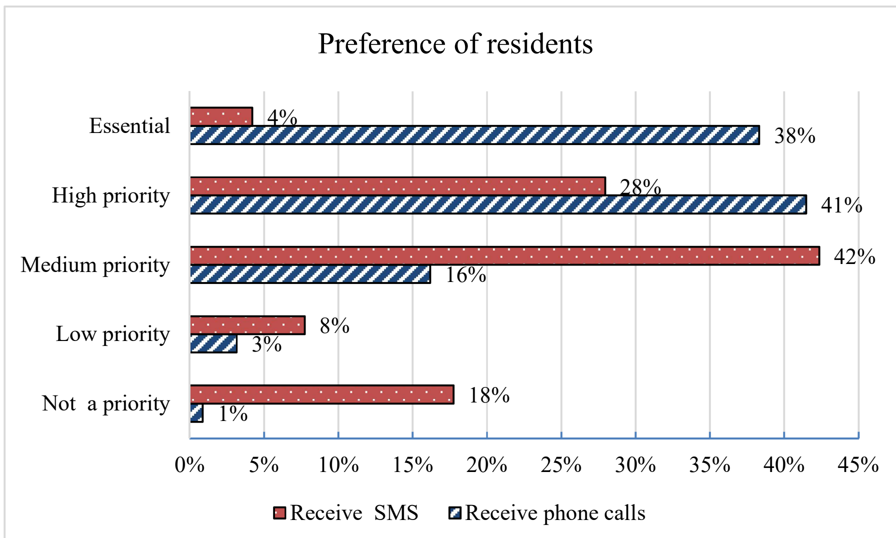


Figure 5.8: Making phone call vs sending SMS in case of a severe flood.

It is interesting to note that around 42% of residents were not sure whether they would want to receive an SMS or not if a severe flood occurs, and 18% and 8% of them thought that they wouldn't want to receive an SMS at all. In summary, in the case of a severe flood, residents in flood prone areas prefer to receive phone calls rather then get text messages for a flood warning from the flooding authority.

As stated in Section 5.3.7, around 37% of residents had never used SMS and only 24% of them have used SMS. Therefore, it must be recognised that there are obstacles preventing residents living in flood risk area from using SMS. The obstacles may be associated with languages, technology skills, or lack of campaigns promoting the use of appropriate technology from government or concerned parties.

5.4 Chapter review

This chapter reported the findings of the two surveys, the field survey and the online survey. The paper-based field survey was to ask/interview residents living in flood prone areas of the case study area in Laos, the targeted respondents of the field survey, farmers, comprised 63.28% of all respondents. The online survey was a self-administered questionnaire, the targeted respondents for the online survey were the flooding experts who work in the flood warning systems associated with flood forecasting and flood information dissemination.

The reasons for the two surveys and having two groups of respondents were:

- To compare the findings gained from the residents and the flooding experts
- To find similarity and differences of their opinions on each question
- To balance findings gained from the two groups of the respondents
- To identify which aspects of the research questions need to be further investigated

The findings of this chapter are summarized as follows:

In terms of language, only the local language (Laotian) can be used for SMS-based warnings in the case study area because the local language is more understandable by the residents.

The Mobile phone penetration in flood prone areas was high. 96.8% residents and 95.8% of farmers had their mobile phones, but 45.8% of the flooding experts agreed that the penetration was high.

The mobile phone coverage was reliable in the flood risk areas based on the opinions of the both residents (65%) and flooding experts (63%).

In terms of *mobile phone affordability*, 37% residents and 32.5% of farmers reported that they can afford mobile phones, while 71% the flooding experts believed that residents living in flood prone areas can afford to use their mobile phones.

The majority of residents and flooding experts believed that the residents in flood prone areas regularly *carry and switch on their mobile phones at work*, but *many of them switch on nor off* (36.7% of farmers).

Comparing *voice calls and text messages*, residents and flooding experts gave their opinions that the residents in flood prone areas would choose phone calls rather than SMS service for a flood warning.

According to resident and flooding expert perspectives, adoption of SMS messages for a flood warning system in the case study area will be possible if it uses the local language (Laotian) for the warnings because the residents know only the local language. It should be noted that although mobile phone technologies are available and high mobile phone penetration in the case study area. Only 24% of the residents including 5% of farmers use SMS, albeit 43.9% of them used to use SMS.

For this reason, Chapter VI will investigate factors motivating residents in the flood prone areas to use SMS and adopt text messages for a flood warning system. Chapter VII also will confirm technology availability findings in this chapter (e.g. mobile phone coverage, penetration). The local language will be used for the trial of the prototype because most residents don't know basic English.

The next chapter, Chapter VI, will formulate a research model for adopting an SMS-based flood warning system in the case study area. The model will be tested to assess the main factors influencing the use of SMS for flood warnings.

CHAPTER VI : THE RESEARCH MODEL

6.1 Introduction

In this chapter a research model is proposed and tested. The research model was based the Technology Acceptance Model (TAM) which was first introduced by Davis (1985); Davis, Bagozzi, and Warshaw (1989).

According to the results of the Chapter V, there was limited use of the technology available to the users in the case study area. Specifically mobile phones were available in the flood prone areas but the residents in the areas didn't use SMS messages (96% mobile phone penetration against only 24% use of SMS). Hence, it was important to seek reasons why the residents didn't use SMS messages in their daily life. In reality, the question is if residents don't use SMS for their daily life, how can they adopt SMS for the proposed flood warning system?

TAM has been used in a number of studies across different disciplines to predict and explain technology acceptance concepts for various information systems. TAM has been improved, extended and adapted by many researchers for studies on technology acceptance (Bagozzi, 2007; Davis, 1985; Davis *et al.*, 1989, 1992; Venkatesh & Davis, 2000; Venkatesh *et al.*, 2003). More recently TAM has been extended and adapted for the acceptance of SMS-based e-government services (Susanto, 2012).

Based on the constructs of TAM by Davis (1985); Davis *et al.* (1989) and the extended technology acceptance model by Van der Heijden (2003), a modified model called SMS Technology Acceptance Model (SMSTAM) was proposed in this study. The SMSTAM was designed specifically to examine the people's *perceived enjoyment*, *perceived usefulness*, *perceived ease of use*, *attitude toward use* and *intention to use* as predictors of adopting SMS messages for a flood alerts.

The proposed model aims to understand why residents living in the case study area didn't use SMS for daily life, even though they have their own mobile phones. The purpose of the model is to identify factors influencing residents' attitude and intention to use SMS for a flood warning system in their areas. The independent factors are key predictors of the adoption of SMS for a flood warning system in the case study area. This chapter contributes to answer to the research question 3 (RQ3) *"What are the key predictors of adopting SMS messages for a flood warning system in the case study area?"*

6.2 Research model development

The research model development was based on the research methodology and research framework as stated in Chapter IV. In this section, the questionnaire development and pre-test are discussed first, followed by construct development and the research model. Finally, data sampling, data collection process and data analysis are presented.

6.2.1 Questionnaire pre-test

Prior to conducting the survey, a face validity and pre-test was used to test the questions in the questionnaire. The face validity refers to an evaluation of whether each question in the questionnaire logically gains the information about the factors of interest, was well designed, clear and concise (Susanto, 2012). The original English questionnaire was translated into the local language (Laotian), since the residents in flood risk areas have limited understanding of English. The English and Lao questionnaire versions were reviewed by three bilingual speaking staff who worked in the Mekong River Commission (MRC).

The main purpose of the pre-test is to verify that the targeted respondents understand questions as intended by the researcher. In this study, due to limitation of volunteer participants for the pre-test, the questionnaire was pre-tested by 10 participants who lived in flood prone areas. The participants were asked to complete the questionnaire and make comments on any questions in the questionnaire. As Perneger *et al.* (2014) stated that 10 pre-tested participants had a power of more than 40% of detecting problem.

The feedback from participants was related to unclear instruction, confusing questions, meaning and irrelevant questions. Based on this feedback, the instructions and some questions were either dropped or modified. As a result, the face validity test produced a modified questionnaire that contained 19 questions to measure 5 constructs of interest. The modified questionnaire in the local language is shown in Appendix 4.

6.2.2 Construct development

The constructs of the research model in this study were based upon the questionnaire development and the original TAM constructs reviewed in the literatures in Chapter II. This study proposed five constructs: *Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Intention to Use* and *Perceived Enjoyment*, and the details are as follows

- ***Perceived Usefulness (PU)***

Perceived usefulness was defined as the degree to which an individual believes that using a particular technology would improve his or her job performance in an organisational context (Davis, 1985; Davis *et al.*, 1989, 1992). In TAM, perceived usefulness is a main factor for measuring attitudes in relation to new technology. In this study, perceived usefulness is an individual's perception of benefit arising from the use of mobile phones and SMS messages for work and for emergency circumstances.

- ***Perceived Ease of Use (PEOU)***

Perceived ease of use in the technology acceptance model (TAM) was adapted from (Davis, 1985; Davis *et al.*, 1989; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000). PEOU was defined as the degree to which an individual believes that using a particular technology is free of effort (Davis, 1985). PEOU has strong influence on intention to accept technology, and an indirect effect on *attitude toward use* (Davis *et al.*, 1989; Igbaria *et al.*, 1997). For this study, PEOU refers to it being easy to use mobile phones and SMS for residents living in flood risk areas because they had technology skills, basic knowledge of the local language and English.

- ***Perceived Enjoyment (PEN)***

The perceived enjoyment component of the research model was adopted from the TAM and the Extended TAM, which is an integrated model of the determinants of perceived usefulness and ease of use (Venkatesh & Bala, 2008). In this study *perceived enjoyment* measures enjoyment of easily using mobile phone functions such as games and camera. Using SMS services for sending and receiving messages to/from friends or other people is enjoyable communication. Accessing social media via the Internet with smart mobile phones is also fun for many users.

- ***Attitude toward use (A)***

Attitude toward use is considered a factor that determines someone's behaviour. Fishbein and Ajzen (1975) highlighted attitude as someone's disposition to react in a favourable or unfavourable manner to a certain object. The disposition may be negative or positive (T. Teo, 2009). For this study, *attitude toward use* is referred to the attitude of residents to using their mobile phones and SMS for everyday life and receiving alerts about a severe flood.

- ***Intention to Use (IU)***

Intention to use is a measure of the likelihood that an individual will adopt a particular technology (Davis *et al.*, 1989). Fishbein and Ajzen (1975) defined intention to use as the extent to which a person has planned to do or not to do some determination in the future. In information systems, intention to use is the degree to which an individual intends using a certain system (Haataja *et al.*, 2011; Venkatesh & Bala, 2008).

In this research, *intention to use* relates to an individual's intention to use SMS for flood warning. The *attitude toward use* could directly influence *intention to use*, because in reality, prior to adopting SMS for a flood warning system, a mobile phone user should use SMS in other activities.

In this current study, 19 items for five constructs (factors) were identified and designed as shown in Table 6.1.

Table 6.1: Items of constructs

Constructs	Items	Questionnaire items
Perceived Usefulness	PU1	Mobile phone is useful for my work
	PU2	Using mobile phone can save my time
	PU3	SMS is good for emergency alerts
	PU4	It is useful to use SMS for flood warning
	PU5	Having mobile phone is very useful
Perceived Ease of Use	PEOU1	SMS is easy to use because I know the local language
	PEOU2	SMS is easy to use because I understand basic English
	PEOU3	Mobile phone is easy to use because I have technology skills
Perceived Enjoyment	PEN1	I always like playing games and other functions on phone
	PEN2	I enjoy chatting via SMS on phone
	PEN3	I like accessing Internet/social media on my phone
Attitude toward Use	A1	I would probably respond to a flood by calling people via mobile phone
	A2	I will make a call to warn people I know if a flood affects my area
	A3	I will use my mobile phone to contact my family members if a severe flood is coming
	A4	I always use my mobile phone for my work
	A5	I may use SMS for a flood warning
Intention to use	IU1	I will send SMS to alert people if a severe flood is coming
	IU2	I will receive incoming SMS from other people during floods
	IU3	I will use my mobile phone for flood warnings

6.2.3 Hypothesis Development

The hypotheses for this study are related to testing the acceptance of SMS technology in the flood risk area. Based on the research questionnaire, the construct development and the research model, the hypotheses for this research are presented in the following subsections.

6.2.3.1 The relationship between Perceived Usefulness, Attitude toward Use and Intention to Use.

Since behavioural intent depends on cognitive choice, a mobile phone user can either respond or not respond using SMS messages for a flood warning. Davis *et al.* (1989), defined *perceived usefulness* as a belief that using technology would increase one's performance or benefits. In this study context, *perceived usefulness* considers benefits of using mobile phones and SMS for work, for an emergency and for a flood warning.

Several researchers such as (Davis *et al.*, 1989, 1992; Venkatesh & Davis, 2000) have validated the construct of *perceived usefulness* (PU) and they reported that PU was significant and positively influenced both *attitude toward use* and *intention to use*. Hence, it is expected that:

H1: there is a positive relationship between perceived usefulness on intention to use SMS for flood warning.

H2: there is a positive relationship between perceived usefulness on attitude toward use of SMS for flood warning.

6.2.3.2 The relationship between perceived ease of use and perceived usefulness

The relationship between *perceived ease of use* and *perceived usefulness* has been positively proved by many researchers (Davis, 1985; Venkatesh & Davis, 2000). Nevertheless many researchers such as Aladwani (2002); Moon and Kim (2001) have conducted studies of the relationship between *perceived ease of use* and *perceived usefulness*, they found that the relationship between them was contradictory. Gefen and Straub (1997), also discovered that the relationship was not significant in predicting e-mail technology acceptance. In this study, adoption of SMS technology for alerting people in flood risk areas might depend on ease of SMS usage such as ease of sending or receiving messages. If people find SMS easy to use, they could be aware of the usefulness of the technology for flood alerts. This leads to the hypothesis H3.

H3: there is a positive relationship between perceived ease of use and perceived usefulness.

6.2.3.3 The relationship between Perceived Ease of Use and Attitude toward Use and Intention to Use

In current research, Perceived Ease of Use (PEOU) is associated with "user friendliness" which includes how easy it is to send a message and receive an incoming message. Clear message content used in SMS and understanding of basic technology are also considered to be *perceived ease of use*. User friendliness and understanding motivate and then intent to use SMS for a flood warning. Thus, this study anticipates that:

H4: there is a positive relationship between perceived ease of use and attitude toward use

H5: there is a positive relationship between perceived ease of use and intention to use

6.2.3.4 The relationship between Perceived Ease of Use and Perceived Enjoyment

Perceived ease of use leads to frequent use of technology. If the technology is infrequently used, a user might as well discard it. In this study, *perceived ease of use* might be the origin of enjoyment for sending and receiving messages, or playing with the mobile phone's functions. Therefore, this study anticipates that:

H6: there is a positive relationship between perceived ease of use and perceived enjoyment.

6.2.3.5 The relationship between perceived enjoyment, attitude toward use and intention to use

There are many motivational reasons that an individual intends to use a product, service or technology. Sometimes it meets his or her needs, or it is because of felling happy or enjoyment from that product due to social influence or fashion of having a new technology. According to Teo and Lim (1999), the *perceived enjoyment* of

Internet users in Singapore has positive impact on *intention to use*. Several researchers such as Moon and Kim (2001); Van der Heijden (2003) viewed *perceived enjoyment* as performance of an activity for no apparent reason other than the process of the performance itself. Their research illustrated that *perceived enjoyment* has an effect on both *attitude* and *intention toward use* of a system. An individual can experience enjoyment for fun from using a specific system, and perceived ease to use new technology to be enjoyable in its own right (Davis *et al.*, 1989). This study, defines *perceived enjoyment* as the degree to which an individual believes that using SMS is fun. Therefore, the study posits:

H7: there is a positive relationship between perceived enjoyment and attitude toward use.

H8: there is a positive relationship between perceived enjoyment and intention to use.

6.2.3.6 The relationship between attitude toward use and intention to use

Attitude toward use is defined as the degree to which an individual's attitude is favourable or unfavourable. Previous empirical studies show that an individual's attitude is influenced by various external variables, which might be system features, compatibility and support (Davis *et al.*, 1989; Lucas & Spitter, 1999). Moon and Kim (2001); Van der Heijden (2003) investigated the relationship between attitude and intention and found that the relationship of these two constructs was positive and significant. In this research, *attitude toward use* can be perceived to influence two beliefs from TAM (*perceived usefulness* and *perceived ease of use*) and an external belief from the extended TAM (*perceived enjoyment*) on both *attitude toward use* and *intention to use* SMS message for a flood warning. Accordingly, the study hypothesised that:

H9: there is a positive relationship between perceived enjoyment and intention to use

In order to find the primary factor influencing the adoption of SMS for a flood warning system and identify the relationship between factors, the research model needs to be estimated and the hypotheses tested. The next section details the findings.

6.2.4 Research model

This section introduces the theoretical model used in this study. The model was based on the research problems, research aim and research questions and the literature review presented in Chapter I and Chapter II. The research model for this study was based on combinations of elements from both the TAM and the Extended TAM by (Van der Heijden, 2003). The new research model is called the SMS Technology Acceptance Model (SMSTAM). The SMSTAM explains and predicts factors influencing *attitude toward use* and *intention to use* SMS messages for flood warnings.

In order to test the hypotheses defined in Section 6.2.3 using the SMSTAM model, there were five main constructs included in the SMSTAM model. The relationships between the five constructs (*Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment, Attitude toward Use* and *Intention to Use*) in the SMSTAM follow and are also presented in Figure 6.1.

- *Perceived Usefulness* of mobile phones and SMS measuring impact on *Attitude toward Use* and *Intention to Use*.
- *Perceived Ease of Use* of mobile phones and SMS, effects *Perceived Usefulness*, *Attitude toward Use*, *Intention to Use* and *Perceived Enjoyment*.

- *Perceived Enjoyment* measures the enjoyment of using SMS and other mobile phone functions, this component effects both *Attitude toward Use* and *Intention to Use*.
- *Attitude toward Use* indicates feelings towards the likelihood of *Intention to Use*.

