

DIGITALLY ENHANCED DISASTER PREPAREDNESS APPROACH TO NATURAL DISASTERS IN SRI LANKA

Rubasin Siriwardhana Senuri Disara

(208070E)

Dissertation submitted in partial fulfillment of the requirements for the
Degree Master of Science (Major Component Research)

Department of Building Economics
Faculty of Architecture

University of Moratuwa
Sri Lanka

February 2022

DECLARATION

Declaration, copyright statement and the statement of the supervisor

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

(R.S.Senuri Disara)

Date:

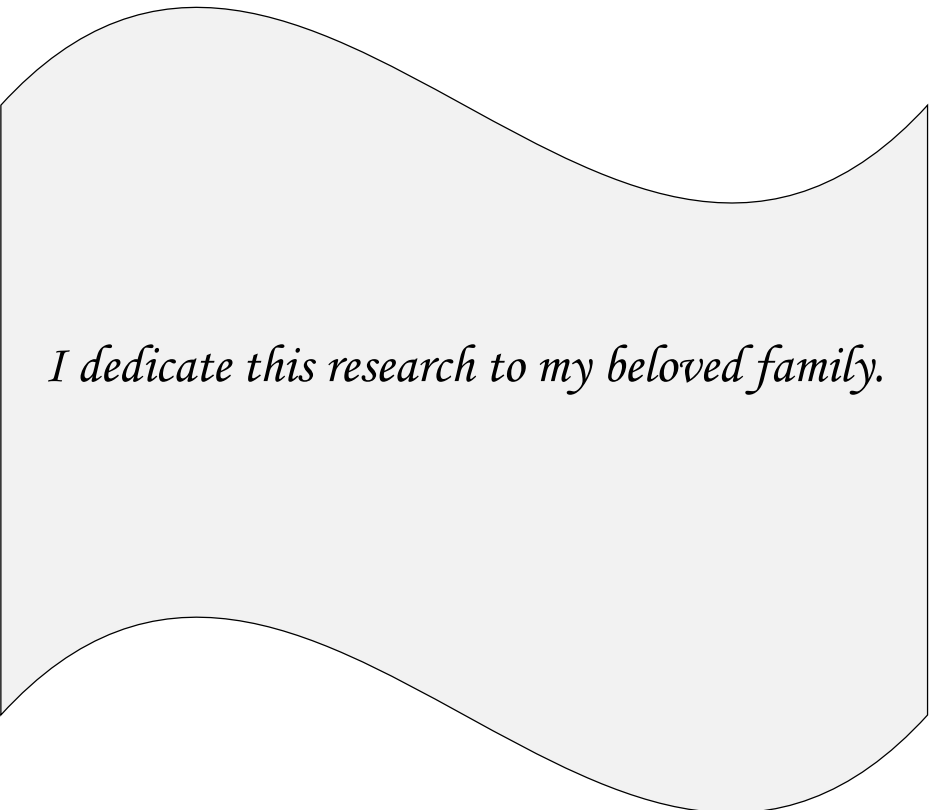
The above candidate has carried out research for the Masters dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of the supervisor: Prof. Udayangani Kulatunga

Signature of the supervisor:

Date :

DEDICATION



I dedicate this research to my beloved family.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to all the individuals and organisations, who have supported me during my MSc journey.

First of all, I am extremely grateful to my supervisor Prof. Udayangani Kulatunga for her continuous guidance, support and care throughout my MSc journey. She influenced me consciously and unconsciously and made me the person, who I am today. It was a real privilege for me to learn from her exceptional subject knowledge and her extraordinary human qualities. I would also like to extend my sincere gratitude to Prof. Terrence Fernando for his continuous support as an advisor throughout my study. Further, I am thankful to Dr. Chethika Abeynayake for her constructive advice and suggestions given to further improve my study.

I further extend my gratitude to Prof. Fernando and University of Salford for offering me a research grant under the research project titled ‘Multi-agency Platforms for Building Resilient Communities (MOBILISE)’ without which I would not have been able to pursue my studies successfully.

Very special thanks go to all academic and non-academic staff of Department of Building Economics, University of Moratuwa, who have contributed immensely to my academic journey at the University. I cannot forget the massive support and continuous encouragement received from my fellow researchers in the Department of Building Economics throughout the study.

My sincere appreciation goes to the interviewees for their immense support that was given to collect data for my research. A deep sense of reverence gratitude goes towards my parents and my sister for their immense support and encouragement throughout the research. Finally, my appreciation goes to all my friends, who have helped me directly and indirectly to make this research a success.

ABSTRACT

Digitally enhanced disaster preparedness approach to natural disasters in Sri Lanka

Disaster preparedness is one of the prominent phases of disaster management that mitigates the impact of hazards and ensures effective response and recovery. In terms of successful disaster preparedness, information and coordination systems play a major role by creating linkages among the different stakeholders and managing preparedness information. However, existing information coordination systems used in disaster preparedness of developing countries like Sri Lanka need to be enhanced by digital technologies in order to obtain successful outcomes of disaster preparedness. Therefore, this research is aimed at enhancing the disaster preparedness approach in Sri Lanka through a digital information and coordination system.

The study initially carried out an extensive literature review. Subsequently, under the interpretivist research philosophy, the data was collected through interviews, documentary review and focus group discussion. The data analysis was conducted through manual code based content analysis and user story analysis to identify existing challenges and user requirements of a digital information and coordination system for disaster preparedness. Empirical findings revealed that existing information and coordination systems for disaster preparedness in Sri Lanka undergo multiple challenges faced by the authority members involved in the preparedness approach and the community. Lack of transparency, lack of accuracy, delays in information dissemination, lack of user-friendliness, lack of capacity have been identified as the topmost challenges, which affected both the authority as well as the community. Hence, the development of a digitally enhanced information and coordination system for disaster preparedness by addressing the existing challenges has become indispensable. To this, the user requirements of such a system were gathered, analysed and presented in a framework through the study by providing the basis for the system development. The features of the developed framework through the study would assist the disaster preparedness practitioners as well as the community to contribute towards an enhanced disaster preparedness approach by addressing the existing challenges and ensuring maximum user satisfaction.

Keywords- Disaster preparedness; Information and coordination, User requirement, Digital enhancement

TABLE OF CONTENT

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENTS	ii
ABSTRACT	iv
TABLE OF CONTENT	v
LIST OF FIGURES	ix
LIST OF TABLES	x
LIST OF ABBREVIATIONS	xi
LIST OF APPENDICES	xii
1 INTRODUCTION	1
1.1 Background	1
1.2 Problem statement	3
1.3 Aim	4
1.4 Objectives	4
1.5 Scope and limitations	4
1.6 Methodology	4
1.7 Chapter breakdown.....	5
1.8 Chapter summary	6
2 RESEARCH METHODOLOGY	7
2.1 Introduction	7
2.2 Graphical representation of the research process	7
2.3 Background and problem identification	8
2.4 Literature review	9
2.4.1 Systematic review with the aim of establishing a working definition for disaster preparedness.....	10
2.4.1.1 Specified Aim, Objective and Research Question for Systematic Review.....	10
2.4.1.2 Source selection.....	11
2.4.1.3 Search strategy	12
2.4.1.4 Eligibility criteria	12

2.4.1.5	Study selection and data extraction	13
2.5	Research methodological design	15
2.5.1	Research philosophy	16
2.5.2	Approach to theory development	18
2.5.3	Methodological choice	19
2.5.4	Research strategy	19
2.5.5	Time horizon	21
2.5.6	Data collection	22
2.5.7	Data analysis	27
2.5.7.1	Qualitative content analysis.....	27
2.5.7.2	User story mapping process as the method of user requirement analysis	29
2.6	Chapter summary	32
3	LITERATURE REVIEW	34
3.1	Natural disasters	34
3.1.1	Natural disasters in Sri Lanka	34
3.2	Disaster management cycle	35
3.3	Disaster preparedness	35
3.4	Working definition for disaster preparedness	36
3.4.1	Category of disaster preparedness.....	37
3.4.2	Aim of disaster preparedness	38
3.4.3	Stakeholders related to disaster preparedness	39
3.4.4	Time frame with reference to a disaster	40
3.5	Major components of disaster preparedness	40
3.6	Digital approach for enhancing disaster preparedness	42
3.7	Digital technologies used within different components of disaster preparedness	43
3.7.1	Risk assessment.....	43
3.7.2	Coordination systems	44
3.7.3	Information systems	45
3.7.4	Resource mobilisation.....	46
3.7.5	Early warning systems	47

3.7.6	Evacuation systems	48
3.7.7	Education and training	49
3.7.8	Psychological preparedness	50
3.8	Challenges of existing practices and technologies	51
3.9	Contribution of information and coordination systems for overall disaster preparedness approach.....	53
3.10	Development of digital information and coordination system	54
3.11	User requirement analysis as the basis for information and coordination system development	55
3.11.1	Introduction to user stories.....	55
3.11.2	User story mapping	56
3.12	Disaster preparedness in Sri Lanka	57
3.13	Chapter summary	58
4	DATA ANALYSIS AND FINDINGS	59
4.1	Data analysis of preliminary interviews	59
4.2	Data analysis of documentary review	59
4.2.1	Details of the reviewed documents	60
4.2.2	Institutional framework for disaster preparedness	60
4.3	Data analysis of expert interviews.....	63
4.3.1	Disaster preparedness process in Sri Lanka	64
4.3.2	Nature of existing information and coordination system for disaster preparedness.....	67
4.3.3	Challenges of existing information and coordination system (authority level).....	70
4.3.4	Challenges of existing information and coordination systems (community).....	76
4.3.5	Overall opinion over the digitally enhanced information system for the disaster preparedness in Sri Lanka	77
4.3.6	User requirement analysis for a digitally enhanced information and coordination system for disaster preparedness in Sri Lanka through user stories	79
4.3.6.1	Development of the user story map.....	79
4.4	Data analysis of focus group discussion.....	92

4.5	User stories selected for the proposed information and coordination system for disaster preparedness in Sri Lanka.....	97
4.6	Chapter summary	97
5	RESEARCH FINDINGS AND DISCUSSION	99
5.1	Disaster preparedness approach	99
5.2	Role of information and coordination in disaster preparedness	100
5.3	Challenges for existing information and coordination systems	100
5.4	Appropriateness of digital information and coordination systems for disaster preparedness	104
5.5	Framework for a digitally enhanced information and coordination system for disaster preparedness	105
5.6	Chapter summary	109
6	CONCLUSION AND RECOMMENDATIONS	111
6.1	Accomplishment of objectives	111
6.2	Recommendations	114
6.3	Contribution to knowledge	115
6.4	Contribution to practice	115
6.5	Limitations of the study.....	116
6.6	Further research directions	116
	REFERENCES.....	117
	APPENDIX A - DEFINITIONS OF SYSTEMATIC REVIEW	140
	APPENDIX B - USER STORIES	145
	APPENDIX C - PRELIMINARY INTERVIEW GUIDELINE.....	156
	APPENDIX D - EXPERT INTERVIEW GUIDELINE.....	158
	APPENDIX E - PRELIMINARY INTERVIEW TRANSCRIPT	161
	APPENDIX F - EXPERT INTERVIEW TRANSCRIPT.....	163

LIST OF FIGURES

Figure 2.1- Graphical representation of research process	8
Figure 2.2- Study selection flow diagram	14
Figure 2.3- Document type contributing to the final analysis.....	15
Figure 2.4- Research onion model. Adapted from (Saunders et al., 2019).....	16
Figure 2.5- Data collection methods used in the study	23
Figure 2.6-Mural canvas	26
Figure 2.7- Coding system in a cognitive map	29
Figure 2.8- Backbone development	30
Figure 2.9- User story map.....	31
Figure 2.10- User Story prioritisation	32
Figure 3.1- Disaster management cycle. Adapted from (Alexander, 2014)	35
Figure 3.2- Definitional attributes of disaster preparedness	36
Figure 3.3- Digital technologies for each disaster preparedness component.....	51
Figure 3.4-System development process.....	54
Figure 4.1- Institutional framework for disaster preparedness	63
Figure 4.2- Perception on the importance of disaster preparedness.....	65
Figure 4.3- Disaster preparedness approach in Sri Lanka.....	67
Figure 4.4- Communication mechanisms available for information sharing and coordination.....	69
Figure 4.5- Challenges of existing information and coordination system	75
Figure 4.6- Community challenges of existing systems	77
Figure 4.7- Strengths and drawbacks of digital information coordination systems for disaster preparedness.....	79
Figure 4.8- Backbone for User 1.....	80
Figure 4.9- User story map (User 1)	81
Figure 4.10- Backbone for User 2.....	83
Figure 4.11- User story map (User 2)	84
Figure 4.12-Backbone for User 3.....	85
Figure 4.13-User story map (User 3)	86
Figure 4.14- Backbone for User 4.....	87
Figure 4.15- User story map (User 4)	88
Figure 4.16- Backbone for User 5.....	89
Figure 4.17- User story map (User 5)	90
Figure 4.18- Overall user story map to be prioritised	91
Figure 4.19- Prioritised user story map.....	93
Figure 5.1- Framework for digitally enhanced information and coordination system for disaster preparedness in Sri Lanka	107

LIST OF TABLES

Table 2.1-Comparison between traditional review and systematic review.....	9
Table 2.2- Logic grid for PICO analysis.....	11
Table 2.3- Eligibility criteria.....	12
Table 2.4- Unfeasibility of the other research strategies.....	20
Table 3.1- Contribution for the category of concept.....	37
Table 3.2- Contribution to the aim.....	38
Table 3.3- Contribution of the stakeholders.....	39
Table 3.4-Components of disaster preparedness.....	41
Table 4.1- Details of the reviewed documents.....	60
Table 4.2- Respondent profile.....	64
Table 4.3- Participant profile	92
Table 4.4- User story 01.....	97

LIST OF ABBREVIATIONS

AI	Artificial intelligence
DMC	Disaster Management Center
DoM	Department of Meteorology
ESCAP	Economic and Social Commission for Asia and the Pacific
EWS	Early Warning Systems
GIS	Geographic Information System
IFRC	International Federation of Red Cross
ISDR	International Strategy for Disaster Reduction
IVEs	Immersive Virtual Environments
NAP	National Adaptation Plan
NBRO	National Building Research Organisation
NCDM	National Council of Disaster Management
NGOs	Non-governmental organisations
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
TIMS	Traffic Incident Management Systems
UN	United Nations
UNDDR	United Nations Office for Disaster Risk Reduction
UNISDR	United Nations International Strategy for Disaster Reduction
VR	Virtual Reality
WHO	World Health Organisation

LIST OF APPENDICES

APPENDIX A - DEFINITIONS OF SYSTEMATIC REVIEW	140
APPENDIX B - USER STORIES	145
APPENDIX C - PRELIMINARY INTERVIEW GUIDELINE	156
APPENDIX D - EXPERT INTERVIEW GUIDELINE	158
APPENDIX E - PRELIMINARY INTERVIEW TRANSCRIPT	161
APPENDIX F - EXPERT INTERVIEW TRANSCRIPT	163

1 INTRODUCTION

1.1 Background

In recent decades, natural disasters have been on the rise (Pamidimukkala, Kermansachi & Karthick, 2020) and their impacts have been significant, mainly due to the effects of unpredicted climate change, which is fueled by the growing socio-economic activities in the modern world (Rosselló, Susanne & Gangallo, 2020). In 2019, for example, disasters such as hurricanes, floods and earthquakes have severely impacted over 25 million people around the world causing over US\$ 17Bn damages to the world's economy (Global Humanitarian Assistance[GHA], 2019). According to Formetta and Feyen (2019), scientists believed that the trend of disaster occurrences may set to continue and the weather-related hazards will become more volatile day by day. Given the increasing intensity and the frequency of natural disasters anticipated due to climate change, Kim and Zakour (2018) suggested that it is important to pay a close attention to disaster management more than ever. The International Federation of Red Cross and Red Crescent Societies (IFRC, 2017) asserted disaster management as the administration of resources and responsibilities in order to deal with every type of humanitarian factors of crises focusing on disaster preparedness, response and recovery. Among the disaster management phases, disaster preparedness absorbs an important role in resisting a greater degree of human suffering (Beura, 2016). As per the findings of Zurich Insurance Company Ltd (2018), although currently, many researchers focus on the response phase, much of the hard work on disaster management is carried out before disasters occur, in the form of disaster preparedness.

Disaster preparedness can be more appropriately viewed as a specific goal in disaster management rather than a programme or a stage that immediately leads to disaster response (American Association of Physics Teachers, 2000; Cutter & Derakhshan, 2019). Sena and Woldemichael (2010) stated that disaster preparedness aims to reduce the adverse impacts of a possible hazard. Continuous preparedness has the potential to save lives, lessen personal sufferings and reduce property damage and economic losses (Sinha et al., 2008), while assisting the affected community for the timely and effective rescue, relief and rehabilitation (Disaster Preparedness and Mitigation Summit, 2002; Queensland Government, 2021). In order to achieve the aforementioned aim, disaster preparedness needs to be formed as a continuous and integrated process resulting from a wide range of activities, assessments and well-coordinated plans. Moreover, it should consist of the measures that can predict and prevent a particular disaster (Keeney, 2004; United Nations Office for Disaster Risk Reduction [UNDRR], 2015).

With the understanding of the importance of disaster preparedness, national governments and the international community, including international financial institutions and development partners all around the world are working collaboratively

in order to improve disaster preparedness at state, provincial, district and regional levels (World Health Organisation [WHO], 2019). Countries pay more attention to develop certain disaster preparedness approaches, focusing on the basic components of preparedness such as early warning and evacuation, risk assessment, coordination, information management and so on (Srivastava et al., 2017). Certain disaster preparedness approaches have been designed targeting social groups like households, business communities and village groups with a diversity of practices according to each group's socio-cultural factors (Tierney et al., 2001). However, according to the analysis of WHO (2019) preparedness levels still remain irregular across and within the countries leaving the communities at substantial short and long term risks.

Ayeb-Karlsson et al. (2019) revealed that several limitations in disaster preparedness practices caused the failure of the overall disaster preparedness systems in countries leaving the community at a higher level of vulnerability. As per the WHO (2019) the major challenge for current approaches is that inconsistency in financing. The inability of states to develop accurate information and coordination systems competent with the scope of community expectations emerges the mistrust of government information among the communities, which has negatively affected the preparedness programmes. Moreover, irresponsible interventions of communities, lack of disaster preparedness education (Al-Dahash et al., 2016), absence of central authority to create strategic plans (Burling & Hyle, 2016), insufficiency of supporting ordinances and security situations (Goodyear, 2009) are the main challenges that contributed to failing the disaster preparedness approaches. Apart from the aforementioned challenges, James (2008) stressed that, over time, existing preparedness principles will be outdated and skills will degrade creating the conditions for the forthcoming disasters to have a huge impact than expected. Therefore, these disaster preparedness efforts need to provide alternatives for the field in order to overcome the existing challenges and timely update the preparedness approaches for effective outcomes (Johnson et al., 2016). To this point, disaster preparedness approaches need to be diversified by paying attention to digital innovations, which have not been widely explored yet (Man Ha, 2018).

Digital technologies are attempting to redefine and restructure existing disaster preparedness approaches (AlHinai, 2020) with the entities called "Born-digital" exploiting internet-era information (Kapucu, 2008). Disaster preparedness as a complex multi-organisational system requires a proper awareness of the determinations and possible interpretations of digital techniques (Oliva & George, 2019; Benssam, Nouali-Taboudjemat, & Nouali, 2016; Fajardo & Oppus, 2010). Carter (2018) emphasised that digital approaches will help the preparedness practitioners to identify, organise and set the foundations for a new digital era in disaster preparedness to manage the developments, seize the opportunities and deal with the challenges.

When considering the adaptability of digital approaches, developed countries have understood the value of digital enhancement and along with their technical, financial and planning capacities they tend to adopt these digital approaches into their national preparedness systems (Goniewicz & Burkle, 2019). Moreover, wealthy countries encourage scientific practitioners to explore innovative digital approaches for disaster preparedness compatible with their own political, economical and socio-cultural structure (Izumi et al., 2019). Nonetheless, developing countries are still reluctant to embrace these digital approaches mainly due to lack of political interest and awareness, conflicting views on priorities, inadequate institutional mechanisms, technical capacity and funding (Goniewicz & Burkle, 2019; WHO, 2019b; Izumi et al., 2019). This tendency in developing countries must be changed since they are extremely vulnerable to natural disasters, which can destroy the development plans.

1.2 Problem statement

Sri Lanka, which has been deeply affected by a series of disasters in the past decades and has considerable potential for future disasters is attempting to reduce the vulnerability with wide-ranging preparedness approaches (Randil et al., 2019). However, as a developing country, it still maintains a lower level of disaster preparedness having a range of sociological, economic, physical, political and cultural gaps in the current disaster preparedness approaches (Siriwardana et al., 2018a). UNDRR (2019) criticised the current system and highlighted the shortcomings of the insufficient digital integration to the preparedness approach compatible with the available resource and human capacities, technical know-how as well as the socio-economic and political features of the country. To this, Dharmasena et al. (2020) added that the poor information and coordination systems between the organisations involved in preparedness and the community is among the principal sources of failures of the overall disaster preparedness system in the country. Hence, there is a necessity for a digital information and coordination system for disaster preparedness approach that can be collaboratively used by the disaster-related agencies as well as the community, which is designed specifically to the Sri Lankan context (Randil et al., 2019; WHO, 2019).

At the same time, Parker (2019) disclosed that methodologically sophisticated studies of digital integration for disaster preparedness approach remain underexplored. The empirical studies covering the digital information and coordination systems for disaster preparedness in a country like Sri Lanka are particularly lacking as the adaptation is at the infancy level (Siriwardana et al., 2018b). Factors such as the paucity of studies focusing on multiple hazards, variations of the social-economical, cultural settings in the existing studies with the Sri Lankan context complicate the efforts to arrive at accurate conclusions over a holistic preparedness approach with digital enhancement (Randil et al., 2019). Hence, this study expects to propose the

nature of a digitally enhanced information and coordination system for disaster preparedness approach, which can be successfully applied to the Sri Lankan disaster management system.

1.3 Aim

The aim of this research is to enhance the disaster preparedness approach in Sri Lanka through a digital information and coordination system.

1.4 Objectives

1. To critically review
 - Definitions related to disaster preparedness
 - Key components of disaster preparedness
 - Current approaches and technologies used in disaster preparedness
2. To identify the challenges of existing disaster preparedness approaches
3. To review the role of information and coordination systems in disaster preparedness
4. To capture user requirements for digitally enhanced information and coordination system for disaster preparedness
5. To develop a framework for digitally enhanced information and coordination system for disaster preparedness

1.5 Scope and limitations

Disaster preparedness can be viewed as a combination of eight components namely risk assessment, coordination systems, information systems, resource mobilisation, early warning systems, evacuation systems, education and training and psychological preparedness. Among the aforementioned components, the scope of the study has been narrowed down to investigate the digital enhancement of information and coordination systems since those components are the pillars that build up the overall connection between all the other components and thereby activate the holistic preparedness system.

1.6 Methodology

The research was conducted in an interpretivist philosophical stance following the qualitative research choice.

As set out in the objectives, the study intended to explore the different views of stakeholders related to disaster preparedness, in order to identify the existing challenges and capture the different user requirements of each stakeholder to develop a robust information and coordination system for disaster preparedness in the country. Hence, the study required an in-depth inquiry into the challenges in current

preparedness systems. Moreover, subjective and attitudinal information from the stakeholders for the user requirements needed to be gathered and the researcher necessitated being a part of the environment by engaging with the respondents. Accordingly, the interpretivist research philosophy was established for the study following the abductive research approach. Moreover, the qualitative research choice was selected as the appropriate research choice for the study as it is suitable for research evaluating social, attitudinal and exploratory behaviours (Naoum, 2007).

At the initial phase, an extensive literature synthesis was conducted to ascertain the existing knowledge related to the disaster preparedness concept, components, current technologies used in disaster preparedness and the role of information and coordination systems in disaster preparedness (Objectives 1 and 3). Further, the challenges of existing disaster preparedness approaches in the global context were also ascertained through the literature review in order to partially achieve Objective 2.

The data collection was conducted in four stages. Initially, three preliminary interviews were carried out to identify the exact gap in the Sri Lankan context with reference to the disaster preparedness components that need to be digitised. Secondly, a documentary review was carried out in order to identify the institutional framework, which is necessary for coordination among the stakeholders with regard to the disaster preparedness approach in the country. Based on the findings of documentary review, the respondents were selected for the in-depth interviews representing national, district, divisional, Grama Niladhari and community levels. Accordingly, ten in-depth interviews (two per each administration level and two from the community) were conducted as the third stage whereby gathered the existing challenges (Objective 2) and the user requirements (Objective 4) with regard to the Sri Lankan context. The final stage of data collection was conducted through a focus group discussion with the participation of four members related to disaster preparedness and system development. The focus group discussion was aimed at prioritising gathered user requirements at the third stage.

Finally, a framework for digitally enhanced information and coordination system for disaster preparedness has been developed with the identified challenges and user requirements from the code-based content analysis and the estimation of user stories (Objective 5).

1.7 Chapter breakdown

The study is organised under five Chapters as follows;

Chapter 01- Introduction

Chapter 1 introduced the background of the study and defined the research problem with aim, objectives, methodology, scope and limitations as well as the structure of the study.

Chapter 02- Research Methodology

This Chapter contained the methodological design that has been used to carry out the study, inclusive of the research philosophy, research choice, research strategy, data collection and data analysis techniques.

Chapter 03- Literature Review

The initial literature review was conducted as a systematic review based upon the publications of the last 5 years utilising two popular databases. Building up a working definition for the “Disaster Preparedness” concept in order to proceed with the study was the main focus of the systematic review and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement that is specifically introduced for reliable systematic reviews was utilised. Moreover, literature related to digital adaptation of disaster preparedness was presented.

Chapter 04- Data Collection and Analysis

Chapter 04 included the data collection process conducted through interviews, documentary review and focus group discussion. The collected data was analysed through manual code-based content analysis and the analysis of user stories.

Chapter 05- Research Findings and Discussion

The key outcomes were outlined and the discussion was conducted on the research findings by revisiting the literature in this Chapter.

Chapter 06- Conclusions and Recommendations

The conclusions from the findings and the recommendations were presented in this Chapter. Proposed recommendations for further studies were also included.

1.8 Chapter summary

The background study, problem statement, aim and objectives, scope and limitations were described in this Chapter. Furthermore, the research methodology was discussed in brief, which has been followed to acquire the aim and objectives of the study. Finally, the breakdown of the Chapters of the research was also presented.

2 RESEARCH METHODOLOGY

2.1 Introduction

Research methodology is a way of systematically resolving the research problem. It is also known as the science of studying how the research is performed logically (Kothari, 2000). The research problem of this study can be identified as the unavailability of a holistic disaster preparedness system to effectively conduct disaster preparedness activities in Sri Lanka. The research methodology that has been adopted in order to address the aforementioned research problem is presented in this Chapter. Accordingly, this Chapter described the systematic approach that has been utilised to develop the literature review and the methodological design for the study including research philosophy, research approach, research strategy, research choice, time horizon and techniques providing relevant justifications.

2.2 Graphical representation of the research process

Figure 2.1 is presented the graphical representation of the research process throughout the study. At the initial phase, background study and literature review were conducted to achieve the first three objectives. The disaster preparedness definition was established through the PRISMA method by a systematic review (Refer Sub-section 2.4.1). The second objective was fully achieved at the data analysis stage by analysing the expert interview findings. The fourth objective, which is the identification of user requirements for a digitally enhanced information and coordination system for disaster preparedness has been accomplished through the user story analysis. The final objective, which is the development of a framework for digitally enhanced information and coordination system for disaster preparedness was achieved through the user story prioritisation.

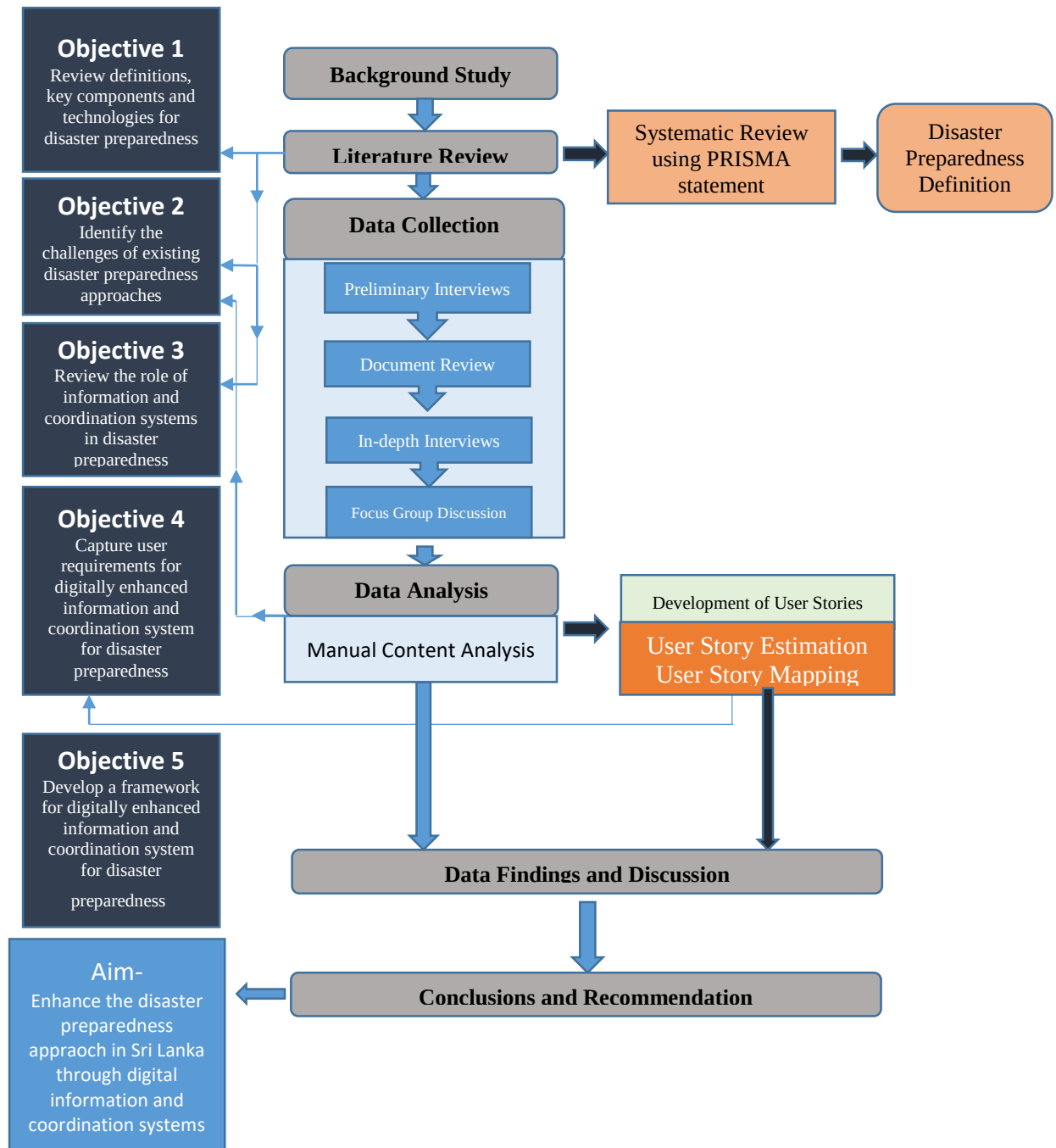


Figure 2.1- Graphical representation of research process

2.3 Background and problem identification

The background study described the nature of the research problem being examined, its scope and the extent to which prior studies have effectively investigated the problem, highlighting any existing gaps that the researchers need to address (Lango, 2020). Accordingly, background study was carried out in Chapter one, which leads the researcher towards identifying the current gap in the research area. Through the

background study, literature on the disaster preparedness concept and the digital involvement for disaster preparedness were reviewed, which directed the necessity of digital enhancement for the successful disaster preparedness implementation. Therefore, the research aim was set to enhance the disaster preparedness approach in Sri Lanka through digital information and coordination system.