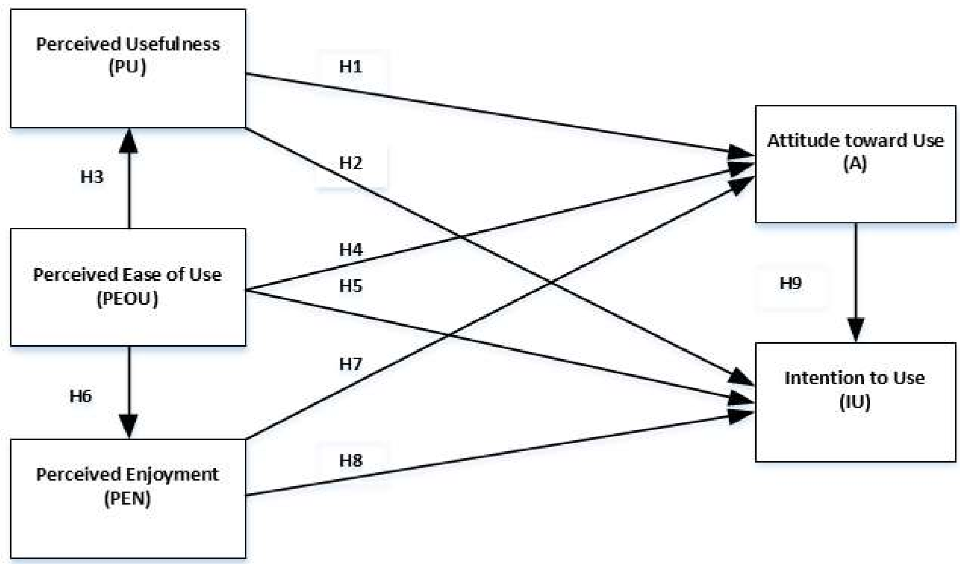


Figure 6.1: The SMS Technology Acceptance Model (SMSTAM)

6.3 Findings

The research model, SMSTAM, is based on the existing literature, and is particularly adopted from the Technology Acceptance Model (TAM). Before estimating the relationships between the constructs in the research model, it is essential to conduct an exploratory factor analysis and confirmatory factor analysis to check the validity and reliability of the constructs and enhance the fit of the research model. All findings in this section used SPSS with AMOS version 22 as the tools for data analysis.

6.3.1 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a statistical method used to study the dimension of a set of variables. EFA explores the interrelationship among a set of variables and looks for ways the data may be reduced or summarised using a smaller set of factors (Pallant, 2013). Tabachnick and Fidell (2007) indicated that EFA seeks to describe and summarise data by grouping together variables that are correlated. In this study, 19 variables (items) from the questionnaire were assessed by running EFA using principal component analysis (PCA) with “Direct Oblimin” rotation.

In order to verify that a data set is suitable for EFA, the Kaiser-Meyer-Olkin (KMO) sampling adequacy and Bartlett’s test of sphericity need to be checked. A KMO value of 0.6 and above is acceptable (Kaiser, 1970, 1974; Pallant, 2013), and a Bartlett’s test of sphericity value is statistically significant below 0.05 (Bartlett, 1954; Pallant, 2013).

Table 6.2: Kaiser-Meyer-Olkin and Bartlett’s tests

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.730
Bartlett's Test of Sphericity	Approx. Chi-Square	3167.594
	df	171
	Sig.	.000

In this study, Table 6.2 shows that the KMO value is 0.73 which exceeds the recommended minimum value, and Bartlett’s test is significant at $p<0.001$ level ($p=0.000$). Therefore, EFA indicates the research model is appropriate in the conduct of this study.

Table 6.3: Eigenvalues of each factor

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	**3.324**	17.495	17.495	3.324	17.495	17.495	2.842
2	**2.514**	13.234	30.729	2.514	13.234	30.729	2.357
3	**2.160**	11.368	42.098	2.160	11.368	42.098	2.112
4	**2.020**	10.633	52.731	2.020	10.633	52.731	2.248
5	**1.239**	6.522	59.253	1.239	6.522	59.253	2.162
6	**1.001**	5.269	64.522	1.001	5.269	64.522	1.437
7	.829	4.361	68.883				
8	.815	4.287	73.170				
9	.715	3.764	76.935				
10	.620	3.263	80.197				
11	.606	3.190	83.387				
12	.564	2.970	86.357				
13	.534	2.808	89.165				
14	.466	2.452	91.617				
15	.413	2.172	93.790				
16	.343	1.807	95.597				
17	.293	1.545	97.141				
18	.283	1.491	98.633				
19	.260	1.367	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

In order to determine how many sets of variables (factors) should be considered in this study, the Kaiser's criterion should be checked for any factor with an initial eigenvalue of 1 or more (Pallant, 2013). In this research, six factors are satisfied with eigenvalues exceeding 1 and these six factors explain 17.49%, 13.23%, 11.36%, 10.63%, 6.52% and 5.26% of the variance respectively (as shown in Table 6.3).

However, Table 6.4 shows that six factors could not be used because item PEOU3 loads into two factors and the sixth factor (6) contains only two loaded items. So extraction of factors is needed.

Table 6.4: Items loaded in six factors

Structure Matrix

	Component					
	1	2	3	4	5	6
PEN1	**.888**	.079	.207	.047	-.139	-.099
PEN2	**.862**	.100	.241	.023	-.232	-.201
PEN3	**.861**	.224	.260	.040	-.073	-.124
A2	.139	**.731**	-.070	-.009	.052	.136
A1	-.042	**.717**	.005	-.030	-.036	.231
A3	.058	**.670**	.044	-.167	-.002	-.207
A4	.245	**.659**	-.058	.084	.239	-.125
A5	**.418**	**.557**	.005	.118	-.044	-.196
IU1	.135	-.052	**.883**	.035	.105	-.083
IU2	.201	-.013	**.878**	-.029	.020	-.093
IU3	.294	.039	**.541**	-.006	.100	-.081
PU1	-.062	.100	.022	**-.770**	-.034	.302
PU2	-.050	.132	-.027	**-.748**	.087	.090
PU3	-.103	-.104	.062	**-.695**	.071	.206
PU4	.039	-.041	-.034	**-.679**	.078	-.246
PEOU2	-.127	.006	.119	-.090	**.882**	.016
PEOU1	-.130	.047	.159	-.124	**.882**	.075
PEOU3	-.302	.027	-.159	.042	**.637**	**.516**
PU5	-.145	.003	-.143	-.265	.132	**.840**

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

After factor extraction, only five factors were suitable for further investigation as shown in Table 6.5

Table 6.5: Extracted factors

Structure Matrix

	Component				
	1	2	3	4	5
PEN1	**.889**	.083	.203	.055	-.168
PEN3	**.862**	.228	.262	.053	-.113
PEN2	**.859**	.106	.257	.049	-.283
A2	.143	**.727**	-.100	-.028	.083
A1	-.036	**.710**	-.054	-.068	.028
A3	.053	**.676**	.095	-.119	-.063
A4	.246	**.663**	-.015	.112	.185
A5	**.415**	**.562**	.047	.152	-.102
IU1	.140	-.051	**.860**	.036	.068
IU2	.204	-.011	**.853**	-.026	-.015
IU3	.298	.042	**.533**	-.022	.064
PU1	-.055	.097	-.053	**-.802**	.050
PU2	-.048	.136	-.040	**-.739**	.104
PU3	-.098	-.104	.014	**-.712**	.122
PU4	.032	-.028	.037	**-.611**	.003
PU5	-.123	-.018	-.341	**-.408**	.359
PEOU1	-.117	.050	.175	-.123	**.846**
PEOU2	-.115	.011	.152	-.080	**.831**
PEOU3	-.283	.015	-.249	-.043	**.744**

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Before making a final decision concerning the number of factors, the rotated five-factor solution should be considered.

The Structure Matrix of Table 6.5 shows items loading on five factors with 19 items loading above a 0.40 threshold level. However, one item (A5) loaded in both factors 1 and 2, so item A5 was dropped from this study. Therefore, 18 items loaded in five factors were included in the final result of the EFA as illustrated in Table 6.6.

Table 6.6: Final result of EFA

Structure Matrix

	Component				
	1	2	3	4	5
PEN1	.893				
PEN3	.872				
PEN2	.867				
A2		.749			
A1		.746			
A3		.699			
A4		.632			
IU1			.860		
IU2			.853		
IU3			.532		
PU1				-.800	
PU2				-.743	
PU3				-.715	
PU4				-.614	
PU5				-.406	
PEOU1					.846
PEOU2					.831
PEOU3					.743

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

6.3.2 Construct validity and reliability

Before estimating a model fit and testing relationships between constructs (factors) in the research model, the validity and reliability between items and factors should be tested for being within acceptable thresholds. Others researchers, like Hair *et al.* (2006); Susanto (2012), stated that the research model is not reliable if it has low validity and reliability between items and factors.

6.3.2.1 Validity

Construct validity determines the extent to which a factor measures variables (items) of interest. Construct validity needs to combine *convergent validity* and *discriminant* *validity.* The *convergent validity* is the degree to which measures of the same items should be correlated if they are valid measures of the concept, while *discriminant validity* is the degree to which measures of different concepts are distinct (Hair *et al.*, 2006; Moon & Kim, 2001).

In the theory, average variance extracted (AVE) measures convergent validity and the AVE measures variance captured by a construct in relation with measurement errors (Hair *et al.*, 2006; Tong, 2007; Yen, 2011). According to Chau (1996); (Yen, 2011), in order to meet a minimum acceptable level of convergent validity, the AVE values needs to greater than 0.50 (AVE>0.50).

Discriminant validity measures whether one item is internally correlated unique and distinct from other items. It is confirmed by comparing √AVE with the squared multiple correlation (R^2) of a construct. If the √AVE is larger than R^2 ($\sqrt{AVE} > R^2$) , then the discriminant validity is verified (Hair *et al.*, 1998; Tong, 2007).

To measure convergent and discriminant validity, the research model added covariance between pairs of measured factors (Figure 6.2).

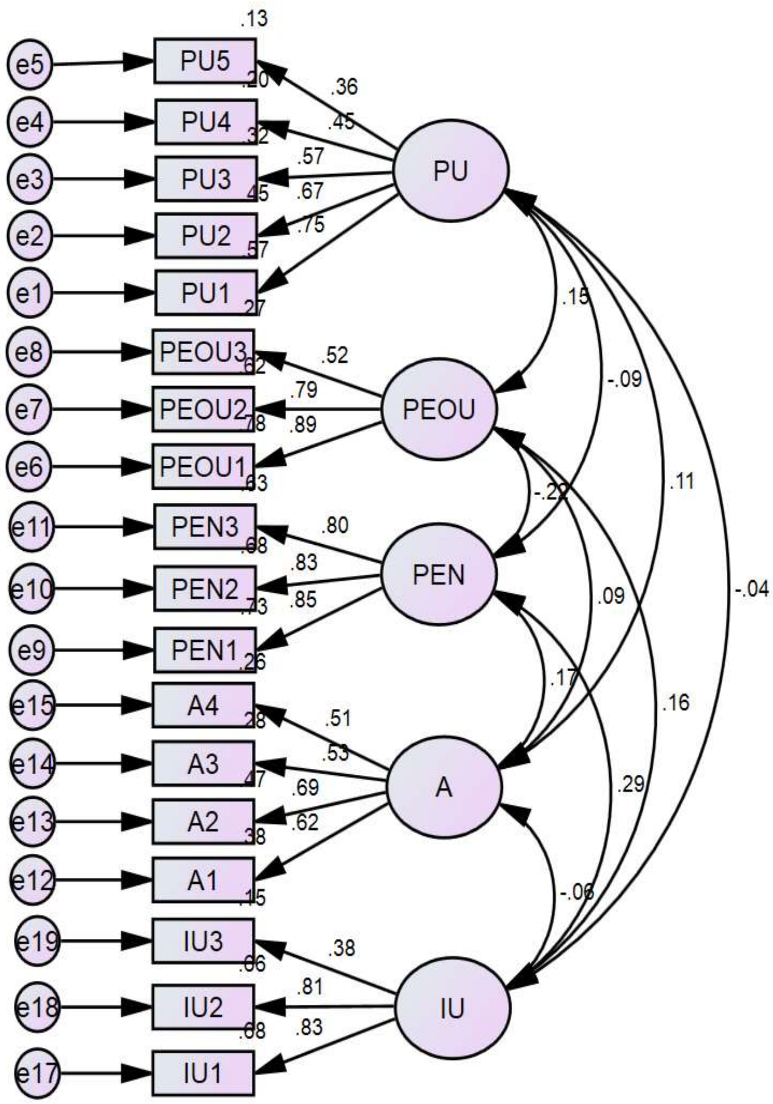


Figure 6.2: The research model correlation for testing constructs validity

After correlating factors, Table 6.7 indicates the standardised regression weight and the squared multiple correlation (R^2) loading into the research model. These standardised regression weights and R^2 were used to calculate the AVE and √AVE as indictors of convergent validity and discriminant validity.

Table 6.7: Standardised regression weight(R) and the R^2 for the research model

Items	Relationships <---	Constructs	Standardised Regression Weight (R)	Squared multiple correlation (R^2)
PU1	<---	PU	0.75	0.57
PU2	<---	PU	0.67	0.45
PU3	<---	PU	0.57	0.32
PU4	<---	PU	0.45	0.20
PU5	<---	PU	0.36	0.13
PEOU1	<---	PEOU	0.89	0.78
PEOU2	<---	PEOU	0.79	0.62
PEOU3	<---	PEOU	0.52	0.27
PEN1	<---	PEN	0.85	0.73
PEN2	<---	PEN	0.83	0.68
PEN3	<---	PEN	0.80	0.64
A1	<---	A	0.62	0.38
A2	<---	A	0.69	0.47
A3	<---	A	0.53	0.28
A4	<---	A	0.51	0.26
IU1	<---	IU	0.83	0.68
IU2	<---	IU	0.81	0.66
IU3	<---	IU	0.38	0.15

Therefore, based on the AVE, the results of convergent validity and discriminant validity were computed and summarised in Table 6.8.

Table 6.8: Convergent validity and discriminant validity of the research model

Constructs	AVE	√AVE
PU	0.45	0.67
PEOU	0.68	0.82
PEN	0.81	0.90
A	0.42	0.65
IU	0.59	0.77

Table 6.8 shows that the AVE of three constructs (PEOU, PEN and IU) met the threshold value of 0.5 which suggests strong convergent validity, while two

constructs (PU and A) were close to the recommended values with values of 0.42 and 0.45 respectively.

For discriminant validity, √AVE greater than R^2 means the discriminant validity is acceptable (Hair *et al.*, 1998; Tong, 2007). The results are summarised as follows:

For Perceived Usefulness (PU): √AVE for PU (0.67) was found to be larger than R^2 for PU1 (0.57), PU2 (0.45), PU3 (0.32), PU4 (0.20) and PU5 (0.13).

For Perceived ease of use (PEOU): √AVE for PEOU (0.82) was found to be larger than R^2 for PEOU1 (0.78), PEOU2 (0.62), PEOU3 (0.27) and PEOU4 (0.73).

For Perceived Enjoyment (PE): √AVE for PE (0.90) was found to be larger than R^2 for PEN1 (0.73), PEN2 (0.68) and PEN3 (0.64).

For Attitude Toward Use (A): √AVE for A (0.65) was found to be larger than R^2 for A1 (0.38), A2 (0.47), A3 (0.28) and A4 (0.26).

For Intention to Use (IU): √AVE for IU (0.77) was found to be larger than R^2 for IU1 (0.68), IU2 (0.66) and IU3 (0.15).

Each √AVE of all constructs is greater than R^2 of the items within constructs, all constructs have acceptable levels of both convergent and discriminant validity.

6.3.2.2 Reliability

The construct reliability refers to a set of variables (items) that will consistently load on the same factor. Cronbach's alpha is the most common method of measuring scale reliability. Kline (2005) recommended that a Cronbach's alpha value of 0.90 is excellent, 0.8 is very good and 0.70 is adequate. Field (2009) and Pallant (2013) suggest that the Cronbach's alpha value above 0.6 is considered acceptable. In this study, SPSS version 22 was used to compute Cronbach's alpha values for the five factors. Table 6.9 shows the values of the Cronbach's alpha coefficient of all five factors, ranging from 0.644 to 0.863, which are well above the acceptable level and were in the range between acceptable and very good. Hence, all five measurement scales are reliable with consistent variables (items).

Table 6.9: Reliability test of measures

Factors	No. of items	Cronbach's Alpha
PEN	3	0.863
PEOU	3	0.767
PU	5	0.644
A	4	0.689
IU	3	0.683

Overall, the validity and reliability of the measures have been checked and were acceptable for the model test. It is also necessary to test a model fit of the structural equation modelling (SEM) of the research model which is covered in the next section.

6.3.3 Confirmatory factor analysis

Confirmatory factor analysis (CFA) is a statistical technique used to verify the factor structure of a set of observed items, and allows the researcher to test the hypotheses of the research model (Suhr, 2006). CFA tests predict factor structure in the research model. CFA in this study covers estimating "a model fit" and testing the hypotheses of the research model.

6.3.3.1 Fit of the Model

The model fit of the research model was tested using confirmatory factor analysis (CFA) before estimating the structural equation modelling as suggested by (Byrne, 2012; Kurkinen, 2012). The fit of the research model was estimated using AMOS version 22.

To achieve goodness-of-fit for the research model, both the constructs and the research model should meet the requirements of fit indices such as *absolute fit indices, incremental fit indices and parsimony fit indices* (Hooper *et al.*, 2008).

Absolute fit indices determine how well a model fits the sample data and is a measure of how well the model fits in comparison to no model at all (Susanto, 2012). Parameters included in this category are Chi-Squared test (χ^2), the Root Mean Square Error of Approximation (RMSEA), the Goodness-of-Fit Index (GFI), the Adjusted Goodness-of-Fit Index (AGFI), and the Rood Mean square Residual (RMR).

Incremental fit indices determine how well a model fits the sample data. It includes the Normed Fit Index (NFI), the Comparative Fit Index (CFI), the Incremental Fit Index (IFI), and the Tucker-Lewis Index (TLI).

Parsimony fit indices determine how well a model fits the sample data by taking into account the complexity of the hypothesized model in the assessment of the overall model fit (Byne, 2010; Susanto, 2012). It includes the Parsimony Goodness-of-Fit Index (PGFI), the Parsimonious Normed Fit Index (PNFI), and the Parsimony Ratio (PRATIO).

According to Hair *et al.* (1998); Hair *et al.* (2006); Susanto (2012), a researcher should report the Chi-square (χ^2) test and at least an absolute index and an incremental index. Hair *et al.* (2006) recommended that the lower the Chi-square value the better the model and an acceptable ratio for relative Chi-square (χ^2/df) is between 1.0 and 5.0. Browne and Cudeck (1993) also pointed out that an RMSEA value of ≤ 0.05 can be considered to be a good fit, values between 0.05 and 0.08 an adequate file, and values > 0.10 are not acceptable. Reinard (2006) suggests that the closer the PRATIO is to 1.0 the more parsimonious the model and the stronger the fit, while Yen (2010) points out that the acceptance level of PRATIO is greater than 0.6 (PRATIO >0.6).

Table 6.10 presents the recommended values for the model fit indices adopted in this study (Hair *et al.*, 1998; Hair *et al.*, 2006; Reinard, 2006; Susanto, 2012; Yen, 2010).

Table 6.10: The Goodness-of-Fit Indices for the research model

Goodness-of-Fit Test	**Authors**	**Acceptance level**
χ^2 (Chi-square)	(Hair *et al.*, 2006)	The lower the better
χ^2/**df**(Chi-squared Degree of Freedom)	(Yen, 2010)	$1.0<\chi^2/df<5.0$
RMSEA (Root Mean Squared Error of Approximation)	(Browne & Cudeck, 1993)	RMSEA<0.05 good fit 0.05-0.08 adequate fit 0.08-0.10 mediocre fit
IFI (Incremental Index of Fit)	(Garson, 2009)	≥0.90
CFI(Comparative Fit Index)	(McDonald & Ho, 2002; Raykov, 2005)	≥0.90
TLI(Tucker-Lewis Index)	(Garson, 2009; Yin, 2009)	≥0.90
PRATIO(Parsimony Ratio)	(Garson, 2009; Reinard, 2006; Yen, 2010)	PRATIO>0.60 The closer to 1.0 the better

Initially, the research model was tested for the basics of goodness-of-fit based on acceptable levels with the results shown in Table 6.12.

AMOS version 22 was used to examine if there were any large values of a pair of covariance errors within the same construct and low loading between items and constructs. Figure 6.3 shows the initial research model result, there were low loading between items and factors (PU→PU5, A→A4 and IU→IU3) and large covariance errors of two pairs (e4, e5 and e18, e19). In order to maximize the model fit, modification and dropping of indices needs to be performed.

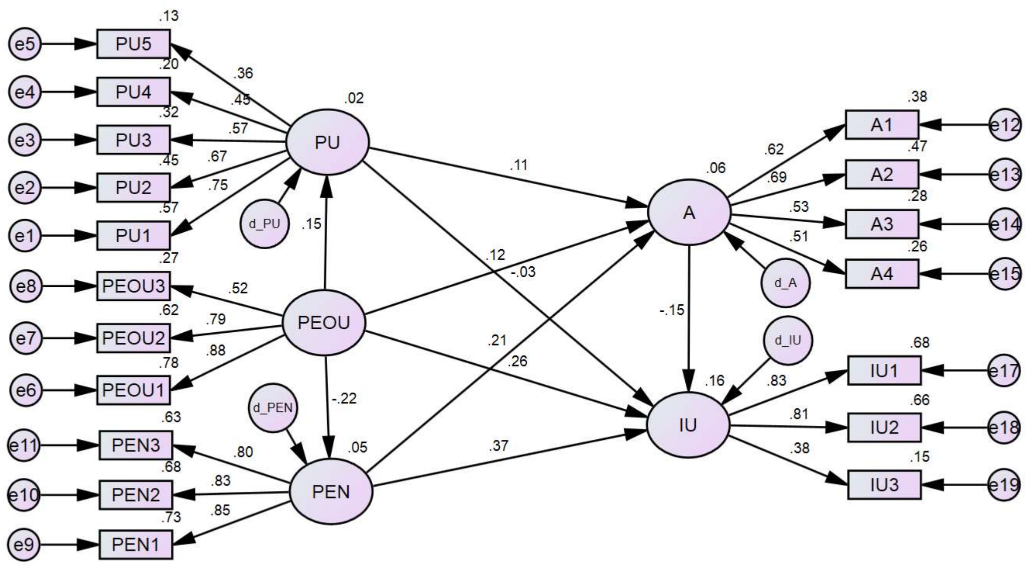


Figure 6.3: The initial research model

The modification indices were improved by joining two pairs of covariance errors (e18←→e19) and (e4←→e5) and dropping out items PU5 and A4. The AMOS output indicated that the research model provides an acceptable level of goodness of fit for the data as presented in Figure 6.4.

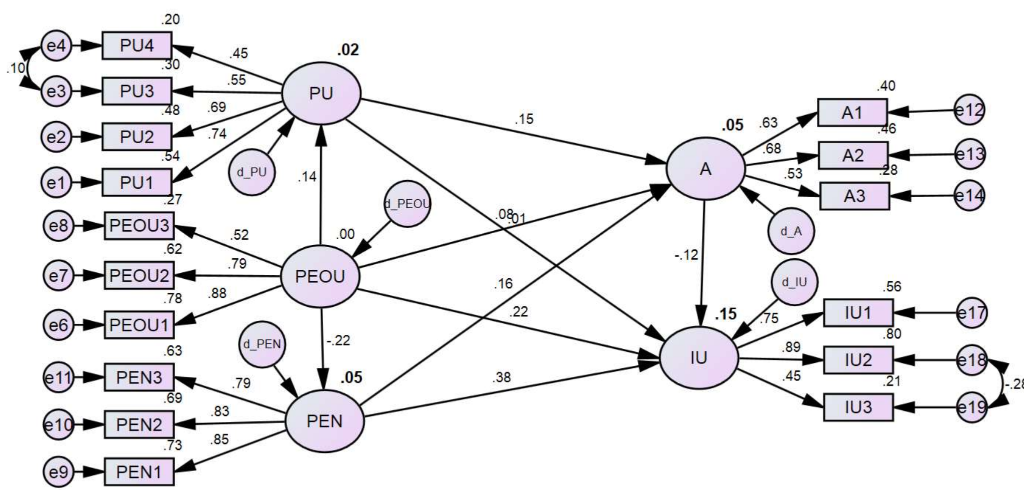


Figure 6. 4: Final research model

Table 6.11 presents a comparison of the model fit, including *"Goodness of Fit",* of the acceptance level between the initial model and the final model. So, after modification of the model, *the good fit indices* improved from (χ^2/df=3.32, RMSEA=0.06, IFI=0.89, CFI=0.89, TLI=0.86, PRATIO=0.83) to (χ^2/df=2.43, RMSEA=0.05, IFI=0.94, CFI=0.94, TLI=0.93, PRATIO=0.79), which indicates a good fit.

Table 6.11: Model fit of the research model

Goodness-of-Fit	**Acceptance Level**	**Initial Model**	**Final Model**
χ^2	The lower the better	475.59	231.17
χ^2**/df**	$1.0<\square^2/df<5.0$	3.32	2.43
RMSEA	RMSEA<0.05 good fit 0.05-0.08 adequate fit 0.08-0.10 mediocre fit	0.06	0.05
IFI	≥0.90	0.89	0.94
CFI	≥0.90	0.89	0.94
TLI	≥0.90	0.86	0.93
PRATIO	PRATIO>0.60 The closer to 1.0, the better	0.83	0.79

6.3.4 Tests of Hypotheses

A fundamental goal of this section was to clarify the main factors influencing the adoption of an SMS service for flood warnings. The eight research hypotheses tested the research model's relationships between *perceived usefulness* (PU), *perceived ease of use* (PEOU), *perceived enjoyment* (PE), *attitude toward use* (A) and *intention to use* (IU). The hypotheses include important indicators, a standardized coefficient beta (β), a weight of significance (p) and a coefficient of determination (R^2).

Table 6. 12: Hypothesised path analysis of the research model

Hypothesis	Hypothesized direction	β-value	p-value	Findings
H1: PU→IU	+	0.011	0.778	Not supported
H2: PU→A	+	0.152	0.014	Supported*
H3: PEOU→PU	+	0.138	0.009	Supported**
H4: PEOU→A	+	0.077	0.187	Not supported
H5: PEOU→PEN	+	-0.223	***	Supported
H5: PEOU→IU	+	0.222	***	Supported
H7: PEN→A	+	0.162	0.005	Supported**
H8: PEN→IU	+	0.379	***	Supported
H9: A→IU	+	-0.121	0.030	Supported*

*** Denotes significance at the P<0.001 level (-) Negative significance
** Denotes significance at the P<0.01 level P-value: significant value
* Denotes significance at the P<0.05 level β-value: path coefficient

As summarised in Table 6.12, seven out of the nine hypotheses were significantly supported by data, and two hypotheses (PU→IU and PEOU→A) were not supported. The results of hypotheses tests were as follows:

6.3.4.1 Hypotheses 1 and 2

Hypotheses 1 and 2 predicted that *perceived usefulness* of using a mobile phone and SMS messages would have a positive effect on both attitude toward use and intention to use SMS for a flood warning (PU→IU;PU→A).

In the current study, hypothesis H1 (PU→IU), *there is a positive relationship of perceived usefulness on intention to use SMS for flood warning,* was not supported with the hypothesis at the $p>0.05$ level ($\beta=0.011$; $p=0.778$). The result is similar to some prior research on the use of mobile phones conducted by (Gao *et al.*, 2010; Robinson *et al.*, 2005). They found that *perceived usefulness* (PU) was not a primary determinant of intention *to use* (IU) a mobile service. In this study, H1 being not supported could mean residents in flood risk areas don't think that mobile phones and SMS could be useful for alerting them in case a severe flood.

However, hypothesis H2 (PU→A), *there is a positive relationship between perceived usefulness and attitude toward use of SMS messages for a flood warning,* was supported at the $p<0.05$ level ($\beta= 0.152$; $p=0.014$). So, H2 shows a direct effect of *perceived usefulness* on *attitude to use* (PU→A), meaning people living in flood risk areas would use their mobile phone for flood warnings if they found it useful.

In summary, in term of *usefulness*, people have an *attitude to use* their mobile phones and SMS for flood warnings, but no *intent to use* it yet.

6.3.4.2 Hypotheses 3, 4, 5 and 6

Hypotheses 3, 4, 5 and 6 hypothesised *perceived ease of use (PEOU)* toward four directions: *perceived usefulness* (PU), *attitude toward use* (A), *intention to use* (IU) and *perceived enjoyment* (PEN).

The hypothesis H3 (PEOU→PU), *there is a positive relationship between perceived ease of use and perceived usefulness,* was supported with direct significance at the $p<0.01$ level ($\beta=0.138$; $p=0.009$). According to the construct in this research, ease of using a mobile phone and SMS messages directly affects the usefulness of the mobile phone.

The hypothesis H4 (PEOU→A), *there is a positive relationship between perceived ease of use and attitude toward use,* was not supported with no statistical significance at the $p>0.05$ level ($\beta=0.077$; $p=0.187$). Hence, in this research, ease of using mobile phone and SMS message does not affect attitude to use.

The hypothesis H5 (PEOU→PEN), *there is a positive relationship between perceived ease of use and intention to use,* was positively significant at the $p<0.001$($\beta=0.222$; p=***).

The hypothesis H6 (PEOU→PEN), *there is a positive relationship between perceived ease of use and perceived enjoyment,* was negatively supported with a statistical significance at the $p<0.001$($\beta=-0.223$; p=***). For this study, the negative path coefficient means people did not enjoy using the technology if they found that it was easy to use (e.g. boring).

6.3.4.3 Hypotheses 7 and 8

The paths from the external variable *perceived enjoyment* (PEN) to both main determinants of TAM (A and IU) were significant.

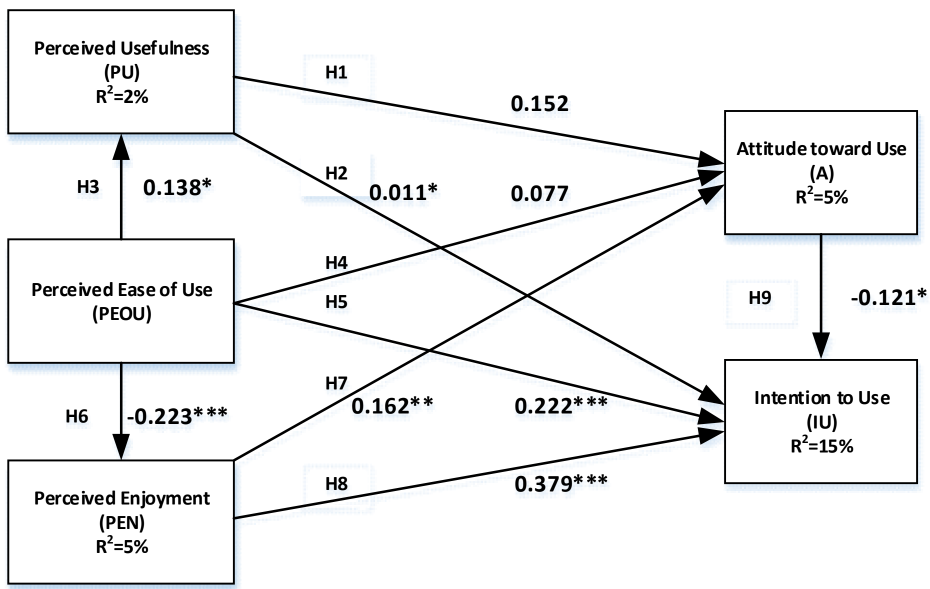
The hypothesis H7 (PEN→A), *there is a positive relationship between perceived enjoyment and attitude toward use,* was directly supported with statistical significance at the $p<0.01$ level ($\beta=0.162$; $p=0.005$).

The hypothesis H8 (PEN→IU), *there is a positive relationship between perceived enjoyment and intention to use,* was strongly supported with statistical significance at $p<0.001$($\beta=0.379$; p=***).

To sum up, the effect of *perceived enjoyment* (PEN) strongly supported the hypotheses with a high path coefficient (β) on both *attitude toward use* (A) and *intention to use* (IU). This indicates that enjoyment enables residents living in flood risk areas have attitude and intention to use SMS for flood warnings.

6.3.4.4 Hypotheses 9

The path from *attitude toward use* on *intention to use* is a primary determinant for the original TAM model. In the current study, hypothesis H9 (A→IU), *there is a* *positive relationship between perceived enjoyment and intention to use,* was supported with significance at p<0.01 level (β=-0.121; p=0.030). It is interesting to note that, even though this relationship is statistically significant, the β-value is negative. The negative value may indicate that residents living in flood risk areas have consideration/attitude to use SMS for flood warning in their areas but that they have not yet made the decision to adopt it.



*** Denotes significance at the P<0.001 level
** Denotes significance at the P<0.01 level
* Denotes significance at the P<0.05 level

Figure 6.5: The final model

6.3.5 The key predictors of the research model

The research model consists of two endogenous constructs of factors (*attitude toward use* and *intention to use*) and three exogenous factors (i.e. *perceived usefulness, perceived ease of use* and *perceived enjoyment*). In order to examine the key predictors of the research model, this study evaluated the *significant value (p)* and the *standardised regression weight* or *coefficient path (β)* for each relationship of the factors.

6.3.5.1 Predictors of attitude toward use

As presented in Figure 6.5, *perceived enjoyment* (PEN) has a significant influence on *attitude toward use* (A) (β=0.162, p<0.01 level). *Perceived usefulness* (PU) has significant influence *attitude toward use* (β=0.152, p<0.05). However, *perceived ease of use* (PEOU) was found to not be significant on *attitude toward use* (A) (β=0.077; p=0.187).

Of the three direct predictors of *attitude toward use (*A) in the research model, *perceived enjoyment* (PEN) was revealed as the most important factor, followed by *perceived usefulness* (PU) and *perceived ease of use* (PEOU) was the weakest factor influencing on *attitude toward use (*A).

6.3.5.2 Predictors of intention to use

Attitude toward use (A) accounts for only 5% of the variance in *intention to use (*IU) with β=-0.121 and significance at the p<0.05 level. Similarly, *perceived enjoyment* (PEN) explained 5% of the variance in *intention to use (*IU) with β=0.379 and significance at the p<0.001 level. The *perceived usefulness* (PU) has no significance and only explained 2% of variance affecting on *intention to use* (IU) with β=0.011 and significance at the p<0.05 level. *Perceived Ease of Use* (PEOU) has a significant effect on *intention to use* (IU) with β=0.222 and significance at the p<0.001 level.

In summary, *perceived enjoyment* (PEN) is revealed as the most important factor influencing both *attitude toward use* (A) and *intention to use (*IU). The second key factor is *perceived ease of use* (PEOU) influencing on IU with β=0.222. However, *attitude toward use* (A) was negatively significant on *intention to use (*IU).

6.4 Chapter review

This chapter dealt with inferential analysis using a research model based on the TAM. Testing the hypotheses of the research model was a key point in seeking factors influencing adoption of SMS messages for a flood warning system in the case study area.

Initially, questionnaire and constructs were developed, and then the research model was proposed based on the TAM. Prior to testing the hypotheses of the research model, the model was subjected to measurement in terms of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) for testing the collected data, checking the construct validity and reliability of the measures and the fit of the research model.

An item (P5) was dropped from the constructs during the EFA process due to loading issues. The construct validity and reliability of the measures were acceptable according to previous study recommendations. After modification of indices and dropped items, the research model (SMSTAM) provides a good fit to the data (χ^2/df=2.43, IFI=0.94, CFI=0.94, TLI=0.93, RMSEA=0.05 and PRATIO=0.79).

The final stage was to test the relationship between factors (test of hypotheses) using SPSS and AMOS 22. The findings of the hypotheses tests show that seven of the nine relationships between factors supported the hypotheses, while two of them were not supported. *Perceived enjoyment (PEN)* was the most important factor for the research model, significantly influencing *attitude toward use* and *intention to use,* albeit with low explained variances. To be specific, *perceived usefulness* (PU) explained R^2_{PU}=2% of variance and both *perceived enjoyment* (PEN) and *attitude* *toward use (A)* explained R^2_A=5% and the most explained variance was *intention to use* (IU) with R^2_{IU}=15% (Figure 6.5).

The low variance explained in *A* and *IU* indicates that the research model was not applicable for the case study area. In other words, other items and constructs are required to include in the current research model. These additional items and constructs could be associated with perceived ICT anxiety, perceived ICT capacity and perceived cost. This is considered a limitation of this study and is discussed further in Chapter VIII.

The next chapter, Chapter VII, answers research question 5 (RQ5) regarding the trial of the proposed system of sending SMS messages to alert people in the flood risk areas of the case study area. The trial provided important evidence to confirm findings of Chapter V and Chapter VI.

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CHAPTER VII : A TRIAL OF THE SYSTEM

7.1 Introduction

This chapter presents the trial of the proposed flood warning system. Important points are addressed include the trial's location, mobile networks available, software and hardware requirements, the data collection process, running the trial, and finally the results of the trial are presented.

According to the findings of the two surveys conducted in 2013 (see Chapter V), mobile phone networks in the case study area were moderately reliable. This trial was to confirm the findings which were analysed in Chapter V and to test the proposed system.

This trial sought additional evidence to support the findings from Chapter VI and focused on assessing message content, local language availability on devices, measuring the reliability of the mobile phone network, the transmission time from the SMS gateway to mobile handsets and delayed and lost messages.

This chapter answers research question 5 (RQ5) which stated that *"Can SMS messaging via mobile phones be the best channel for flood warning systems in developing countries where mobile phone networks are available rather than the Internet?"*

In this trial, variables to be assessed included reliability of the mobile phone networks, mobile phone brands used by mobile users, SMS content (language) and, most importantly for flood warnings, the lag time in transmitting from an SMS gateway to mobile phones in the flood prone areas.

7.2 Trial preparations

This section covers preparation and resources for the trial including sample data collection, SMS getaway of the trial, hardware and software, trial design, authority approval and message development.

7.2.1 Sample data collection

Data needed for the trial included mobile phone numbers, mobile phone provider details, and type of mobile phones (basic or smartphone).

As discussed at section 4.3.3.1 for the trial, 120 sample of the selected mobile phone users living in the case study area were used to collect the information and were informed of the trial by researcher and the researcher assistants. The consent form, which was approved by their head of village, was given to each participant before asking for their details. Although participating in this interview was voluntary, a participant could withdraw at or after the interview.