2.4 Literature review

The literature review is an expedient approach to gain an in-depth understanding of a research domain (He et al., 2017). It helps the researcher to grasp the existing knowledge from other scholars regarding a particular subject area and most importantly that the researcher is not reinventing the same issues that have been previously explored. In a literature review, the major factors, issues, findings and research methods pertinent to the study are extracted and synthesised (Rudestam & Newton, 2007). Basically, there are two types of literature reviews that are introduced as traditional or narrative and systematic (Bruette & Fitzig, 2014). A traditional or narrative review presents a comprehensive literature background by refining research questions as well as developing conceptual and theoretical frameworks. A systematic review is a well-structured, more rigorous literature review that can be utilised to address the well-structured and specific research problems. The identification of the differences between these two major types is important while choosing the most relevant literature review type for a study. Thus, the comparison between these two major types has been presented in Table 2.1.

Table 2.1-Comparison between traditional review and systematic review

Factors	Traditional or Narrative Review	Systematic Review
Study protocol	Variety of styles	Structured approach
Research question	Broad to a specific question	Specific question with PICO components (Refer Sub-section 2.4.1.1)
Search strategy	No specific search strategy	Detailed and comprehensive search strategy
Selection criteria	Selection criteria are subjective	Specific inclusion and exclusion criteria

Source: (Demeyin, 2016)

As per Table 2.1, the traditional literature review is performed without a specific methodological approach, where the findings are subjective while the systematic

review is performed under an explicit methodological approach with evidence-based findings (Demeyin, 2016).

Accordingly, the literature review of this study has been adopted both the aforementioned types in align with the aim and objectives into two stages. The initial literature review has been conducted as a systematic review based upon the publications of the last five years utilising two popular databases. Building up a working definition for the “Disaster Preparedness” concept in order to proceed with the study was the main focus of the systematic review. At the second stage, an extensive traditional literature review was carried out to reveal the major components of disaster preparedness, the digital adaptation of disaster preparedness, challenges of existing preparedness systems in Sri Lanka and the role of information and coordination systems in the preparedness. The methodological approach that was utilised for the systematic review is presented in Sub-section 2.4.1.

2.4.1 Systematic review with the aim of establishing a working definition for disaster preparedness

Among different types of reviews, the systematic reviewing approach has become popular due to its specific features, which cannot be seen in other traditional reviewing methods (Pahlevan-sharif, Mura, & Wijesinghe, 2019). Biolchini, Mian, Nataliand, and Travassos (2005) described the systematic review as a process that follows a well-organised pre-defined sequence of methodological stages so that others who refer to the review can replicate the same protocol and acquire a judgement on the reliability, validity and adequacy of the chosen standards. Accordingly, a systematic review has been adopted for this study as it provides unbiased results from the literature with a high level of quality and efficiency (Liberati et al., 2009), which is paramount in analysing several viewpoints of different researchers from different times and backgrounds regarding the term Disaster Preparedness. The systematic review was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Liberati et al., 2009).

2.4.1.1 Specified Aim, Objective and Research Question for Systematic Review

Initially, there should be a sound research question supported by a precise aim and objectives in order to develop the search strategy, the eligibility criteria and the study selection (which are very important components of the PRISMA checklist) (Eriksen & Frandsen, 2018; Liberati et al., 2009). Accordingly, the aim of carrying out a systematic review was defined as “to establish a working definition for disaster preparedness within the context of natural disasters”. The objectives for achieving this aim were set out as: (1) conducting a systematic literature review to disclose the different definitions for natural disaster preparedness from past research and (2) building up a working definition by analysing these different definitions.

In order to derive the search terms for the systematic review, the research question was formulated using a PICO template. PICO is typically used in formulating clinical questions in medical disciplines, but recently this approach has been applied in social science studies (Eriksen & Frandsen, 2018). Miller (2001) stated that there are two types of templates when applying the PICO method: “PICO” (P- Population, I- Intervention, C- Comparison, O- Outcome) and “PICO” (P- Population, I- Interest and Co- Context)”, which have slight differences considering the features of the study. Since the research question in this study is generic and there is no “Comparison” component, the research question was constructed utilising the “PICO” template. Accordingly, “How has the term ‘Disaster Preparedness’ been established as a definition by previous scholars within the context of natural disasters?” was formulated as the research question through PICO. Thereafter, a comprehensive logic grid (Table 2.2) was prepared by inserting the alternative terms that can be used for each component of PICO.

Table 2.2- Logic grid for PICO analysis

PICO Component	Key term in Question	Alternative 1	Alternative 2	Alternative 3
P-Population	Definition	Explanation	-	-
I- Interest	Disaster Preparedness	Emergency Preparedness	Hazard Preparedness	Disaster Readiness
Co- Context	Natural Disasters	-	-	-

Table 2.2 identified the key terms of the research question and indicated the synonyms, which have been used in past literature as the alternatives for each key term. Aromataris and Riitano (2014) described that such a logic grid helps to build up the final search string for a study by combining each key term and synonyms.

2.4.1.2 Source selection

Since the use of high-ranking and indexed scholarly articles is recommended by Simons, Brocke, Niehaves, Niehaves and Reimer (2009), the search was conducted within two highly recognised citation databases: Scopus and Web of Science. Both the databases provide a literature search within a broad range of international scientific journals, as well as within high-ranking conference proceedings (Geekiyanage et al., 2020).

2.4.1.3 Search strategy

An interactive search strategy was developed with the aid of the logic grid (Table 2.2) by combining and refining the search terms. The development of the strategy was conducted using the Scopus database due to its user-friendliness. The adopted technique used boolean operators, truncations and filters. Jankowski (2008) defined truncation as the purposeful shortening of a search term, generally at its core, using wildcard characters (*, #, ?, !) in order to sort out the variants occurring due to language or tense dissimilarities. The search string was developed using the terms of the logic grid (Table 2.2) by merging the key terms and their alternatives using “OR” along the row and merging the terms in different rows using “AND”. Moreover, truncation was used for the word “Natural” as “Natur*”. The initial search was based upon title, abstract and keywords. However, many of the articles did not mention the terms “Definition” and “Explanation” within the title, abstract and keywords even though they are included within the text. Therefore, in order to avoid losing the relevant important articles while conducting the initial search, the terms “Definition” and “Explanation” were eliminated from the string. Accordingly, **“Disaster Preparedness” OR “Emergency Preparedness” OR “Hazard Preparedness” OR “Disaster Readiness” AND “Natur*”** was the search string used. A similar protocol was followed for Web of Science.

2.4.1.4 Eligibility criteria

It is necessary to have eligibility criteria for the selection, which need to be appraised for the validity, applicability and comprehensiveness of a review (Liberati et al., 2009). These eligibility criteria identify the inclusion and exclusion conditions for the study. Table 2.3 presents the eligibility criteria for this study.

Table 2.3- Eligibility criteria

Inclusion Criteria	Exclusion Criteria	Rationale
Sources published in English language	Sources published other than in English	English is the international and the universal language.
Publication year from 2015 - 2020	Publication year prior to 2015	Avoiding out of date results, plus the adequacy of 5 years' articles for the review
Published and unpublished sources	-	Unpublished articles also have the latest results
Research areas: Social Sciences, Environmental Science, Earth and	Research areas: Computer Science, Medicine, Business	Research areas related to natural disasters

Planetary, Engineering, Energy	Management and Accounting, Economics and Finance	
Document type: Articles, Conference Papers, Book Chapters, Reviews, Books	-	-

The papers were not screened for considering the methodological quality as the aim of the systematic review was to gather information on a definition. As per Table 2.3, the filtering criteria was developed through Scopus initially and the final search string was:

TITLE-ABS-KEY ("Disaster Preparedness" OR "Hazard Preparedness" OR "Disaster Readiness" OR "Emergency Preparedness" AND "Natur*") AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "bk")) AND (LIMIT-TO (SUBJAREA , "SOC") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "ENER")) AND (LIMIT-TO (LANGUAGE , "English"))

2.4.1.5 Study selection and data extraction

The title, abstract, keywords, authors' names and affiliations, journal name and year of publication, access type and source name of the identified records were exported to a MS Excel spreadsheet. All the identified articles were subjected to title and abstract screening initially and categorised as: relevant, irrelevant and unsure by a single reviewer. In this stage (1) articles not relating to natural disasters, (2) articles not contributing to the definition of disaster preparedness and (3) articles that were completely irrelevant to the research area were excluded. The appropriateness of whether to include the unsure articles in the second screening process was discussed among two reviewers and, thus, the final set of articles was concluded for the second screening. In the second screening process, the full texts of all the relevant articles were reviewed and the necessary data was extracted. According to Masnoon, Shakib, Kalisch-ellett and Caughey (2017), a pre-defined extraction sheet should be prepared in order to ensure consistent data extraction in this exercise. As per this study, the extracted items used were the definitions of disaster preparedness and its associated terms (such as disaster mitigation, disaster recovery and disaster response) in order to elaborate how the distinction of the definition of disaster preparedness was made and defined. The selection of the articles is depicted in the following flow diagram (Figure 2.2).

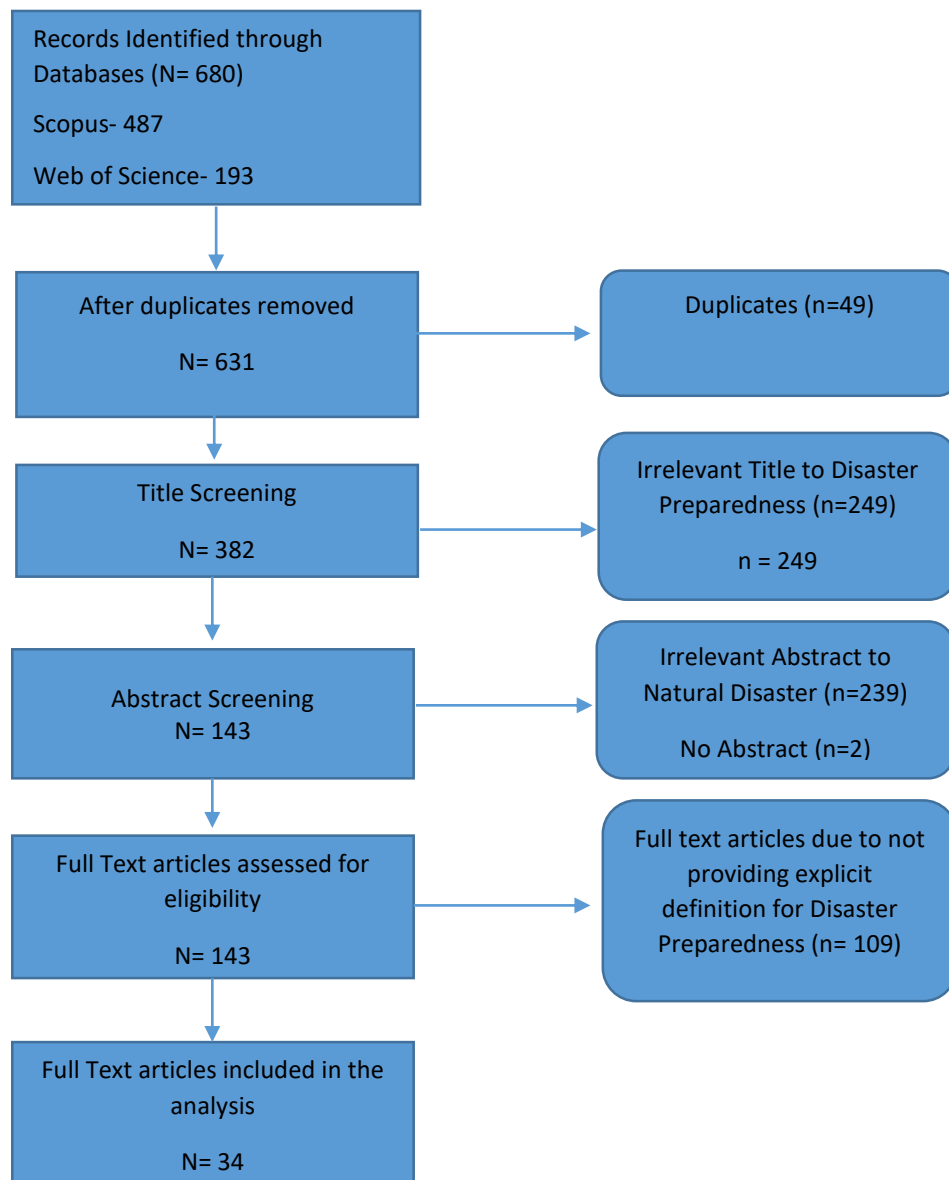


Figure 2.2- Study selection flow diagram

As per Figure 2.2, the complete search found 680 records from Scopus and Web of Science. Among them, 49 duplicates were excluded. At the title screening, 249 records were excluded due to the irrelevancy of their title to the study. 239 abstracts were disregarded (as they were out of the natural disaster context) and 2 records had to be ignored as they had no abstract in the abstract screening phase. 143 articles were selected for the full-text screening. Finally, 34 articles were obtained for the in-depth analysis (after removing 109 records that did not provide an explicit definition for disaster preparedness).

A summary of the final selected articles for the in-depth analysis is presented by a graph showing their classification per document type (Figure 2.3).

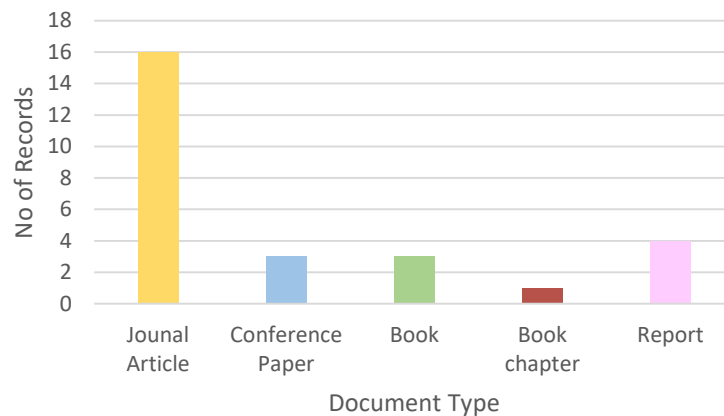


Figure 2.3- Document type contributing to the final analysis

Figure 2.3 demonstrates that the majority of the articles are from journals, which indicates the robustness of findings.

2.5 Research methodological design

The establishment of the appropriate methodological design is the most important step of research since it describes the detailed procedure of conducting the research (Billing, 2004). Researchers, therefore, developed different types of methodological models that can be adapted to determine the research procedure for a particular study following a systematic inquiry. The nested model by Kagioglou et al. (2000) and the research onion model by Saunders et al. (2019) are the two most popular research models. Among them, the research onion model is widely used by social science researchers for the construction of the theoretical framework of the research due to multiple benefits.

According to Muranganwa and Thinyane (2015), research onion principles provide a solid base for creating a cohesive and logical research design. Further, Raithatha (2017) noticed that the research onion model guides the researcher to design the appropriate research methodology step-by-step and therefore it can be considered as the main academic research model. Research onion model can be considered as an extension of the nested model, where several new layers were added (Sridarran, 2018). The research onion model is illustrated in Figure 2.4.

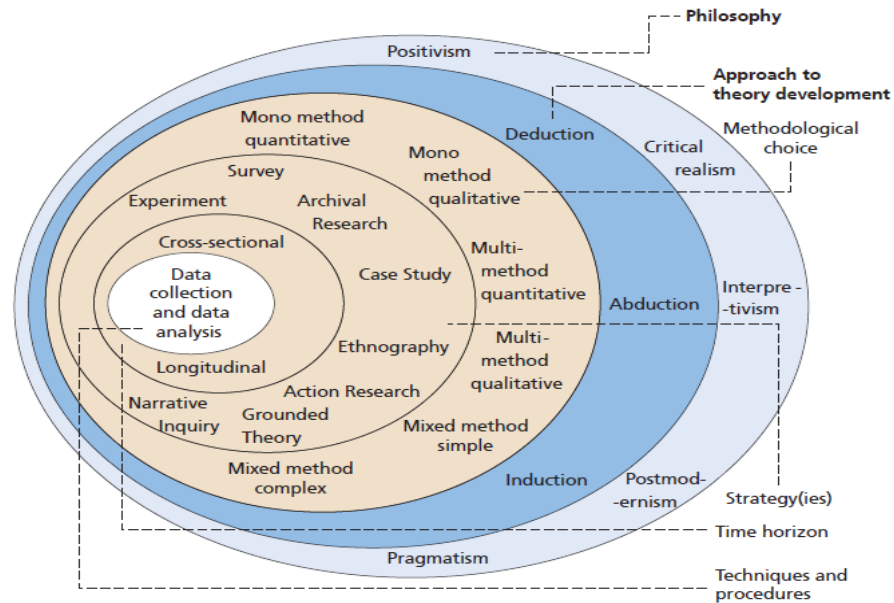


Figure 2.4- Research onion model. Adapted from (Saunders et al., 2019)

As per Figure 2.4, there are six layers of research onion as philosophy, approach to theory development, methodological choice, strategies, data collection and data analysis. The researcher needs to unravel each layer starting with the outermost layer in order to understand the next layer. Accordingly, the design of the research methodology to this study is presented in the next section based upon the layers of the research onion.

2.5.1 Research philosophy

A classical research methodology is based on a certain philosophical stance, which subsequently entails research strategies and techniques (Melnikovas, 2018). According to Saunders et al. (2019), research philosophy refers to a set of beliefs and assumptions regarding the knowledge being investigated. There are three major assumptions as ontology, epistemology and axiology, which help the researcher to understand the philosophical stance of the research (Žukauskas et al., 2018).

Ontology refers to the nature of reality and its characteristics (Saunders et al., 2019). There are two ends of ontology as realism and idealism. According to Amaratunga et al. (2015b) in realism, the researcher is regarded as being born into a living, social environment with its own reality that exists out there. Idealism assumes that reality begins with ideas or thoughts, based upon different perspectives of people. Hence, in idealism, the reality can vary from place to place and across time. In this study, the identification of existing challenges of disaster preparedness systems and user requirements of digitally enhanced disaster preparedness systems solely depends upon the users of the proposed system. The challenges of existing systems may vary on the

basis of each administration level of the users. Since the reality of the study is based upon human interaction, this study is more towards to idealistic nature.

Epistemology deals with the assumptions on acceptable and valid knowledge and the way of communicating the knowledge to others (Burrell & Morgan, 2019). Epistemology also has two extremes. One extreme suggests that the knowledge is observable and evidence-based with objectivity. Further, Saunders et al. (2019) explained that this extreme encourages quantifiable observations with statistical analysis. Conversely, the other extreme relies upon the knowledge based on people and their opinions, where subjectivity is encouraged. Therefore, in this study since the users' opinions are considered to build up the knowledge, subjectivity is highlighted in the epistemological viewpoint.

“**Axiology** refers to the set of values and ethics throughout the research process, which incorporates questions about how we as researchers, deal with our own values and also with those of our research participants (Saunders et al, 2019, p.151)”. Value-laden and value-free are the two main extremes of axiological assumption. According to Easterby-Smith et al. (2018), in a value-free study, the choice of what and how to study is decided by objective criteria, while in value-laden research the choice is based upon human values and experiences. This study necessitated the researcher to be a part of the environment and interconnected with the community to gather the values demonstrating the characteristics of a value-laden research.

Based on the aforementioned assumptions, three major philosophical stances are introduced as positivism, interpretivism and pragmatism.

Positivism

Positivism is a philosophical stance taken by the researchers, who work with observable reality in society to arrive at conclusions. Positivism has the ontological assumption that reality is having a pre-determined nature and structure, which is called realism. Furthermore, the positivist is connected with the epistemological belief that the features of reality must be measured objectively rather than subjectively through sensation and reflection (Easterby-Smith et al., 2018). Positivism believes that observer must be independent and human values must be irrelevant, which leads to the value-free approach in the axiological perspective. On the main, positivism focuses on the significance of what is presented in general, with a greater focus on pure data and facts that are not impacted by human interpretation bias (Saunders et al., 2019; Scotland, 2012).

Interpretivism

Interpretivism involves the researchers to integrate human interests into a study. Accordingly, interpretivist rely upon idealism in light of ontological assumption

indicating that reality is based upon social constructions such as language, shared attitudes and beliefs (Dudovskiy, 2018). Furthermore, interpretivism tends toward subjectivist epistemology, in which knowledge is dependent on subjective measurements and humans cannot be separated from their knowledge (Grix, 2019). Dudovskiy (2018), therefore emphasised that there is a close relationship between the researcher and the study in interpretivism. Due to this close interaction of the knowledge and the people, interpretivist believes that values are an integral part of the study and that no value is incorrect (Aliyu et al., 2017). Hence, interpretivism follows value-laden approach in the axiological viewpoint. On the main, interpretivism focuses on the multiple observations of reality that is subjective and socially constructed through shared values.

Pragmatism

Pragmatism is a research paradigm that resembles the characteristics in between two extremes; positivism and interpretivism (Goldkuhl, 2012). It has been argued that there are strengths and weaknesses in both the two extremes and thus pragmatism is offered as the middle ground of two ends. In the ontological viewpoint, pragmatists believe that whilst there is an objective reality existing to the individual, it is based upon the environment and the experience of each individual. When considering the epistemological assumption, pragmatists view the process of acquiring knowledge as a continuum, rather than as two opposing poles of objectivity and subjectivity. Further, pragmatism takes a middle position of axiological viewpoint as well by emphasising that values are relevant and important only insofar as they influence what to study and how to do so (Goles & Hirschheim, 2000).

Accordingly, it can be summarised that since the study acknowledged that the reality is based upon social constructions, where the knowledge depends on the subjective measurements by considering human values and experiences as a part of the study, interpretivism is the most appropriate research philosophy for the study.

2.5.2 Approach to theory development

The research approach refers to the form of theory development, generally described by three approaches based upon the selected form of reasoning, namely deductive, inductive and abductive (Lipscomb, 2012; Saunders et al., 2019). In deductive reasoning, the hypothesis is derived from existing theory and the empirical investigation is conducted in order to test the validity of the particular hypothesis. On the other hand, the inductive approach begins with a few preconceptions as possible and then allows the theory to emerge from the empirical investigation (O'Reilly, 2009). Abductive reasoning is a combination of both deduction and induction in which a researcher performs an empirical investigation to generate a new theory or modify an existing theory, which is subsequently tested for validity through additional data

collection (Saunders et al., 2019). This study initially considered some pre-developed theories of disaster preparedness and afterward established the features of a digitally enhanced information and coordination system that can be used for disaster preparedness in Sri Lanka based on those theories and additional data collection of user requirements.

Therefore, the abductive research approach has been adopted since the study has combined the features of both inductive and deductive approaches.

2.5.3 Methodological choice

The methodological choice, which is the third external layer of research onion involves basically selecting among qualitative, quantitative and mix methods. The quantitative approach is defined as the process of finding data using collected records and the evidence (Naoum, 2007). Furthermore, Creswell (2003) mentioned that the quantitative approach mainly focuses on statistical procedures. The quantitative study would be more appropriate for the researches, which initiate the research question with 'what', 'who', 'where', 'how much' and 'how many' (Smith, Thorpe, & Lowe, 2007). The qualitative research approach is most appropriate for cases evaluating social, attitudinal and exploratory behaviours and beliefs (Naoum, 2007). Moreover, the qualitative approach is noteworthy in terms of considering a specific group of people, representing their opinions and aspects (Yin, 2011). Ritchie and Lewis (2003) expressed in their study that when the research question starts with 'how' and 'why', the qualitative approach is more suitable.

The mixed approach is not a substitute for the qualitative or quantitative approaches, but a combination of both approaches, which avoids the negative points of the two approaches (Johnson & Onwuegbuzie, 2004). Therefore, mixed research choice offers the researchers a better understanding rather than the reliance on a single method alone (Nguyen et al., 2018).

In terms of this study, since it was intended to investigate the challenges of existing preparedness systems and the user requirements for a digitally enhanced system that required subjective and attitudinal information, a qualitative research choice was adopted.

2.5.4 Research strategy

The research strategy, which represents the fourth layer of research onion describes the formal procedure of conducting the study in order to achieve the aim and objectives of the research (Yin, 2014). According to Saunders et al. (2019), there are major research strategies as experiment, survey, case study, ethnography, action research, grounded theory and archival research.

Among these strategies, the survey research strategy was adopted for the study. Survey can be defined as the collection of information from a sample of individuals through their responses to questions (Check & Schutt, 2012). The significance is that survey strategy allows the researchers to utilise a variety of data collection methods including quantitative techniques such as questionnaires as well as qualitative techniques such as in-depth interviews and focus group discussions or both the techniques (Singleton & Straits, 2009). Further, survey strategy is ideal for exploring human behaviours and preferences in a more rigorous manner using multiple valid and reliable instruments (Ponto, 2015). Since this study adopted qualitative data collection methods such as in-depth interviews, focus group discussions and also considered human preferences while gathering user requirements for a digital information system, qualitative survey strategy is much appropriate.

Besides, Table 2.4 demonstrates the rationales for the unfeasibility of the other research strategies to this particular study, which further justifies the suitability of survey strategy to the study.

Table 2.4- Unfeasibility of the other research strategies

Research Strategy	Description	Source	Rationale for the unfeasibility to the present study
Experiments	Deals with validating or falsifying a research hypothesis following a scientific method conducted within a controlled environment. Experiment strategy is more towards testing existing theories that are more suitable for the studies with deductive in nature	(Crossley & Jansen, 2021)	Present study focused on in-depth inquiry of people in an uncontrolled environment, experiment strategy cannot be adapted to the study.
Action Research	Action research is a process that the researcher and the participants collaboratively work to address the research problem related to the interactions within the real world. Action research undertakes practical approaches, which are prominently conducted through fieldwork and involves a controlled group for data collection.	(Ragsdell, 2009; Saunders et al., 2019)	Present study does not require practical approaches and field works and thus, action research is not applicable.

Ethnography	Ethnography involves the investigation of experience and social-cultural aspects of people in which the researcher becomes a member of the research environment for a prolonged period.	(Yin, 2014)	Since ethnography requires a prolonged period to collect data it is unfeasible with the time limitations of this study.
Grounded Theory	The theory is developed based on the collected data on social context and people's behavior. Generally, grounded theory is used, when there is no existing theory that offers an explanation for a phenomenon under consideration.	(Sridarran, 2018; Toloie-shlaghy et al., 2011)	Present study is based upon some pre-developed theories of disaster preparedness in anticipation of a certain level of data that eliminates the grounded theory for the strategy.
Case study	"Case study refers to the in-depth analysis of a bounded system that characterises a particular type of phenomenon"	(Burt et al., 2017, p.130)	Since this study is not bound into a particular context or a system it is not suitable to adopt case studies
Archival research	Archival studies are based upon materials that already exist (Secondary data) and study is conducted solely reviewing those existing data. This strategy is well suited for historical researches	(Crossley & Jansen, 2021)	Since the study requires primary data from an empirical investigation this strategy cannot be adopted

By eliminating research strategies as per the justifications of Table 2.4, the qualitative survey research strategy was adopted as the most suitable strategy.

2.5.5 Time horizon

This layer of the research onion explains the time frame of the research. Accordingly, any research can be categorised into two types based on time as longitudinal and cross-sectional (Saunders et al., 2019). The longitudinal study refers to the study of a phenomenon over a period of time in order to compare the data (Caruana et al., 2015). A cross-sectional study can be considered as a 'Snap-shot' study, where the phenomenon is investigated at a specific point of time (Setia, 2016). According to Saunders et al. (2019), generally surveys and case studies (short-term) adopt a cross-sectional time frame, while ethnography, action research, archival research and case study (long-term) adopt longitudinal time horizon. Since this study considered the present challenges of disaster preparedness and user requirements of a proper information and coordination system that does not require chronological attributes of data, cross-sectional time horizon was applied.

2.5.6 Data collection

The data collection can be conducted through several techniques such as literature reviews, observations, document reviews, questionnaires, interviews and focus group discussions. Among them, the most commonly utilised techniques for a qualitative study are literature reviews, observations, interviews, document reviews and focus group discussions (Gill et al., 2008). This study adopted several data collection techniques in different stages in order to achieve the objectives. Accordingly, Figure 2.5 presents the data collection techniques chosen for the study.