Finally, the data were recorded on a spreadsheet by the researcher. After checking for missing data or inappropriate mobile phone numbers, it was found that 116 users were suitable for the trial and the information of the 116 users was entered into the database of the SMS gateway.

7.2.2 SMS gateway

There are four mobile phone providers serving Laos and all of them service the trial area: ETL (Enterprise of Telecommunications Lao), Lao Telecom (LAO GSM), Unitel and Beeline. ETL is a public company, while the others are joint-venture companies between the government and business sectors.

For this trial, Lao Telecom was selected as the mobile network for the SMS gateway because its network provides the best coverage in the country and it had 2 million users of its 2G and 3G services in 2013.

7.2.3 Hardware and software

The hardware for the trial was a laptop computer running an SMS gateway and an Android mobile phone for running a GSM modem. The software included SMS gateway software installed on the laptop for communicating between the laptop computer and the modem (an Android mobile phone).

The laptop computer contained an Intel Core i3 CPU at 2.1 GHz with 4GB RAM and Windows 7 as its operating system. Microsoft Office 2010 was installed with Microsoft Access as the database and Firefox 20 as the web browser. The details of 116 mobile users were entered and stored in the database of the SMS gateway.

Diafaan SMS Sever version 2.1.5 (trial edition) was installed on laptop as the SMS gateway. It is a product of the Dutch company, Diafaan communication software (Diafaan SMS Server, 2014). This software was chosen since it was free of charge (October, 2014), easy to setup and had a user friendly interface. It had a built-in web-based interface to manage, send and receive SMS messages and for retrieving the log files of events.

The Android mobile phone was a HUWEI Ascend Y320 with Android 4.2 with a 1300 MHz dual core processor and 512 MB RAM. It was used as a GSM modem to send and receive SMS messages over the mobile network. A GSM modem emulator was installed on the Android mobile phone and a Lao Telecom GSM SIM card was used. The emulator created a Wi-Fi connection between the laptop and the Android mobile phone.

Figure 7.1 illustrates the main user interface for this trial: "*Saysoth_GSM Modem Gateway*" was added by the researcher. There are six functional menus in the SMS gateway: *Status, Send Messages, Send log, Receive log, Event and Reports.*

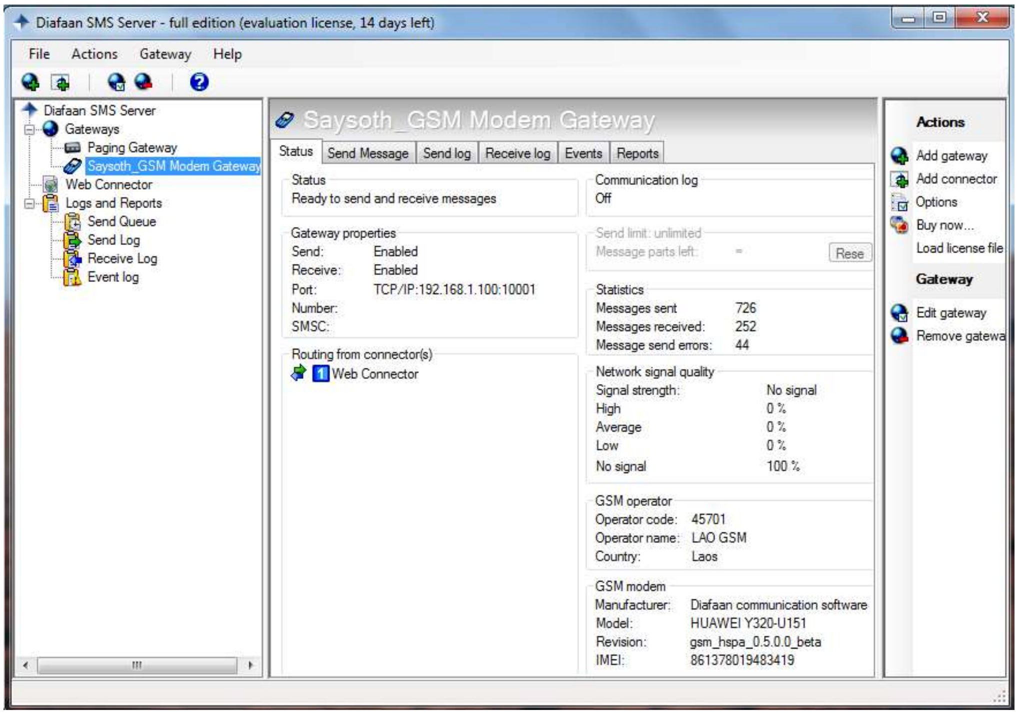


Figure 7.1: User interface of the SMS gateway

In summary, the laptop communicates with the GSM modem (mobile phone) via Wi-Fi and the modem sends or receives SMS messages over the mobile networks via the SIM card. The report of the event can be viewed and exported from the "logs and report" menu.

7.2.4 Design of the Trial

The proposed system consisted of three main parts: an SMS gateway with GSM modem, GSM base transceiver stations and mobile phone users in the flood prone area.

The first part of the trial included the laptop installed with the SMS gateway and the GSM modem on the Android mobile phone connecting to the laptop via the Wi-Fi.

The second part included the SMS centre (SMSC) and GSM base transceiver stations that belong to mobile phone networks. The SMSC is to store, forward, convert and deliver SMS messages, while the GSM base transceiver stations communicate between mobile phones within the same and different networks.

The final part was a group of mobile users, residents living in flood prone areas will receive the SMS message from the SMS gateway via the GSM modem. In this trial, the four mobile phone service providers were included because the residents in flood prone areas use these mobile services.

In this trial the flood warning messages (bulk SMS) were sent by the researcher and authorities from the first part (SMS gateway) simultaneously to mobile phone users living in the flood prone areas, via the SMS centre and mobile phone network operators as illustrated in Figure 7.2.

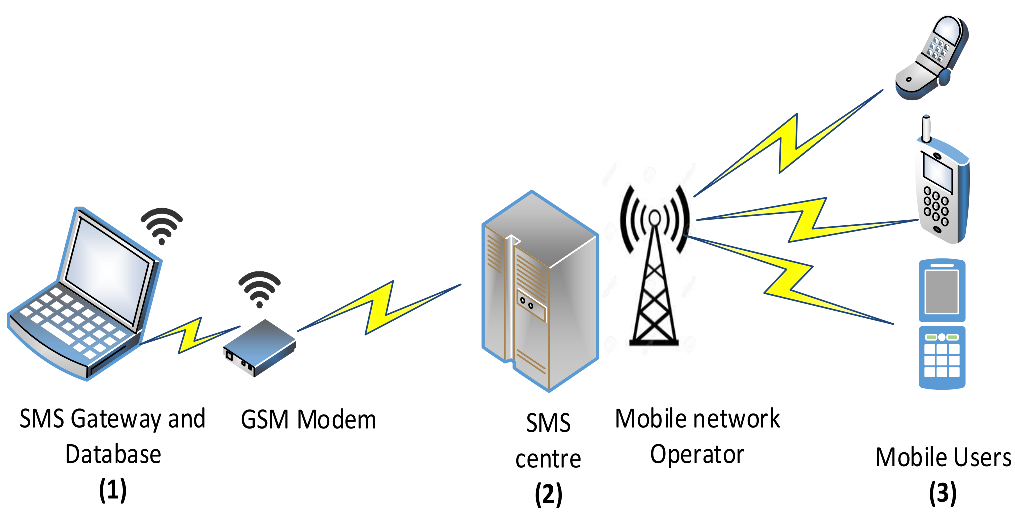


Figure 7.2: The trial setup

7.2.5 Local authority approval

Emergency alerts could be taken to be fraudulent information, be misunderstood or mistrusted, so obtaining permission for the trial from local authorities and other concerned parties was necessary.

For this trial two organisations, the Mekong River Commission (MRC) and Department of Meteorology and Hydrology (DMH), were informed because they manage the current flood warning system for the case study area.

People living in flood risk areas may be sensitive to warnings for this trial because they might have had experience with flooding disasters before, so the Chief of District and Head of Villages had to be contacted for approval of the trial because they are the first points of contact for the district and for each village (Decree, 2003). Therefore, the consent form was approved by heads of villages prior to conducting the trial (Appendix 6).

7.2.6 Message content development

A flood warning message provides information on what a flood prediction will mean to local communities and what the communities should do, it should also be easily understood by stakeholder who involved in the process of forecast and warning. Hence, the flood warning message content is very import for the targeted population. It needs to be clear, understandable, and to persuade recipients to take appropriate action.

According to AEM (2009), the warning message must be user friendly, should explain what is happening and what will happen, where and how the flood will affect the mobile users and what he or she can do about it. Others have also pointed out that an SMS message has the limitation of up to 160 characters, needs to contain critical information, in clear language which is comprehended by the targeted residents(AEM, 2009; Holmes *et al.*, 2012).

The SMS content for the trial was based on the technical criteria for SMS messages mentioned above and best practices from previous researches and studies. The messages must be clear, understandable and persuasive, as well as being suitable for the targeted residents. Prior to conducting the trial, a pilot trial was performed.

7.3 Trial procedure

This section covers the procedure for the trial. This procedure includes a trial pilot test and running the trial as follows.

7.3.1 Trial pilot test

The goal of the pilot trial was to find out whether the contents of the SMS messages were clear, understandable and accepted by people in flood prone area. The pilot trial was conducted in the local language in the case study area. Five people were selected for the pilot trial, three from the flood prone area and two from flood warning authorities. Feedback from the pilot trial was obtained by interviewing the participants to ask them whether the messages were clear and understandable or not. In response to the feedback regarding language structure and content, minor changes to the SMS content were made.

> "A cyclone and heavy rain will hit your areas by five hours, immediate flash flood and high water level in your areas. Please prepare, now!" National disaster Centre, Tel: 02022476112

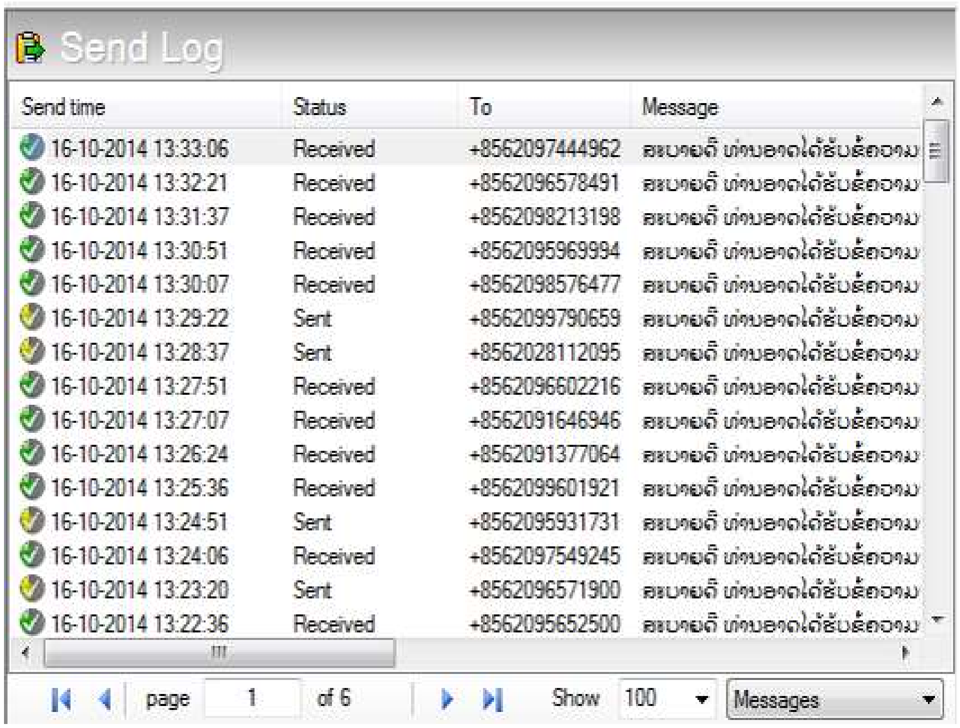
The final content of this trial contains 154 characters with spaces as presented above and the local language version (143 characters with spaces) can be found in the Appendix 8.

7.3.2 Running the trial

The trial of the proposed system was launched from the capital city, Vientiane, where the mobile phone signal was strong and reliable and the current flood warning system is located. In this trial, the local language was used to send bulk SMS flood warning messages, as if they were real messages, to reach targeted people. The 116 mobile phone numbers and their details were stored in the database of the SMS gateway as registered mobile phone numbers of residents in this trial. Prior to running this trial, the power supply of the SMS gateway and modem, the mobile SIM credits (because this trial used a Pre-paid SIM card) and mobile phone numbers were checked.

The actual trial was run in October 2014, which was in the monsoon season of the study area. There had already been minor flooding in the area and residents were aware flooding could still occur. The trial was divided into two (2) warnings. The first trial was sent in the daytime and the second warning was sent about four hours later. The second message informed the residents that the first warning was just a mock warning for testing.

Figure 7.3 shows details of the "*Send Log*" including *Send time*, *Status*, *to* (recipient numbers), and *Messages* (content of message in local language). This log file can be exported into a spreadsheet file (.csv or .xls).


Send Log

Send time	Status	To	Message
16-10-2014 13:33:06	Received	+8562097444962	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:32:21	Received	+8562096578491	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:31:37	Received	+8562098213198	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:30:51	Received	+8562095969994	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:30:07	Received	+8562098576477	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:29:22	Sent	+8562099790659	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:28:37	Sent	+8562028112095	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:27:51	Received	+8562096602216	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:27:07	Received	+8562091646946	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:26:24	Received	+8562091377064	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:25:36	Received	+8562099601921	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:24:51	Sent	+8562095931731	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:24:06	Received	+8562097549245	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:23:20	Sent	+8562096571900	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ
16-10-2014 13:22:36	Received	+8562095652500	ສະບາຍດີ ທ່ານອາດໄດ້ຮັບຂໍ້ຄວາມ

page 1 of 6 Show 100 Messages

Figure 7. 3: The Send Log file of the trial

The *Send Log* shows a low sending capacity for sending messages ranging from 1 to 2 messages per minute. According to the Diafaan SMS gateway manual, when using the Android mobile phone as a modem, up to 4 message parts per minute should be sent (Diafaan SMS Server, 2014).

The "*Status*" screen indicates the messages were received by mobile handsets (*Received*) or still being sent (*Sent*), but not yet received.

This trial did not assess the sending capacity of the modem or of the SMS gateway, the trial was to assess the transmission time between the SMS gateway and mobile users in the flood prone area. The transmission time is discussed in the following section.

7.4 Data analysis and results

The data to be analysed included phone numbers, mobile phone brand names, mobile network names, send time, receive time and status of messages (error, still sending, or received on mobile phones). SPSS version 22 software and a spreadsheet were used for the descriptive data analysis. The results are presented in the following sections.

7.4.1 Mobile phone profile

Table 7.1 indicates percentage of mobile phone providers and mobile phone brands from the selected mobile users for this trial. Unitel was the majority service provider (66.4%), Lao Telecom provided 22.4%, followed by ETL 8.6% and Beeline 2.6%.

Table 7.1: Mobile phone profile for the trial

Description		Frequency	Percentage
Mobile Network providers	Unitel	77	66.4%
	Lao Telecom	26	22.4%
	ETL	10	8.6%
	Beeline	3	2.6%
	Total	**116**	**100.0%**
Mobile Brands	Nokia	34	29.3%
	Samsung	32	27.6%
	Unitel	14	12.1%
	iMobile	12	10.3%
	MPhone	10	8.6%
	iPhone	7	6.0%
	Huawei	5	4.3%
	ZTE	2	1.7%
	Total	**116**	**100.0%**

There were 8 mobile phone brands. The majority of the mobile phones were Nokia (29.3%) and Samsung (27.6%). Other mobile phones used in flood risk areas were Unitel, i-Mobile and Mphone presenting 12.1%, 10.3% and 8.6%. Only 7% were the most expensive brand, the iPhone. The least popular phones were Huawei and ZTE, representing 4.3% and just 1.7% respectively.

7.4.2 Transmission time

Transmission time is the time taken to send an SMS message from the SMS gateway to a mobile phone as shown in Table 7.2. The SMS application recorded the three main SMS code states which indicate success or failure of the messages sent.

The three states are:

Code Status 200, Success: Message accepted by the GSM modem and waiting for sending.

Code Status 201, Success: Message already received by mobile phone handsets.

Code Status 301, Error: Error after message accepted by a mobile phone provider.

Table 7. 2: SMS message delivery

Mobile providers		Messages status: 200 Success: Message accepted by GSM modem gateway and waited for sending	Messages status: 201 Success: Message received on Mobile phones	Messages status: 301 Error after the message accepted by the mobile phone operator	Total
Lao Telecom	Count	4	22	0	26
	% within mobile network	15.4%	84.6%	0.0%	100.0%
	% of Total	3.4%	19.0%	0.0%	22.4%
ETL	Count	1	9	0	10
	% within mobile network	10.0%	90.0%	0.0%	100.0%
	% of Total	.9%	7.8%	0.0%	8.6%
Unitel	Count	16	60	1	77
	% within mobile network	20.8%	77.9%	1.3%	100.0%
	% of Total	13.8%	51.7%	.9%	66.4%
4 Beeline	Count	0	2	1	3
	% within mobile network	0.0%	66.7%	33.3%	100.0%
	% of Total	0.0%	1.7%	.9%	2.6%
Total	Count	21	93	2	116
	% within mobile network	18.1%	80.2%	1.7%	100.0%
	% of Total	18.1%	80.2%	1.7%	100.0%

Table 7.2 shows the percentage of the message delivery status (accepted by the modem but not yet received by mobile phone, received by mobile phones and error after being accepted by mobile phone operator). Generally, the trial results were met as expected with 80.2% of the mobile phones receiving the trial warning messages, 18.1% were accepted by the modem gateway and waiting to be sent, and 1.7% of the mobile phone messages sent to resulted in a lost message after the messages was accepted by the mobile phone operator.

Table 7.3 indicates that transmission time of the received messages ranges from 5 seconds to 48 minutes 34 seconds with an average of one minute and 59 seconds.

Table 7. 3: Transmission time of the trial messages

Descriptive Statistics

	N	Minimum	Maximum	Mean
Transmission time (h:mm:ss)	93	0:00:05	0:48:34	0:01:59

Of the four mobile networks, *Unitel* was the most used by residents in the case study area, followed by *Lao Telecom*, representing 66.4% and 22.4% respectively, while *ETL* and *Beeline* were less used by the residents. Within the case study area, mobile network *Lao Telecom* was the most reliable with 84.6% of Lao Telecom network users receiving the trial warning, followed by Unitel network with 77.9%. So Unitel and Lao Telecom networks were the most available and reliable in terms of numbers of mobile phones available and numbers of SMS messages received by the recipients.

7.4.3 Do people access the Internet

Table 7.4 shows the proportion of smart phones was greater than that of the basic phone, 54.3% and 45.7% respectively. As a result, it was worth investigating whether or not the smart phones have been used to access the Internet. 55.6% of smartphone users have never used their phones to access the Internet, meaning a large percentage of smart phones were used as basic phones, while only 44.4% of them (24.1% of the total phones) were used to access the Internet.

Table 7. 4: The smart phones and Internet access

Mobile phone types		Internet access		Total
		Accessed the internet	Never access the internet	
Basic phone	Count	0	53	53
	% within mobile type	0.0%	100.0%	100.0%
	% of Total	0.0%	45.7%	45.7%
Smart phone	Count	28	35	63
	% within mobile type	44.4%	55.6%	100.0%
	% of Total	24.1%	30.2%	54.3%
Total	Count	28	88	116
	% within mobile type	24.1%	75.9%	100.0%
	% of Total	24.1%	75.9%	100.0%

Even through the number of smart phone users was greater than basic phone use, they have not used them to access the Internet but just for basic phone function.

7.5 Post- trial interview

7.5.1 Purpose of the interview

The researcher sought feedback after the trial in order to obtain additional information relating to the content of the warning and action taken in response to the flood. Ten (10) participants from five high risk flood villages (2 participants from each village) who took part in the trial were selected for this survey. Five of participants were heads of the villages because they are focal point of disaster management committee as stated in 3.6 of Chapter III. The survey was conducted via phone calls.

The survey was conducted two hours after launching the trial as mobile phone users should have received the trial warning message. The researcher allowed participants to check their SMS inbox before answering the questions.

7.5.2 Questions of feedback

The questions were close-ended with "yes" or "no" answers to enable quantitative analysis of the questions. Six questions were asked by the researcher:

Q1. Did you receive the warning about the flood?

> This question was to determine if the resident received the warning or not. In order to determine if the resident recognised the message, the researcher provided the mobile number of the SMS modem which sent the warning to the respondent.

Q2. Did you understand basic Laotian (the native language)?

> This question confirmed whether the resident was able to understand basic local language (the language of the warning).

Q3. Could you read the message?

> This question checks if the local language is available or installed in the mobile phone. If the message was not understandable means the local language was not installed in that mobile phone or the resident does not understand Laotian which was checked in question.

Q4. Does your mobile phone have Laotian?

> This question was to confirm that the mobile phone had the local language installed.

Q5. Were you threatened by this warning?

> This question checked the feeling of the resident if he/she believed the warning.

Q6. Were you ready to evacuate?

This question assessed the action of the resident on recept of to the threat warning.

7.5.3 Results and discussion

The data from the feedback was quantitatively analysed using SPSS version 22 and Microsoft Excel 2013. The message was sent in the local language, so if the mobile phone users did not understand/read the warning it means they did not have basic local language skills or the local language was not available in their mobile phones.

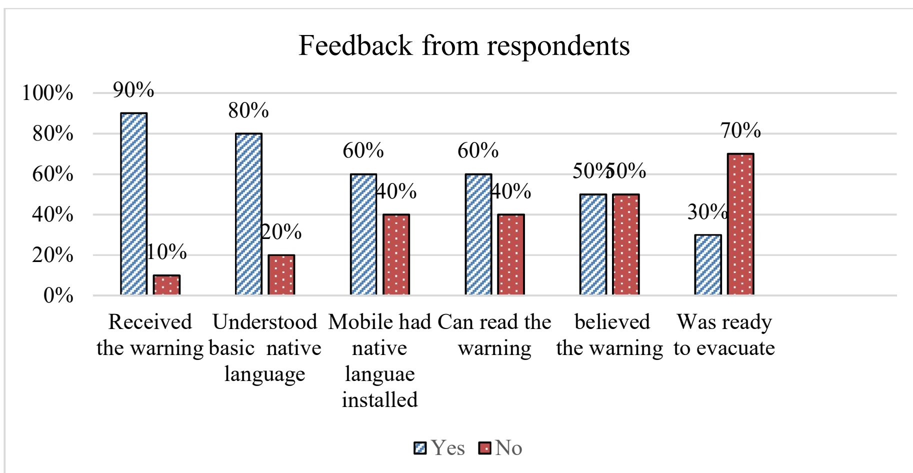


Figure 7.4: Feedback after the trial

Figure 7.4 summaries the answers to the questions asked for feedback from the trial. The bar chart shows that 90% of the residents for this feedback received the trial warning, 80% of them had basic native language skills, 60% of mobile phones had the local language installed, and 60% of the residents could read the warning. With regard to action in response to the warning, the residents doubted whether they believed the trial warning or not (50% and 50%), which resulted in them not being ready to evacuate (70%).

On the other hand, 40% of the residents could not read the warning message, which could be the result of their native language level and/or the local language settings on their mobile phones.

Table 7.5 and Table 7.6 show the cross tab between residents who understood the local language and could read the warning in the local language installed in their mobile phone. Table 7.5 shows that 40% of the residents could not read the warning because they did not understand the local language (20%), with the other 20% was able to understand the local language, but could not read the warning. Table 7.6 shows that 40% of the residents could not read the messages due to mobile phones that did not have the local language installed. By comparing the two tables it can be seen that 20% of residents have basic local language skills, but could not read the warning because of no local language installation in their mobile phones.

Table 7. 5: Residents understood the native language and could read the warning

Understand basic local language		Can read the warning		
		No	Yes	Total
No	Count	2	0	2
	% of Total	20.0%	0.0%	20.0%
Yes	Count	2	6	8
	% of Total	20.0%	60.0%	80.0%
Total	Count	4	6	10
	% of Total	40.0%	60.0%	100.0%

Table 7. 6: Mobile phone had local language and could read the warning

Local language installed on mobile phone		Can read the warning		Total
		No	Yes	
No	Count	4	0	4
	% of Total	40.0%	0.0%	40.0%
Yes	Count	0	6	6
	% of Total	0.0%	60.0%	60.0%
Total	Count	4	6	10
	% of Total	40.0%	60.0%	100.0%

In summary, the feedback showed that the residents could not understand/read the trial messages because they could did not read the local language and their mobile phones had no local language support.

7.6 Conclusion

This chapter presented the results of the trial of sending the bulk SMS to alert people about a severe flood in the case study area. The results indicated that the majority of mobile phone users (80.2%) in the flood prone area received the warnings within one hour, 18.1% of them did not receive the message but it was still waiting to be sent and around 1.7% of the messages were lost. The average time for the warning message to reach the mobile phone recipients were 0:01:59(one minutes and 59 seconds) ranging from 0:00:5 to 0:48:34 (Table 7.4)

The interview after the trial confirmed that 40% of the interviewees (residents) could not read the trial warning message because the interviewees could not read basic local language and it was not installed on some mobile phones.

Based on the results of the trial, it can be considered that an SMS-based flood warning system is suitable for the case study area because 80.2% of mobile phone users from the trial received the warning by 0:01:59 in overage (1 minutes and 59 seconds), which indicates that the mobile phone networks of the four mobile phone operators in the case study were relatively reliable.

Although the trial found that 40% of mobile phones had no local language installed, the issue can be solved by the government encouraging the population to use mobile phones with the local language installed. Using an SMS service as well as phone calls could also be an alternative option. For example, a head of village who can read Laotian has to register and receive the flood warning from the flood warning system, then other farmers can be contacted by the head of village by phone.

An increase in the use of smartphones among residents in flood risk areas can provide opportunities for the smartphone users to access the Internet and check flood warning details on the website of the MRC.

7.7 Limitations of the trial

As in the case of all research efforts, the trial had some limitations as described below.

- Even though the trial was conducted in the monsoon season, there was no flood at the time of sending the warning, so the trial was considered to be a mock trial. This resulted in having a bias associated with *"the action in response to floods"*.
- Other limitation was that, this trial used an Android mobile phone as a GSM modem to send the warning messages. Given the fact that an Android mobile phone blocks messages when they are sent too quickly, this limits the sending messages to a maximum of 4 messages per minute by default (Diafaan SMS

Server, 2014). Consequently in the log files of this trial, on average only around 2 messages per minutes were sent out (as shown in Figure 7.3).

- Communication between the SMS gateway (the laptop) and the GSM modem (the Android phone) was via Wi-Fi. This might be a bottleneck during sending bulk SMS messages from the SMS gateway via the modem to mobile phone users in flood prone areas. However, upgrade equipment would fix this problem.

7.8 Chapter review

This chapter reported on the trial of the proposed flood warning system. The purpose of the trial was to confirm the technology availability and to confirm the reliability of mobile networks in the flood prone area of the case study area. The main outcomes are summarised as follows.

In this trial, 80.2% of mobile phone users received the warning messages. A further 18.1% of the messages were accepted by the modem gateway and waiting to be sent, and 1.7 % of the messages were lost. The mean transmission time that the mobile phone users received the warning message was 0:01:59(one minute and 59 seconds), ranging from 0:00:5 to 0:48:34.

There were four main mobile phone operator services in the trial area: *Lao Telecom, ETL*, *Unitel* and *Beeline*. The operators *Unitel* and *Lao Telecom* were the most used in the trial area representing 66.4% and 22.4% respectively, while *ETL* and *Beeline* accounted for only 8.6% and 2.6% of mobile phone users. The mobile phone provider used for sending SMS warning messages was *Lao Telecom*. 54.3% of the mobile phones in the trial were smartphones, although only 24.1% of all mobile phone users used their phone to access the Internet.

The feedback post-trial indicated that the local language was not installed on 40% of the mobile phones and 20% of the participants could not read the basic local language resulting in 40% of them not reading the warning.

Based on the trial results, adopting an SMS-based flood warning system is suitable for the case study area because 80.2% of mobile phone users from the trial received the warning in 0:01:59 in average (1 minutes and 59 second), which indicates that the mobile phone networks in the case study were relatively reliable.

Chapter VIII discusses the main findings of Chapter V, Chapter VI and Chapter VII, followed by a presentation of the combination of the findings.

CHAPTER VIII : DISCUSSION OF THE FINDINGS

8.1 Introduction

In order to answer the research questions posed in Chapter I, a field survey and an online survey were conducted. The results from these surveys were used to develop a research model which was used to test hypotheses, and a trial of the proposed SMS-based flood warning system was carried out.

This chapter discusses the main findings of the two surveys (detailed in Chapter V), the research model (detailed in Chapter VI) and the trial of the proposed system (detailed in Chapter VII).

8.2 Discussion of findings of the surveys

The two surveys, the field survey and the online survey, were concurrently conducted for this study. The primary targeted respondents of the paper-based field survey were vulnerable residents living in flood prone areas of the case study area. The targeted respondents of the online survey were the flooding experts who worked in the current flood warning systems of the case study area. The main findings arising from comparing opinions of the two groups of respondents are discussed below.

8.2.1 Literacy level

Having a basic *of literacy level* in the local language or English contributes to easier use of SMS because creating messages to send and reading messages received requires at least a basic level of literacy. The results from the two surveys found that the residents living in flood prone areas of the case study area have more knowledge of the local language (75%) in comparison to English skills (38.4%) at the fair level and above. For targeted respondents (farmers), only 39% of them had knowledge of the local language and only 3.2% of them understood basic English. This finding is supported by Sengthong (2008) who reveals that in the case study area the literacy rate of the population was higher in the urban areas, lowest in rural areas and varied among age groups.

Therefore, the local language (Laotian) must be the preferred language for SMS content sent as part of an SMS-based flood warning system for the case study area.

8.2.2 Mobile phone networks in the flood risk areas

Availability and reliability of mobile phone networks in the case study area indicates a high probability of reception of SMS messages by residents living in flood risk areas.

A comparison between opinions from the targeted residents and flooding experts regarding the *mobile phone network* in the case study area showed 65% of residents surveyed have experienced reliable mobile signals, with 63% of the flooding experts believing that mobile phone coverage in flood risk areas was reliable. The perspective given by the flooding experts confirmed reliability of mobile phone networks in the case study area because they had to use their mobile phones during field trips and visits to hydrological stations (MRC, 2011b).

Therefore, if an SMS-based flood warning system is implemented, the warning is likely to reach a majority of mobile users in the flood prone areas.

8.2.3 Mobile phone penetration

High mobile phone penetration indicates a greater chance of residents receiving SMS messages because they have mobile phones. This study found that 96.84% of respondents have mobile phones. However, the flooding experts gave the opinion that only 46% of residents in flood prone areas have their own mobile phones. It is worth noting that there were contrary opinions between the flooding experts and the residents regarding the numbers of mobile phones. This could be because of the fact that flooding experts gave their opinions based on old information since mobile phone penetration has been increasing dramatically. The report conducted by ITU (2013a) found that mobile phone users in the case study area reached 68 users per 100 inhabitants, compared to that of the Internet with 10 users per 100 inhabitants. Hence, mobile phones, in the case study area, are seen to be a widespread communication tool.

8.2.4 Mobile phone affordability

There is no point in having a mobile phone if it is not *affordable* to use by paying for monthly top ups or a contract plan. The results of the surveys show that 37% of residents in the case study area said that they could afford to top up monthly, but 57% of them felt that they either can afford or cannot. By contrast, 71% of the flooding experts thought that residents always can afford to use their phone.

Therefore, if an SMS-based flood warning system is proposed for the case study area, there will be no issue of affordability for residents maintaining their mobile phone connectivity. The affordability of an SMS-based flood warning system is reinforced by the fact that residents only receive messages which do not incur cost.

8.2.5 Carry and switch on

Always *carrying* and *switching on* mobile phones are required in order to receive flood warning messages from authorities. In the case study area, the majority of the target residents work in the field (e.g., rice fields) and at other agricultural activities. Due to the fields where residents work potentially being far from their homes, it is worth assessing whether they carry their mobile phones to work and whether their phones are switched on.

The results of the surveys indicated that there was a similar proportion of opinions from both residents and flooding experts that residents regularly carry their mobile phones to work (63% and 66% respectively), whereas around 30% of both respondent groups said that sometimes they carry and sometimes they don't. There was similar results in terms of switching on their phones with 67% of residents and 66% of flooding experts indicating that they regularly switch on their mobile phones, followed by 30% and 24% of them respectively that they sometimes had their phones turned on and sometimes their phones were off.

As much as 30% of both respondent groups stated that the residents do not carry their phones and/or switch their phone off. During the conduct of the field survey in 2013, the researcher was advised that some residents did not carry mobile phones to work and they always turn them off during monsoon season because they were afraid of *lightning strikes*. It was observed that a number of residents mentioned that lighting had hit individuals who worked in open fields while using mobile phones. According to Althaus (2006), there were similar cases in China, Korea and Malaysia where people died after being struck by lightning while using their mobile phones outdoors during storms. The Australian Standard for Lightning Protection recommends that metallic objects, including cordless or mobile phones, should not be carried during thunderstorms (Althaus, 2006; Telstra, 2015).

Nevertheless, if a flood warning via SMS could alert to residents in flood risk areas, more than half of them could receive messages and then tell others by word of mouth as a supplementary option of the flood warning.

8.2.6 SMS penetration

The findings of the field survey revealed that mobile penetration in the case study area was high at 96%, whereas the SMS penetration was very low. To be more precise, 24% of residents surveyed stated they used SMS regularly, while 37% of them never used it. 56.1% of farmers who never used SMS, but only 5% of them used SMS messages regularly (2.8% of usually and 2.2% of always). Interestingly around 43.9% of the farmers seem to have knowledge of use SMS. Similarly, 25% of flooding experts gave their opinion that residents use SMS, while 54% of them believed that residents do not use SMS.

The result of the surveys is contrary to previous reports and studies suggesting that the greater the mobile user penetration, the greater the number of active SMS users. According to the ITU report, in 2012 mobile phone users worldwide represented 96% (6.8 billion mobile users per 7.1 billion inhabitants), while the total number of active SMS users reached 5.9 billion worldwide, this mathematically indicates that 91% of the world's population could be reached by SMS (ITU, 2013b). Other studies pointed out that in China alone there were over 1.1 billion mobile subscribers in 2013, and 760 million (69%) of them used SMS (Ahonen & Moore, 2012b; ITU, 2013c).

It is worth investigating obstacles preventing residents in the case study area from using SMS messages in their daily life or for flood warnings.

8.2.7 Making phone calls or using SMS

The surveys assessed a preference between receiving *a voice call* or *an SMS* for alerts about a severe flood. The results revealed that residents preferred phone calls over SMS for alerts of severe floods. 79% of the residents in flood risk areas preferred receiving a phone call (41% and 38% high priority and essential for their choice respectively), whereas 32% of them would use SMS (28% and 4% with high priority and essential levels respectively). This number shows that voice calls are the first preference for flood warnings for residents living in the case study area.

8.2.8 The current flood warning system

The findings in relation to the effectiveness *of the current flood warning system* showed contradictory opinions between residents and flooding experts. Only 40% of residents surveyed agreed that the current flood warning system was effective, whereas 60% of the flooding experts believed that it was effective. It is important to stress that the flood warning system could be useful to the flooding experts because the technology is available to them, whereas it is not useful to residents in flood risk areas due to their lack of literacy, technology skills or the technology not being available in residents' communities. In other words, the residents surveyed were not happy with the current flood warning system.

8.2.9 Possibility of adoption of SMS message for a flood warning system

The findings from the surveys has shown that 83% of residents and 71% of flooding experts believed it was highly possible to adopt SMS messages for a flood warning system for the case study area. It must be emphasized that the majority of both respondent groups believe that an SMS-based flood warnings is highly possible based on several factors such as a reliable mobile phone network and affordability of using a mobile phone. Moreover, the residents in the case study area were not happy with the current flood warning system, so they would seek an alternative system that makes use of their mobile phones.

8.2.10 Summary

In summary, the two surveys were carried out in the case study area with the aim of identifying motivation for adopting SMS for flood warnings in developing countries. The results of the surveys revealed that the local language was likely to be the language to use for adopting SMS services in the case study area because of higher literacy in the local language in comparison to English. The findings of the two surveys indicate that communication technologies were available in the case study area, including reliable mobile phone networks and high mobile phone user penetration. The results of the surveys suggested that many people in flood risk areas always carry their phones and have switch them on when they work. However, SMS user penetration was very low (24%) compared to mobile phone penetration (96%), but the residents were ready to adopt SMS messages for flood warnings.

It would be strongly desirable to find the barrier preventing the use of SMS amongst the targeted population in the case study area, even though they have their own mobile phones. Hence, the next section discusses findings of the research model that indicates factors influencing use of SMS by people in flood risk areas of the case study area.

8.3 Discussion of the findings of the research model

The research model proposed was the SMS Technology Acceptance Model (SMSTAM) and was presented in Figure 6.1 in Chapter VI. The purpose of developing the research model was to test hypotheses to discover key factors contributing to adoption of an SMS-based flood warning system in the case study area.

Based on the questionnaire and construct development, the research model is composed of five main constructs. Data from 569 residents in flood risk areas of the case study area were used to estimate the model and test hypotheses using exploratory factor analysis (EFA), confirmatory factor analysis (CFA), structural equation modelling (SEM) and SPSS version 22 with Analysis of Moment Structure (AMOS). The research model, SMSTAM, provides a compatible fit to the data (χ^2/df=2.43, IFI=0.94, CFI=0.94, TLI=0.93, RMSEA=0.05 and PRATIO=0.79), exceeding the acceptable level of model fit as shown in Table 6.13 (Hair *et al.*, 1998; Hair *et al.*, 2006; Susanto, 2012; Yen, 2010, 2011).