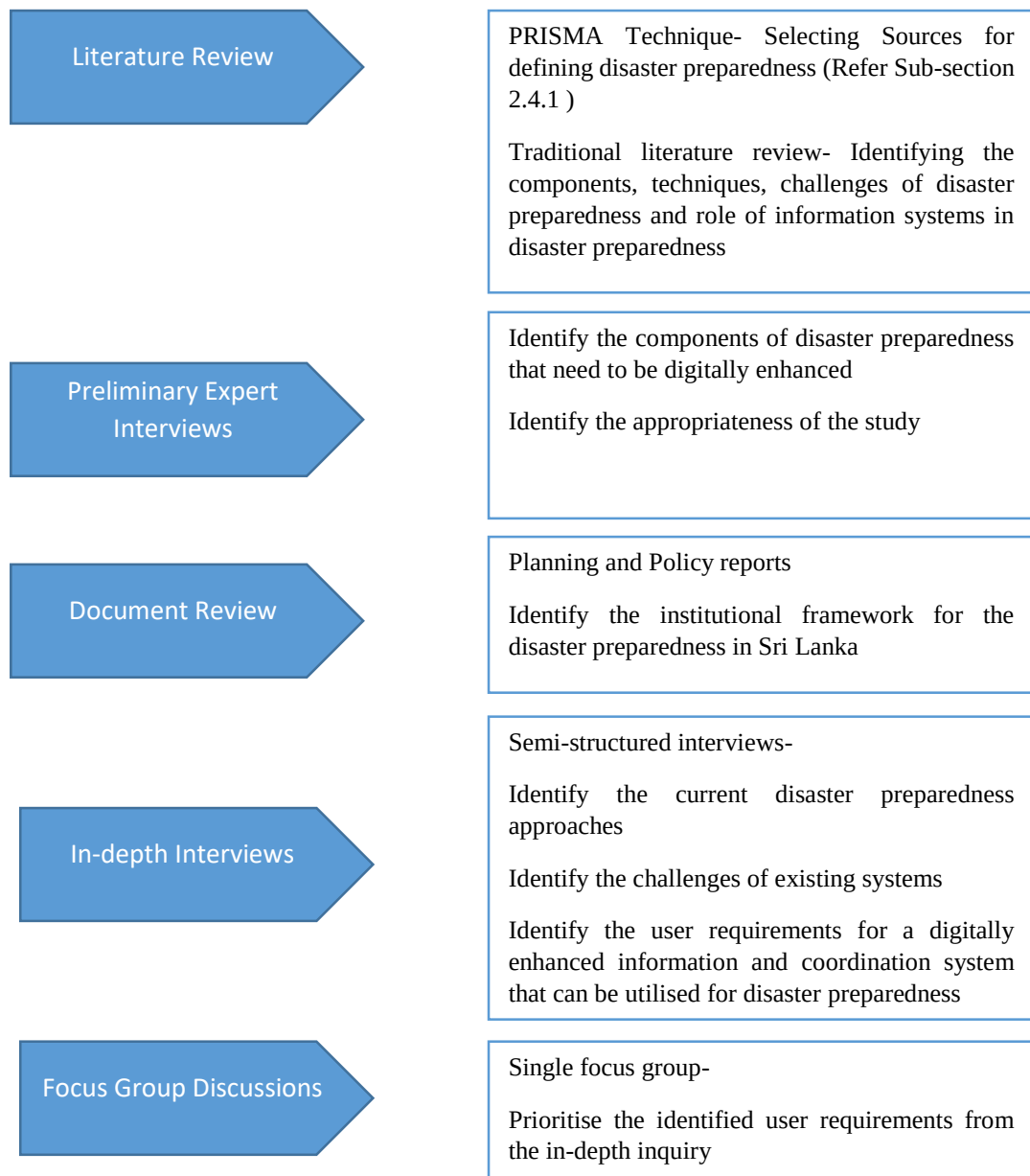


Figure 2.5- Data collection methods used in the study

As described in the Sub-section 2.4.1 an initial systematic review was conducted to define the disaster preparedness utilising the PRISMA statement as the data collection technique. Other data collection techniques that were adopted are described below.

Preliminary Interviews

In advance of the in-depth investigation, it became necessary to explore the actual nature of the disaster preparedness approach conducted in Sri Lanka to identify the best area that needs to be digitally enhanced in order to effectively perform the whole disaster preparedness process within the country. Further, it was required to discover the appropriateness of the study to the Sri Lankan context. To this, three preliminary

expert interviews were conducted considering the time limitations with the professionals involved in the disaster preparedness approach in Sri Lanka. As recommended by Arain et al. (2010) preliminary interviews are useful to decide whether to proceed as planned, modify or change the approach in the study. Semi-structured interview guideline was adopted that allows obtaining the relevant details from the experts to a maximum level for known and speculated perspectives while maintaining a degree of control over the direction of the interview.

Documentary Review

Documentary review is a systematic procedure for reviewing or evaluating documents (Bowen, 2009). Like other data collection methods in qualitative research, documentary review requires that data be examined and interpreted in order to elicit meaning, gain understanding and develop empirical knowledge (Corbin & Strauss, 2008). A documentary review was conducted for this study with the intention of identifying the institutional framework of disaster management that helps to determine the coordination structure of the disaster preparedness process in Sri Lanka and thereby discover the different types of stakeholders, who are involved with disaster preparedness activities. Considering the aforementioned factors, several reports that are published by the Disaster Management Center in Sri Lanka and the Disaster Management Act, No: 13 of 2005 were reviewed as recommended by the experts of preliminary interviews. The documents were electronic versions that were available online.

In-depth Interviews

In-depth interviews have been identified as the commonly used method of data collection to carry out an in-depth inquiry regarding a phenomenon and they mainly fall within the qualitative research (Kumar, 2011). Interviews can be three types namely structured, semi-structured and unstructured. To this study, semi-structured interviews were adopted allowing the researcher to ask both structured and unstructured questions and thereby clarify the doubts (Berg, 2009). In a qualitative study, it is more crucial to evaluate the in-depth nature of the research, the appropriateness of the respondents, and the informativeness of the sample than the sample size (Neuman, 2005; Saunders et al., 2019). Accordingly, twelve semi-structured interviews were carried out among the experts, who are involved in the disaster preparedness process in Sri Lanka. The respondents represented different levels of the institutional framework of disaster preparedness (National, District, Divisional and Grama Niladhari) as defined in the document review. The interview guideline was structured to gather information about the challenges of the existing information and coordination system (Objective 2) and the user requirement for a digitally enhanced information and coordination system (Objective 4) with regard to the disaster preparedness approach in Sri Lanka.

Focus Group Discussion

Tonkiss (2004) defined focus group discussions as “a small group discussion focused on a particular topic that is facilitated by a researcher (p.94)”. Further, Tonkiss (2004) appreciated the ability of this method to explore the attitudes, meanings and definitions through the participants’ own terms as a group. Among the multiple instances that the focus groups can be adopted in a particular study, Gill et al. (2008) emphasised the suitability of the method to clarify, extend, qualify or challenge the data collected through other methods. Accordingly, in this study, focus group discussion was adopted to clarify and extend the user requirements collected through the in-depth interviews allowing the participants of the group to prioritise the identified user requirements. Since the user requirements have been already analysed adopting the ‘User Stories’ technique (Refer Sub-section 3.11.1), the participants were requested to prioritise the user stories as per the MoSCoW method (Must-haves, Should-haves, Could-haves and Won’t-haves) (Refer sub-section 2.5.7.2). In terms of the group size, since Peek and Fothergill (2009) and Doria et al. (2018) pinpointed through their experience that a number of participants between 3-12 is ideal for a focus group rather than larger groups, four participants were selected through purposive sampling. In order to address both the areas of disaster preparedness and digital system development, three participants with overall knowledge of the disaster preparedness approach in Sri Lanka and one participant, who is a system developer were chosen. According to Carla and Da Silva (2013), visualisation supported web-based focus groups were introduced for effective performance, which allow gathering stakeholders, who cannot easily meet in a physical focus group into a collaborative platform. This method was adopted due to the time and place constraints of participants and the travel restrictions imposed for the Covid-19 pandemic. Accordingly, mural canvas (<https://www.mural.co/>), which offers a digital workspace for visual collaboration has been utilised to conduct the session.

The screenshot displays a Miro workspace for a user story prioritization workshop. The main board is titled "USER STORY P..." and includes a "Facilitator" role. The board is organized into several sections:

- Introduction Sheet:** A document on the left side of the board, titled "Introduction Sheet", which provides context for the workshop. It includes a "Background" section and a "Objective" section.
- Background:** A section titled "Background" that outlines the purpose of the study and the user requirements of a digitally enhanced information and coordination system for disaster preparedness in Sri Lanka.
- Prioritizing User Stories:** Three templates for prioritizing user stories, each with columns for "MUST HAVE", "SHOULD HAVE", "COULD HAVE", and "WOULDN'T HAVE". These templates are used to categorize and prioritize user stories based on their importance and feasibility.
- Facilitator:** A role assigned to the facilitator, indicated by a "Facilitator" button.
- Share:** A button to share the board, labeled "Share".
- Zoom Settings:** A panel at the bottom right of the board, showing "Zoom Settings" and a "8%" zoom level.

The board also features a "SD" (Sustainable Development) icon and a "Zoom Settings" panel at the bottom right.

Figure 2.6 illustrates the mural canvas that was prepared for the focus group discussion.

2.5.7 Data analysis

Data analysis generally is highly dependent on the researcher's empirical thinking and interpretation style (Sridarran, 2018). Data analysis is a process of reducing a large amount of collected data to make sensible interpretations (Kawulich, 2004). Patton (1987) described the phases of data analysis as organising data, reducing through summarising, categorising and identifying and thereby linking the patterns and themes in the data.

2.5.7.1 Qualitative content analysis

There are multiple data analysis methods for qualitative studies such as content analysis, narrative analysis, discourse analysis, thematic analysis and so on. Among them, content analysis was adopted to this study for analysing the data gathered through interviews and focus group discussions. The content analysis process includes the reduction of data into a coding system that defines the phenomenon by developing categories, conceptual systems and conceptual maps that help to interpret the data in a meaningful manner (Elo & Kyngas, 2007; Hsieh & Shannon, 2015). This type of analysis is more useful to analyse the large amounts of verbal data that are collected through in-depth interviews or focus groups (Schreier, 2012).

Qualitative content analysis can be conducted in two main methods as conventional (inductive), directed (deductive) and summative based upon their specific differences in the coding system (Hsieh & Shannon, 2005).

Conventional Content Analysis- In this method, the coding categories are emerged from the collected data by avoiding any pre-defined categories (Kondracki et al., 2002). This is adopted when the existing theories and research on the subject area are limited. Further, this can be considered as the most commonly used method in qualitative content analysis, where the researcher completely relies upon the data to accomplish new insights (Hsieh & Shannon, 2005).

Directed Content Analysis- In contrast with the conventional approach, this method identifies key concepts as initial coding categories based upon existing theory or prior research (Hsieh & Shannon, 2005). The directed approach follows a more structured process compared to the conventional method since it is based upon a pre-existing theory. Accordingly, this method is directed to validate or extend existing theory through a pre-defined coding system (Stock, 2012).

Summative Content Analysis- This method initiates with counting and comparison of specific words or content in the data with the intention of extracting the contextual use of them (Hsieh & Shannon, 2005). The major objective of this approach is to explore the usage of specific words or contents disregarding their meanings. This method begins by searching for a certain text and counting the number of times it appears, then attempting to reveal the basic context for the use of the words (Swati et al., 2014).

This study has been focused on the challenges of existing information and coordination systems for disaster preparedness and the user requirements of disaster preparedness, where context-specific information is required with limited existing research on the area. Since the study is heavily reliant on respondents' opinions presented in a variety of ways, merely word counting would not be appropriate to achieve the study's ultimate goal. Considering the aforementioned facts, conventional content analysis method (Inductive coding) has been adopted to the study.

Accordingly, the narratives of the respondents with the quotations were extracted from the collected data related to the phenomenon being studied. Observing the common patterns, the extracted narratives were categorised into several 'concepts'. These concepts are named using content characteristic words, phrases, or sentences. In some instances, these main concepts are also derived into 'sub-concepts' considering different patterns and relationships within the main concepts. After extracting narratives, main concepts and sub-concepts, the relationships among them were developed with regard to the question under consideration. Ultimately, these relationships were integrated to develop cognitive maps, which presented the overall picture of the phenomenon under consideration. The coding system adopted in this study has been illustrated in a cognitive map in Figure 2.7

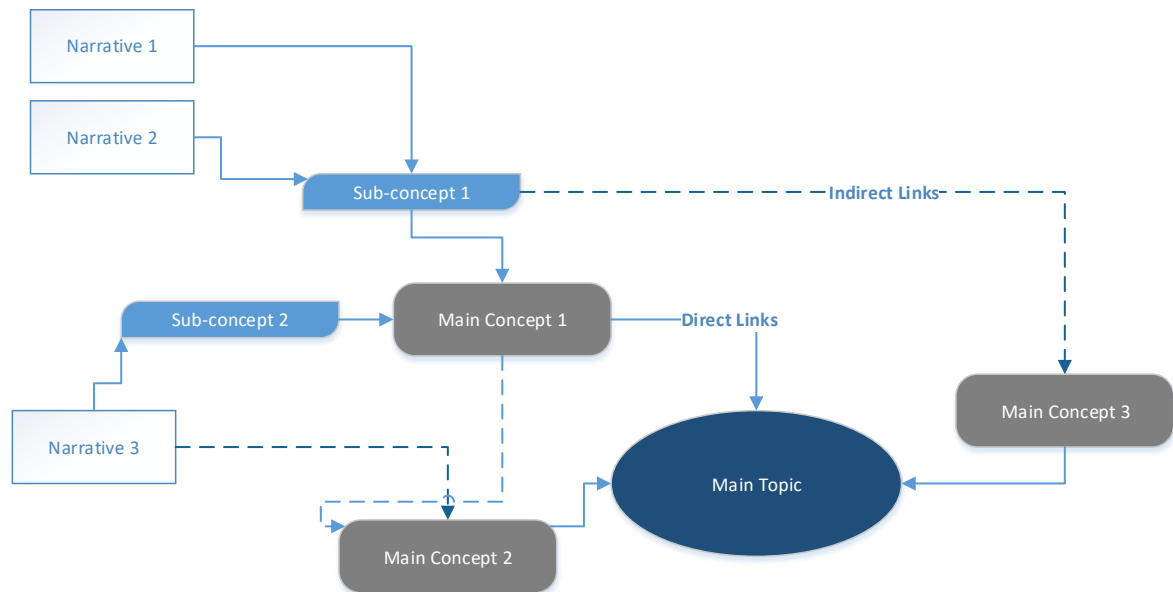


Figure 2.7- Coding system in a cognitive map

As per Figure 2.7, the arrow lines between narratives, sub-concepts, main concepts and the main topic show the direct relationships among the attributes while the dotted arrow lines demonstrate the indirect relationships.

In addition to the qualitative content analysis, the user requirements of a digitally enhanced information and coordination system for disaster preparedness were analysed through the user story evaluation and user story mapping processes, which are commonly adopted for the user requirement analysis in agile system development. The user story mapping process that was utilised for analysing user stories and prioritising them is explained in detail in the Sub-section 2.5.7.2.

2.5.7.2 User story mapping process as the method of user requirement analysis

The introduction to user stories and user story mapping has been provided in the Sub-section 3.11.1. Since the users of a digital information and coordination system to be utilised for a disaster preparedness approach in Sri Lanka have less knowledge about these types of systems, capturing their user requirements in a simple format is more suitable. Therefore, the user story method was adopted to investigate the user requirements.

For the analysis of user requirements, User Story Mapping Methodology is conducted in several steps. The process is discussed below pertaining to this study with appropriate justifications.

Step 1- Establishing the vision

Initially, the intention of the development of a user story map should be established. The description of the system that needs to be developed is identified in this step. As per this study, the vision is “development of the information and coordination system that can be utilised to perform the disaster preparedness approach in Sri Lanka”

Step 2- Identifying the users of the system

At the second step, the users of the particular system are identified. As per the proposed system of the study, the following users were determined to be interviewed.

- Officers in the disaster preparedness unit of Disaster Management Center
- Disaster Management Officers at District level
- Disaster Management Officers at Divisional level
- Grama Niladharis
- Community Members

Step 3- Build the backbone

The backbone is the top row of the user story map. It outlines the essential capabilities that the system needs to have (Muldoon, 2020). The backbone is determined through the interviews of users. The user is asked to explain their process from the beginning to the end including all the high-level activities that the user will perform using the system (Refer Figure 2.8). The backbone expects a smooth user journey through the system without having in-depth information. As per this study, each user is asked about their role within the information and coordination system for disaster preparedness (Refer Sub-section 4.3.6.1).

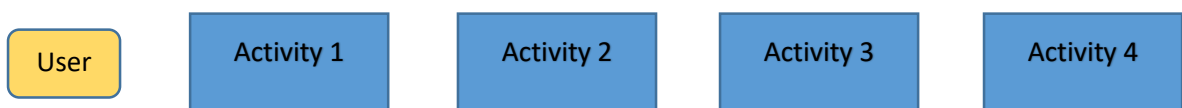


Figure 2.8- Backbone development

Step 5- Break the activities into user stories

The identified activities are broken into several user stories (Tasks) at this step. Users are requested to explain their requirements (describing more specific tasks) in the format of user stories under relevant activities (Refer Figure 2.9). In this study, the users were requested to explain their tasks under each role with reference to the information and coordination system for disaster preparedness. Thereafter, with the combination of user

story maps of all the users, a holistic final user story map will be prepared at the end, which is directed to the prioritisation process. In this stage, the user stories that indicate similar meanings will be replaced with a single user story (Patton, 2014). In this way, the user story map will be well structured by the elimination of repetitions of user requirements.

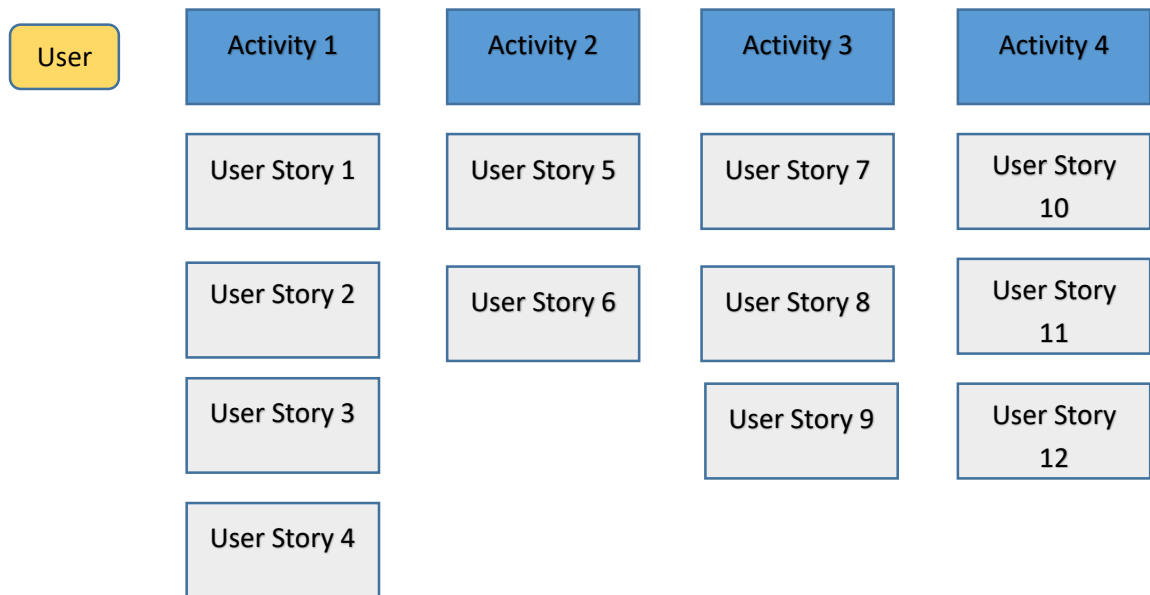


Figure 2.9- User story map

Step 5- User story prioritisation

After conducting interviews with each user there might be a large number of user stories for the overall system. However, it is not practicable to implement all the user stories into a single system at the very first release. Therefore, in this step user stories are prioritised by estimating the value of those user stories in users' perspectives and selecting the most valuable user stories to be included in this proposed system. There are several prioritisation methods in practice such as MoSCoW method, complexity matrix, walking skeleton method and so on. Among these prioritisation methods, MoSCoW method is commonly used due to its simplicity and the user-friendliness that helps the users to prioritise the user stories easily. The term MoSCoW stands for Must-haves, Should-haves, Could-haves and Won't-haves as described below.

- **M- Must have** - Describe the requirements that must be included in the final solution.

- **S-Should have** - Represent the high priority item that should be included in the solution if it is possible
- **C-Could have** - Describe the requirements which are desirable, but not necessary.
- **W- Won't have** - Describe the requirements that the stakeholders have agreed will not be implemented in a given system.

Through this technique, the users are requested to categorise the identified user stories under each group (Refer to Figure 2.10). The prioritisation is most commonly conducted by focus group discussions and user story workshops since the overall opinion of the users related to the value of each user story should be captured (Cohn, 2000). Therefore, to this study, a focus group discussion was conducted to prioritise identified user stories with the participation of the users (Sub-section 4.4).

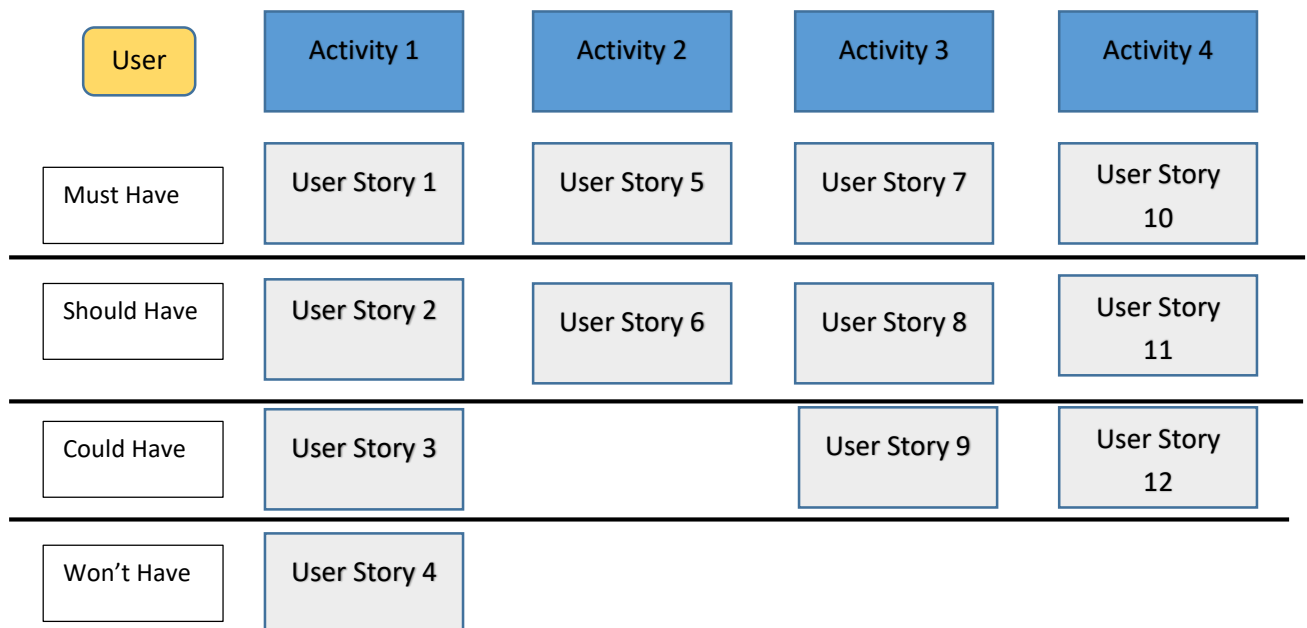


Figure 2.10- User Story prioritisation

2.6 Chapter summary

This Chapter provided a detailed view on the research methodology carried out in this study. Under the qualitative research choice, survey research strategy has been utilised to acquire an in-depth understanding on the challenges of existing information and coordination systems for disaster preparedness and user requirements for the proposed digitally enhanced disaster preparedness approach. Interviews, documentary review and

focus group discussion were used in order to gather the relevant data. The collected data was then analysed using qualitative content analysis in order to derive the findings.

3 LITERATURE REVIEW

3.1 Natural disasters

A disaster is known as the occurrence of an extreme hazard event that affects vulnerable communities triggering substantial damage, disruption, possible casualties and thereby leaving the affected communities incapable of functioning normally without outside support (Benson, Twigg, & Tiziana, 2007; Bilau, Witt, & Lill, 2015). Lindell and Prater (2003) stated that a natural disaster occurs when an extreme geological, meteorological, or hydrological event surpasses the capacity of a community to adapt to that occasion. However, there is a long-term argument that a natural hazard cannot cause substantial losses and damages by itself, but that poorly managed interactions between society and the environment, along with a lack of community capacity, may turn natural hazards into disasters (Kulatunga, 2010). Kulatunga (2010) further highlighted the human intervention of natural disasters stating as poor preparedness approaches like poor planning and regulations, lack of awareness and knowledge among the community, poor governance systems have increased the intensity, frequency and changing patterns of natural disasters.

Natural disasters have measurable short and long-term impacts on the overall viability of communities in the world (Lindell & Prater, 2003). The impact of the disaster majorly can be determined by the nature of the physical event, for example, the loss of lives and destruction of assets (Deeny & McFetridge, 2005). However, Barakat (2015) revealed that the impact of these disasters is higher in developing countries like Sri Lanka compared to industrialised countries.

3.1.1 Natural disasters in Sri Lanka

Sri Lanka is an island that is separated from other countries and fully attached to nature, the most dynamic element of which is the climate. In the past recent years, Sri Lanka has experienced a growth in natural disasters resulting in several economic problems that negatively affected the country's development gains (Disaster Management Center, 2017). As per the latest report of Disaster Management Center (2019), the human death rate due to disasters in Sri Lanka shows a decreasing trend while disaster damages, losses and the variety of people affected are on the increase, compared to the global trend. It has been identified that there are many types of disastrous events in the country; but the most common hydrological and geological hazards are landslides and floods (Ministry of National Policies and Economic Affairs, 2008). "In terms of the frequency of disasters which affect the people and economy in Sri Lanka, flood is the highest (56%) followed by landslides (20%), droughts (14%) and high winds (10%) (Disaster Management Centre, 2017, P.4)". The frequency and the intensity of disasters have been increased in

past decades specifically in floods, landslides and drought due to human intervention, environmental degradation and uncontrolled developments (Ministry of National Policies and Economic Affairs, 2008).

3.2 Disaster management cycle

Disaster management can be defined as the process of taking immediate and appropriate actions to manage disasters and their post consequences under time pressure and threat with insufficient resources (Khorram-Manesh, 2017). According to Warfield (2017) main objective of disaster management is to avoid or reduce the possible losses from hazards and achieve effective recovery. Specifically, disaster management is divided into mitigation, preparedness, response and recovery phases as a cyclic process, which is known as the disaster management cycle (Figure 3.1) (Vitalii et al., 2017).

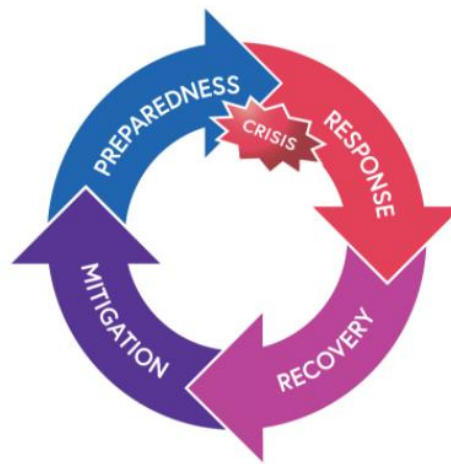


Figure 3.1- Disaster management cycle. Adapted from (Alexander, 2014)

Among these phases, disaster preparedness absorbs an important role in resisting a greater degree of human suffering (Beura, 2016). As per the findings of Sena and Woldemichael (2010), although currently many researchers mainly focus on the response phase of disaster management, much of the hard work on disaster management is carried out before disasters occur, in the form of disaster preparedness.

3.3 Disaster preparedness

Disaster preparedness can be considered as the most researchable phase of disaster management, which is very dynamic and in a state of flux (Covington & Simpson, 2006). The concept of disaster preparedness deals with a continuous and integrated approach,

which requires the contributions of many different areas ranging from individual-based programmes to institutional developments (American Association of Physics Teachers, 2000). Therefore, it is necessary to have a sound knowledge on the definition of disaster preparedness prior to proceed with the study.

3.4 Working definition for disaster preparedness

In order to define the scope of natural disaster preparedness, a clear definition of the specific term must be established initially. Unfortunately, there is no common universal definition for disaster preparedness (Keim & Giannone, 2006; Ritchie & MacDonald, 2010; Indahningrum, 2013). The terms relating to disaster management such as disaster preparedness, disaster mitigation, disaster prevention, are ambiguous at present (Ritchie & MacDonald, 2010) making it difficult to isolate disaster preparedness from the other phases of disaster management (Dekens, 2007). Therefore, the clear working definition which is suitable for the study has been derived through the findings acquired from the systematic review (Refer Sub-section 2.4.1).

According to Sympson (2020), the format of a good definition should consist of two parts: (1) the category of concept and (2) differentiating characteristics. The category of concept refers to the category or class that the concept fits into. Differentiating characteristics are the specific characteristics that set your term apart from other terms within that category. Accordingly, the definitional attributes that should be included in the disaster preparedness definition have been identified as per Figure 3.2.

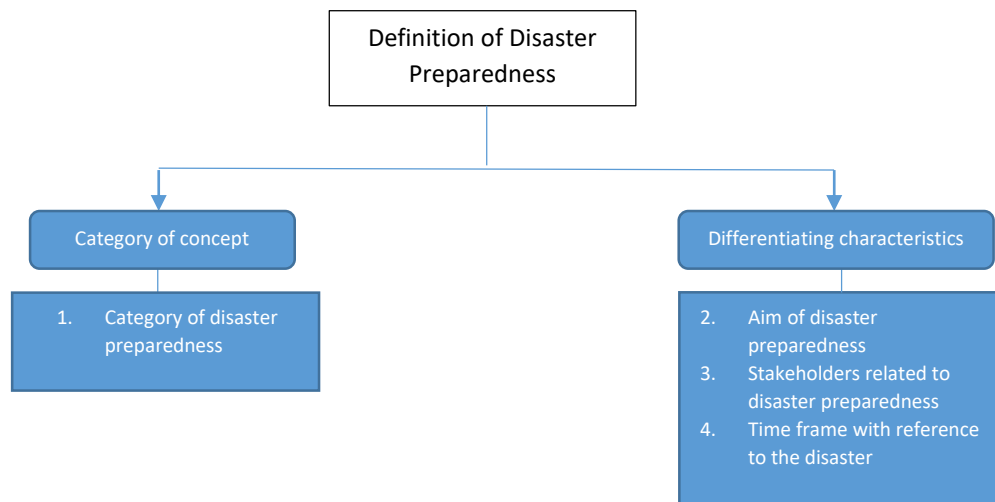


Figure 3.2- Definitional attributes of disaster preparedness

As per Figure 3.2, the working definition has been developed with the identification of four definitional attributes called category of disaster preparedness, aim of disaster preparedness, stakeholders related to disaster preparedness, time frame with reference to disasters which have been discussed below.

3.4.1 Category of disaster preparedness

The category, which disaster preparedness fits into is disclosed in different definitions as follows.

Table 3.1- Contribution for the category of concept

Category of Concept	Sources (Refer Appendix-A)	Number of definitions/ Percentages
Set of activities	[3], [4], [6], [8],[12],[13],[14], [21],[22],[23], [27],[28],[29],[30]	14 (41%)
Capacities	[5],[7],[11],[16],[19],[32],[33]	7 (20%)
Measures	[1],[2],[15],[20],[26]	5 (14%)
State of readiness	[18],[31],[34]	3 (8%)
Systems and capabilities	[17]	1 (2%)
Specific efforts	[25]	1 (2%)

According to Table 3.1, the majority of articles (14) identified DP as a “set of activities. Moreover, 7 and 5 articles have defined it as “capacities” and “measures” respectively. Other terms like “state of readiness” and “specific efforts” were found in only a few definitions.

Disaster preparedness activities can be considered as the set of actions that build up the capacities of communities to cope with and minimise the effect of a disaster. Preparedness capacities are the qualities and resources that an individual or a community can use and develop to anticipate, cope with, resist and recover from the impact of a hazard (American Association of Physics Teachers, 2000). According to Anderson (1994), these capacities consist of material capacities such as food, animals, cash and tools; social capacities such as leadership, experience and networks and attitudinal capacities such as beliefs, motivations, work values and creativity. As mentioned above, these capacities are built up through disaster preparedness activities. Disaster preparedness measures are designed for an evaluation of the relative level of disaster preparedness (Simpson, 2008). These measures provide an indication for the decision-makers of how prepared a particular

community is for handling a certain type of disaster. The level of experience, the level of knowledge, socio-economic factors and demographic characteristics can be considered as measures of disaster preparedness (Granberg, 2013).

As per the definitions presented by the majority, the heaviest burden of the disaster preparedness concept is carried out under the category of “activities”. However, this term cannot be completely included under the category of “activities” as it has some relations with “measures” and “capacities” too. Moreover, there is an interconnection between these three categories with reference to disaster preparedness. Disaster preparedness activities help to build up the preparedness capacities while preparedness measures evaluate those capacities and decide the state of preparedness. Given the interconnection between these three categories and their relationship to disaster preparedness, it can be concluded that disaster preparedness is considered as a “set of activities, measures and capacities” because the concept can be discussed under all three categories.

3.4.2 Aim of disaster preparedness

The aim of disaster preparedness has been described in definitions as follows:

Table 3.2- Contribution to the aim

Aim of Disaster Preparedness	Sources (Refer Appendix A)	No of Definitions/ Percentage
Effective response and recovery	[2],[3],[4],[6],[7],[8],[9],[10],[11],[13],[14],[15],[16],[1],[9],[22],[23],[26],[27],[29],[30],[3][1],[32],[34]	23(67%)
Mitigate the impact of hazard	[8],[10],[11],[12],[15],[16],[19],[20],[23],[25],[26],[2],[7],[28],[30],[31],[33],[34]	17(50%)
Minimize possible negative impacts of disasters	[5],[12]	2(5%)
Reducing loss of life, injuries and property damage	[1]	1(2%)
Improve chances of successfully dealing with an emergency	[21]	1(2%)

As given in Table 3.2, the most commonly used aim (in 67% of the studies) for disaster preparedness is ‘to ensure the effective response and recovery’. Effective response and

recovery not only reduce injury, loss of life and damage to the property of vulnerable communities, but also contribute to the resilience that leads to sustainable development in long run (United Nations for Disaster Risk Reduction [UNDRR], 2019). The second most common aim is ‘to mitigate the impact of the hazard’ (presented in 50% of the studies). Even though natural disasters cannot be prevented, there are ways to avoid the worst-case scenarios and diminish the magnitude of a disaster so that some of the adverse consequences will be mitigated (Brower & Schwab, 2000). The significant fact is that 10 studies have highlighted both the aforementioned aims within their definition indicating that achieving both of them is equally important within the preparedness concept. Therefore, considering the opinions expressed in the majority of the examined studies and the importance of both the aims, “to mitigate the impact of hazard and to ensure effective response and recovery” is established as the aim of disaster preparedness for the working definition.

3.4.3 Stakeholders related to disaster preparedness

This section discussed the target group with regard to disaster preparedness (‘To whom’) and the population engaged in disaster preparedness (‘By whom’). An analysis of the definitions is presented in Table 3.3.

Table 3.3- Contribution of the stakeholders

Population Type	Population	Sources (Refer Appendix A)
To whom	Vulnerable populations	[20],[26],[28]
	Individuals, communities and organisations	[7]
By whom	Government agencies, Non-Governmental Organisations (NGOs), communities, or individuals	[1],[4],[5],[6],[7],[9],[11],[14],[16],[17],[19],[31],[32],[34]

As shown in Table 3.3, many of the definitions have not paid much attention to the target group. However, from the reported definitions, the majority have emphasised the target group as the “vulnerable population” for disasters. Governments, NGOs, communities and individuals have been identified, within 14 of the articles, as the stakeholders engaged in the disaster preparedness while the rest of the definitions remain silent about stakeholder engagement. Hence, as per the findings from the definitions’ analysis, “Vulnerable Communities” as the target group and “Governments, NGOs, communities and individuals” as the population engaged in disaster preparedness have been finalised as appropriate for the working definition.

3.4.4 Time frame with reference to a disaster

The time frame with reference to a disaster is very important when distinguishing disaster preparedness from other disaster management phases. 20 records out of the 34 studies (representing the majority (58%)) asserted that the ‘disaster preparedness concept is conducted prior to the disaster’ while the other definitions did not mention the time frame. Even though ‘preparedness’ itself indicates implementation prior to a disaster, authors argue that it is better to mention the time frame to derive a comprehensive definition.

As per the final analysis of the aforementioned key definitional attributes, the working definition for DP has been defined as follows:

Disaster Preparedness refers to a set of activities, measures and capacities that are developed by governments, NGOs, communities and individuals prior to a disaster with the aim of helping vulnerable populations to **mitigate** the impact of hazards and to support their effective **response and recovery**.

The working definition derived through the systematic literature review includes all the other three phases of disaster management which proves the interconnection between these concepts. Moreover, disaster preparedness should be given the best priority as it is directly linked with all the other stages of disaster management. Further, it is evident that successful preparedness is the key to accomplishing the success of the mitigation, response and recovery phases and, thereby, achieving the success of overall disaster management.

3.5 Major components of disaster preparedness

Disaster preparedness, as already stated in the definition (Sub-section 3.4) is a broad concept, which consists of a set of activities, measures and capacities. The key success of disaster preparedness can be achieved through preparedness activities, as they help the vulnerable communities to build up the capacities to cope with and minimise, the effect of a disaster (Sutton & Tierney, 2016). These disaster preparedness activities are categorised under eight major components of disaster preparedness (Table 3.4), which lead to design a comprehensive disaster preparedness system as follows (American Association of Physics Teachers, 2000; Keeney, 2014; Twigg, 2004).

Table 3.4-Components of disaster preparedness

Risk Assessment	Coordination Systems	Information Systems	Resource Mobilisation
Early Warning Systems	Evacuation Systems	Education and Training	Psychological Preparedness

Each component provides a unique contribution to a holistic disaster preparedness approach as described below.

Risk Assessment- the initiative process of preparedness to determine the nature and extent of a possible disaster by analysing existing hazardous conditions that could potentially harm the vulnerable community, property and the environment on which they depend (Bureau for Crisis Prevention and Recovery, 2010). According to Safaie, Stepanyan, Houdijk and Onur (2017), risk assessment is the foundation of the decision and policy-making process, which requires a close corporation between different organisations and the target community.

Coordination System- Coordination in disaster preparedness among the institutions at international, national, regional and community levels have become increasingly significant (Prizzia, 2008). Rodriguez-Espindola et al. (2017) defined coordination in preparedness as the corporation of different independent entities involved in disaster preparedness in order to eliminate the gaps in service delivery and unnecessary duplications. Madan and Routray (2015) pinpointed that a sound coordination system for disaster preparedness is based upon the productiveness of the institutional framework with proper delegation of authority in decision making.

Information Systems- Perry (2015) indicated that the whole disaster preparedness phase is driven by the information. Disaster preparedness deals with gathering, analysing and acting on timely and accurate information before, during and after disasters. The comprehensive information system ensures the usability, availability, stability and reliability of the information with integration to a timely decision-making process (American Association of Physics Teachers, 2000). Krumay (2015) described that these systems are designed upon different concepts such as open or closed source, network-based or integrated into other systems and consist of diversified functionalities.

Resource Mobilisation- This is one of the planning strategies to identify potential material, technical and human resources. This includes the identification of emergency

shelters, locations of food supplies and other necessary materials, skilled human resources for assistance that would be available during disasters (Keeney, 2014).

Early Warning Systems- These systems protect the vulnerable community by notifying the risk prior to a disaster with the aid of scientific monitoring and detection systems, which include social design factors (Collins & Kapucu, 2011). Early warning systems are enriched with scientific, managerial and technical elements as well as communication processes. Successful early warning systems need to be designed in an understandable manner and relevant to the communities, which they serve (Villagrán de León et al., 2009).

Evacuation Systems- Evacuation will be the fundamental response to disaster warnings. Therefore, the creation of systematic escape routes and shelters is essential (Twigg, 2004). Evacuation systems should be designed following three steps: identifying safe areas to be evacuated, determining optimum evacuation route and grouping of building blocks related to each safe area (Naghdi et al., 2012). In order to ensure the effectiveness of evacuation systems, it is crucial to provide awareness and practice to the community involved with the facility's general operation, which will help them to respond calmly in an emergency event (Berau of Child Care Licensing, 2017).

Education and Training- The main aim of conducting education and training programmes is to prepare the community and the other teams for effective disaster response and recovery. Moreover, teaching basic skills includes informing communities about the ways of accessing accurate information, enhancing safety by following proper evacuation systems in the event of a disaster (Keeney, 2014). In addition, these programmes build up psychological disaster preparedness too (Ronan et al., 2015).

Psychological Preparedness- Reser and Morrissey (2009) described psychological preparedness as an intra-individual and a psychological state of awareness, anticipation and readiness capacity to anticipate and manage one's psychological response in an emergency situation. Incorporating psychological preparedness into the existing disaster preparedness system will help the vulnerable communities to cope with the mental distress experienced during or after a disaster and to adopt long-standing resilience (Zulch, 2019).

3.6 Digital approach for enhancing disaster preparedness

With the rapid enhancement of science and technology in the recent decade, the development of technologies to get prepared for future hazards has become a major focus of disaster-related organisations all around the world (Economic and Social Commission for Asia and the Pacific [ESCAP], 2015). According to State Government of Victoria (2019), digital technologies are known as electronic tools, systems and resources that can generate, store and process data. Innovative technologies such as robotics, drone

technology, Geographic Information Systems (GIS) and evolving technologies like Artificial Intelligence (AI), the Internet of Things (IoT), cloud computing and Big Data are currently recommended for many advanced aspects of disaster management (Mehta, 2019).

Digital technologies provide numerous advantages by addressing the limitations of traditional preparedness practices (Shaw et al., 2016) and provide various tools that help to cope with disasters in an effective manner (Hu et al., 2018). Digital technologies enable to store, access and monitor a large amount of information locally, remotely and virtually, which is very much important for disaster preparedness systems as they are dealing with multiple information from different organisations (Tech & Money, 2019). Moreover, the aims of disaster preparedness can be achieved by the capitalisation of real-time information offered by digital technologies to better monitor the movements of people and enhance their awareness (AlHinai, 2020). In addition, faster connections, global access advantages, data security are some of the qualities of digital technologies that can serve to get the best outcome from the disaster preparedness systems (Tech & Money, 2019).

3.7 Digital technologies used within different components of disaster preparedness

Disaster preparedness depends upon a set of complex and multidimensional processes that are difficult to operationalise if any of the pieces are missing. Most of the countries in the world seek to work on the improved preparedness activities with technological advancements and integrate them into a more systematic approach in order to demonstrate a high level of disaster preparedness (WHO, 2019a). This section discussed the digitally enhanced disaster preparedness practices introduced in the global context under each component of disaster preparedness.

3.7.1 Risk assessment

Various risk assessment practices are adopted for the formulation of national and regional disaster preparedness systems covering areas such as climate change adaptation, urban development planning and humanitarian planning (Bureau for Crisis Prevention and Recovery, 2010).

The vital part of risk assessment is producing risk information that is productive for users to analyse and generate the output. Many countries maintain databases, to update and disseminate information and to estimate and measure the impacts of disasters on the community and the property (United Nations Office for Disaster Risk Reduction [UNISDR], 2016). These databases include historical hazard records and scientific data, inventories of assets and the community of the vulnerable area (Asian Development Bank,

2017). However, the periodical update of the databases requires the contribution of different stakeholders at different levels that highlights the necessity of continuous interaction between them (Lin, 2018).

Hazard mapping has become a popular tool recently for professional risk analysis and information dissemination to the public (International Strategy for Disaster Risk Reduction [ISDR], 2014). Tsai and Chen (2011) asserted that comprehensive hazard index maps are very useful at the local level, which provide details of potential cumulative risks and overall damage. Moreover, they are applicable for spatial and land use planning. Currently, Geographical Information Systems (GIS) are widespread as a good technique for spatial hazard analysis and mapping. These computer-based information systems provide different information by presenting complete and up-to-date pictures of hazards, their possible effects and response protocols (Administration for Children and Families, 2016).

Digital Humanitarian Network (DHN) is another system, which acts as an interface between the disaster management stakeholders and the community. This provides collective expertise in Geographic Information Systems (GIS), online mapping, data analysis and statistics. This has been designed in a user-friendly manner particularly targeting the vulnerable population (ISDR, 2014).

3.7.2 Coordination systems

Due to the influence of the United Nations under the implementation of the Hyogo Framework, most of the nations created at least a very simple institutional arrangement that can manage a disastrous event (Laaser & Beluli, 2016). The primary goal is to formulate and implement disaster-related policy systems and build up the coordination between stakeholders through establishing their responsibilities (Maqbool & Hussain, 2017).

Gautam and Bhandari (2019) described that Disaster Management Acts are enabled to establish the institutional structures from national level (Disaster Management Authorities) to local level (community disaster management committees and their volunteer task groups), which outline the roles and responsibilities of government and non-government partners as well as the community involved in disaster preparedness.

Explicit coordination between these institutions is required to ensure the maximum contribution to the response and recovery phases by avoiding unnecessary duplications (American Association of Physics Teachers, 2000). The coordination of the roles and responsibilities of each organisation can be built up through mutually acceptable agreements presenting each organisation's operational region, individual and joint contribution to the disaster management process. However, due to the difficulty of handling a number of different stakeholders manually, digital solutions are adopted for

coordination mainly due to their nature of interoperability. For instance, an electronic organisation registry can help immensely (Chanawongse, 2013). A gap identification chart is a tool that can be used for identification of the responsibility of each activity, existing gaps and overlaps of the framework (IFRC, 2000). Databases for sharing information have been developed in most of the developed countries. For example, Data Warehouse Systems (DWS) integrate the data of all institutions and provide the unified presentation of data which is very helpful for performance analysis and effective decision making (Krasniqi, 2015). The internet also plays a major role through online portals and particular websites in order to share information among institutions as well as communities (Md Hassan, 2015).

3.7.3 Information systems

The effectiveness of disaster reduction, response and recovery relies greatly on the management of relevant information. Hence, the development of information systems has become a crucial responsibility in the phase of disaster preparedness (Asian Disaster Preparedness Center, 2011). Recent technological innovations have also improved the quality of information systems while many countries embraced new systems to acquire, analyse and share the necessary information (AlHinai, 2020).

Digital technologies have integrated different communication systems existed over the last two decades. Information and communication systems based upon the internet, mobile phones, e-mails and fax have become more functional by facilitating timely information for preparedness. Wireless digital communication and wireless application protocols encourage mobile phone usage when the other electronic platforms get failed (Beura, 2016).

The media such as radio and television broadcasting systems plays a major role in transmitting the information. Considering the drawbacks of traditional operation of radio platforms, digital radio alert systems have been introduced that can react even if the radio is switched off. This alarm is activated through a flag integrated into the receiving end and the radio would automatically tune (Dunnette, 2006). A satellite radio system is another improvement that covers a much wider geographical area compared to normal radio signals. The information can be delivered outside the network coverage range regardless of the obstructions such as tunnels and buildings (Chanawongse, 2013). Emergency Transmitting Vehicles, suitcase radio systems and computer mapping software are currently integrated into the public broadcast systems in order to enhance the efficiency of disaster information dissemination (International Telecommunication Union, 2017).

In addition, real-time social media has become a rich source of information for assisting operational decision-making in the response phase (Brouwer, 2016). Therefore, designing robust social media platforms may help for effective response in terms of information

management. Social media platforms such as Facebook, Twitter, Wikis enable online data exchange via context-rich content such as embedded texts, videos, images and conversations (Ogie et al., 2018). Therefore, social media can mobilise and organise the vulnerable community to achieve the various objectives of disaster preparedness and update them with the most up-to-date information (Lee et al., 2015; Lerman & Ghosh, 2010). Moreover, the community trusts the information posted by the social media influencers as valuable, notable and informative. Therefore, conveying disaster-related information through such influencers may be more effective as some communities have trust issues with government bodies (Lee Hughes & Palen, 2009).

In addition, Tabish and Syed (2015) mentioned that web-based information systems and the public access to raw data sources expand the usage of existing information by the stakeholders and enhance government transparency.

3.7.4 Resource mobilisation

Preparedness systems should develop strategies, agreements and procedures for mobilising and acquiring emergency funds, supplies and equipment in case of a disaster (American Association of Physics Teachers, 2000; Twigg, 2004).

Designating, stocking and maintaining warehouses, investigating options for the delivery of supplies to rural areas, developing the procurement systems that can rapidly use for acquiring resources in the response and recovery phases can be considered as the major activities under this component (American Association of Physics Teachers, 2000).

The readiness of medical facilities is another important aspect. The hospitals should have adequately trained staff, necessary medical equipment and first aid supplies in order to minimise the death rates and injuries from a disaster (Burling & Hyle, 2016). Some countries have introduced telemedicine systems in order to use in an emergency, that can provide multiple functions such as medical diagnosis, treatment and patient care (Tabish & Syed, 2015).

Maintaining the inventory on the local capacity and location of resources is very important for positioning specialised material and human resources for disaster response (Sena & Woldemichael, 2010). The online inventories are maintained by many developed countries with the assistance of the GIS recording the information about the specific resources, contact details, quantity availability, location, operator provision and transport options (Asian Disaster Preparedness Center, 2011). Logistic systems for the predicted needs for health and social services need to be planned (Sena & Woldemichael, 2010).

3.7.5 Early warning systems

Early Warning Systems (EWS) comprise three phases as monitoring of precursors, forecasting the probable disaster and notification of a warning about the event to the vulnerable population (Villagrán de León et al., 2009).

The monitoring phase of EWS deals with the collecting of information with risk-related proxy variables, which can be conducted by risk assessment as per Sub-section 3.7.1 (Brazzola & Helander, 2018). The approaches that can address multiple hazards with the engagement of various monitoring agencies are proved to be more effective (Villagrán de León et al., 2009). For that, disaster-related institutions need to be properly linked with each other and with the decision-making body, which suggests the necessity of institutional frameworks (Sub-section 3.7.2). Modern technologies such as remote sensing, satellite observations and on-ground measurements facilitate the methods for combining data from multiple monitoring sources with high accuracy. Moreover, trend analysis of online communication can indicate information about future disasters (Brazzola & Helander, 2018). Brazzola and Helander (2018) further stated that community monitoring systems are established in many countries by expanding automated and manual monitoring stations across the country. These systems should be well equipped with necessary technologies such as remote sensing, trained staff and backup systems with the capacity of providing ongoing data analysis during a disaster (ISDR, 2008).

The productivity of the detection and prediction technologies decides the effectiveness of an early warning system (Asian Disaster Preparedness Center, 2011). Decision support of prediction systems is based upon analysing historical data and creating summaries (Beura, 2016). Currently, these systems are supported by the analytical decision-making procedure that will be effectively functioned utilising Artificial Intelligence (AI) modelling (Menon, 2017). These prediction systems use AI fuzzy model software to produce the contents for forecasting (Beura, 2016).

Notification of the warning to the vulnerable community is the most important phase of the early warning systems. The traditional method is to utilise the sirens systems for alerting as quickly as possible (Rao et al., 2007). However, with the development of telecommunication systems, last-mile communication models have been introduced (Brazzola & Helander, 2018). Current dissemination technologies and practices are discussed in Sub-section 3.7.3 under information systems. Apart from them, the early warning app development has become a successful trend in many developed countries with the increment of mobile usage (Brazzola & Helander, 2018).

In addition, effective people-centered EWS are established with the participation of volunteer groups using local communication methods and local hazard monitoring

systems (ISDR, 2014). This ‘bottom-up’ approach enables multi-dimensional response to the community issues related to warning systems (Md Hassan, 2015).

3.7.6 Evacuation systems

Having established clear evacuation systems at the pre-disaster phase is essential when a population is threatened by a disaster (Tabish & Syed, 2015). Evacuation systems or plans contribute to determine safe areas, evacuation routes and evacuation shelters (Naghdi et al., 2012).

Evacuation analysis is vital to determine the size of the vulnerable population and its capability for transportation. GIS can be adopted in order to determine the evacuation routes, safe shelters and available primary resources in the area and its locality that can be mobilised in the event of a disaster (Naghdi et al., 2012). Location-based evacuation systems are developed on mobile phones using OpenStreetMaps (OSM), providing both audio and visual messages. This technology is widely used by the tourists and blind community due to the availability of map information around the world and the initiation of cost-effective GPS devices (Rahman et al., 2012).

The transportation networks that can be used to overcome traffic congestions need to be established (Nunes et al., 2014). Traffic control measures can be developed such as separation of pedestrians and vehicle traffic. Moreover, Traffic Incident Management Systems (TIMS) are integrated into the evacuation systems focusing on monitoring the traffic volume to the travelling direction and discovering alternative routes (Al-azawi, 2014).

Evacuation plans should have identified safer temporary shelter supports such as schools, community halls in case of a disaster. Many countries have formulated their disaster-related legislation systems with the provisions of voluntary evacuation and enforced evacuation (Nunes et al., 2014). Further, Xu et al. (2018) presented optimal evacuation planning systems focusing on large populations to acquire improved convergence rates and balanced capacity in surrounding shelters with the aid of Internet of Things (IoT) technology and mobile cloud computing platforms.

Specified evacuation systems have been developed targeting the elderly and disabled communities. Identifying special shelters with wheelchairs, medical and restroom facilities, forming information sources with closed caption evacuation instructions for hearing impaired people, creating special evacuation teams for assisting these special communities are performed by the disaster preparedness organisations (Dee, 2011). Moreover, wireless technologies are developed to assist them in the response stage (Xu et al., 2018).

3.7.7 Education and training

The aim of disaster preparedness education and training is to create an informed, alert and self-reliant community and preparedness teams, with the capability of actively playing their roles incorporation with the government and other organisations (American Association of Physics Teachers, 2000). According to Laaser and Beluli (2016), major education and training types for disaster preparedness are walkthroughs (workshops and orientation seminars), tabletop exercises (discussion-based informal sessions related to scenarios and experiences), drills (controlled, supervised method to practice a disaster management function; ex- evacuation), functional exercises (practices for the competences of disaster managers in time depending manner) and full-scale exercises (scenario-based event mirroring an actual disaster). These education programmes are very valuable to develop the awareness of the technological aspects of disaster preparedness such as familiarising with early warning and evacuation systems, usage of satellite images to gather real-time data and most importantly build up mental disaster preparedness (Shiwaku & Fernandez, 2016).

Education programmes should differ from one to the other with respect to the target audience. For an instance, child and youth programmes should be more interactive with social-based learning comprising of group discussions and friendly competitions to enhance the interaction and engagement while providing home-based activities with their parents (Ronan et al., 2015). Trainings should be implemented to the government officials and other practitioners in order to develop their professional capacities to manage the vulnerable population in a hazardous situation. Some countries conduct these training programmes targetting decision-makers such as politicians and mayors too (ISDR, 2014).

Several countries address the importance of traditional knowledge while designing training programmes as it can play a major role in convincing the public (Man Ha, 2018). Some countries have proved that the modern education methods integrated with the local wisdom are much more successful compared to sole modern methods (ISDR, 2014).

Digital technologies support distance education, which can recruit people from underrepresented groups and thereby disseminate the knowledge to the whole group and strengthen the productivity of low-incidence programs (Ludlow, 2011). Internet is one of the timely examples. People and professionals can access disaster preparedness information easily through the disaster education websites like PreventionWeb. Therefore, the responsible parties (teachers, authorities) for the preparedness education need to find out methods to apply them in real-life scenarios (Izumi et al., 2019). Some countries have developed virtual academies for disaster education, which are known as internet-based content management systems. These academies provide practitioners and communities all

around the world to exchange their knowledge and experience with best preparedness practices (ISDR, 2014). Moreover, Virtual Reality (VR) based training programmes for disaster preparedness have been widely introduced as a good alternative for traditional drills and tabletop exercises (Sharma et al., 2014). Virtual environments encourage the learning methods while providing real-time experience to the community through interfacing them with real-world disastrous situations (Vincent et al., 2008).

3.7.8 Psychological preparedness

Psychological preparedness enables the community to identify their feelings towards a disaster and manage their emotional responses confidently, resulting in the performance of better coping mechanisms (Zulch, 2019). Many psychological preparedness activities are conducted by the specialists, in a procedure of training (Kar, 2011).

Modern technologies offer advanced ways to deliver mental disaster preparedness mainly utilising mobile platforms (Dodgen et al., 2016). Mobile mental health technologies used in disaster preparedness can expand their geographical area up to rural parts, where mental health clinicians are scarce. Several mobile apps are developed focusing on the vulnerable population in order to build up their mental confidence to think that they can be effective in disaster response by managing their distress and changing behaviour. These apps include skills training with modeling, individualised assessment, goal setting and self-monitoring interventions in a creative manner to attract multiple subscriptions (Kuester et al., 2016).

With the development of virtual reality, Immersive Virtual Environments (IVEs), which are advantageous in psychological treatments have been used to develop disaster preparedness too. IVEs are low-risk and cost-efficient practices to convince the uneducated community about the risk of the potential disaster and build up their mindsets to follow proper evacuations at the response stage (Zou et al., 2017). Serious games, which are known as games designed for the purposes such as training, simulation, education as well as entertainment is good example for a virtual environment in disaster preparedness. Serious games are specially targeting the psychological preparedness of children and youth by conducting evacuation tasks similar to those in real-life settings (Susi et al., 2015).

Identified technologies with reference to each disaster preparedness component is summerised in Figure 3.3 below.

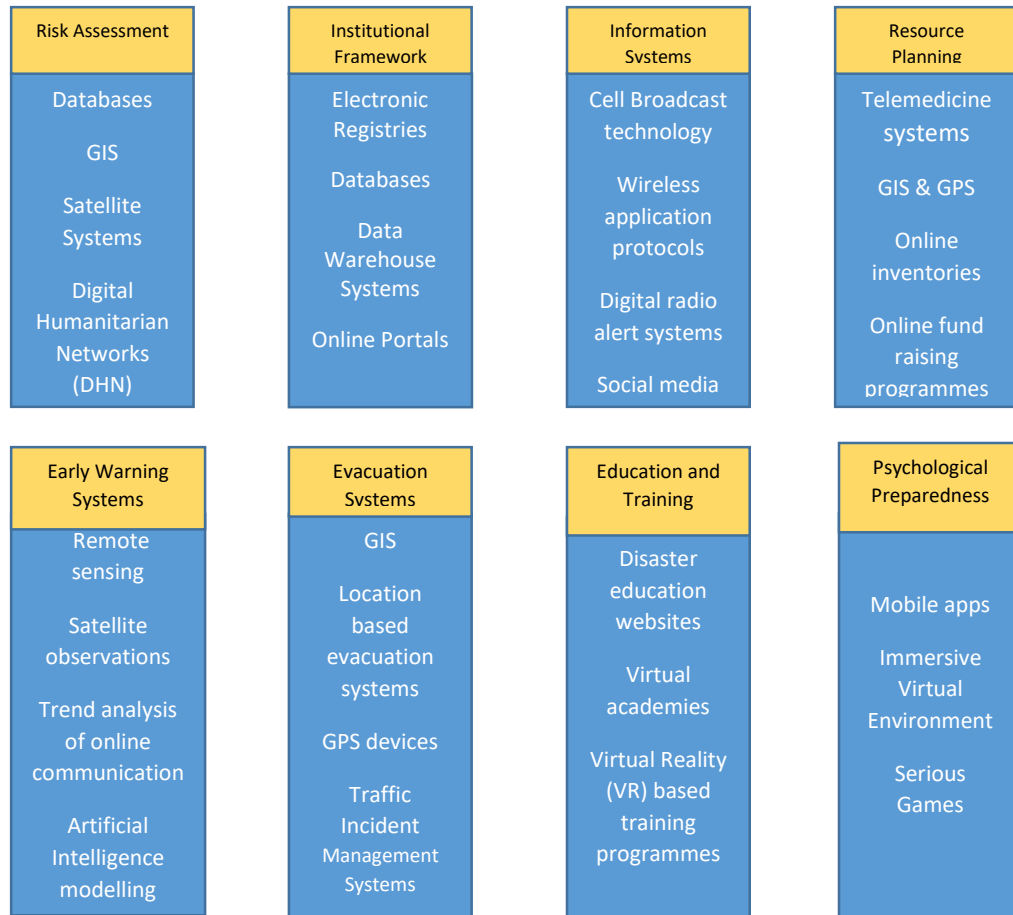


Figure 3.3- Digital technologies for each disaster preparedness component

3.8 Challenges of existing practices and technologies

Badrudin (2012) revealed that even though many digital technologies have been introduced, still several challenges in existing disaster preparedness approaches have hampered the overall disaster preparedness systems in countries leaving the community at a higher level of vulnerability. The challenges of existing practices and technologies in the global context are discussed in this Section.