Overall, the findings of the SMSTAM research model as presented in Table 6.14 and Figure 6.5, suggests that the construct relationships (PU→A, PEOU→PU, PEOU→PEN, PEN→A, PEN→IU and A→IU) were significantly supported by the data, while relationships between the main constructs (PU→IU and PEOU→A) were not supported. The result of estimating the research model also showed that the model SMSTAM explains only 5% of the variance in attitude to use (A) and just 15% in intention to use (IU). The main findings of the research model are discussed as follows.

8.3.1 H1 and H2: There is a positive relationship between Perceived Usefulness on Attitude toward Use and Intention to Use.

Perceived usefulness (PU) was confirmed by a number of researchers as the key determinant to *attitude toward use* (A) and *intention to use* (IU) (Davis, 1985; Davis *et al.*, 1989, 1992; Venkatesh & Davis, 2000). The research model found that the *perceived usefulness* had significant positive relationship to *attitude toward use* and supported the hypothesis with path coefficient β=0.152 at p=0.014. It had not supported the hypothesis on *intention to use (*β=0.011; p=0.778).

According to the *construct development* in Section 6.2.2, *perceived usefulness* associates with frequency (always switch on) and benefits (saving time, being useful for work) of using a mobile phone which will lead to use of SMS for a flood warning. Hence, it might be that the residents had not yet formed a clear picture of using SMS for a flood warning system.

The residents living in the flood risk area prioritised how they operated their mobile phone. Based on the evidence shown in the survey results in Section 5.3.10, residents preferred receiving a phone call rather than receiving SMS (79% against 32% respectively). In addition, the priority between making a phone call and sending an SMS might relate to the ages of residents because young people in the case study seem to have more basic education and technology skills compared to aged people. In this study around 46% of residents surveyed were aged above 40 years old (presented in section 5.2.1.3).

This finding is consistent with previous studies conducted by Niemelä-Nyrhinen (2009), who stated that elderly and youthful respondents have different interests toward new products and new, innovative, technology-based services.

Hence, the combination of results from the surveys and from the research model show a barrier preventing use of SMS among residents living in the case study area could be associated with technology skills and basic education level.

8.3.2 H3, H4, H5 and H6: There is a positive relationships between Perceived Ease of Use on Perceived Usefulness, Perceived Enjoyment, Attitude toward Use and Intention to Use

Perceived ease of use (PEOU) is a main construct of the Technology Acceptance Model introduced by Davis (1985). For this research model, *perceived ease of use* refers to the ease of using a mobile phone and SMS because residents have basic technology skill and basic knowledge of language.

The results of the model revealed that PEOU was significantly positively supported in *perceived usefulness* (PU) with path coefficient β=0.138, *intention to use* (IU) with path coefficient β=0.222 and negatively in *perceived enjoyment* (PEN) with path coefficient β=-0.223, whereas it does not supported the hypothesis on *attitude toward use* (A) with path coefficient β=0.077.

Regarding *perceived ease of use,* it not supporting *attitude toward use* can be explained by residents who can use only a mobile phone but not SMS (because they do not have basic skills or language), they might not have an attitude to use SMS. This finding is consistent with a previous study by Davis *et al.* (1989) which found that PEOU had an indirect effect on *attitude toward use*. Hance, in this study *perceived ease of use* is also a key factor in the intent to adopt SMS among the residents living in flood risk areas.

8.3.3 H7 and H8: There is a positive relationships between Perceived Enjoyment on Attitude toward Use and Intention to Use

Perceived enjoyment (PEN) is defined as the extent to which using a specific technology is perceived to be enjoyable, it is a determinant of behavioural intention for the TAM model. In this study, *perceived enjoyment* associates with enjoyment of using mobile phone functions such as sending SMS messages, playing games, enjoying taking photos with a camera and having fun accessing social media.

The result of the research model indicates that *perceived enjoyment (PEN)* was a strong factor having positive significant influence on both *attitude toward use* (A) with path coefficient β=0.162 and *intention to use* (IU) with path coefficient β=0.378. This can be explained by the respondents having the perception of fun when using their mobile phones. According to the research on technology systems by Davis *et al.* (1992), *perceived enjoyment* was found to explain up to 75% of variance in intention to use. Hence, *perceived enjoyment* was revealed as a key factor for this research model.

8.3.4 H9: There is a positive relationship between Attitude toward Use and Intention to Use

The path from *attitude toward use* on *intention to use* is a primary determinant for the original TAM model. In the current study, hypothesis H9 (A→IU), *there is a positive relationship between perceived enjoyment and intention to use,* was supported with significance at $p<0.01$ level (β=-0.121; p=0.030). It is interesting to note that, even though this relationship is statistically significant, the β-value is negative. The negative value may indicate that residents living in flood risk areas have consideration/attitude to use SMS for flood warning in their areas but that they have not yet made the decision to adopt it.

8.3.5 Summary

In summary, for the research model, *perceived enjoyment* (PEN) is revealed as the most influential predictor, followed by *perceived ease of use* (PEOU) on both *attitude toward use* and *intention to use*. The model indicated that variance of constructs on *intention to use* is relatively low (R^2=15%), in which *perceived usefulness* (PU) explained only about 2% of variance, and both *perceived enjoyment* (PEN) and *attitude toward use (A)* explained only 5%. The low percentage of explained variance indicates that items and constructs of the research model were less suitable to estimate the research model for the case study area. Hence, in the research model, other constructs or factors could be included such as *perceived technology capacity, perceived anxiety towards technology* and *perceived cost*.

8.4 Discussion of findings of the trial

In the trial, bulk SMS messages were sent to residents living in the case study area to warn about a severe flood. This warning was sent as a real SMS-based flood warning to mobile phones. The aim of this trial was to seek additional evidence to support the findings of Chapter V and Chapter VI. The main parameters assessed in this trial were message transmission time, message content and action in response to the flood warning.

One hundred and sixteen residents living in flood prone areas took part in the trial. The local language (Laotian) was used for the warning messages sent in this trial. The key findings can be summarised as follows:

Nokia (29.3%) and Samsung (27.6%) were the majority of the eight mobile phone brands used for this trial. 54.3% of them were smartphones, 45.7% were standard phones and only 24.1% of the total phones(44.4% of smartphones) were used to access the Internet (Table 7.2).

In terms of the *message delivery*, 80.2% of mobile phones received the warning messages, with 18.1% of messages being stuck in the gateway waiting to be sent and around 1.7% of the messages lost. Within one hour, the trial message reached the mobile phone users in overage of 0:01:59(one minutes and fifty five seconds), ranging from 0:0:05 to 0:48:34. Hence, the *transmission time* for this trial confirms the results from Chapter V which indicated that mobile coverage in flood risk areas was reliable. From a technical perspective, *transmission time* indicates how quickly the warning reaches people living in flood prone areas so that they have time to seek measures to mitigate against flood impact or seeking places of safety. *Transmission time* of this trial was sufficient for a flash flood that occur after a few hours of heavy rain(MRC, 2010).

In addition, the result of an interview after the trial showed that the majority of residents interviewed (90%) received the warning during the trial, but 40% of them could not read the warning messages. It was also found that 40% of mobile phones did not have the local language installed on mobile phones and 20% of the interviewees did not have basic skill in the local language.

The data shows that unavailability of the local language on mobile phones and lack of knowledge of the local language are the main obstacles to mobile phone users not being able to read the messages. These obstacles could lead to the non-use of the SMS service among the population in the case study area.

8.5 Conclusion of discussion

Emerging from these three methods are key points to be narrowed down in order to identify the key findings for this study. These are summarised as follows.

The surveys (presented in Chapter V) found that mobile technology is available for the case study area. To be precise, 96% of respondents, who were randomly recruited in the field survey, had their own mobile phones, while only 46% of flooding experts (the online survey) thought that residents in the case study area have their own mobile phones. In addition, more than half of respondents who were surveyed experienced that *mobile phone coverage* in the case study area was reliable (65% given by residents and 63% given by flooding experts). Despite availability of the technologies and high mobile phone use, the surveys found that SMS use was very low, with only 24.1% of the residents surveyed indicating that they use SMS.

The field survey indicated that although only 37% confirmed that they can afford using their mobile phone by, for example, paying for monthly credit top ups. However, limitation of affordably to top up mobile phones should not effect an adoption of SMS messages for flood warnings. The proposed system uses *Push Mode SMS* with the notification message being sent from the authority to residents living in flood prone areas or from government to citizen (G2C), which is consistent with (Susanto, 2012; Susanto & Goodwin, 2006). There is no cost for receiving a message, so residents will only incur a cost if the system employs *Pull Mode SMS* requiring the resident to send an SMS in order to receive information in reply.

The research model (presented in Chapter VI) suggested that *perceived enjoyment (PEN)* and *perceived ease of use (PEOU)* were the key predictors influencing use of SMS and adoption of SMS for a flood warning system. The model shows that the residents, in the case study area, did not have a clear picture of the adoption of SMS for flood warnings. It must be recognised that the current research model was not suitable for the case study area context because it only explains 15% of the variances effected on *intention to use* (IU). To improve the current model to be useful for the case study area, other items and constructs need to be included in the research model such as perceived cost and perceived ICT anxiety.

The trial found that the majority of mobile phones (80.2%) participating in the trial received the trial messages, while just 1.7% of the messages were lost. Therefore, this trial confirmed the results from Chapter V which indicated that mobile coverage in flood risk areas was reliable.

The interview after the trial also showed that 40% of interviewees could not understand the trial message because the local language was not installed on their mobile phones and 20% of residents have lack of literacy in the native language. The finding is consistent with a past report by the UN (2012) that highlighted that although the literacy among the population in urban areas reached 89% in Laos, the literacy rate was low (54%) in rural areas (UN, 2012). Similarly, the result of the surveys (in Chapter V) also shows that although 75% of respondents participated in the survey had basic local language skills, but only 39% of the farmers have basic local language skills at a fair level. Therefore, illiteracy of the local language among the targeted population and unavailability of the local language on their mobile phones could be significant obstacles preventing people living in flood risk areas from using SMS for their daily life and in its adoption for flood warnings.

In conclusion, adoption of an SMS-based flood warning system that sends messages to all residents in the case study area is currently not feasible due to low numbers of active SMS users resulting from lack of literary level in the local language among residents and some mobile phones not having the local language installed.

The adoption of an SMS-based flood warning system could be highly possible in the case study area if the following actions were taken:

- Encouraging and promoting the population to use SMS messages, and campaigning to install local languages on mobile phones could increase the number of active SMS users because the mobile phone technology is already available with high mobile phone penetration in the case study area.
- A special mobile phone number, that is easy to remember, to be used as the sender of warning messages, for example, a number that has triple digits at the beginning or at the end or if all digits are the same. This kind of phone number will attract recipients wanting to know who was sending the message

and for what. Even through the recipient might not understand the content of the message, he or she could identify the source as the flood warning authorities and allow the recipient to find somebody to read the message. For example, their children can read the SMS message warning for them since, as stated in Chapter III and a report by the UN (2012), showed that the literacy rate of young people was higher than that among older people in the case study area.

- Moreover, as mentioned earlier in Chapter III, for flood management in the case study area, the Disaster Management Committees (national, provincial, district and village levels) were established. At the village level, the head of village is a focal point for the village and gets flood information from the higher levels to prepare a disaster management plan and procedure for their location.

  Hence, an SMS-based flood warning can be sent to the heads of villages, then they can call villagers by phones about an incoming flood. Alternatively household heads can be called to a meeting to discuss activities in preparation for response to a severe flood. A warning system that sends SMS messages to heads of villages is feasible.

For the case study area, flood warnings via SMS-base system could be more efficient than to the current flood warning system and traditional warning methods. Due to the current flood warning system is web-based system, so it is required at lease a basic technology skills to access the system, which is not suitable for residents living in flood risk area. The traditional waring method like television and radio has also limitations at a night time because they could be turned off. and SMS-based flood warning system has no that issue, even though in a case a mobile phone is switch off during sending a flood warning, a recipient will receive the waring while the mobile phone is switch on.

Finally, the last chapter (Chapter IX) sums up this study and major findings regarding whether the aims and objectives were met and the research questions were answered or not. The contribution of this study to practical implication and its limitations will also be presented.

CHAPTER IX : CONCLUSION AND FUTURE WORK

The aim of this study was to investigate the feasibility of adopting SMS messaging as a flood warning system to alert people in flood risk areas in developing countries, where mobile phone technologies are available, but there is a lack of Internet access. The aim was achieved by performing objectives fruitfully. The objectives of this study were:

- To review flood impacts, worldwide available flood warning systems, technologies used in flood warning systems and ICT development.
- To conduct surveys to seek primary motivation of adopting SMS for flood warnings in developing countries.
- To develop a research model and test hypotheses to identify factors influencing intent to use SMS for flood warnings in flood risk areas.
- To run a trial in the case study area to seek additional information to support and confirm the findings from the surveys and the hypotheses testing.

The quantitative multi-method approach and the case study were applied for this study. Combination of results from the surveys, the research model and the trial, is a significant finding for this study.

9.1 Conclusion

In this study, it was evident that developing countries were more vulnerable to flooding impact than developed countries due to there being bureaucratic inefficiency and lack of appropriate technology adoption. This study claims that the warning communication often failed as a result of weak inter-personal and inter-agency relationships, including between early warning services and response authorities. The study also highlighted that flood warning systems in developing countries were mostly based on mass media (radio and television stations), newspapers and websites, while in developed countries the flood warning systems were integrated and flood information is disseminated through multiple channels to alert people in the risk areas. There was a number of technologies could be used for alerting of an emergency, although beneficial technologies for flood warning systems depends on the nature of disaster, regions, social-economic status, political architecture and technology availability. This study also identified that mobile phone network development was advanced compared to other communication technologies like the Internet and fixed phones in developing countries. SMS services have been popular in developing countries where SMS technology has been adopted in various domains, although other instant messages have gradually developed.

The study concurrently conducted two surveys, the field survey and online survey. The paper-based field survey interviewed residents living in flood prone areas of the case study area. The online survey was a web-based, self-administered questionnaire with the targeted respondents being the flooding experts who work in the flood warning systems associating with flood forecasting and flood information dissemination. The results of the surveys identified that mobile phone technologies were available in the case study area, although SMS user penetration was low. SMS-based services should be applied in the local language which was more acceptable than English by the farmers.

The research model based on the Technology Acceptance Model (TAM) and the hypotheses were proposed and tested. The research model was to find out key predictors influencing adoption of SMS for flood warning systems in the case study area. The finding shows that seven of the nine relationships between factors supported the hypotheses, while two of them were not supported. The findings of the model showed that the *Perceived enjoyment (PEN)* is the most influential predictor in the research model for adopting SMS for a flood warning in the case study area, although there was very minor variance from the main determinants (*perceived usefulness* (PU) and *perceived ease of use* (PEOU) in *intention to use* (IU) (R^2=15%)).

The trial was conducted by sending bulk SMS to alert people about severe flood in the case study area. The trial aimed to seek additional evidence to support and confirm the findings from the surveys. The main results of the trial indicated that the majority of mobile phone users (80.2%) in the flood prone area received the warnings within one hour, 18.1% of them received by GSM modem but still waited for sending, and 1.7% of messages were lost. The interview of the post-trial shows that 40% of warning messages to mobile phones were not readable since their mobile phones have no local language or were not installed with local language.

9.2 Answering the research questions

This section concludes the major findings of this study regarding answering the research questions as presented in Section 1.4.

1. To answer research question 1 (RQ1*: What are the available flood warning systems and technologies used?*), this study reviewed a number of previous studies, leading reports and government documents in Chapter II and Chapter III. In summary:

   In the most developed countries, flood warning systems have been implemented and alert the public about natural hazard threats such as floods, tsunamis and hurricanes using a wide range of methods and technologies for the warning. Developed countries have applied various technologies and communication channels for disseminating the warning so as to ensuring reaching individuals in the risk areas. These channels include mass media (radio and television stations), mobile phone networks, satellite and Internet.

However, in most developing countries, warnings about floods were sent via traditional media, radio, TV stations and newspapers. The flood warning systems in some developing countries used technologies that are not accessible by citizens, particularly those in rural areas. Flood warnings often failed because of a disconnection between key technical agencies and authorities, lack of adoption of appropriate technology, and existence of bureaucratic inefficiency.

The technologies used in flood warning systems include traditional media, Internet and mobile phone networks. Social media via mobile access to the Internet also has boomed in developing countries, but with low penetration due to unavailability of technology and lack of affordability among populations. An SMS service has an advantage over cell broadcast because of its availability on almost all mobile phones, its friendly use and popularity.

2. To answer research question 2 (*RQ2: What are key elements motivating the adoption of SMS for flood warnings in the case study area?*). A comparison of findings from two surveys found that in the case study area, mobile networks were highly available and relatively reliable, and penetration was very high. Both the residents in the flood risk areas and the flooding experts agreed that it was possible to adopt SMS for a flood warning system in the case study area. Therefore, a reliable mobile phone network, a high mobile phone per user penetration, and a strong commitment are key elements for adopting SMS in a flood warning system in the case study area.
3. To answer research question 3 (RQ3: What *are the key predictors of adopting SMS messages for a flood warning system in the case study area?*), this study developed a

research model and tested the hypotheses (Figure 6.1). *Perceived enjoyment* (PEN) is revealed as the most influential predictor in *Intention to use* (IU) with β=0.38. The second key predictor is Perceived *Ease of Use* (PEOU) influencing IU with β=0.22. However, in the research model, there were not enough predictors because it explained only R^2=15% of variance in *Intention to use* (IU).

In summary, the research model had a lack of supporting items and factors for the case study context, there should be other factors included in the current research model. The other factors could be included *perceived technology capacity, perceived anxiety technology* and *perceived cost.*

4. To answer research question 4 *(RQ4: What kind of flood warning system would be suitable in the case study area?),* the results from the literature reviews, the findings from the surveys, the research model and the trial of the flood warning system were combined. In the case study area, Internet penetration is very low (10 users per 100 inhabitants), while mobile phone user penetration was relatively high (96 users per 100 inhabitants in the flood risk area). Although currently, in the case study area, an SMS-based flood warning system is unlikely to be accepted by residents due to low numbers of SMS users resulting from a lack of local language installation on mobile phones and illiteracy among the population.

   However, an SMS-based flood warning system through mobile phones has high possible in the case study area if the following actions were implemented:

   - The government ought to encourage and promote the population to use SMS messages, and campaign to install local languages on mobile phones could increase the number of active SMS users because the mobile phone technology is already available with high mobile phone penetration in the case study area.

- An attractive mobile phone number (e.g. 9999 9999) have to be used for sending a flood warning to residents living in the flood risk areas because it can interest a recipient in the message and allows someone to read the message to him/her.
- The heads of villages are focal point for the villages and get flood information from the higher levels to prepare a disaster management plan and procedure for their location. Hence, an SMS-based flood warning can be sent to the heads of villages, and then they can call villagers by phones about an incoming flood.