The usage of current hazard maps using GIS systems is not at a sufficient level among the practitioners and local end-users due to the lack of knowledge about these techniques (Quero, 2017). The existing standards of risk assessment practices in many countries are problematic due to the implementation of multiple risk assessments by several organisations without a properly coordinated institutional framework (ISDR, 2014). Moreover, focusing only on a single consequence rather than multiple consequences, lack

of transparency, evaluating risks based upon subjective measures are some other loopholes in the current risk assessment practices (UNISDR, 2016).

Even though many institutional mechanisms are introduced by several countries for disaster preparedness, they are almost non-existent, at the local level (Ainuddin & Routray, 2015). Governments have failed to percolate their preparedness policies up to the district and local levels leaving the local district administrations are unaware of the responsibilities and implementation. This lack of coordination makes confusions regarding the line of authority at the response stage delaying the necessary actions (Quero, 2017).

There are challenges for the information accessibility due to different types of discrimination and marginalisation such as gender, disability, literacy, age, religion. In many instances, the necessary information dissemination in local languages or suited cultural conditions is lacking (Asian Disaster Preparedness Center, 2011; Ayeb-Karlsson et al., 2019). In some developing countries, there is an inability to provide information and warnings to the rural areas 24 hours a day due to the lack of energy sources and alternatives (ISDR, 2014). Some countries are struggling with incomplete and outdated data sets owing to their financial issues and skills shortages to collect and maintain comprehensive data sets (Benson et al., 2015).

Communities having little faith in the early warning systems is another challenge in the preparedness stage. This is mainly due to human nature to ignore what appears inconvenient at the time, to a common misunderstanding of the warning messages, or to frustration with yet another false alarm (ESCAP, 2015). Another fact is that a vast number of people simply ignore these warnings due to their cultural perceptions. For an instance, people who believe that the disaster is God's punishment for their sins, are reluctant to leave as per the warnings with the intention of facing the punishment (Cannon & Schipper, 2014). In some cases, the community takes decisions with their previous experiences without knowing the actual risk, believing that there is nothing to fear as they have survived earlier disasters too (Ayeb-Karlsson et al., 2019). Moreover, community participation in the development of early warning systems has not been adequately fostered (ISDR, 2014). Further, the report elaborated that current national monitoring and warning systems deal with multi-sectorial information from government, NGOs and international agencies without having a proper integration in a timely and concise manner that can lead to many problems.

Even though many technology-based practices for disaster preparedness have been introduced, their implementation is not at a sufficient level mainly because of the absence of proper education and training programmes to make aware the community as well as the

practitioners about the importance and usage of those practices (Lin et al., 2018). Policymakers do not pay much attention to disaster preparedness education and as a result, departments, schools and universities do not integrate preparedness education into their systems (ISDR, 2014). Lack of technological and financial resources for educational purposes is a major drawback and scarcity of teaching staff with necessary technological know-how and skills have made the situation worse (Beydoun et al., 2018). Time constraints have become another challenge for conducting drills and exercise programmes since people are reluctant to allocate time for such kinds of programmes from their busy lifestyles (Shiwaku & Fernandez, 2016).

3.9 Contribution of information and coordination systems for overall disaster preparedness approach

The components that have been identified in Sub-section 3.5 are very important since they are the base for designing a holistic disaster preparedness approach for a particular context. However, among these components, information systems and coordination systems play a dominant role since they are the ones that create a logical interconnection between these components and thereby facilitating a holistic disaster preparedness approach. It is clearly evident that all the other components need the contribution of information and coordination systems when considering technological enhancement (Refer Sub-section 3.7).

In order to be prepared for future disasters, the optimal usage of information concerning the situation in a well-coordinated manner is an essential requirement (Meissner et al., 2012). This was further described by Quero (2012) stating that even though all the necessary information related to risk assessments, early warnings, evacuation, education, resource mobilisation are available in the separate institutions, all those information may become useless if there is no strategic coordination system among the institutions and the community to act on them. On the other hand, coordination necessitates contemporary information that must be communicated upstream and downstream between institutions and the community (Meissner et al., 2012). Therefore, this mutual relationship between information and coordination with the overall disaster preparedness approach (including the other six components) indicates the importance of having an efficient information and coordination system that can be utilised for an effective disaster preparedness approach.

The main focus of a particular information and coordination system is to facilitate fast and clear communication among stakeholders including the cooperation of virtual teams and online experts and dissemination of information to the community with regard to disaster preparedness (Yun et al., 2012). In addition, these systems are expected to have the

features for storing information securely since a great deal of confidential data is circulated at the preparedness phase (Turoff, 2019). Further, certain requirements with regard to the usability, availability, stability and reliability of information systems should be fulfilled for the successful implementation of disaster preparedness (Turoff, 2019; Walle et al., 2009). Moreover, Carver (2018) highlighted that these types of information and coordination systems need to have logical and easy-to-understand user interfaces without confusing the users from different educational levels. Considering all the aforementioned factors, it is vital to have a digitally enhanced information and coordination system for the overall disaster preparedness approach while giving prominent attention to the user requirements.

3.10 Development of digital information and coordination system

The development of any kind of information system has a particular methodological process that includes user requirement analysis, system designing, system development, system deployment and system testing as presented in Figure 3.4 (Gillis, 2020).

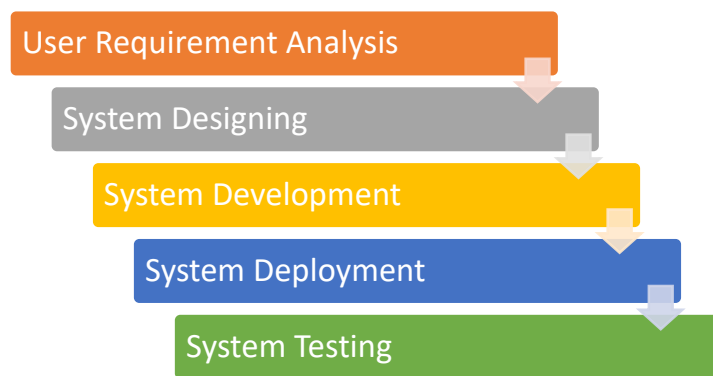


Figure 3.4-System development process

Each step of the system development process is briefly described below.

User requirement analysis- This is the initial and most important phase of system development, where the challenges of existing systems and the user requirements of the proposed system are identified and analysed. Accordingly, the functions and the capabilities of the system are sketched in order to address the existing challenges and the new user requirements (Rajen, 2021).

System designing- Based on the user requirement analysis, the system architecture is designed for the proposed system at this phase (Rajen, 2021).

System development- In this phase, the design documentation is converted into an actual system (Burak, 2019).

System deployment- The developed system is implemented for a particular context according to a well-defined plan (Gillis, 2020).

System testing- The success of the new system is evaluated by identifying the existing errors (Burak, 2019).

Among the above stages, user requirement analysis can be considered as the most important phase that provides the basis for the development of information and coordination systems.

3.11 User requirement analysis as the basis for information and coordination system development

The user requirement is a particular feature or a function that the user of the system needs. The final output of a user requirement analysis can be considered as the overall image of the system from the users' viewpoint (Chakraborty et al., 2012). Since the users are the ultimate target of any kind of system, analysis of user requirements and thereby ensuring that they are fulfilled at the final design is essential for the successful implementation of a system (Subhan & Bhatti, 2015). Among the several methods for user requirement analysis such as data flow diagram, as-is and to-be analysis, use case analysis, user stories and business model analysis (Visual Paradigm, 2021), user stories have been identified as the most popular method (Lucassen et al., 2016; Schul, 2019; Wautelet et al., 2017).

3.11.1 Introduction to user stories

User stories are commonly adopted in system developments in order to capture the user requirements of the particular system (Robeer et al., 2016). User stories are short, simple descriptions of a feature told from the perspective of the person, who desires the new capability from a system. User stories are therefore, particularly well suited to describe digital systems, in which human and organisational aspects play a key role (Wautelet et al., 2017). The user story format has become more popular of expressing user requirements because it focuses on the perspective of the user, who is impacted by the system, it defines the requirements in a simple language that is understandable and it helps to clarify the true reason for the requirement (Aguilar et al., 2020).

Cohn (2004) stated that user stories consist of three components known as 3Cs (Card, Conversation and Confirmation).

Card is a short description of the user story used for planning and prioritising the user requirements. Card follows a standard predefined format to capture three distinct aspects of a user requirement as follows;

- 1) Who wants the functionality;
- 2) What functionality do the end-users or stakeholders want the system to provide; and
- 3) Why do the end-users and stakeholders need this functionality (optional).

These three aspects are captured in a simple textual template to form a running sentence (Robeer et al., 2016). Although many different templates exist, the commonly accepted template for user stories is presented below.

As < **Role**>, I want to <**Outcome**> so that <**Value**>.

Role- User's job role
Outcome- what need to achieve
Value- overall benefit of the activity

The **Conversation** refers to the necessary details around the user story, which help to capture the background of the user requirement.

The **Confirmation** includes conditions and criteria that the user requests from the system for the final outcome to be accepted or rejected (Bik et al., 2017).

The presentation of user stories has several methods while 'user story mapping' is commonly agreed as the most appropriate visual representation of user stories. The user story maps allow the production teams to discuss all the user stories by taking them into a single map and evaluating the importance of each user story. Therefore, in practice, the user stories are gathered following the methodology that enables the user story mapping (Sub-section 2.5.7.2).

3.11.2 User story mapping

User story mapping is the visual representation of user stories that helps the development teams and users to define the final system that will create the most delightful user experience (Foehrenbach, 2017). User story maps are intended to enhance the collaboration among the developers and users of a particular system by providing an overall image of how the digital system flows and fits together. This is very important for system developers because losing sight of the system as a whole is a common challenge

that is likely to arise when utilising a discrete list of user stories (Kaley, 2021). The User Story Mapping Methodology is conducted in several steps. The process is discussed in Sub-section 2.5.7.2 with reference to this study with appropriate justifications.

3.12 Disaster preparedness in Sri Lanka

Currently, Sri Lanka has several agencies to manage disaster-related issues. Department of Meteorology and Irrigation Department monitor the disasters within their expertise while technical institutions are responsible for forecasting and issuing warning alerts (Disaster Management Center, 2014). The National Disaster Management Act was enforced in 2005 after the shocking tsunami, establishing organisations for national to local levels such as National Disaster Management Council, the Disaster Management Centre and Technical Advisory Committees (UNDRR, 2019). Disaster management coordinating units have been formulated at district levels with the aid of army and navy troops.

In the aftermath of the Tsunami in 2004 Government of Sri Lanka paid much attention to develop a holistic disaster preparedness approach by introducing several practices and technologies from time to time (Disaster Management Center, 2014).

A risk profile is maintained with the support of the technical agencies focusing on five major disasters: floods, drought, landslides, cyclones and coastal hazards (UNDRR, 2019).

The National Adaptation Plan (NAP) for Climate Change Impacts of 2016-2025 was designed targeting the main vulnerable sectors such as agriculture, human settlements and etc (Ministry of Mahaweli Development and Environment, 2016). This plan has combined Coastal Zone Management Plan and National Physical Plan together with linkages of climate changes and current institutional frameworks. Moreover, NAP proposes institutional mechanisms with resource mobilisation strategies that can be implemented in a realistic timeframe.

Training and education has been conducted for district and divisional levels to enhance the technical know-how of disaster preparedness practices and technologies. Local government officials, as well as the community members, were focused on these programmes while the management of the rural community is challenged (National Disaster Management Office, 2015).

School-based psychological preparedness programmes are conducted to build up the mental capacity to effectively respond to a disaster focusing the children and women (Khan et al., 2015). In this programmes, the community was educated on basic mental health aspects by psychiatrists, nurses and social workers. The techniques such as yoga

and meditation practices were adopted for the training targeting the Buddhist communities (Srivastava et al., 2017).

3.13 Chapter summary

The literature review strengthens the background of disaster preparedness and the nature of the technological improvements for the enhancement of disaster preparedness. A working definition for disaster preparedness has been developed through a systematic review due to the unavailability of an established definition. The literature has been effectively utilised to discover the importance of digital information and coordination system for disaster preparedness and currently introduced digital preparedness approaches in the global context. Subsequently, the challenges of current disaster preparedness approaches have been synthesised. The status of disaster preparedness in Sri Lanka has been revealed as the foundation to investigate the role of digital technologies in disaster preparedness in the Sri Lankan context.

4 DATA ANALYSIS AND FINDINGS

This Chapter presented a detailed analysis of the collected data through preliminary interviews, documentary review, in-depth interviews and focus group discussion in order to achieve the aim and objectives of the study.

4.1 Data analysis of preliminary interviews

The respondents were initially presented the disaster preparedness components (Risk assessment, coordination systems, resource mobilisation, information systems, development of evacuation systems, early warning system development, training, psychological preparedness) that have been discovered from the literature review (Sub-section 3.5) and requested them to identify the most suitable components that need to be digitally enhanced for the effective disaster preparedness.

All three respondents appreciated the study explaining that this study is much more suitable for the Sri Lankan context since there are several challenges with regard to the current disaster preparedness system. Further, all three respondents have pinpointed that the absence of a robust information and coordination mechanism among the practitioners of disaster preparedness at national, district and divisional levels has become the major challenge compared to the other factors. Further, two of the respondents described that since information and coordination is the component that creates the interconnections between all the other preparedness components, digital integration for information and coordination mechanism is a timely necessity for successful disaster preparedness implementation in Sri Lanka.

Moreover, the respondents advised to review the institutional framework for disaster preparedness and its implementation at each administration level since it governs the coordination process and responsibilities of different authority members as well as the community in terms of information management. They further highlighted that pre-review of the institutional framework will be helpful to select the most suitable users for the digitally enhanced disaster preparedness system in Sri Lanka.

4.2 Data analysis of documentary review

The intention of reviewing grey literature was to establish the perfect understanding of the institutional framework of the disaster preparedness approach and thereby determine the stakeholders who are responsible for disaster preparedness practices. As per the findings of the literature review (Sub-sections 3.5 and 3.7.2) and preliminary interviews, the institutional framework is closely related to information dissemination and coordination while it provides the base for the identification of the most suitable stakeholders who can

be considered as the users of a digitally enhanced disaster preparedness approach. Hence, it was fruitful to conduct a documentary review prior to gathering user requirements.

4.2.1 Details of the reviewed documents

Accordingly, the selected sources are presented in Table 4.1. These sources include Acts, policy reports, planning reports, which have been published by the government authorities of Sri Lanka.

Table 4.1- Details of the reviewed documents

Ref. No	Source Name	Published Year	Nature of the Source
DR1	Sri Lanka Disaster Management Act No. 13	2003	Act
DR2	Disaster Management Policy and Practice in Sri Lanka	2007	Policy
DR3	Sri Lanka Comprehensive Disaster Management Programme 2014-2018	2014	Planning Report
DR4	Sri Lanka National Disaster Management Plan 2013-2018	2014	Planning Report
DR5	A Road Map for Disaster Risk Management	2005	Planning Report
DR6	Disaster Risk Reduction in Sri Lanka	2019	Status Report

The documents stated in Table 4.1 discussed the disaster management approach conducted in Sri Lanka. Since disaster preparedness is one of the phases of disaster management, the same Acts, policies and status reports are applicable to disaster preparedness as well. Further, most of the planning reports are directly related to disaster preparedness since they highlight the planning process at the preparedness stage. Besides, the preliminary interview findings also revealed that there are fewer reports that are specified to preparedness stage commenting as *“since disaster management covers the preparedness stage, having a single policy and institutional framework for overall disaster management is effective”*

4.2.2 Institutional framework for disaster preparedness

The institutional framework for holistic disaster management was established under the Disaster Management Act of 2005 (DR1). Accordingly, the disaster management process including disaster preparedness was implemented based on this Act. The information and

coordination mechanism was developed according to the institutional framework since the coordination structure should be aligned with the command and control.

National Level

The Disaster Management Act mandated the establishment of the National Council of Disaster Management (NCDM) and the Disaster Management Center (DMC) at the national level as stated in DR1 and DR6. The NCDM consists of President as the chairman, Prime Minister as the vice-chairman, Leader of the Opposition, Ministers in charge of twenty subject areas (including social welfare, science and technology, power, police, finance), and chief ministers of every provincial council. According to DR1, the NCDM has the responsibility to formulate the national policy and programmes on the effective usage of resources for preparedness, pre-disaster planning, awareness and training, capacity building and so on. Most importantly, DMC is established under NCDM, whereas NCDM is in charge of assigning functions and responsibilities to the DMC, as well as directing, coordinating and monitoring such operations.

DR1 included the functions of DMC with reference to disaster preparedness as assisting for the development of preparedness plans to NCDM, directing, monitoring and coordinating the implementation of disaster preparedness plans at district, divisional and village levels and promoting research and development programmes. In DR5, it is stated that DMC has to collaboratively conduct disaster preparedness activities with different types of line agencies with regard to the National Disaster Management Plan. Under the Disaster Management Act (DR1), there is a provision for dealing with Non- Government Organisations (NGOs) by the council upon the necessity of their assistance. As exemplified in DR3, DMC needs to share information related to disaster risk reduction at the preparedness stage from the Department of Meteorology (DoM), Irrigation Department, National Building Research Organisation (NBRO) and Agriculture Department. Further, DMC needs to deal with Central Bank and treasury as well in order to ensure the financial availability for preparedness plans. Ministry of Education is also contributing to enhance the awareness about preparedness plans by including the aspects of disaster preparedness to school syllabuses as described in DR5. Likewise, several line departments and ministries are working together to achieve the overall goals of disaster preparedness.

District Level

A systematic institutional framework for the disaster management of district levels has been established with the guidance of the national-level initiatives. Disaster Management Committee has been established at the district level headed by the district secretary. The coordination of the whole disaster management process including disaster preparedness is

conducted through the District Disaster Management Unit that is established in the District Secretariat. According to DR2, District Disaster Management Committee includes elected Members of Parliament of the district, Divisional Secretaries of the district, District Director of Planning, district representatives of the Police Department and heads of government departments such as irrigation, health, water supply, electricity, communication and transport. Further, as stated in DR3, NGOs collaboratively work with district disaster preparedness programmes while taking part in the district committee. The committee under the guidance of the district secretary is entrusted with the responsibility to formulate local disaster preparedness plans and supervise effective implementation with the support of divisional-level disaster management committees appointed in each Divisional Secretariat. The district-level disaster preparedness plans are supported by the staff of DMC. According to DR4, channels of communication have been established from the district level to divisional levels and from the district level to national administration. District Disaster Management Unit consists of armed forces and police officers as well.

Divisional Level

The divisional level disaster preparedness approach is governed by the divisional secretaries as explained in DR2. With the assistance of disaster management staff members at the divisional level, the divisional disaster management committee is established with the representation of the Chairman of the Pradeshiya Sabha (Local Authority), planning officer of the division, technical officer, Samurdhi Managers, Grama Niladhari, Accountant, OIC of Police, eminent people selected from civil society and a representative from a womens' organisation as per DR2. In DR3, it has been specified that the divisional level disaster preparedness activities such as identifying vulnerable areas within the division, formulating divisional level plans, collecting information related to past disasters and notifying the divisional disaster status to the district level are conducted with the collaboration of the divisional disaster management committee.

Grama Niladhari Level

Well-prepared communities are the first line of defense against any natural disaster as suggested in DR5. This can be facilitated by the institutionalisation of grass root level, which can be considered as the Grama-Niladhari and village levels. As per DR2, at the Grama- Niladhari levels, village committees that comprise village officials, community leaders, religious heads and members of local community-based organisations have been established with the guidance of the Grama Niladhari. Every village is connected to the Divisional Secretariat by lines of communication with the respective Grama Niladharis. According to DR3, village-level disaster preparedness plans are developed by the village committees and necessary responsibilities are assigned. It is further highlighted in DR3

that planning of disaster preparedness activities at the village level allows the community to actively participate in the disaster preparedness approach with the assistance of different agencies and thereby develop their capacities to be well prepared for future disasters. With regard to the findings of the documentary review, the institutional framework for the disaster preparedness process can be demonstrated in the following Figure 4.1.

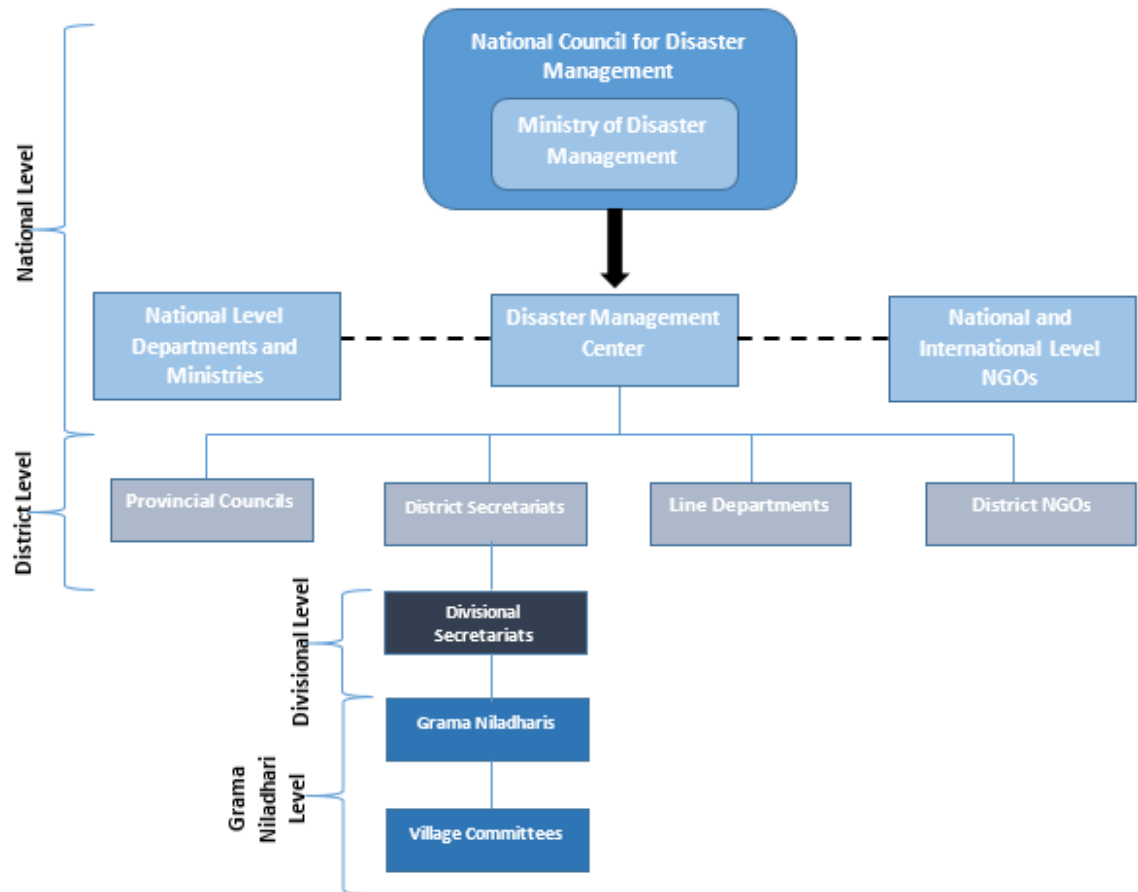


Figure 4.1- Institutional framework for disaster preparedness

As per Figure 4.1, the collective contribution of all the administrative levels in a well-coordinated manner creates a successful disaster preparedness approach in the country.

4.3 Data analysis of expert interviews

Since it is intended to investigate the existing challenges and user requirements for a digitally enhanced information and coordination system that can be utilised by the stakeholders involved in the disaster preparedness approach, there might be conflicting interests according to the different job roles. Therefore, the respondents were selected representing all the institutional levels from the national level to the grass-root level

(National, District, Divisional and Grama- Niladhari) of disaster preparedness to minimise the bias. Respondents were interviewed until the collected data got saturated. In Table 4.2, profile of the respondents has been tabulated.

Table 4.2- Respondent profile

Respondent Code	Designation	Experience in Disaster Preparedness
R1	Assistant Director – Disaster Management Center	12
R2	Staff Member – Disaster Management Center	15
R3	District Disaster Management Officer	8
R4	District Disaster Management Officer	13
R5	Divisional Disaster Management Officer	8
R6	Divisional Disaster Management Officer	7
R7	Grama Niladhari	30
R8	Grama Niladhari	7
R9	Village Committee Member	Appointed to the post 2 years ago
R10	Village Committee Member	Appointed to the post 2 years ago
R11	Community Member	Not Applicable
R12	Community Member	Not Applicable

According to Table 4.2, the experience of the respondents demonstrated their expertise and skills in preparedness in Sri Lanka.

The findings of expert interviews with regard to the disaster preparedness approach in Sri Lanka, user requirements of a digitally enhanced information and coordination system for the disaster preparedness approach and the existing challenges of disaster preparedness in Sri Lanka have been presented in this Sub-section.

4.3.1 Disaster preparedness process in Sri Lanka

The respondents were questioned about the disaster preparedness process in Sri Lanka initially. As per the opinions, the majority of the authority members had an understanding of the disaster preparedness process, its institutional framework and the delegation of the authority.

Initially, respondents were questioned about the importance of a well-structured disaster preparedness approach for a country like Sri Lanka. The majority of the authority members emphasised the importance of disaster preparedness. Accordingly, R1 emphasised that disaster preparedness can be considered as the heart of disaster management. He further cited the parable *“If it is necessary to play a match, the pitch should be well- prepared”* as an example and explained that *“Similarly, if we equate the match to the emergency operation in case of a disaster, the enhanced preparedness approach is just like the well-prepared pitch.”* In addition, R3 described the importance in the economic perspective stating that the investments in disaster preparedness can be several times more worth at the response stage. When analysing the community opinions, about disaster preparedness, the majority accepted that preparing for disasters can minimise the drastic consequences of a disaster. However, there was a confusion about the time frame with reference to disaster preparedness, where some of the respondents among the community believe that the disaster preparedness process starts after the issuance of the early warnings. Supporting to this, R9 who is a village committee member stated that the community believes that without having the early warnings for a disaster in near future, it is useless to make efforts to get prepared for an unforeseen disaster. R2 criticised this perception and proposed that each administration level should work hard to educate the community on the importance of the entire disaster preparedness approach since they are the vulnerable groups, who should combat the consequences of the disasters. Accordingly, Figure 4.2 demonstrates the summary of the findings.

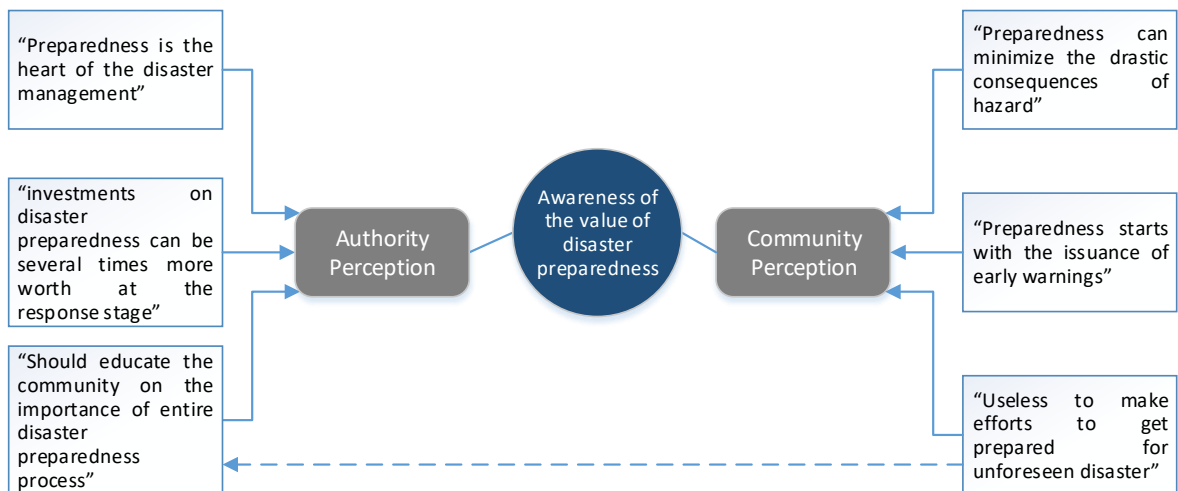


Figure 4.2- Perception on the importance of disaster preparedness

The disaster preparedness procedure, in the opinion of the respondents, is quite similar to the findings of the document review. R4 described that each administration level is

effectively implementing disaster preparedness plans while adhering to the Ministry of Disaster Management's periodic circulars. The respondents at the national level identified disaster preparedness plans as the core of the successful disaster preparedness approach. R2 described as *“the main aim of these preparedness plans is to take the whole administration staff into a central coordination which is very important for a successful disaster management system.”* Acknowledging this, R2 expressed that the disaster preparedness plans include all the disaster preparedness activities that need to be implemented under each administration level such as resource planning, training and awareness programmes, identification of vulnerable communities, identification of evacuation routes and so on. Further, R4 highlighted the importance of developing alternative emergency operation plans apart from the main plan that can be implemented when the main plan got failed due to unexpected circumstances. The respondent further exemplified as *“the national emergency operation plan got delayed in the district level since the majority of the Divisional Secretariats got affected in floods, 2017. So, from the district level, the alternative district plan has to be implemented under the coordination and monitoring of the district secretary”*

Further, the contribution of separate Disaster Management Committees at District, Divisional, Grama Niladhari levels to successfully implement the disaster preparedness approach is appreciated by most of the respondents. According to R5, these committees meet quarterly under normal circumstances and discuss the implementation of disaster preparedness activities. R6 expressed the process of disaster preparedness within the committee as *“All the issues and proposals related to disaster preparedness activities such as resource shortages, preparation of evacuation maps, conducting awareness programmes and technical issues with early warning systems are discussed during this committee meeting. The issues or proposals out of the authority of the committee will be sent to the immediate top administration level.”*

Accordingly, the relationship between disaster preparedness approach, preparedness committees and preparedness plans is illustrated in Figure 4.3.

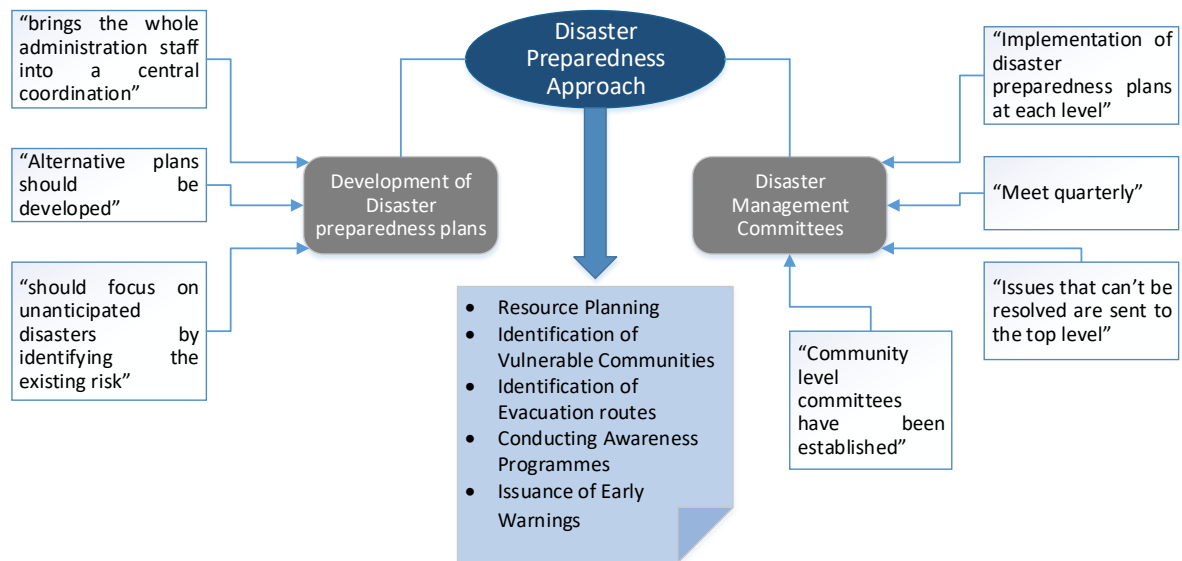


Figure 4.3- Disaster preparedness approach in Sri Lanka

As per Figure 4.3, it is evident that the whole disaster preparedness approach is conducted by two actors; preparedness plans and disaster management committees. The disaster management committees at each administration level follow the preparedness plans and implement the preparedness activities such as resource planning, identifying the vulnerable areas, issuance of early warnings and so on.

4.3.2 Nature of existing information and coordination system for disaster preparedness

The success of a disaster preparedness system depends upon the overall information and coordination system utilised to disseminate information from the national level to the grass-root level. R4 expressed that undisrupted information and coordination mechanisms from the national level to the community level accelerate the disaster preparedness process while enhancing transparency. For example, R5 stated as *“the early warning messages should be passed from the technical departments at national level such as hydrometeorological department through the central coordination system to the bottom levels of institutional hierarchy without being disrupted.”* As per R2, multiple stakeholders from several departments and authorities in each administration level as well as the community members are collaboratively working on the disaster preparedness approach while several types of information are shared between those parties. Hence, R2 emphasised the necessity of each party's understanding of their responsibilities in terms of information exchange as per the institutional framework.

Within the Sri Lankan context, it is apparent that the majority of the respondents knew their responsibility of information management and coordination while implementing the disaster preparedness approach. R5 described that *“We are well aware of our line of authority, the sort of information that should be shared, with whom it should be shared and the frequency with which it should be shared.”* R1 stated that one single mistake of information sharing and coordination in disaster preparedness can result in unexpected negative consequences. False alarms can be taken as an example. R8 shared his experience as *“As a result of a false tsunami alert, the community was panicked into evacuation, resulting several accidents. Consequently, the community has lost their faith in early warnings, which is a serious problem.”* Therefore, it is necessary to have holistic information and coordination system to manage the disaster preparedness approach in Sri Lanka.

When considering the existing information and coordination systems, R2 who is an officer of the national level asserted that they have adopted novel technologies such as video conferencing, satellite systems and Whatsapp messages for information sharing and coordination at the national level. R1 commented as *“Since we are dealing with international agencies while developing national-level preparedness strategies, novel technologies are very much useful.”* Further, R2 expressed that there is a network for Emergency Operation Center that can be used to contact all the parties within a few seconds.

Although few innovative digital technologies are available at the national level, it appears that the information systems are under-developed at the district, divisional and Grama Niladhari levels. The majority of the officers accepted that information sharing and coordination are at the very primary level at district, divisional and Grama Niladhari levels. R3 expressed as *“Many of the decisions are taken through the table discussions and then the decisions and relevant information are shared through the letter communication”* Further, he stated that since the district officers are dealing with a large set of information, few databases have been developed.”

As per the views of respondents at district, divisional and Grama Niladhari levels, the vertical communication and information sharing between hierarchical levels are mostly performed through letters and fax messages. R5 expressed that apart from the letter communications and fax messaging, Whatsapp messaging and telephone conversations have been established for the horizontal communication and information sharing between the officers in the same hierarchical level. However, these telephone conversations and Whatsapp messaging were appreciated by R3, R5 and R8 stating that *“Since we are in a collaborative working environment with our fellow officers, for many instances telephone*

conversations would be sufficient to get the work done.” Contradictorily, R4 stressed that current techniques such as letter communication and telephone conversations resulted in delays in decision-making at critical times. Further, it has been identified at the Grama Niladhari level that the records are still documented manually, which is time-consuming as commented by R7.

When considering the community level, the functionality of information and coordination is insufficient. The village committee members are not involved in the aforementioned information and coordination networks according to R10. R12 expressed as “*we are informed about disaster preparedness activities through Grama Niladharis*”. However, R8 who is a Grama Niladhari explained that due to the unavailability of a proper information and coordination system focusing on the community, they have to personally visit the community members and inform some messages.

The overall behaviour of the current information and coordination system is presented in Figure 4.4.

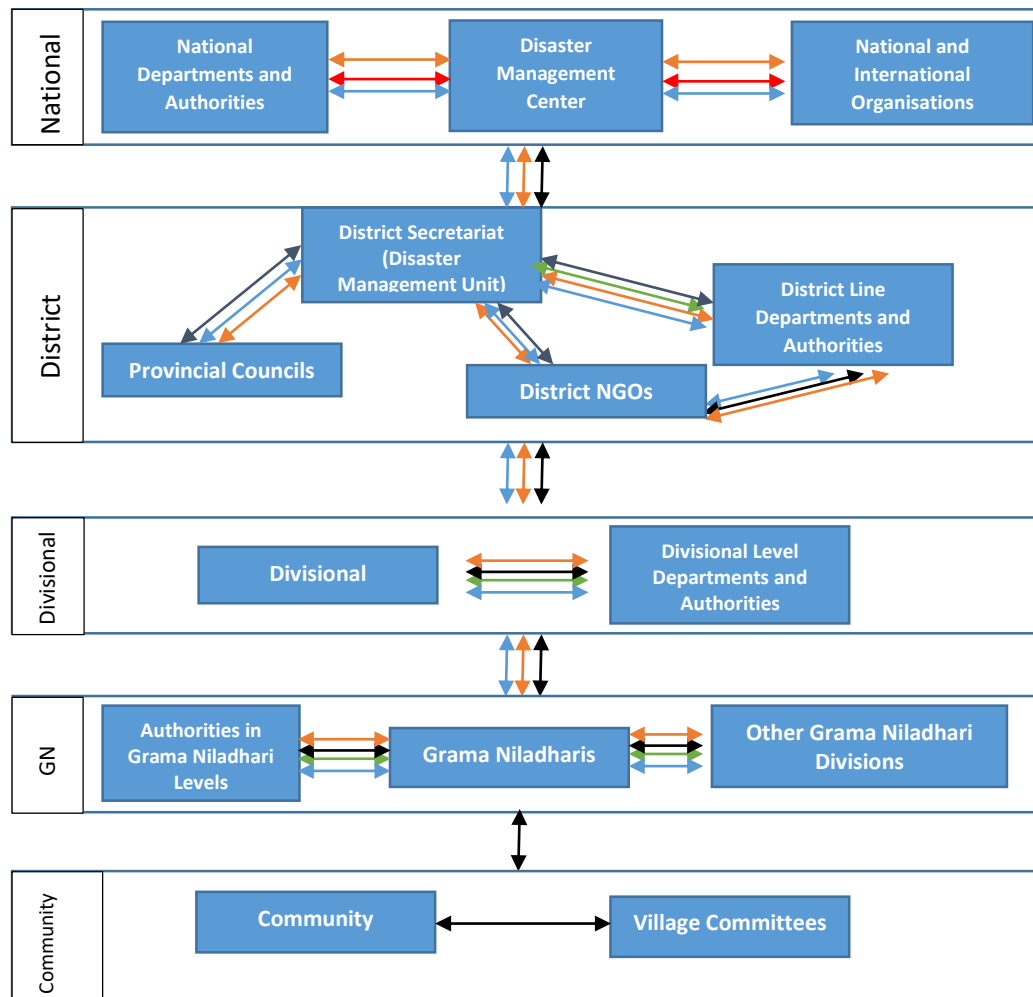


Figure 4.4- Communication mechanisms available for information sharing and coordination



As per Figure 4.4, it is evident that there is no central information and coordination system that can be utilised by all stakeholders who are engaged in the disaster preparedness approach. Further, the unavailability of a proper information coordination mechanism at the community level is remarkable.

4.3.3 Challenges of existing information and coordination system (authority level)

Several challenges have been identified in each administration level with reference to the existing information and coordination systems as analysed below.

Less accuracy

The respondents have opined that there are several issues with the accuracy of the real-time data that they receive from the other administration levels. R1 described that at the national level they expect aggregate information from all the 25 districts and then the decisions and action plans are developed based on those statistical figures. Acknowledging this R2 elaborated as *“a slight mistake at the Grama Niladhari level might escalate to the national level, causing the aggregated data to become inaccurate.”*. The respondents accepted that at the moment, receiving inaccurate data is a critical issue at the national level since existing information systems are less transparent and officers on the ground level rely mostly on manual data collection and analysis methods. Further, R2 emphasised that there is a high possibility of occurring human errors due to the unavailability of proper information analysis systems.

Less transparency

National level respondents highlighted the issues of bottom level information due to the lack of transparency. As a result, R2 assumed that there is a possibility of sharing manipulated data due to the reasons such as political favouritism. For example, there might be changes in resource requirements at the grass-root level due to several external political influences as per R2. Lack of transparency as an issue has emerged from the divisional level as well from a different perspective. Accordingly, R5 expressed that the decisions made by the national level with regard to disaster preparedness should be transparent with necessary justifications. Supporting to this, R6 explained as *“From time*

to time, decisions are made that are outside the scope of disaster preparedness plans. Grama Niladharis, in such situations, question those decisions before implementation because they are only responsible for implementing the disaster preparedness plans”.

Unavailability of centralised coordination system

This is a major challenge of the existing system, which has been arisen from both the top and the bottom administration levels. Accordingly, R1 has pinpointed that there are multiple types of information that have been collected relevant to disaster preparedness components such as risk assessments, resource allocation, education and evacuation in every department and ministry, which are not accessible to the other officers due to several security reasons. He further commented as *“Actions may be delayed as a result of the lengthy process of obtaining authorisation for access to such information.”*. Similarly, R8 who is a Grama Niladhari shared his experience as *“When performing vulnerability assessments, it is sometimes necessary to have the identity details of the vulnerable community. However, we are not permitted to obtain such information from the identification card office without going through a lengthy procedure.”* Therefore, there is a necessity for a centralised platform to access the information that needs to be visible to the necessary parties.

Existing systems are not user friendly

The majority of the respondents expressed that existing systems are not user-friendly. For example, still, the documentations are performed manually at the Grama Niladhari levels. R7 expressed as *“there are several files (hard copies) related to disaster histories, vulnerable populations for each year, resource details and etc. in our office.”* Acknowledging this, R8 claimed that it is extremely difficult to obtain the required information in an emergency and the storage difficulties have arisen as a result of the insufficient space at their offices. As per the opinions of the respondents, these types of manual systems are time-consuming while there is a possibility of losing the historical data due to space limitations. Further, owing to the improper analysis methods, users have faced difficulties in finding out necessary details through the existing systems as per the opinion of R4 who is a district-level officer.

Information is not focused enough

Generally, there are two types of information called macro information (aggregated information) and micro information (disaggregated information), when it comes to disaster preparedness. As described by R1 national level requires macro information while divisional and Grama Niladhari levels require micro information. R3, R6 and R7 have complained that there is a problem with the focus of the information provided by the

national levels. R6 expressed his opinion in this regard as *“most of the information is generalised (macro details) that is not applicable for the small community groups.”* Supporting to this R7 provided an example as there is a necessity of the details of exact risk locations in order to educate the community, whereas generic information reduces the effectiveness of such preparedness activities. R3 also agreed with the aforementioned opinion and indicated that due to these macro details not being specified, they have to bear the losses in terms of time and cost. Moreover, R7 stated the main reason for the dissemination of generic information as the unavailability of a well-established mechanism to collect specified details of every community member at the grass-root level. At the same time, R1 and R2 at the national level appreciated the macro information received from the ground level, which is required for the decision-making process. On the main, it is evident that the details should be provided considering the requirements of each administration level.

Lack of capacity for information management

Another challenge in the Sri Lankan context is the lack of human resources and technological capacity for information management related to disaster preparedness. R3 described this issue as *“there is a significant amount of data gathered on each division at the district level. However, there is no appropriate information management system capable of analysing the information in a useful manner.”* Moreover, R5 highlighted the absence of human intelligence capable of managing this information with the aid of analytical systems. R6 expressed that this issue is experienced by both district and divisional levels, where the disaster relief officers have to conduct the disaster preparedness activities while undertaking disaster relief works as well. R7 proposed that it is better if the data analysts can be recruited for the information management under their supervision, which would aid in the establishment of a disaster preparedness information management system. On the other hand, R2 explained that in order to enhance the technological capacity at the divisional and district levels, a considerable financial allocation is required, which is challenging given the country's present economic situation.

Delays in information sharing and coordination

R4 at the district level has encountered delays in information sharing and coordination, particularly when obtaining essential approvals. In line with this, R3 noted that the approval process of financial allocations for disaster preparedness initiatives is a lengthy process. The respondent further explained through an example as *“if a suitable proposal for disaster preparedness from community level is received, it is necessary to present the proposals to the top administration levels for the approval of necessary finances. The divisional-level finances are then released for the proposal execution. This is a time-*

consuming procedure”. Accepting the R3’s opinion R6 also commented that the bottom-up approach has been demotivated through this lengthy procedure and delays in information sharing. R8 who is a Grama Niladhari stated as *“we had to disregard some of the valuable proposals from the village committees due to the time-consuming procedure for the approvals”*

Inefficiency of coordination and monitoring

This could be seen at the village level. Accordingly, the committee members, who are appointed to initiate the disaster preparedness activities from the community are not actively working at the village level as per R8. One of such committee members (R9) expressed that even though the meetings were taken initially by the Grama Niladharis and district-level officers, such activities were subsequently discontinued and now they only meet if an early warning has been received. This may be mainly due to the inefficiency of regular monitoring of disaster preparedness activities by the authorities. R10 explained as *“Grama Niladharis did not inform us of our committee's future plans and we have no authority to initiate such activities without the permission of Grama Niladhari”*. According to R9, another reason for the inactivity of village committees is that government does not promote this sort of voluntary participation by offering a monthly allowance.

Inefficiency of technical information sharing

The majority of bottom-level respondents stated that the technical information is not properly shared up to their level. R8 implied that technical agencies may feel that lower-level officials lack the technical competencies necessary to understand such information. However, R6 expressed this as *“we have common knowledge and experience with regard to the technical specifics. For example, if we receive the flood level and rainfall statistics on the daily basis from the technical agencies, then we may take necessary actions to alert the Grama Niladharis in case of unusual changes”*

Ineffective record updating

Disaster preparedness deals with numerous historical disaster information, details of vulnerable areas and communities, details of evacuation centers/routes, details of training programmes and etc. that should be regularly updated. However, R7 claimed that the record updating is not properly performed at divisional and Grama Niladhari levels. For example, one of the divisional officers (R5) expressed as *“Some Grama Niladharis update the false information with certain assumptions after observing the historical data without taking the actual information from the villages.”* If this is the case, it will severely affect the decision-making at the national level since the overall decisions are made based upon

these grass root level information as mentioned by R1. However, R8 rejected the aforementioned statement and explained the situation as *“It's true that, in the midst of juggling a massive workload, we occasionally fail to update the records. We are not, however, manipulating data.”* In addition, it is proposed by R8 that the workload of Grama Niladharis with regard to disaster management should be delegated to the village committees in order to effectively conduct disaster preparedness activities.

The summary of challenges in the existing information and coordination system for disaster preparedness in Sri Lanka is presented in Figure 4.5.

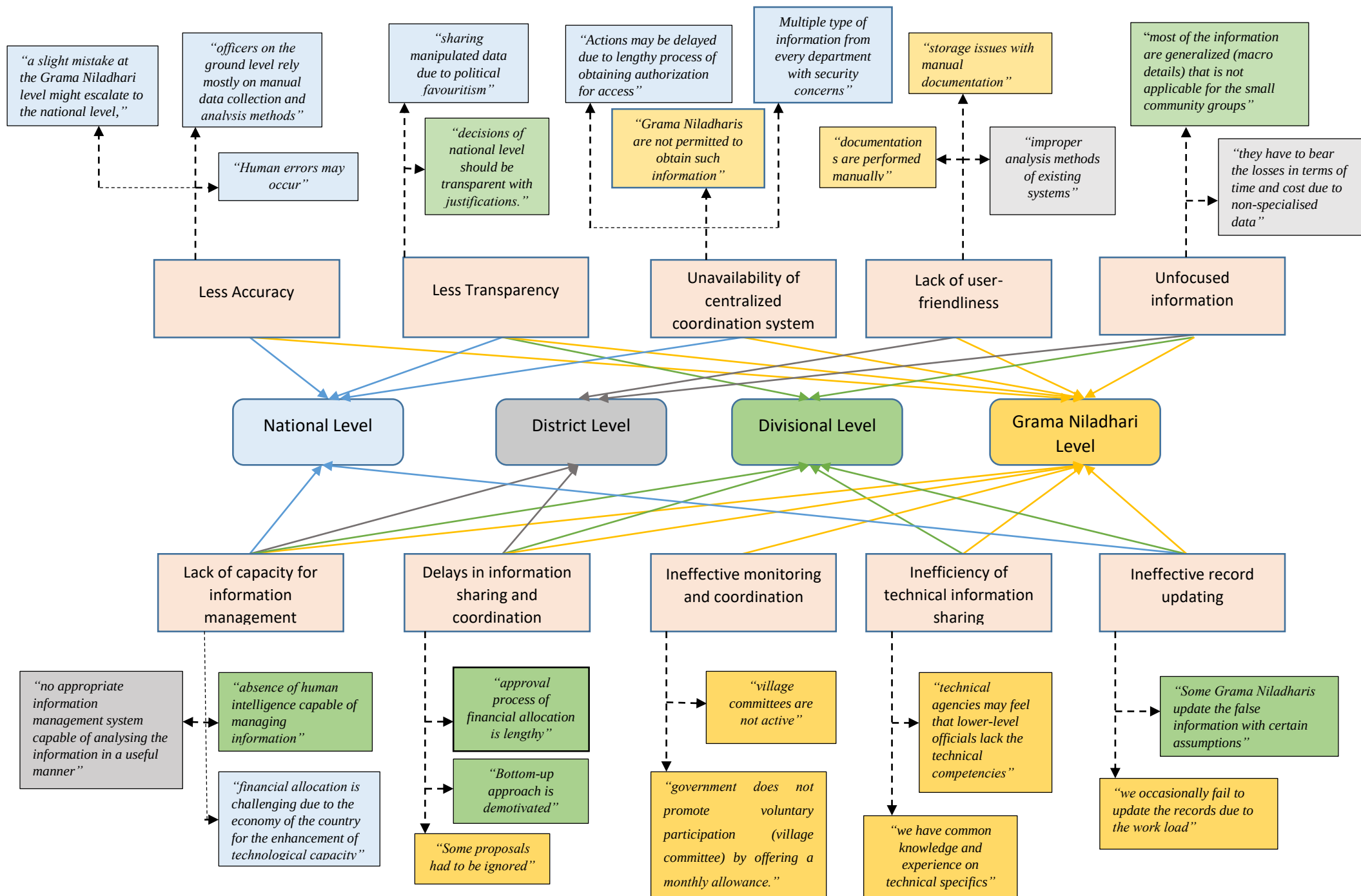


Figure 4.5- Challenges of existing information and coordination system

4.3.4 Challenges of existing information and coordination systems (community)

The absence of a well-structured information and coordination system to conduct disaster preparedness activities is the major challenge that emerged at the community level. Due to this, the community is unaware of the importance and the scope of the disaster preparedness approach as mentioned by R10. R11 explained that some of the community members do not participate in the awareness programmes as well. R8 shared his experience as *“Most of the time, males tend to disregard these programmes and send the women or elders within their families on behalf of them. Since the contribution of males is very much important in disaster preparedness this issue needs to be rectified”*. Therefore, R8 highlighted the necessity of an effective coordination system to encourage and monitor community participation in these types of programmes.

Further, R12 explained that there are issues with resource establishments while the community does not directly inform those issues to Grama Niladharis since they feel that those are not priorities when no disaster is predicted in near future.

According to R11, the community has issues with early warning systems due to false alerts. The respondent further elaborated as *“we have experienced several false alarms for tsunami. We panicked and evacuated numerous times in response to these alarms and it was a great emotional and physical strain.”* Another incident occurred as a result of the absence of an appropriate information and coordination system, that the community was evacuated on the presumption of a real tsunami for an early warning drill, owing to a misreading of the message sent to the community.

When considering the digital information systems, there are issues with resource shortages (mobile phones) and coverage issues as per R11. The respondent further stated that in order to effectively establish information and coordination systems at villages it is compulsory to overcome this challenge at the very first instance. The opinions of the community in light of the existing challenges have been demonstrated in Figure 4.6.

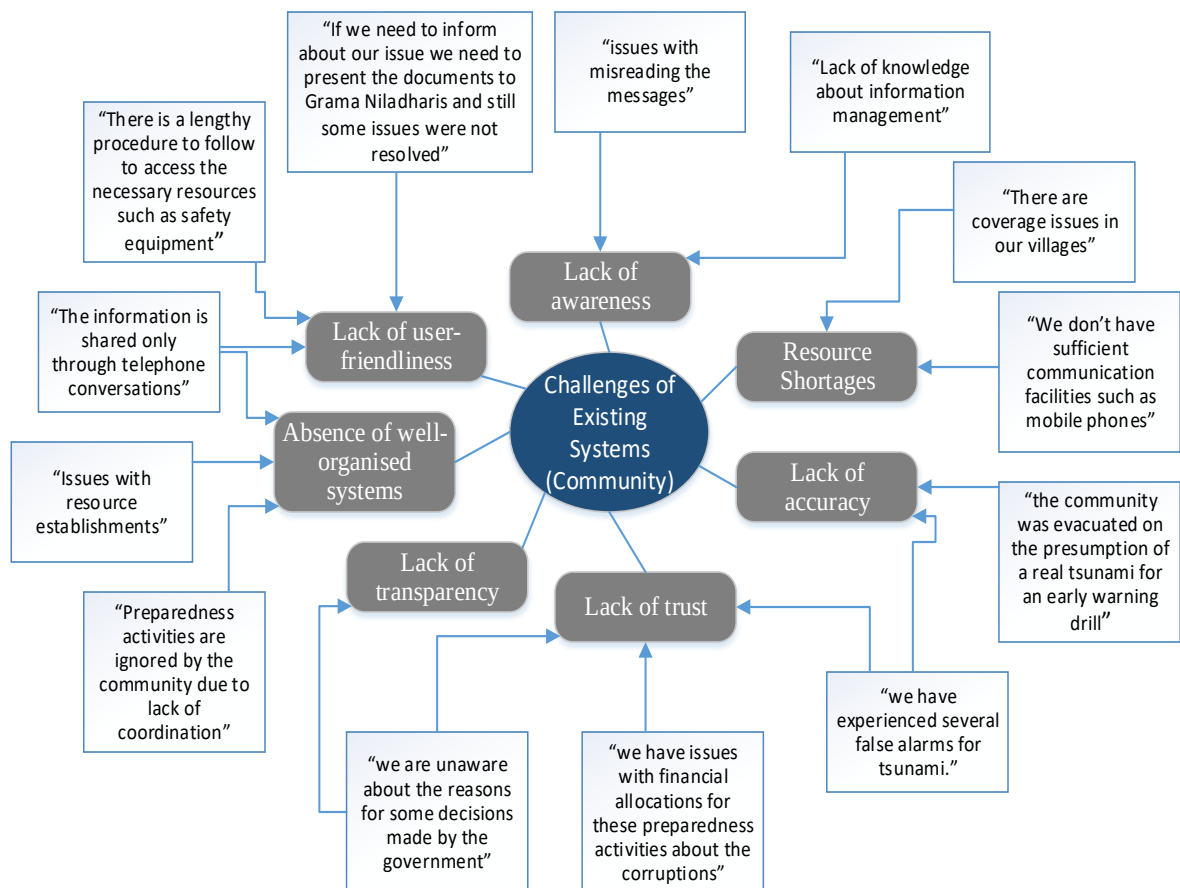


Figure 4.6- Community challenges of existing systems

As per Figure 4.6, the community has issues with lack of trust in the information caused due to false alarms and less transparent decisions, lack of accuracy, resource shortages, lack of awareness, lack of user-friendliness, lack of transparency and absence of well-organised systems.

4.3.5 Overall opinion over the digitally enhanced information system for the disaster preparedness in Sri Lanka

The majority of the authority and the community appreciated the approach of a digitally enhanced information and coordination system. R2 at the national level stated the advantages of digitalisation as *“can have precise aggregate information minimising human errors for decision making”* Further, the respondent expressed that the digital system may assist for the project prioritisation for the effective funding and resource allocation, which has become very difficult to perform at the national level due to human favoritism issues. R2 accepted that even though digital systems have been already established focusing on the disaster response stage, digitalisation is mostly needed for the information management at the

preparedness. R2 elaborated as *“the investments are mainly focused on response. But investments on this type of system in preparedness will be very useful for the disaster risk reduction and effective response”*

Similarly, other respondents of the authority also highlighted the importance of digitalisation. However, R4 expressed that at the grass-root level all the micro details should be focused on; otherwise the system will be useless. R6 stated that digitalisation may help to enhance the regular monitoring of the existing disaster preparedness approaches since it may take both the authority and the community into a single platform. Moreover, R5 revealed as *“Most importantly digitalisation will enhance the transparency of the process and thereby the faith among the communities over the preparedness system will also be enhanced.”* In addition, R8 recommended that this type of system should be mainly focused on the community at the ground level since they are the vulnerable population who have to combat the disasters.

The community members also admired the digital approach stating their opinion as *“this will be a novel approach for us. But it is very helpful for us to be prepared and be educated about preparedness process”* R12 further described the features of a digital system as *“community should have the ability to know whether they are in the risk, what are the preparedness programmes conducted around them, the evacuation centers and the evacuation team that they need to contact, safety precautions that need to be followed through this type of digital system”*

However, both the authorities and the community discovered that even though the digital systems have been developed, it is useless if these systems cannot be successfully implemented at the ground level. To this, R7 added that there are many implementation issues including a shortage of digital technologies on the ground level, coverage issues in villages and the unwillingness of certain community members and senior officers to embrace digitalisation. Agreeing with R7, R3 pinpointed that still there are the authority members who do not have necessary resources such as smartphones and laptops. R3 further elaborated that it is needed to supply those necessary resources prior to implement the digital systems, otherwise, the system would only be limited to the national level. R10 who is a community member highlighted the necessity of education and training programmes prior to implementing these types of systems since the village members have insufficient knowledge about the technology. Supporting to this, R12 opined as *“we know nothing about these technological features. So it is important to educate the unlimited benefits of these systems and provide the coverage facilities to use these systems.”* Figure 4.7 presents the strengths and weaknesses of a digitally enhanced information and coordination system for disaster preparedness.

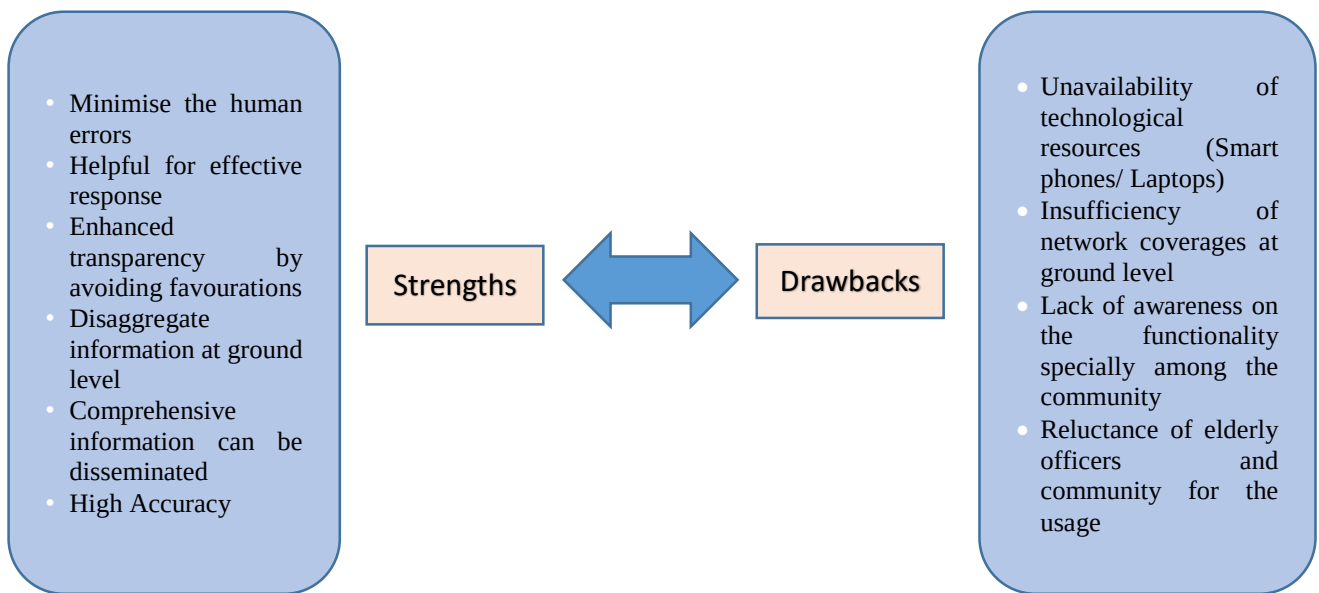


Figure 4.7- Strengths and drawbacks of digital information coordination systems for disaster preparedness

As suggested by Figure 4.7, despite the numerous benefits of digital information and coordination systems, such as increased effectiveness, high accuracy and high transparency, barriers such as insufficient financial, resource and human capabilities must be overcome in order to successfully implement these systems, particularly at the community level.