Therefore, an SMS-based warning system via mobile phone network can be efficient than the current flood warning system and the traditional warning channels like television and radio stations.

5. To answer the last research question 5 (*RQ5: Can an SMS message via mobile phone be a best channel for flood warning system in developing countries where mobile phone networks are available rather than the Internet*), as stated in Section 2.3, it has been stated that effectiveness of flood warning systems depends on the nature of the disasters, the affected regions, socio-economic status of the effected communities, action of response to floods, management policies and technologies used.

   Hence this study recommended that for developing countries where mobile phone networks are more widely developed than the Internet, an SMS-based flood warning system can be applied if:

   - An SMS use by residents is moderate to high.
   - There is a fair literacy level among the population in flood risk areas.
   - And the local language is available on mobile phones.

A combination of SMS service and phone calls in the local language for a flood warning could also be possible. For instance, a resident in a flood risk area can register and receive SMS warnings from the authority, while others can be contacted by phone to receive the warning or warned by the local residents.

9.3 Contribution of the study

This study assists governments in the case study area, in countries of the Mekong river Basin and in other developing countries in planning and operating their flood warning systems and to evaluate appropriate technologies for their flood warning systems

This study made a contribution for policy makers, flood warning authorities and specialists to design and initiate flood warning that integrate communication technologies that would be accessed and accepted by local residents of the flood risk areas.

This study contributes knowledge and gives guidance to environment institutions, practitioners, forecasting and warning authorities who are currently developing SMS services or intend to develop SMS services for a flood warning system in a flood area. Moreover, this study assists governments or stakeholders to consider to apply to deliver messages of non-disaster information to the local communities in timely manner such as warning of elections or remaining traditional festivals.

The research model of the study, SMSTAM, provides theoretical and practical contributions to researchers for current and future research on adopting SMS messages for a flood warning system in developing countries where the mobile phone network is further developed in comparison to the Internet.

9.4 Limitations of the study

As in the case of all research efforts, this study has some limitations.

One of the main limitations is the research model design. Due to lack of budget for a field trip, collecting the data for a field survey and for a research model was conducted at the same time. This affected the research model development because before defining the measurement for the model, the survey should be completed and used to identify the measures. As a result, the developed model provided a very low explanation of *intention to use* (R^2=15%). This study could be missing other relevant items and factors which could be suitable for the case study area context. Also, the model could be developed to explain more value in relation to attitude *toward use* (A) and *intention to use* (IU). Another drawback relates to the questionnaire design. For this research, all questions in the questionnaire were made using a 5-point Likert scale. This scale might have had a biasing effect on the response, even though it could not be detected, particularly on neutral response options. However, it could be better if the 6-point Likert scale was applied in this study because this could reduce bias due to avoidance of the neutral value (Garland, 1991; Leung, 2011).

Another limitation is that the field survey questionnaire was translated from English into the local language. In this process, some instructions for questions might have lost the original meanings resulting in misunderstandings occurring during the field survey for researcher's assistants and respondents. In addition, in this study, many participants of the online survey withdrew in the middle of the survey. According to Kitchenhan and Pfleeger (2002); Knapp and Kirk (2003), one of the criticisms of unsupervised (online) surveys is that participants can actually misread or misunderstand questions and may not answer survey questions completely honestly.

The last limitation was that the trial of the proposed system was not conducted in a full flood situation. Since there was no severe flood at the time of the trial, so "action of response to floods" was biased or ignored by the residents (details in Section 7.7).

9.5 Future research directions

Future study may further improve the research model, SMSTAM, by including other items and factors such as perceived technology capacity and perceived cost. The future field research could also be conducted in other Lower Mekong Basin countries (Cambodia, Thailand and Vietnam).

Other future research work could experiment with sending flood warnings to smartphones since this study found that (Table 7.4) the number of smartphones exceeded the number of basic phones during the trial, although only 24.1% of smartphones of the trial were used to access the Internet through the mobile networks. Hence, it would be strongly desirable to conduct research on a location-based emergency service system through smartphones in the case study area as found in previous studies (Aloudat & Michael, 2011; Aloudat *et al.*, 2007).

Testing an SMS warning system that targets heads of villages of the case study area who then contact other villagers by phones, is deemed to be investigated.

9.6 Summary

This study was conducted to investigate the feasibility of adopting SMS messages for a flood warning system in developing countries where mobile phone networks have been widely developed in comparison to Internet access. To achieve the study's aims, two surveys were conducted, a research model was developed and a trial was carried out.

The findings of the surveys indicated that in the case study area mobile networks were widely available and relatively reliable in parallel with a large number of mobile phone users. The number of active SMS users was relatively low.

In this study, the research model suggested that key factors influencing the adoption of SMS messages for a flood warning in the case study area were *"perceived enjoyment"* and *"perceived ease of use"*. However, the model lacked supporting items and factors for the case study context, there should be other factors capturing perceived technology capacity, perceived anxiety towards technology and perceived cost.

The trial confirmed that in the case study area mobile technology was available and reliable. The trial also found that the absence of local language installation on some mobile phones, low literacy of the local language, and illiteracy in English, was common in the population. These facts explain the low SMS use in the case study area.

The study recommends that in developing countries where the mobile phone network has been more widely developed than the Internet, adoption of an SMS-based flood warning system through the mobile phone network is highly possible, but the warning must be sent in the language understood by a majority of residents.

This study provides information for governments and flood warning authorities in developing countries on how to evaluate appropriate technologies used in the flood warning systems. The research model provides theoretical and practical contributions for current and future research on the adoption of SMS messages for a flood warning and other warning systems.

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Appendix 1: The Letter of approval for the MRC

To: **Mr Hance CUTTMAN……………………………**Date: 21/01/2013

CEO of the Mekong River Commission Secretariat (MRCS)

SUBJECT: Letter of Permission for a Survey and Data Collection at the MRCS

Dear Sir/Madam

I am writing this letter to seek your permission to distribute a survey questionnaire to the MRCS staff to participate in my research survey. I am currently pursuing my PhD of Information Technology focusing on *a real-time flood warning system using mobile devices* such as mobile phones. For my project the Lower Mekong Basin (LMRB) in Lao PDR is selected as my research case study area.

I would like to ask you/your staff for your kind assistance to contribute your points of view on online survey questionnaires of 5 pages. The relevant MRCS staff will be distributed through emails and asked for seek their perspectives about the flood warning experiences in the LMRB, the existing LMB flood systems, mobile network and residents living in flood risk areas.

Moreover, to support my research the MRCS hydrological data of the selected flood risk areas in the Lao PDR is needed, this data is for testing and support my research project.

Details of required data and questionnaire are attached herewith including the research background and research questions, preliminary requested data collection plan, my curriculum vitae and other supporting documents.
I look forward to your soon response. Your cooperation and support will be very much appreciated.

Yours Sincerely,

Saysoth KEODUANGSINE
PhD Candidate/Researcher

Appendix 2: The Questionnaires to Residents

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CRICOS Provider No. 00114A

The Questionnaires for Residents Living in a Risk Flood Area

Section I: Research information

1. *The Research Purpose*

This questionnaire is to find out how residents (you), in flood prone areas, intend adopting technology to prevent impacts from floods, how reliable is the mobile network in flood risk areas, what is the penetration of mobile phones and SMS usage and how residents feel about using SMS for flood warnings. Answering these questions will assist in identify important factors and design of a future flood warning.

2. *Questionnaires Directions*

We would be grateful if you could spend about 15 minutes to complete the following short questionnaire. Please answer the following questions by ticking the relevant boxes and writing down your answer in the dotted space provided. Your participation is voluntary and all your provided information is kept anonymously and confidentially.

EXAMPLE of how to complete this questionnaire:
Gender? (√ "Male" if you are male)
☑ Male ☐ Female

Section II: Personal details

This section of the questionnaire refers to your personal information. Although we are aware of the potentially sensitive nature of the questions in this section, the information will allow us to compare groups of respondents.

1. What is yours gender?
   ☐ Male ☐ Female

2. What is your age? (years)

   ☐ 18-20 ☐ 21-30 ☐ 31-40
   ☐ 41-50 ☐ 51-60 ☐ >60

3. How would you describe your work status?

☐ Employee (govt. /private) ☐ Businessperson
☐ Farmer/Fisherman ☐ Student
☐ Other, please specify…

	Yes	No
4. Do you have Mobile phone?	☐	☐

5. How do you describe your level of literacy? Please tick one box for each question
(1= cannot; 5 =Very good)

Level of literacy	Cannot 0-4%	Poor 5-40%	Fair 41-60%	Good 61-80%	Very good 81-100%
I can read and write my native language (Laotian)	☐1	☐2	☐3	☐4	☐5
I can understand basic English	☐1	☐2	☐3	☐4	☐5

Section III: General questions about mobile phone network, mobile phone and SMS penetration and current flood warning system.

6. How do you describe the mobile phone signal in your area?(1= not reliable at all; 5=Very reliable)

Not reliable at all 0-4%	Somewhat not reliable 5-40%	Neither not reliable/ reliable 41-60%	reliable 61-80%	Very reliable 81-100%
☐1	☐2	☐3	☐4	☐5

7. How do you describe the affordability of topping up your mobile phone credit? (1= not affordable at all; 5=very affordable)

Status	Not affordable at all 0- 4%	Somewhat not affordable 5-40%	Neither not affordable/ affordable 41-60%	Affordable 61-80%	Very affordabl e 81-100%
I can afford monthly top up	☐1	☐2	☐3	☐4	☐5

8. How do you agree with the following statements? (1= Strong disagree; 5=Strong agree)

Use of mobile phone	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither Disagree/ Agree 41-60%	Agree 61-80%	Strong agree 81-100%
I always carry my mobile phone	☐1	☐2	☐3	☐4	☐5
I always turn on my mobile phone	☐1	☐2	☐3	☐4	☐5

9. How often do you use SMS (send or receive) messages each week? (1= Never; 5= always)

Never 0- 4%	Sometimes 5-40%	Sometime use/not use 41-60%	Often 61-80%	Always 81-100%
☐1	☐2	☐3	☐4	☐5

10. In case of a severe flood, which of the following actions do you take? (1= Strong disagree; 5=Strong agree)

Circumstances	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither Disagree/ Agree 41-60%	Agree 61-80%	Strong agree 81-100%
I will check SMS	☐1	☐2	☐3	☐4	☐5
I will receive phone calls	☐1	☐2	☐3	☐4	☐5

11. How do you rate the effectiveness of the current flood warning systems in your areas? Please tick one box. ?(1= not effective at all; 5=Very affective)

Not effective at all 0-4%	Somewhat effective 5-40%	Neither effective not effective 41-60%	Effective 61-80%	Very Effective 81-100%
☐1	☐2	☐3	☐4	☐5

12. Do you think flood warnings via SMS should be provided to you in your area?

Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/disagree 41-60%	Agree 61-80%	Strong agree 81-100%
☐1	☐2	☐3	☐4	☐5

Section IV: Technology Acceptance Model (TAM)

<u>Perceived Usefulness (PU)</u>

13. How useful is your mobile phone and SMS? (1= Strong disagree; 5=Strong agree)

Usefulness	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/disagree 41-60%	Agree 61-80%	Strong agree 81-100%
Mobile phone is useful for my work	☐1	☐2	☐3	☐4	☐5
Using mobile phone can save my time	☐1	☐2	☐3	☐4	☐5
SMS is good for emergency alerts	☐1	☐2	☐3	☐4	☐5
It is useful to use SMS for flood waring	☐1	☐2	☐3	☐4	☐5
Having a mobile phone is very useful	☐1	☐2	☐3	☐4	☐5

Perceived Ease of Use (PEOU)

14. How easy is it for you to use SMS? Please tick one box for each question (1= Strong disagree; 5=Strong agree)

Ease of use	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/ disagree 41-60%	Agree 61-80%	Strong agree 81-100%
SMS is easy to use because I know my local language	☐1	☐2	☐3	☐4	☐5
SMS is easy to use because I understand basic English	☐1	☐2	☐3	☐4	☐5
Mobile phone is easy to use because I have technology skills	☐1	☐2	☐3	☐4	☐5

Perceived Enjoyment (PEN)

1. How much do you agree the following mobile phone functions? Please tick one box for each question (1= Strong disagree; 5=Strong agree).

Enjoyment	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/ disagree 41-60%	Agree 61-80%	Strong agree 81-100%
I always like playing games and other functions on my mobile phone	☐1	☐2	☐3	☐4	☐5
I enjoy chatting via SMS on phone	☐1	☐2	☐3	☐4	☐5
I like accessing Internet/Social media on my phone	☐1	☐2	☐3	☐4	☐5

Attitude toward Use (A)

2. How do you agree the following mobile phone statements? Please tick one box for each question (1=Strong disagree; 5=Strong agree)

Your attitude toward use	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/ disagree 41-60%	Agree 61-80%	Strong agree 81-100%
I would probably respond to flood warning via my mobile phone	☐1	☐2	☐3	☐4	☐5
I will make a call to warn people that I know if a flood affects my area	☐1	☐2	☐3	☐4	☐5
I will use my mobile phone to contact my family members if a severe flood is coming	☐1	☐2	☐3	☐4	☐5
I always use my mobile phone for my work	☐1	☐2	☐3	☐4	☐5
I may use SMS for a flood warning	☐1	☐2	☐3	☐4	☐5

Intention of Use (IU)

15. How would you intend to send and receive SMS messages to warn people in your area in a case of a severe flood? (1= Strong disagree; 5=Strong agree).

Intention	Strong Disagree 0-4%	Somewhat Disagree 5-40%	Neither agree/ disagree 41-60%	Agree 61-80%	Strong agree 81-100%
I will send SMS about flood to alert people if a severe flood is coming	☐1	☐2	☐3	☐4	☐5
I will receive incoming SMS from other people during floods	☐1	☐2	☐3	☐4	☐5
I will use my mobile phone for flood warnings	☐1	☐2	☐3	☐4	☐5

Thank you for your kind assistance!

Appendix 3: The questionnaires to flooding experts

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The questionnaires to flooding experts who work at the Mekong River Commission and the national line agency

Section A: Research information

This research questionnaire aims to seek the views of staff/officials who work at the water-related organisations and government agencies in Laos, particularly the Mekong River Commission and Ministry of Natural Resources and Environment, where the flood warning systems are available.

The staff will be asked for their opinions regarding the current flood warning systems in their organisations, issues relating to the their flood warning systems during floods and the feasibility of using SMS for flood warnings in the Lower Mekong River basin (LMRB).

Their answers to this questionnaire explore communication factors essential for flood alerts to enable a better flood warning system to be designed for developing countries.

Questionnaire Instruction

We would be grateful if you could spend about 10 minutes completing the following short questionnaire. **Residents** refer to people living in flood risk areas; **staff** refer to people working in a flood warning system or part of the system; **you** or **your** refers to the person answering this questionnaire.

Please answer the following questions by ticking the relevant number or writing down your answer in the dotted space provided.

EXAMPLE of how to complete this questionnaire:
Gender? (√"Male" if you are male)
☑ Male ☐ Female

Section B: Personal details

This section of the questionnaire refers to your personal information. Although we are aware of the potentially sensitive nature of the questions in this section, the information will allow us to compare groups of respondents. We assure you that your response will remain anonymous and confidential.

1. What is your Gender ☐ Male ☐ Female

2. What is your age? (in years)

☐ 18-20 ☐ 21-30 ☐ 31-40 ☐ 41-50
☐ 51-60 ☐ >60

3. How would you describe your job? Please tick one box.

   ☐ Forecasting Expert ☐ Flood forecaster ☐ Hydrologist

   ☐ Meteorologist ☐ Other, Please specify………………

4. Which organisation do you work for? Please tick one box

   ☐ Mekong River Commission Secretariat
   ☐ Ministry of National Resource and Environment (Laos)
   ☐ Other, please specify………………

Section D: About residents and an SMS-based flood warning system

5. How do you ***describe the literacy*** level of residents in the flood risk areas? (**1**=Strong disagree; **5**= Strong agree)

Circumstances	Strongly Disagree 0-4%	Somewhat disagree 5-40%	Neither disagree/ agree 41-60%	Agree 61-80%	Strongly Agree 81-100%
Residents can understand native language	☐1	☐2	☐3	☐4	☐5
Residents can understand English	☐1	☐2	☐3	☐4	☐5

6. How do you describe the ***stability*** of mobile phone networks in the Lower Mekong River basin? (1= not reliable at all; 5=Very reliable)

Not reliable at all 0-4%	Somewhat unreliable 5-40%	Neither reliable Neither Not reliable 41-60%	reliable 61-80%	Very reliable 81-100
☐1	☐2	☐3	☐4	☐5

7. Do you ***agree*** with the following circumstances of residents living in flood prone areas of the Lower Mekong River basin? Please tick one box each question(**1**=Strong disagree; **5** = Strong agree)

Circumstances	Strongly Disagree 0-4%	Somewhat disagree 5-40%	Neither disagree/ agree 41-60%	Agree 61-80%	Strongly Agree 81-100%
Residents have their mobile phone	☐1	☐2	☐3	☐4	☐5
Residents can afford to use mobile phones	☐1	☐2	☐3	☐4	☐5
Residents can use SMS	☐1	☐2	☐3	☐4	☐5
Residents always carry their mobile phones	☐1	☐2	☐3	☐4	☐5
Residents always turn on their mobile phones	☐1	☐2	☐3	☐4	☐5

8. How do you rate the overall ***effectiveness*** of the current flood warning systems in the Lower Mekong River basin?(1= not effective at all; 5=Very affective)

Not effective at all 0-4%	Somewhat Not effective 5-40%	Neither effective Neither not 41-60%	Effective 61-80%	Very Effective 81-100%
☐1	☐2	☐3	☐4	☐5

9. Do you think *it is possible* to use SMS messages as flood warning alerts in flood risk areas for the LMRB?(**1**= impossible at all; **5**=Very high possible)

Not impossible at all 0-4%	Somewhat impossible 5-40%	Neither impossible/ possible 41-60%	Possible 61-80%	Very high possible 81-100%
☐1	☐2	☐3	☐4	☐5

Thank you so much for your cooperation in completing this questionnaire.