4.3.6 User requirement analysis for a digitally enhanced information and coordination system for disaster preparedness in Sri Lanka through user stories

The data gathered for the user story mapping process is analysed in this sub-section.

4.3.6.1 Development of the user story map

As per the findings of the interviews the user story maps were developed with regard to each user.

Officers in the Disaster Preparedness Unit in the National Level (User 1)

Initially, the major activities of User 1 were identified to build up the backbone.

According to the viewpoint of R1 the major role of the national level disaster preparedness officers is the **preparation of disaster preparedness plans**. These officers have the responsibility of the development of national plans and other sectoral plans as per the request by the relevant authorities. R1 mentioned a few of the plans that are developed under their responsibility as below.

-Plans specified to the national, district, divisional and village levels for the disaster

management.

- Specific plans such as South West Monsoon operational plans, North East Monsoon Operational Plans
- Sectorial plans for disaster management (Ex- Plans for the health sector, education plans (School safety plans))

R1 further expressed that the composition of each plan is different from one to the other, which requires different types of information.

Another important activity that is related to the planning is the preparation of common guidelines that can be applied to any agency while developing their own plan. R2 described the importance of a common guideline as *“it is difficult to prepare plans for technical agencies since we have less understanding of their operational procedure. In such circumstances, we provide this common guideline and ask them to prepare their own plan”*

In order to prepare the plans, R1 emphasised that multiple types of aggregate information need to be managed. Therefore, these officers have a huge responsibility with regard to **information management**.

Further, the officers should **direct, monitor and coordinate** the implementation of these preparedness plans at other administration levels as per R2. To this, R1 explained that several **communication** methods need to be followed. According to R2, it is their role to receive feedback for the progress of disaster preparedness at each administration level and timely report the matters relevant to the disaster preparedness to the council.

The national level officers need to **deal with international and local non-government organisations** to raise the disaster management funds and collaboratively work for the disaster preparedness approach according to R2. R1 expressed that the management of NGOs is really challenging due to the issues with the collaborative working environment.

After identifying the backbone (Figure 4.8) including major activities, a final user story map has been developed by inserting the tasks with reference to each activity. Figure 4.9 presents the user story map for User 1.

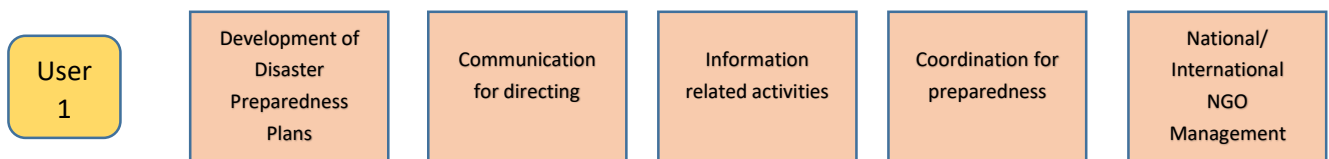


Figure 4.8- Backbone for User 1

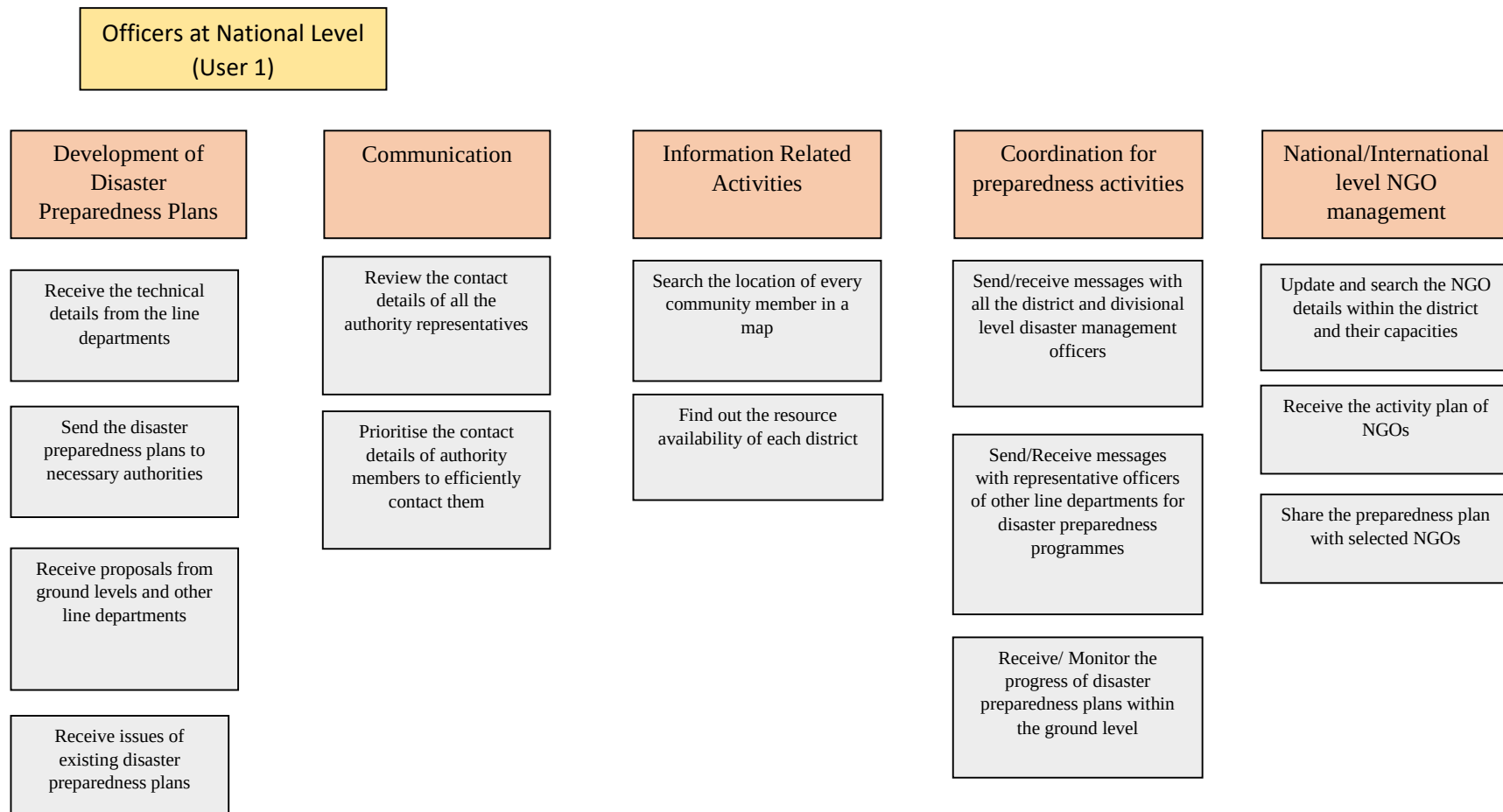


Figure 4.9- User story map (User 1)

Disaster Management Officers at District level (User 2)

The backbone was developed from the identified major activities of User 2 as discussed below.

R3 explained that district-level officers have the responsibility to **identify the hazardous zones** for each disaster within the district. The technical information should be gathered from the district level technical offices such as District National Building Research Organisation (NBRO), District Irrigation Department and so on. Having identified the hazard zones, the district level officers should inform the situations to divisional levels and advise them to take necessary measures as per R4.

The directing, monitoring and coordination of district-level disaster preparedness activities are conducted by the district-level officers. Therefore, they need to **communicate** with officers from other district-level departments and also with the officers at divisional levels. According to R3, the close connection between the officers enhances the effectiveness of preparedness plan implementation.

The **coordination of preparedness activities** is conducted by district-level officers throughout the district as per R4. The progress reviewing of the preparedness activities, providing approvals for the proposals developed at the divisional levels, sending matters of divisional levels to the national level that can't be resolved through the district disaster management committee, preparing budget proposals for the disaster preparedness activities at district level are some of the activities that are conducted under the coordination.

District-level officers identified one of their major activities as **record management**. As per R3, multiple information is received from external parties, which are very useful for future activities. Therefore, the records related to suitable food and medical suppliers, transportation suppliers, evacuation centers, evacuation routes, district level NGOs, locations of pharmacies, hospitals and schools, locations for helicopter landing should be managed properly at the district level. R3 expressed the importance of record-keeping as *“it is true that these records are managed at divisional levels as well. However, we should keep separate records at the district level because disasters can often affect all divisional levels and in such cases having alternate records at the district level is quite beneficial”*

The **planning and monitoring of awareness programmes** at the district level is another preparedness activity performed by district-level officers. According to R4, supervising disaster preparedness drills with the assistance of the national level technical agencies, conducting psychological programmes are the main considerations. Further, R3 elaborated the importance of conducting awareness and training programmes for the disaster management officers within the district as *“It is important to improve these officers' mental preparedness in order to effectively manage catastrophes, as they are the ones who become*

stressed during a crisis owing to the failure to handle the massive workload.”

The backbone for User 2 is demonstrated in Figure 4.10.

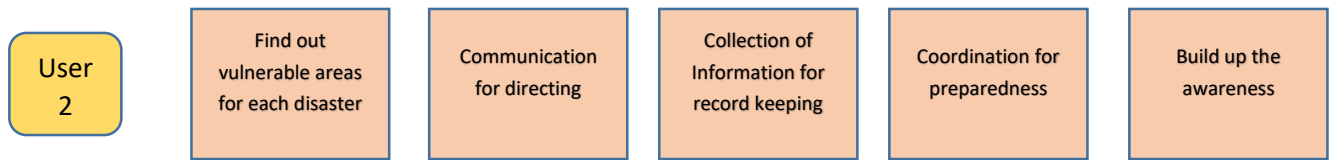


Figure 4.10- Backbone for User 2

After the development of the backbone, the user story map has been prepared as below (Figure 4.11).

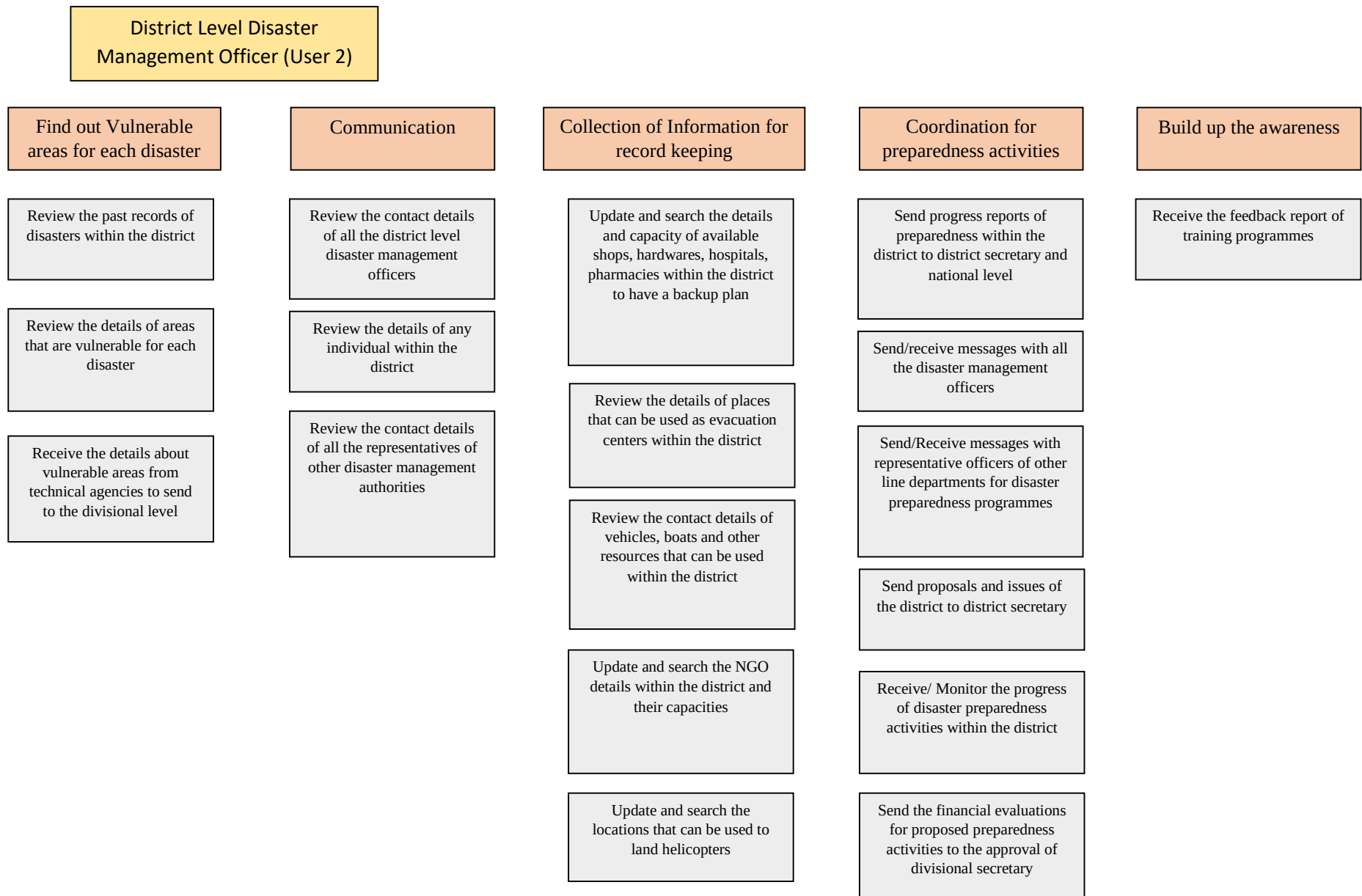


Figure 4.11- User story map (User 2)

Disaster Management Officer at Divisional Level (User 3)

As per the opinions of the respondents, most of the activities are similar to district-level activities. Accordingly, the **identification of vulnerable areas** within the division is a responsibility of divisional-level officers as per R5. Further, **communication for directing, collection of relevant information** (evacuation centers, details of pharmacies, hospitals and schools, details of food suppliers) and **record-keeping within the divisional level, coordination for preparedness and building up awareness** can be considered as the major activities that are performed by the officers with related to the information management and coordination.

However, R6 stated that when considering the enhancement of awareness, divisional level officers have a higher responsibility than district level officers for the coordination and planning of the awareness programmes. Accordingly, the backbone for User 3 is developed as following Figure 4.12.

The user story map for User 3 is presented in Figure 4.13.

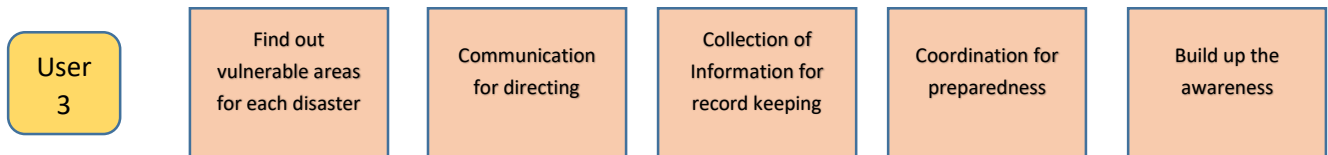


Figure 4.12-Backbone for User 3

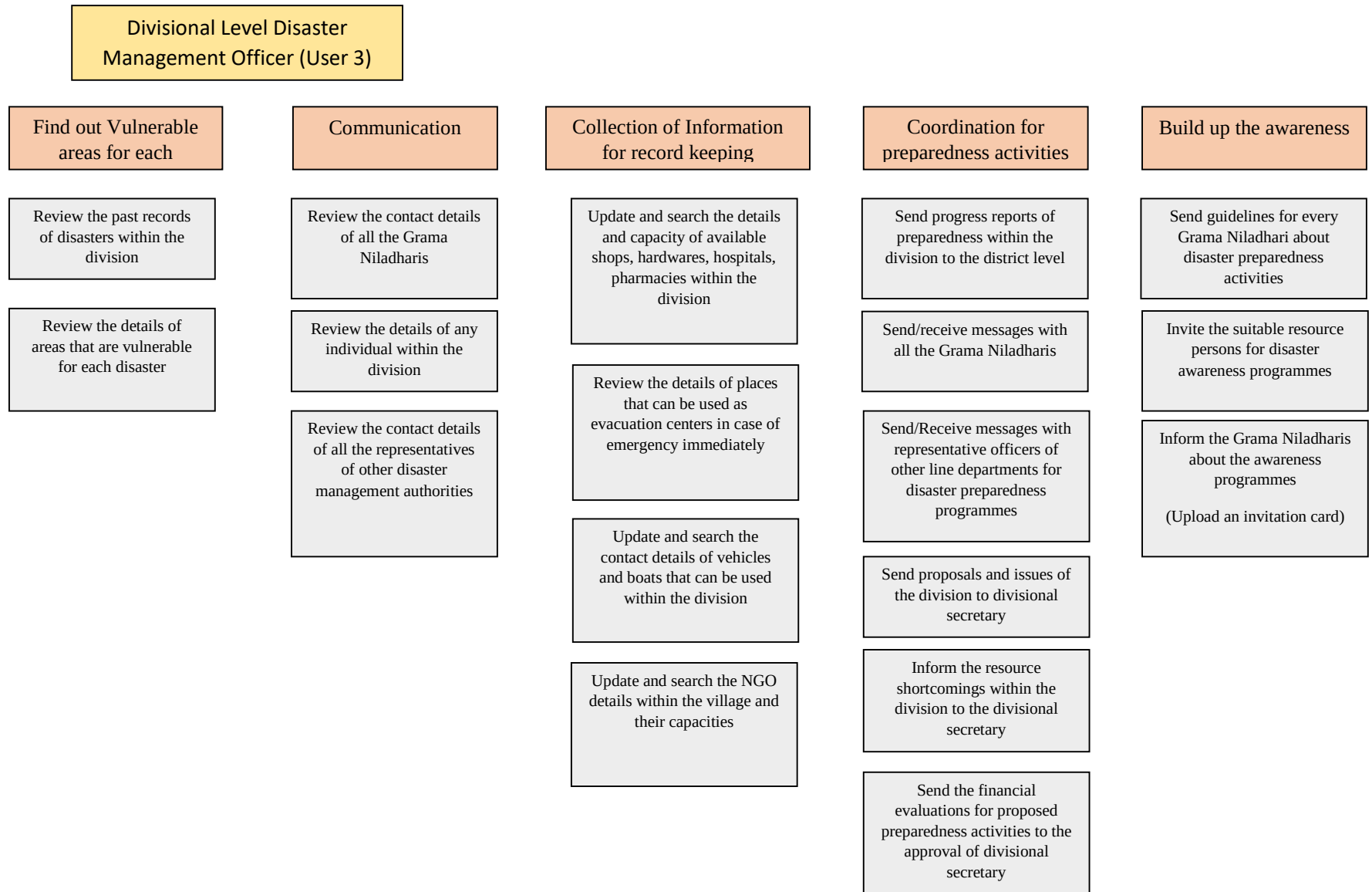


Figure 4.13-User story map (User 3)

Grama Niladhari (GN) (User 4)

R8 stated that Grama Niladharis have a huge responsibility in terms of disaster preparedness since they are the officers who deal with the community directly. Similar to the district and divisional levels, the **identification of vulnerable areas** within the village is one of the major activities that need to be fulfilled by the Grama Niladhari. Apart from that Grama Niladharis should **develop communication maps** within the village that is a specific role for Grama Niladharis. R8 described communication maps as *“these maps show the details of the community groups that are established to act together in case of a disaster, possible contact details of every villager (separately categorising users of landlines, mobile phones and internet). These maps are prepared comprehensively so that every member could detect the details of their communication groups”*.

Apart from the aforementioned activities, Grama Niladharis have a special activity of management of village committees. R7 expressed that the **establishment of village committees**, assigning the responsibilities for them and advising them with preparedness plans are the responsibilities of Grama Niladharis. To this, it is necessary to have educational and professional qualification details of the villagers. The assignment of duties for village committees has been described by R8 as *“the communication responsibility regarding disaster preparedness activities to 10 families are assigned to single committee member”*

As per the findings, other activities such as **record updating, coordination and conducting awareness programmes** are similar to the district and divisional level responsibilities.

The backbone for User 4 is presented in Figure 4.14.

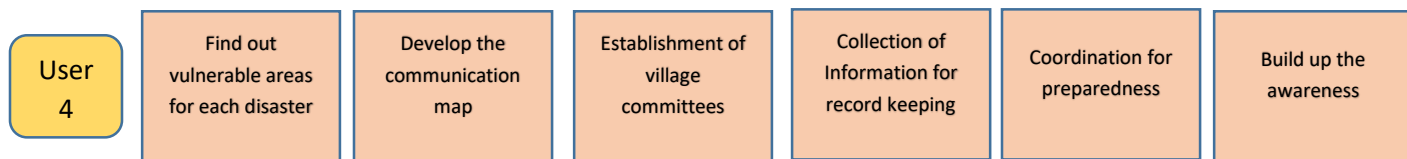


Figure 4.14- Backbone for User 4

Figure 4.15 demonstrates the user story map for User 4.

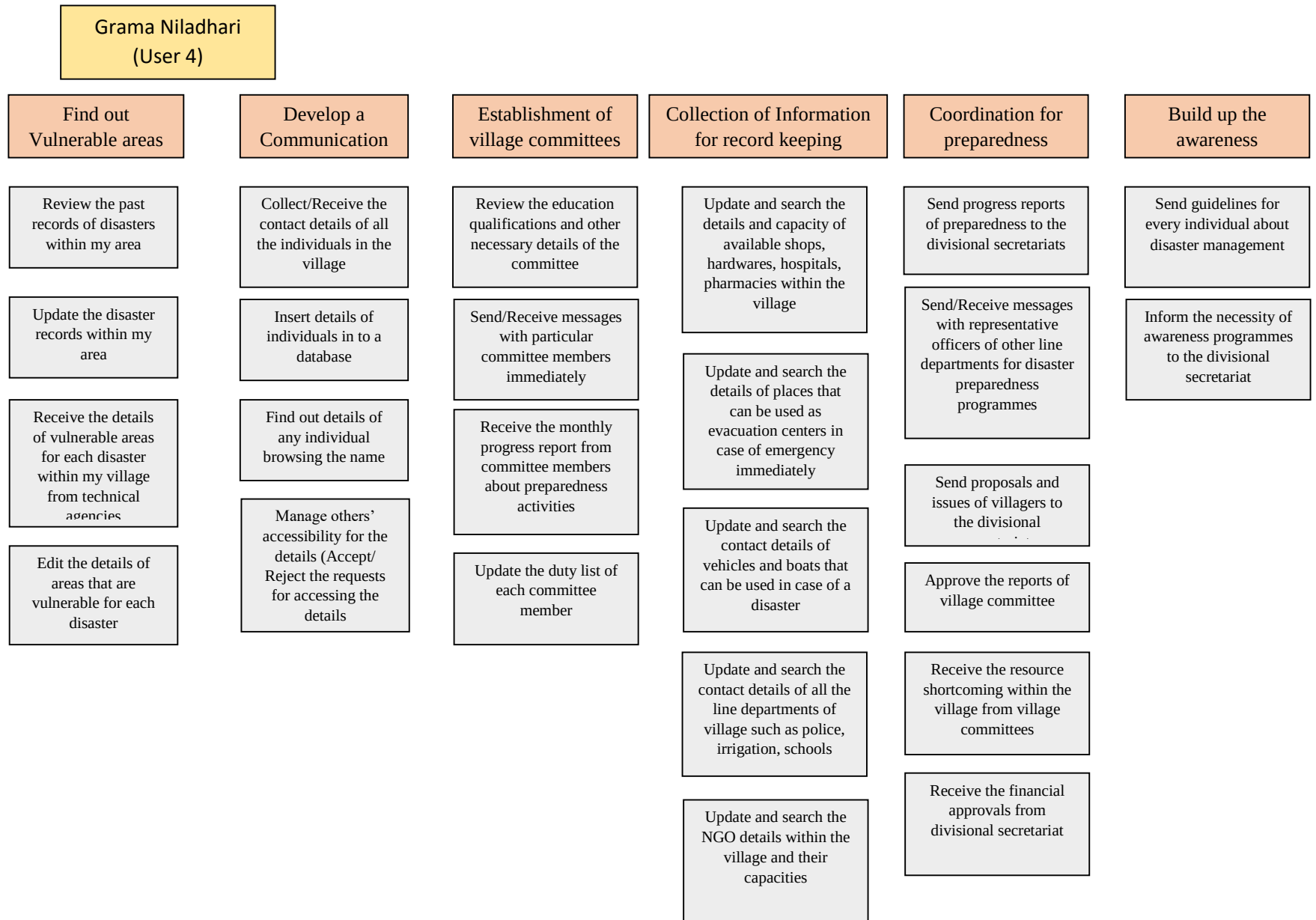


Figure 4.15- User story map (User 4)

Community Member (User 5)

A community member can be considered as the most important user in this proposed information and coordination system since it has been identified the unavailability of proper information and coordination system at the grass-root level. However, the major activities that the community members are expecting from this kind of system are very much similar to the divisional level while the tasks (user-stories) under each activity have several changes.

In terms of the analysis, the **identification of vulnerable areas** is a major activity that community members expect from this type of system. However, the role of a community member in this aspect is different from the role of the authority. As explained by R10, they only need to review the details of vulnerable areas instead of data collection and recording.

The next activity is operating the **communication map**. The community users require to review the maps instead of changing or updating the details. Likewise, R12 revealed that with regard to **information management**, the community needs to have the details of the shops, food suppliers, medical facilitators and etc., which are used for reviewing purposes only. Similarly, **coordination and enhancement of awareness** are the other major activities required by the users of the system while the user stories are different from the authority requirements. Figure 4.16 illustrates the backbone of User 5.

Based upon the above backbone, the user story map was developed as presented in Figure 4.17.

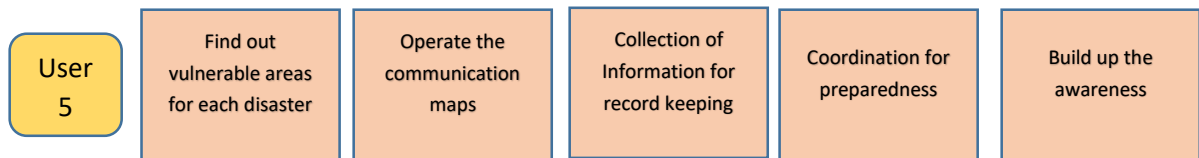


Figure 4.16- Backbone for User 5

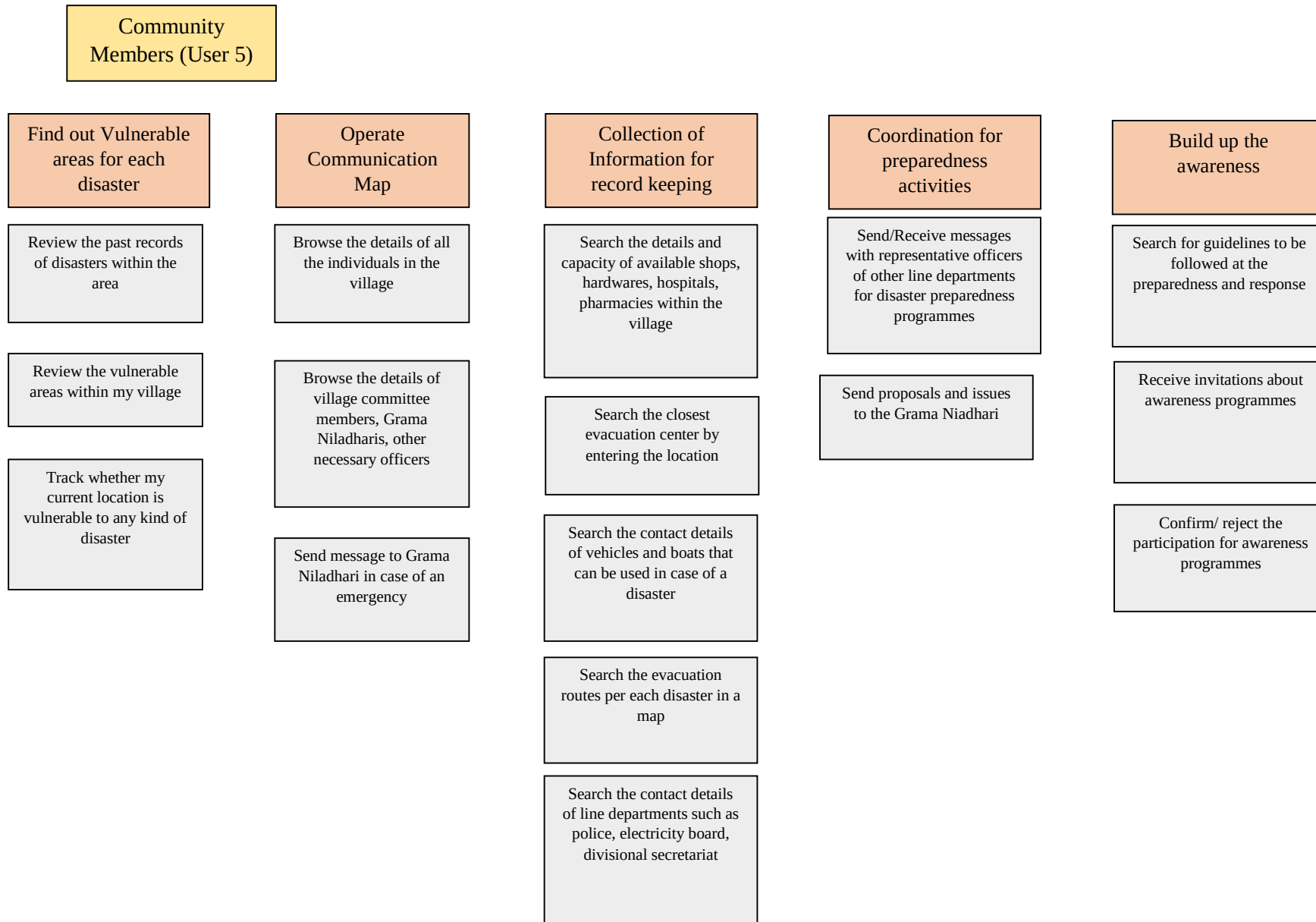


Figure 4.17- User story map (User 5)

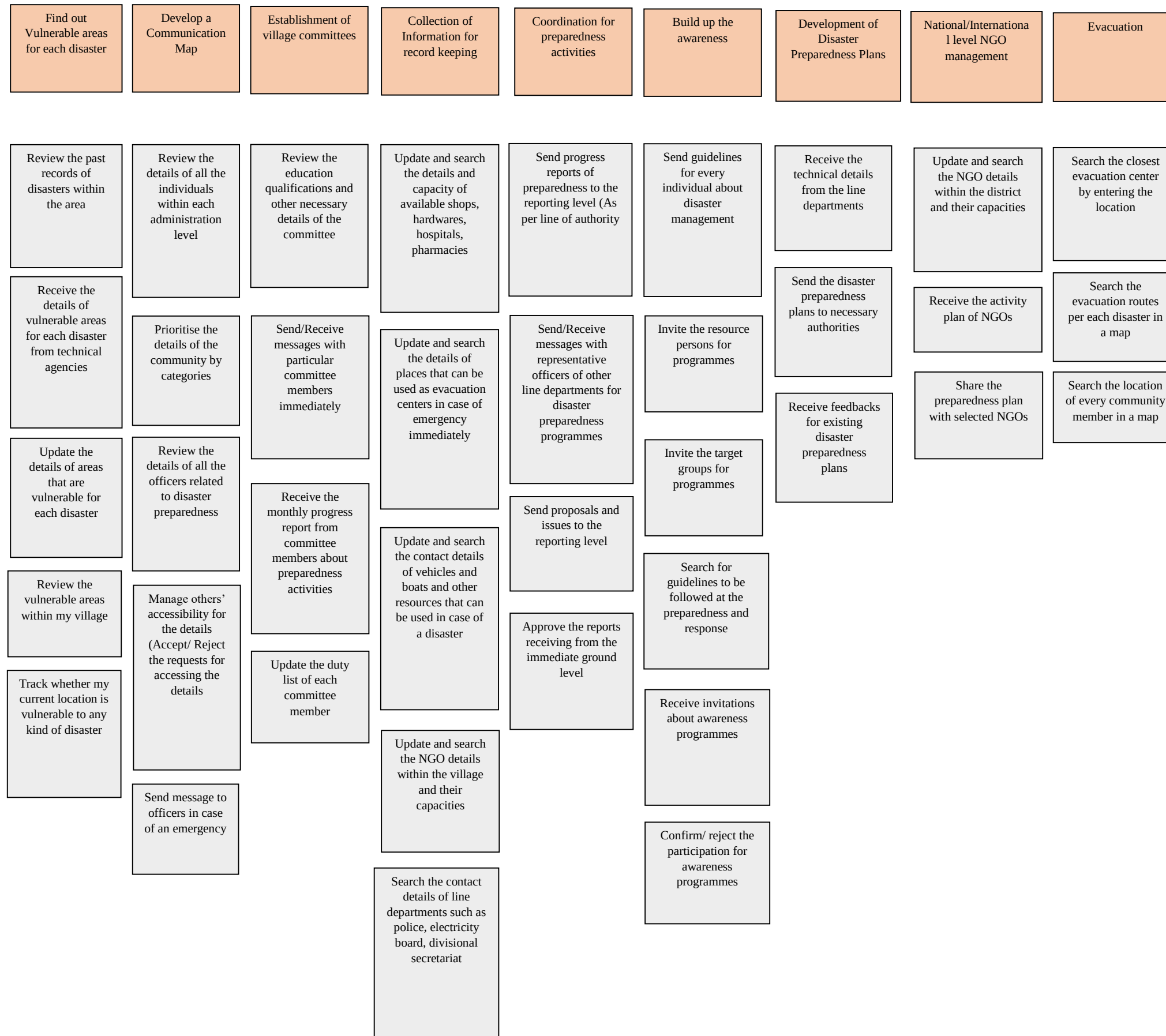


Figure 4.18- Overall user story map to be prioritised

After the close monitoring process, the overall user story map is prepared by integrating all the user stories (Figure 4.18) into a single map. The final user story map considers all the users of the project and the requirements were placed in a well-organised manner. The overall map has been presented for the prioritisation with the summarised user stories.