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Appendix 4: The questionnaire to residents (Local language version)

ບົດສອບຖາມຕໍ່ປະຊາຊົນທີ່ອາໃສໃນເຂດນໍ້າຖ້ວມ

ພາກທີ I: ຈຸດປະສົງ

<u>ຈຸດປະສົງ</u>

ແບບສອບຖາມນີ້ມີຈຸດປະສົງເພື່ອຊອກຫານການປະພຶດຂອງປະຊາຊົນຕໍ່ເຫດການນໍ້າຖ້ວມໃນໄລຍະຜ່ານມາ, ໂດຍສະເພາະການທ້າງຫາກະກຽມເຕືອນໄພນໍ້າຖ້ວມ ແລະ ເຂົາເຈົ້າໄຊ້ເຕັກໂນໂລຢີຫຍັງແດ່ເພື່ອເຕືອນເຊີ່ງກັນ ແລະ ກັນ. ບັນດາຄຳຖາມດັ່ງກ່າວແມ່ນກ່ຽວພັນເຖິງການໃຊ້ໂທລະຊັບມືຖື, ປະສົບການໃນຂະນະທີ່ນໍ້າຖ້ວມ ແລະ ການເຕືອນບອກກ່ຽວກັບໄພນໍ້າຖ້ວມຈະມາເຖິງຕໍ່ປະຊາຊົນໃນຊຸມຊົນ. ນອກຈາກນີ້ແບບສອບຖາມຍັງໄດ້ກ່າວເຖິງຄຳເຫັນຂອງເຂົາເຈົ້າຕໍ່ລະບົບເຕືອນໄພນໍ້າຖ້ວມທີ່ມີໃນປະຈຸບັນ ແລະ ໃນທ້າຍບົດສອບຖາມຍັງຖາມຄວາມຄຸ້ນເຄີຍຂອງປະຊາຊົນຕໍ່ການໄຊ້ມືຖື ແລະ ຂໍ້ຄວາມ.

<u>ການແນະນຳວິທີຕອບແບບສອບຖາມ</u>

ພວກເຮົາສຸດແສນດີໃຈຖ້າຫາກທ່ານໃຊ້ເວລາປະມານ 15 ນາທີເພື່ອຕອບຄຳຖາມນີ້. ກະລຸນນາຂີດ ໝາຍຖືກ Ĕ ໃສ່ບ່ອນທີ່ເໝາະສົມ ຫຼື ຂຽນໃສ່ຫຫ່ວາງທີ່ກຳນົດໄວ້.

ຕົວຢ່າງ

ເພດໃດ? (ຂີດ√ ໃສ່ຮູບຈະຕຸລັດດັ່ງລຸ່ມນີ້ ຖ້າເພດຊາຍ)

☑ *ຊາຍ* ☐ *ຍິງ*

ພາກທີ II: ຂໍ້ມູນສ່ວນຕົວ.

ແບບສອບຖາມໃນພາກນີ້ແມ່ນເວົ້າເຖິງຂໍ້ມູນສ່ວນຕົວຂອງທ່ານ,ແຕ່ຂໍ້ມູນນີ້ຈະຊ່ວຍໃຫ້ພວກເຮົາສົມທຽບລະຫວ່າງກຸ່ມຕົວຢ່າງໃນແບບສອບຖາມນີ້ ແລະ ພວກເຮົາຮັບປະກັນວ່າຊື່ຂອງທ່ານຈະບໍ່ປະສົງອອກນາມ ແລະ ຈະບໍ່ມີຜົນຮ້າຍຕໍ່ທ່ານ.

1. ເພດ.

☐ ຍິງ ☐ ຊາຍ

2. ອາຍຸ(ປີ)

☐ 18-20 ☐ 21-30 ☐ 31-40
☐ 41-50 ☐ 51-60 ☐ >60

3. ກະລຸນນາ ຈົ່ງບອກໜ້າວຽກທີ່ໃກ້ຄຽງຂອງເຈົ້າດັ່ງລຸ່ມນີ້?

☐ ພະນັກງານລັດ ☐ ນັກທຸລະກິດ
☐ ຊາວນາ ☐ ນັກຮຽນ ☐ ອື່ນໆ...

4. ກະລຸນາບອກລະດັບ ຄວາມຮູ້ໜັງສືຂອງທ່ານ? (1=ບໍ່ຮູ້ຈັກໜ້ອຍ; 5 =ດີຫຼາຍ)

ຄວາມຮູ້ໜັງສື	ບໍ່ຮູ້ 0-4%	ຮູ້ໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ດີ 61-80%	ດີຫລາຍ 81-100%
ຂຽນ ແລະ ອ່ານພາສາລາວ	☐1	☐2	☐3	☐4	☐5
ສາມາດເຂົ້າໃຈພາສາອັງກິດ	☐1	☐2	☐3	☐4	☐5

ພາກທີ III: ການໃຊ້ໂທລະຊັບມືຖື,ປະສົບການໃນການໃຊ້ໂທລະຊັບມືຖື ແລະ ຂໍ້ຄວາມ .

5. ເຈົ້າມີໂທລະຊັບມືຖືບໍ່? ມີ ☐ ບໍ່ມີ ☐

6. ທ່ານອະທິບາຍການສັນຍານໂທລະສັບມືຖືໃນເຂດພື້ນທີ່ຂອງທ່ານ(1=ບໍ່ດີ, 5 =ດີຫຼາຍ)

ບໍ່ດີ 0-4%	ດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ດີ 61-80%	ດີຫລາຍ 81-100%
☐1	☐2	☐3	☐4	☐5

7. ທ່ານມີຄວາມສາມາດຕື່ມບັດຫລາຍປານໃດ? (1= ບໍ່ໃດ້ ,5= ໃດ້ ຫລາຍ)

ຄວາມສາມາດ ຕື່ມບັດ	ບໍ່ໃດ້ 0- 4%	ໃດ້ໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ໃດ້ 61- 80%	ໃດ້ ຫລາຍ 81-100%
ທ່ານມີຄວາມສາມາດ ຕື່ມບັດບໍ່	☐1	☐2	☐3	☐4	☐5

8. ທ່ານເຫັນດີກັບບັນຫາຫລື ບໍ່(1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ໃຊ້ໂທລະສັບມືຖື	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
ຖືຕະຫຼອດ	☐1	☐2	☐3	☐4	☐5
ເປີດຕະຫຼອດ	☐1	☐2	☐3	☐4	☐5

9. ເຈົ້າໃຊ້ ຂໍ້ຄວາມ SMS ເລື້ອຍໆບໍ່?(1= ບໍ່ເຄີຍໃຊ້; 5= ໃຊ້ ເລື້ອຍໆ)

ບໍ່ເຄີຍໃຊ້ 0- 4%	ເຄີຍໃຊ້ ໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຄີຍໃຊ້ 61-80%	ເຄີຍໃຊ້ ເລື້ອຍໆ 81-100%
☐1	☐2	☐3	☐4	☐5

10. ລະບົບເຕືອນໃນປະຈຸບັນເປັນແນວໃດ(1=ບໍ່ດີ, 5 =ດີຫຼາຍ)

ບໍ່ດີ 0-4%	ດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ດີ 61-80%	ດີຫລາຍ 81-100%
☐1	☐2	☐3	☐4	☐5

11. ທ່ານຄິດວ່າລະບົບເຕືອນຜ່ານSMSຈະດີສຳລັບບ້ານຂອງທ່ານ(1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
☐1	☐2	☐3	☐4	☐5

12. ໃນກໍລະນີຂອງນ້ຳຖ້ວມຮ້າຍແຮງ? (1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ຜົນປະໂຫຍດ	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
ສົ່ງຂໍ້ຄວາມ	☐1	☐2	☐3	☐4	☐5
ໂທມືຖື	☐1	☐2	☐3	☐4	☐5

Section IV: ຕັກໂນໂລຊີຕົວແບບ(TAM)

Perceived Usefulness (PU)

13. ຝົນດີໃນການໃຊ້ມືຖື ແລະ ຂໍ້ຄວາມ SMS? (1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ຜົນປະໂຫຍດ	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
ມືຖືມີຜົນປະໂຫຍດຕໍ່ວຽກ	☐1	☐2	☐3	☐4	☐5
ໃຊ້ມືຖືສາມາດປະຍັດເວລາ	☐1	☐2	☐3	☐4	☐5
ຂໍ້ຄວາມSMS ດີຕໍ່ການເຕືອນໄພມະຊາດ	☐1	☐2	☐3	☐4	☐5
ຂໍ້ຄວາມ SMS ດີຕໍ່ການເຕືອນໄພນໍ້າຖ້ວມ	☐1	☐2	☐3	☐4	☐5
ມືຖືມີຜົນປະໂຫຍດ	☐1	☐2	☐3	☐4	☐5

Perceived Ease of Use (PEOU)

14. ມືຖື ແລະ ຂໍ້ຄວາມ SMS ງ່າຍຕໍ່ການນໍາໃຊ້ແນວໃດ?(1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ງ່າຍຕໍ່ການໃຊ້	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
ມືຖືງ່າຍຕໍ່ການໃຊ້	☐1	☐2	☐3	☐4	☐5
ຂໍ້ຄວາມSMS ງ່າຍຕໍ່ການໃຊ້ ເພາະວ່າຂ້ອຍຮູ້ພາສາລາວດີ	☐1	☐2	☐3	☐4	☐5
ຂໍ້ຄວາມSMS ງ່າຍຕໍ່ການໃຊ້ ເພາະວ່າຮູ້ພາສາອັງກິດ	☐1	☐2	☐3	☐4	☐5

Perceived Enjoyment (PEN)

15. ທ່ານມັກເຫລື້ນມືຖືປານໃດ(1= ບໍ່ມັກ; 5= ມັກຫລາຍ

ຄວາມມັກ	ບໍ່ມັກ 0- 4%	ມັກໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ມັກ 61-80%	ມັກຫລາຍ 81-100%
ຂ້ອຍມັກເກມ ແລະ ອື່ນໆ	☐1	☐2	☐3	☐4	☐5
ຂ້ອຍມັກຂໍ້ຄວາມ SMS	☐1	☐2	☐3	☐4	☐5
ຂ້ອຍມັກ ອິນເຕີເນັດ	☐1	☐2	☐3	☐4	☐5

Attitude toward Use (A)

16. ທ່ານເຫັນດີກັບບັນຫາຫລື ບໍ່(1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ທັດສະນະ ການໃຊ້	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີຫລາຍ 81-100%
ອາດຈະເຕືອນຜ່ານມືຖື	☐1	☐2	☐3	☐4	☐5
ອາດຈະເຕືອນປະຊາຊົນຜ່ານມືຖື	☐1	☐2	☐3	☐4	☐5
ອາດຈະເຕືອນຄອບຄົວດ້ວຍມືຖື	☐1	☐2	☐3	☐4	☐5
ຂ້ອຍຈະໃຊ້ມືຖືໃນວລາເຮັດວຽກ	☐1	☐2	☐3	☐4	☐5
ຂ້າພະເຈົ້າອາດຈະນໍາໃຊ້ SMS	☐1	☐2	☐3	☐4	☐5

Intention of Use (IU)

17. ທ່ານມີຈຸດປະສົງ ໃຊ້ SMS ໃນກໍລະນີນ້ຳຖ້ວມ(1= ບໍ່ເຫັນດີ; 5=ເຫັນດີຫຼາຍ)

ຈຸດປະສົງ	ບໍ່ເຫັນດີ 0-4%	ເຫັນດີໜ້ອຍ ໜຶ່ງ 5-40%	ປານກາງ 41-60%	ເຫັນດີ 61-80%	ເຫັນດີ ຫລາຍ 81-100%
ຂ້ອຍຈະສົ່ງຂໍ້ຄວາມ ເຕືອນໃນ ໃນເວລານ້ຳຖ້ວມ	☐1	☐2	☐3	☐4	☐5
ຂອ້ຍຈະຮັບຄວາມ ໃນ ເວລານ້ຳຖ້ວມ	☐1	☐2	☐3	☐4	☐5
ຈະນຳໃຊ້ໂທລະສັບມືຖື ສຳລັບການເຕືອນໄພນ້ຳຖ້ວມ	☐1	☐2	☐3	☐4	☐5

ຂອບໃຈທ່ານທີ່ເສຍສະລະເວລາຕອບຄຳຖາມດັ່ງກ່າວ!.

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CRICOS Provider No. 00114A

Appendix 5: Letter of Introduction

LETTER OF INTRODUCTION

Dear Sir/Madam

This letter is to introduce *Mr Saysoth Keoduangsine* who is a PhD student in the School of Computer Science, Engineering and Mathematics at Flinders University.

He is undertaking research into a flood warning system for the lower Mekong river basin (LMRB). His research will focus on providing a flood warning system via SMS messaging.

He would be most grateful if you would volunteer to assist him in this project, by answering the questionnaire which seeks information on your experiences and communication during floods and how do you alert people when a flood occurs. Completing the questionnaire it should take no more than 15 minutes.

Be assured that any information provided will be treated in the strictest confidence and none of the participants will be individually identifiable in the resulting thesis, report or other publications and your name will be anonymous.

Any enquiries you may have concerning this project should be directed to me at the address given above or by telephone on +6188201 3113 or by email (robert.goodwind@flinders.edu.au).

Thank you for your kind assistance and cooperation.

Yours sincerely

R. D Goodwin

Dr Robert Goodwin
Senior Lecturer
School of Computer Science, Engineering and Mathematics

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (5954). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

Appendix 6: Letter of approval from head of village

ສາທາລະນະລັດ ປະຊາທິປະໄຕ ປະຊາຊົນລາວ

ສັນຕິພາບ ເອກະລາດ ປະຊາທິປະໄຕ ເອກະພາບ ວັດທະນາຖາວອນ

ໃບສະເໜີ

ເຖິງ: ຄະນະບ້ານ : ....

ເລື່ອງ : ຂໍລົງເກັບກຳຂໍ້ມູນຢູ່ບາງບ້ານທີ່ເຄີຍປະສົບໄພນ້ຳຖ້ວມ.

(ວິທີເກັບກຳຂໍ້ມູນແມ່ນຢາຍແບບສອບຖາມ ແລະສຳພາດ).

ຂ້າພະເຈົ້າ ທ. ຊາຍໄຊດ ແກ້ວດວງສີນ ປະຈຸບັນຢູ່ ໜ່ວຍ22 ບ້ານຈອມມະນີ,ມ ໄຊເສດຖາ ນະຄອນຫຼວງວຽງຈັນ, ຂ້າພະເຈົ້າກຳລັງຄົ້ນຄ້ວາ ຢູ່ໂຮງຮຽນ: Flinders University, ປະເທດ ອົດສະຕາລີ, ສາຂາວິຊາໄອທີ, ຫົວຂໍ້ທີ່ຂອງການຄົ້ນຄ້ວາແມ່ນ: ***ການເປັນໄປໄດ້ຂອງການນຳໃຊ້ ໂທລະສັບມືຖື ເພື່ອເຕືອນໄພນ້ຳຖ້ວມໃນ ສປປລ***, ສະນັ້ນຂ້າພະເຈົ້າຈຳເປັນຕ້ອງມີຂໍ້ມູນປະຊາກອນທີ່ນຳໃຊ້ມືຖືຢູ່ໃນເຂດທີ່ເຄີຍມີນ້ຳຖ້ວມຜ່ານມາ (ລາຍລະອຽດມີແບບສອບຖາມຕິດຂັດ) ເພື່ອຈະໃຊ້ລະບົບເຕືອນໄພນ້ຳຈະຖ້ວມຜ່ານມືຖືໂດຍອັດຕະໂນມັດ.

ຜົນຂອງການສຶກສາທີ່ຄາດວ່າຈະໄດ້ຮັບ, ຈະຊ່ວຍປະຊາຊົນໃນເຂດນ້ຳຖ້ວມຮູ້ລ່ວງໜ້າວ່າຈະມີໄພນ້ຳຖ້ວມເກີດຂຶ້ນເພື່ອ ຫາວິທີໜີໄພ ແລະ ຊ່ວຍປະຊາຊົນຫຼຸດຜ່ອນການເສຍຫາຍຊີວິດ ແລະ ຊັບສິນ.

ສະນັ້ນ,ຂ້າພະເຈົ້າຈິ່ງຂໍລົງເກັບກຳຂໍ້ມູນດັ່ງກ່າວ. ຂ້າພະເຈົ້າໃຫ້ຄຳໝັ້ນສັນຍາວ່າຂໍ້ມູນທີ່ຂ້າພະເຈົ້າໄດ້ມານີ້ຈະຊ່ວຍພັດທະນາປະເທດຊາດຂອງພວກເຮົາ ແລະ ຈະບໍ່ໄຊ້ໄປໃນທາງທີ່ບໍ່ດີເດັດຂາດ.

ຫວັງຢ່າງຍິ່ງວ່າອຳນາດການປົກຄອງທຸກຂັ້ນທີ່ກ່ຽວຂ້ອງຈະຊ່ວຍ ແລະ ອຳນວຍຄວາມສະດວກໃນການລົງເກັບກຳຂໍ້ມູນເພື່ອມາຄົ້ນຄ້ວາ, ວິໄຈ ຂອງພວກເຮົາໃນຄັ້ງນີ້ດ້ວຍ.

ວັນທີ 29 ເດືອນ 04 ປີ 2013.

ຄະນະບ້ານ..................   ຄະນະບ້ານຈອມມະນີ   ຜູ້ລົງເກັບກຳຂໍ້ມູນ.

ນາຍບ້ານ

ຈອມມະນີ

2 9 Apr 2013

Appendix 7: The feedback questions of the trial

English version	Local language version
1. Did you receive the warning about the flood last 4 hour? Yes ☐ No ☐ 2. Did you understand basic Laotian (the native language) Yes ☐ No ☐ 3. Could you read the message? Yes ☐ No ☐ 4. Does your mobile phone have Laotian installed? Yes ☐ No ☐ 5. Were you threatened by this warning? Yes ☐ No ☐ 6. Were you ready to evacuate according to this warning. Yes No	1. ເຈົ້າໄດ້ຮັບການເຕືອນໄພນ້ຳຖ້ວມພາຍໃນ 4 ຊົ່ວໂມງນີ້ບໍ? ເຈົ້າ ☐ ບໍ່ ☐ 2. ເຈົ້າເຂົ້າໃຈພື້ນຖານພາສາລາວບໍ? ເຈົ້າ ☐ ບໍ່ ☐ 3.ທ່ານສາມາດອ່ານຂໍ້ຄວາມ ນ້ຳຖ້ວມໄດ້ ບໍ? ເຈົ້າ ☐ ບໍ່ ☐ 4. ໂທລະສັບມືຖືຂອງເຈົ້າ ມີພາສາລາວ? ເຈົ້າ ☐ ບໍ່ ☐ 5.ເຈົ້າຢ້ານກງ່ວກັບການໂດຍຄຳເຕືອນນີ້ ບໍ? ເຈົ້າ ☐ ບໍ່ ☐ 6. ເຈົ້າໄດ້ພ້ອມທີ່ຈະຍ້າຍ ບໍ? ເຈົ້າ ☐ ບໍ່ ☐

Appendix 8: The warring message of the trial

English version (154 characters with spaces)

“A cyclone and heavy rain will hit your areas by five hours, immediate flash flood and high water level in your areas. Please prepare, now!” National disaster Centre, Tel: 02022476112

Local language version (143 characters with spaces)

“ພະຍຸແລະຝົນຈະຕົກແຮງພາຍໃນຫ້າຊົ່ວໂມງໜ້ານີ້, ພະຍຸຈະພາໃຫ້ເກີດນ້ຳຖ້ວມ
ໃນເຂດຂອງທ່ານຢູ່.ຈົ່ງພາກັນກະກຽມ ຢ່າງຮີບດ່ວນ!”,ສູນໄພພິບັດແຫ່ງຊາດ, ໂທ:02022476112