4.4 Data analysis of focus group discussion

The user story prioritisation has been conducted by a focus group discussion. The participants were chosen to represent a broad range of expertise in disaster preparedness and system development. The participant details of the focus group discussion are presented in Table 4.3

Table 4.3- Participant profile

Participant Code	Participant description	Expertise
FG1	The government officer who is engaged with the overall disaster preparedness process	12 years experience in disaster management activities
FG2	Scientist who researches on disaster preparedness	10 years experience in disaster management activities
FG3	Scientist who researches on disaster preparedness	5 years experience in disaster management activities
FG4	Business Analyst	5 years experience in software development
F	Facilitator	-

The discussion started with the introduction to the study by the facilitator and inviting the participants to provide their opinions about the suitability of the study. FG1 expressed that there is an absence of a robust information and coordination system that can be used by all parties involved in disaster preparedness as well as the general public. Adding to this, FG2 explained that the information and coordination should be properly operationalised from the national level to the ground level community without any interruptions in between. Therefore the group agreed that the development of a robust information and coordination system is a timely necessity for enhanced disaster preparedness.

The developed user story map (Figure 4.18) was then presented to the participants and asked them to categorise the user stories under ‘MoSCoW’ concept (See Sub-section 2.5.7.2). The final output for the user story prioritisation that is obtained from the discussion is presented in Figure 4.19.

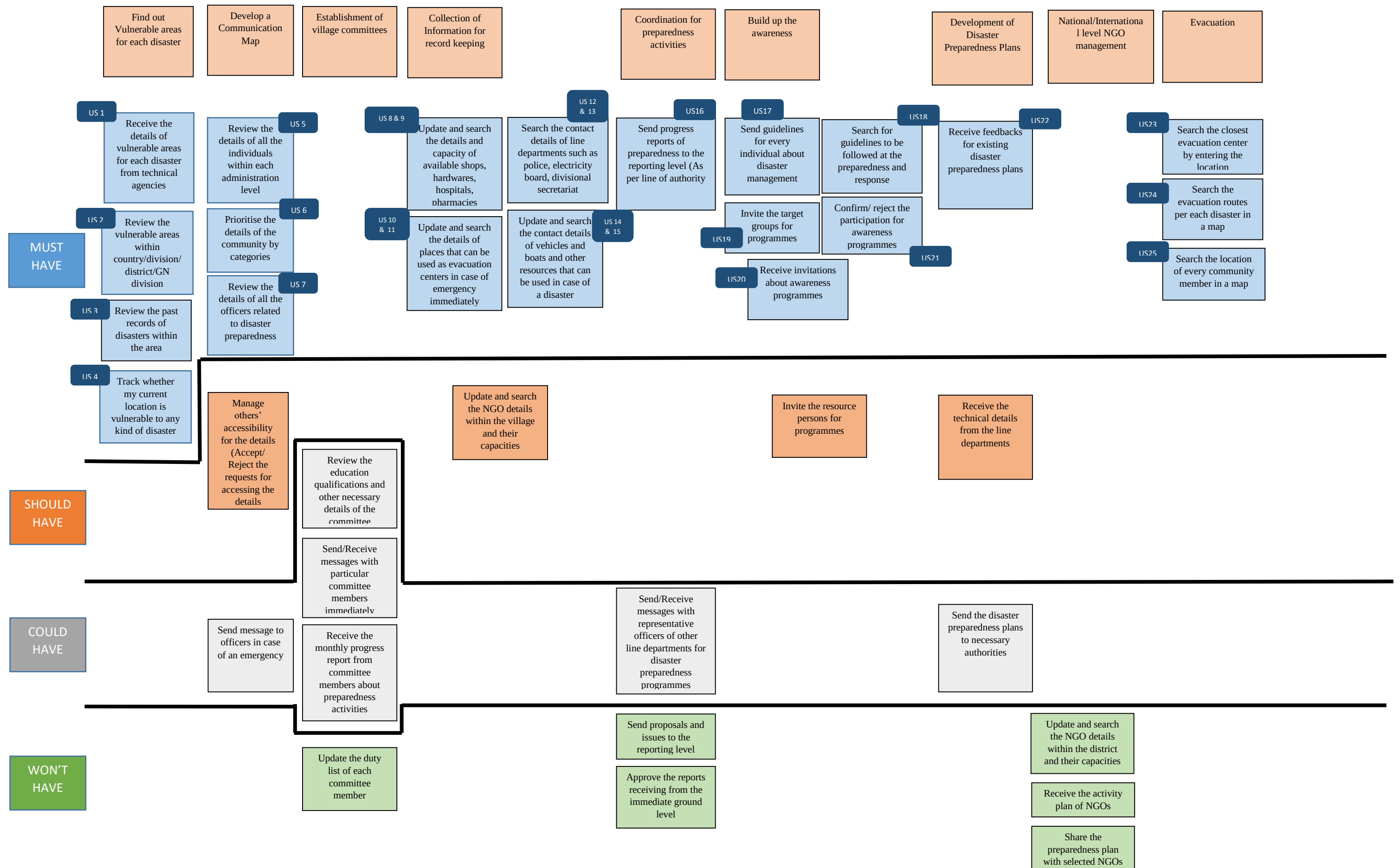


Figure 4.19- Prioritised user story map

As per Figure 4.19, the prioritisation of user stories by the participants was based upon the following discussion.

Find out vulnerable areas

FG1 has established at the very beginning that understanding the risk is of the utmost importance when it comes to disaster preparedness. FG1 further explained that *“initially it is needed to identify and prioritise the risk. Then only we can have the preparedness plans based upon those risk factors”*. Supporting to FG1, FG3 further expressed that after the risk identification the proper solutions are made and even there is no risk, still there might be a residual risk that needs to be addressed. FG2 also agreed with other participants and stated that all the user stories are very important since they are needed to identify the magnitude of future disasters. Hence, all of the requirements were placed in ‘must have’ and ‘should have’ categories.

Communication

All the participants have discussed and placed ‘Reviewing the details of each individual and categorising them’ under the ‘Must Have’ category. FG2 further elaborated that the details such as permanent address, family members, age, name, gender, property details, education level should be kept in this kind of system. FG1 also described as *“This is a timely necessity, if we can take this information from a system, that would be easy for the decision making. Also, the community will be able to know the necessary details of the people around them, which is very effective at the response phase”*. FG3 explained that the ability to review the details through categories that are developed based upon gender, age, marginalisation will also be helpful to find the details easily specially at the decision making for resource allocation and training programmes. FG1 and FG2 stated that ‘Reviewing contact details of the preparedness officers’ is important for the community to easily connect with the authority representatives. Moreover, FG3 explained that initially the officers should be categorised under technical agencies (Irrigation, NBRO, Meteorological), response agencies (Army, navy air force), utility agencies (Electricity board, telecom), community representatives and administrative agencies. Further, management of others accessibility to the details was identified as the ‘Must Have’ item at first and later on FG4 expressed that the privacy and security related requirements for this kind of a system can be separately presented as a non-functional requirement and hence it has been shifted to ‘Should Have’ category. However, all the participants didn’t see much importance in sharing messages with the officers at the emergency from this kind of preparedness-focused system. FG1 expressed as *“there are several such systems that can be utilised at an emergency already”*.

Establishment of village committees

All the participants were agreed to keep the whole set in the ‘Could Have’ category. FG1 expressed that, updating the duty lists, receiving the messages have less importance for this kind of system. FG1 further elaborated as *“when there is a standard operation procedure, we mostly rely upon government officers. Their accountability is tested if we put the responsibility on committee members or political parties”*. Besides, FG3 asserted that since the ground level committees are inactive at present, initially the robust committee structure should be established and thereafter these requirements can be included to the system.

Collection of information for record-keeping

All the participants opined this as another important set of requirements. However, FG2 explained that ‘updating the details of pharmacies, medical authorities and available resources’ should be kept in ‘Must Have’ category while ‘updating hardware and shops details’ should be shifted to the ‘Should Have’ category. Opposing to this, FG3 and FG4 established that all those details should be kept as “Must Have” list since the food and other resource capacities of shops and hardwares within the disaster risk areas should also be known by the community as well as the ground level officers. However, all the participants accepted that details of the medical facilities should be given priority. To this, R4 expressed that in the system developer’s viewpoint all these user stories follow a similar repetitive method while developing the system and therefore including all those details wouldn’t be a matter. However, participants agreed to categorise the ‘updating NGOs details’ under the ‘Could Have’ group. FG1 and FG2 explained this as *“NGOs are currently working collaboratively with us without any issues. Besides, it is impractical to evaluate the NGO details from this kind of system.”*

Coordinate for preparedness activities

R1 expressed that ‘sharing progress reports of preparedness activities’ is very important for the preparation of annual reports and future plans. He further suggested as *“Rather than sending reports, it is better if there is a standard format to fill these details in a system. It is expected to include the number of participants (Categorised as gender-based, marginalised community), spent budget and the description of the preparedness activities”*. Adding to this, FG2 explained as *“for an example, from the progress records of awareness programmes, what we expect is to have the understanding on the number of people who got educated for the preparedness and how will they respond in future events, otherwise the details like a number of refreshments provided are irrelevant.”* However, for the ‘sharing of proposals/issues’, ‘sending messages through this kind of a system’ are not much important according to the participants. FG3 described that while filling the standard format as a progress record is important, all other sharing of messages and proposals are more towards administration rather than preparedness and so may be kept off the table. FG1 also

emphasised that visualising the unanticipated things will be very helpful for preparedness. He further stated as *“this can be done through virtual reality; by the collection of building footprints, flood and landslide information (GIS based) and then digitise them in maps.”*

Build up awareness

All the participants accepted that the development of awareness among the officers and the community is a major intention of disaster preparedness. Accordingly, search for guidelines, receiving invitations, acknowledging the invitations are shifted to the ‘Must Have’ category. Further, FG1 discovered that with regard to the guideline, it is better if specifics such as the magnitude of future possible disasters, what to do at the response, how to go for evacuation centers, whom should be contacted, which items should be taken with you can be visually demonstrated from maps and video presentations. FG1, FG2 and FG3 expressed that ‘inviting for the resource persons’ from this kind of a system is not ethically appropriate.

Establishment of preparedness plans

Participants agreed that there should be a structured protocol to receive feedback on the existing disaster preparedness plans in order to modify them in the future. However, FG1, FG2 and FG3 had doubts about whether it is possible to include them in this particular system. Hence, the decision was oscillating between the ‘Must Have’ and ‘Should Have’ categories. FG4 commented that it can be kept under ‘Must Have’ category and at the development stage, if it is not feasible then can be shifted to ‘Should Have’. Receiving the technical details from the line departments such as river water levels, reservoir status, rainfall, landslide risk maps can be categorised under ‘Should Have’ since it is effective to have such details from a single system even in the future development stage as per FG2.

National/International NGO management

This whole section was moved to ‘Won’t Have’ category with the collaborative decision by all the participants. FG1 expressed that NGOs can be considered as the human salient response for a collective effort, which are more helpful in relief and recovery phases rather than preparedness. FG2 added as *“Even some NGO’s contribute for early warning development and cooperate responsibility, they can only provide the financial support”*.

Evacuation

Having well-structured information about evacuation routes and evacuation centers is also another main expectation from this kind of system as per the opinions of the participants. FG3 added that this is very important for the community for effective evacuation. Further, FG2 highlighted as *“Even a person who is new to the area (not a*

permanent resident in the area) should be able to find out these evacuation routes and the evacuation centers near to him based on his location". FG1 also appreciated the opinion of FG2 and expressed that the system should be useful to tourists and travellers as well.

4.5 User stories selected for the proposed information and coordination system for disaster preparedness in Sri Lanka

As per the results of user story prioritisation in Section 4.4, 'Must Have' user stories have been selected for the initial phase of the development of information and coordination system. Accordingly, Card, Conversation and Confirmation (3Cs- Refer Sub-section 3.11.1) components of each user story in 'Must Have' category have been developed through the interview data. The 3Cs for the first user story are presented in Table 4.4 as below.

Table 4.4- User story 01

User Story Number	US-01
User Story (Card)	As a GN/Divisional Officer /District Officer, I need to receive the details of vulnerable areas for each disaster from technical agencies so that I will be able to develop the preparedness plans accordingly.
Conversation	Technical Agencies- Irrigation department, NBRO, Meteorological department Details- Irrigation Department- Areas vulnerable to floods around river basins, NBRO- areas vulnerable for landslides, meteorological department- areas vulnerable to winds, heavy rainfalls
Confirmation	User needs to select the date and the technical agency from a drop-down and search for their updated daily reports on the disaster risks.

As per Table 4.4, this user requirement has been requested by three users and the further details that are required by the developer to design the user story are presented in the conversation. Confirmation provides the features that the user will accept in the final system with regard to the particular user story. Likewise, 25 user stories were extracted (as labelled in Figure 4. 19) for the system in 'Must Have' category. The remaining user stories are presented in Appendix B.

4.6 Chapter summary

The Chapter presented the analysis of data that were collected through preliminary interviews, documentary review, in-depth interviews and focus group discussion. The synthesis of preliminary interviews emphasised the necessity of a digitally enhanced information and coordination system considering the existing gaps of preparedness approach in Sri Lanka. The document analysis provided the institutional framework of disaster preparedness highlighting the responsibilities of each administration level,

which directed to identify the patterns of coordination and resource persons for in-depth interviews. The disaster preparedness process, nature of existing information and coordination system and the challenges of existing systems were analysed through in-depth interviews. Further, the user requirements for a digitally enhanced information and coordination system to be utilised in the disaster preparedness approach have been identified. The user requirements were presented in user story maps. The user stories were prioritised in order to identify the most important user stories that need to be adopted in the initial system based upon the data analysis of the focus group discussion. The Chapter concludes by providing prioritised user story map that is recommended for the digitally enhanced information and coordination system to be utilised in the disaster preparedness approach in Sri Lanka.

5 RESEARCH FINDINGS AND DISCUSSION

The research was aimed at enhancing the disaster preparedness approach in Sri Lanka through digital information and coordination system. The accomplishment of the aim required to be justified using the analysed data and discussing them by revisiting the literature. Therefore, this Chapter focused on the establishment of the findings by discussing the empirical data with literature.

5.1 Disaster preparedness approach

The findings of the study revealed that satisfactory consideration has been given for disaster preparedness while establishing the institutional frameworks and policy procedures in Sri Lanka. Accordingly, preparedness planning has been treated as the essence of disaster preparedness. According to International Organisation of Supreme Audit Institutions (INTOSAI, 2015) preparedness planning involves determining roles and responsibilities, establishing institutional frameworks and ultimately developing policies and procedures covering the plans for preparedness activities. Similarly, the institutional framework was introduced under Disaster Management Act in 2005 and thereby the roles and responsibilities have been established focusing on all the administration levels (National, district, divisional and Grama Niladhari) as described in Sub-section 4.2.2. Each administration level is empowered with a disaster management committee to implement the preparedness plans. However, the successful implementation of these plans completely depends upon the successful coordination mechanisms following the institutional framework.

According to the primary data, the institutional framework favours a top-down approach in which most of the decisions are made at the national level and then conveyed to the community level via district and divisional levels. This has resulted the lack of community participation in disaster preparedness decision-making, which decreased the capacity of the vulnerable populations to cope with disasters. As expressed by Ibarra, (2015) any meaningful preparedness strategy requires a proper understanding of the vulnerable population; otherwise, significant divides and institutional failures may result. Therefore, many countries have established community disaster management committees to formulate regional disaster management plans and policies (Ishiwatari, 2021). Similarly, these types of community committees have been established under Disaster Management Act in 2005, focusing on the active participation of the community in disaster preparedness planning. However, findings revealed that these community-level committees are not well-structured practically due to the lack of supervision and the attitudes of the community regarding the importance of preparedness. For example, the community believes that disaster planning is pointless if there is no warning of impending disaster. Therefore, it has been revealed that community preparedness planning should be

further developed by enhancing community awareness on the importance of disaster preparedness.

5.2 Role of information and coordination in disaster preparedness

The study identified eight components of disaster preparedness that lead to design a comprehensive disaster preparedness system (Refer Section 3.5) as risk assessment, coordination systems, resource mobilisation, information systems, evacuation systems, education and training, early warning systems and psychological preparedness. The collective contribution of all the components creates a holistic disaster preparedness system. However, empirical findings revealed that among these eight components, information and coordination systems play a major role since it connects all the other components together and ensure the overall functionality of the preparedness system without failure. Similarly, the study of Amyan (2016), also identified that a lack of proper information and coordination can lead to poor planning and failure to reach the essential target groups with preparation activities. Proving the statement, it has been identified that many of the disaster preparedness approaches are not properly communicated to the vulnerable community in Sri Lanka due to the gaps in coordination and information sharing from the national level to the community level.

Disaster Management Center (2020) stated that there are few information management systems in Sri Lanka such as DesInventar with an emphasis on risk assessments, historical data analysis and early warnings. However, the findings suggest that there is no holistic information and coordination system that can be utilised to combine all the disaster preparedness components together for successful outcomes. Further, in the current context, findings highlighted the importance of technological innovations such as geographical information systems, remote sensing and satellite communication to be integrated into these information and coordination systems for having high quality and highly accurate outcomes.

5.3 Challenges for existing information and coordination systems

Authority level challenges

The findings revealed that the challenges of existing information and coordination systems have been affected to different administration levels in different manners. This might be due to the differences between the nature of data that are circulated among these administration levels. For example, the inadequacy of detailed information (Disaggregate data) was a gap that was identified at Grama Niladhari level whereas, the national level had issues with the accuracy of aggregate information that is provided for the decision making. To this, Gonzalez and Bharosa (2009) described that many of the failures of information flows between different administration levels resulted due to the unawareness of authority members on the data requirement of other

agencies; as a consequence, the nature of the details that need to be filtered or added for another organisation for their utilisation is unknown. Similar example can be taken from Fiji where intra-government information sharing has become challenging because it is always not known who needs to know what (International Strategy for Disaster Reduction, 2015). Further, Black et al. (2003) justified that this could be mainly due to the unavailability of well-defined formats at each level to avoid arbitrary data that hindered coordination both in vertical and horizontal directions between organisations. Another key challenge that resulted many issues between administration levels while sharing information and coordination in Sri Lanka is the lack of trust among the members of different administration levels. This was elaborated by Bharosa et al. (2012) as, since the information on disaster preparedness is a valuable asset for any organisation, the fear of information being used against the organisation's interests, mistrust of the source of information and lack of confidence in other organisations' ability to protect critical information can be the reasons for ineffective data sharing between organisations at various levels of administration.

In addition, primary data revealed many of the problems with existing systems, such as lack of accuracy, transparency and efficiency in data analysis, that have been identified to be caused by the use of manual data collecting, record keeping and analytic methods. Non-computerisation of data and lack of usage of technological tools for data analysis and record keeping have resulted the popularity of manual methods among the authority members that are time and cost-consuming (Baskerville et al., 2014). Furthermore, lack of technology knowledge of officers inhibits them from using technological instruments for data administration, giving manual approaches an unnecessary advantage. This has been pinpointed by International Strategy for Disaster Reduction (2015) and stated that lack of financing for technological capacity development at organisational levels has become a major concern in developing countries that need to be addressed in near future.

On the other hand, there are some instances in information management when technical instruments alone will not be able to complete the task without the assistance of human intellect. For an instance, in disaster predictions, the situations may change frequently and their cause-effect relationships should be closely monitored and analysed by the dominant involvement of human expertise (Gonzalez & Bharosa, 2009). In addition, Gonzalez and Bharosa (2009) expressed that disaster management officers have the responsibilities of keeping track of the inflow of disaster information from multiple resources and making critical decisions throughout the preparedness planning phase. Besides, since disaster preparedness deals with too much information including historical data, prioritisation of important information for further analysis needs human intervention (Nishida et al., 2013). Therefore, improved human resource capacity for information management and coordination is compulsory; however, in Sri Lanka this human resource capacity is not at an adequate level. The literature findings

revealed that the non-availability of an appraisal system to reward, monitor and distribute the workload, insufficient training and education may negatively affect for the capacity development of human resources (Gryszkiewicz & Chen, 2010; Smilowitz & Dolinskaya, 2011).

Contradict opinions on the officers in different administration levels could be observed from the empirical findings with regard to data manipulation. This has been caused by the lack of transparency at ground level information collection and analysis with the concerns of accuracy. Similarly, data manipulation in grass root levels is a common scenario as per the findings by Shahid et al. (2014), with the aim of having personal benefits through political agendas and kinship.

Many of the literature findings accepted the non-availability of centralised information and coordination systems as a key challenge for successful coordination in disaster preparedness due to the multi-organisation collaboration (Fisher & Kingma, 2012; Khawaja & Xinhai, 2013; Morelli et al., 2010). The findings from Iran explained that suggestions of different coordinates by different information systems have delayed decision-making processes in disaster planning (Fisher & Kingma, 2012). However, it has been suggested by Shahid et al. (2014) that there should be a standard security system for a centralised system that controls the accessibility to the data since very valuable and confidential information will be stored in such a system.

Another key finding of the study is that almost all the challenges of existing information and coordination systems are directly affected to the Grama Niladhari levels, which is the bottom layer of administration levels. Since Grama Niladhari level is directly connected to the community level, these challenges critically affect the information and coordination of the community level as well. Furthermore, issues in ground levels such as inadequate monitoring and coordination, as well as inefficient technical information sharing, have hampered the engagement in decision making by the bottom-level officers who are well-versed in community perspectives. This may discourage the bottom-up approach, causing critical demands of vulnerable communities to be overlooked in preparation planning. A similar fact has been pointed out by Maiers et al. (2005) through their study in Kenya and Ethiopia. Maiers et al. (2005) expressed that there is a disconnection between the systems mandated at the national level and the availability and the usability at the ground level. Further, they highlighted that it is easy to mandate the preparedness plans from the ground level to the community since national levels have less understanding of communities.

On the main, it can be deduced that the existing challenges should be addressed considering the nature of data required at each administration level. Further, the enhancement of financial, technological and human resource capacities of each level will help to overcome most of the challenges.

Community challenges

Preparedness is a key factor in a community's ability to successfully respond to a disaster. Since the community is the target population of the overall disaster preparedness approach, ensuring all the preparedness-related information is properly disseminated to the community and all the preparedness activities are well-coordinated at the community level is the ultimate goal of a successful disaster preparedness mechanism of a country. Therefore, community challenges of existing information and coordination systems were separately investigated and discussed in the study.

The survey conducted in Sri Lanka recently identified that awareness of the community on disaster preparedness seems to be low due to the fact that the information of preparedness plans is not properly communicated among the population (Steele et al., 2017). As per the same study, even though the authorities claim that a large population is covered by the existing information and coordination systems, only 34% were aware on how to successfully respond to disasters.

According to the empirical findings, the major challenge has been identified as the absence of well-organised information and coordination system at the community level. This is mainly caused by the lack of resources such as communication sources and coverage facilities. The same issue has been highlighted by Nasreen et al. (2014) from Bangladesh where volunteerism was adopted for the assistance and they were unable to process with coordination owing to the lack of technological resources at the community levels. In her study, Perry (2010) expressed that both the information and the resources to carry out the preparedness measures are unequally distributed throughout the society.

In addition, even though several systems have been developed to enhance information dissemination at the community level, the practical adoption of those systems was unsuccessful due to the unawareness of the community on the usage and the importance of these systems. This issue has been emphasised in the study of Bangladesh as well, where the community members were unable to understand the messages disseminated by the indicators of the existing information and coordination system (Choudhury et al., 2019). Similarly, empirical findings show some incidents that community members in Sri Lanka also misread the information and got panicked about the evacuation training programmes, anticipating a real crisis.

Further, it is worth noticing that some of the loopholes in the existing systems have caused cascading effects that ultimately resulted many issues among the community. For example, lack of accuracy and lack of transparency lead the community to distrust the information provided by the government and thereby the community avoids evacuating at the pre-disaster phase. These types of incidents may cause an escalated risk for the community. Similarly, in the earthquake in L'Aquila, Italy, the initial early warning was incorrect and the people who evacuated unnecessarily no longer trusted

the institutions, which led to the rejection of evacuation when the actual alert was broadcast (Torpan et al., 2021). On the other hand, Choudhury et al. (2019) pinpointed that some communities trust their local knowledge and experience on the disaster predictions rather than the information provided by government technical institutions.

When considering the identified challenges from both literature and empirical findings, it is imperative to identify concrete solutions for community-related challenges of existing information and coordination systems as well for a successful implementation of disaster preparedness.

5.4 Appropriateness of digital information and coordination systems for disaster preparedness

In the global context, there is a growing concern about the use of digital information and coordination systems for the disaster preparedness activities such as preparedness planning, development of early warning systems, evacuation system development and so on (Md Hassan, 2015). However, Wattegama (2017) noticed that developed countries have been able to minimise the damage from disasters through enhanced preparedness with the timely integration of digital technologies while developing countries still struggling with these technological adoptions.

As a developing country, the appropriateness of digital information and coordination systems to the Sri Lankan context has been investigated through the study. Accordingly, the findings revealed that many of the existing challenges such as lack of accuracy and transparency, inefficiency in technical information management, ineffective updating and record-keeping, delays in information sharing can be overcome through the enhancement of digital integration to the existing systems. Accordingly, reduced human errors, enhanced transparency that avoids favours, comprehensive information dissemination, high quality of information, user-friendliness were identified as the benefits of digital systems for effective disaster preparedness. Supporting to the empirical findings, literature findings also discovered the importance of digitally enhanced information and coordination systems that can be utilised for disaster preparedness. As per the literature findings, Schempp et al. (2019) described that the conversion of traditional data sources into digital sources has improved the distribution of information between hospitals, evacuation centers, government authorities and communities effectively. In another instance, Kirac and Milburn (2018) adopted a digitally enhanced data system in Haiti to the logistic planning at the disaster response which was very successful. In another study by Brenda and Elizabeth (2016), the benefits of wireless technologies were emphasised to the improvement of awareness specifically focusing on the marginalised community.

Even though there are many advantages of the digitalisation of information and coordination systems for disaster preparedness activities, few of the loopholes in the Sri Lankan context have hindered the adoption. As per the primary data findings, the absence of technological, financial and human resource capacities specially at local levels is the major reason for the slow adoption of these digital systems successfully. To this, AlHinai (2020) added that no matter how technologically advanced systems can be introduced, they are useless at the implementation stage without rigorous functionality, accessibility and capability. Accepting this, empirical findings highlighted that although digital systems were introduced through disaster preparedness plans by the national level, the implementation of those systems is unsuccessful at the ground level due to the aforementioned incapacities. Steele et al. (2017) further elaborated that successful implementation of these systems depends upon the level of financial investments by the government with the assistance of international funds and NGOs.

On the main, it is evident that integration of digitally enhanced information and coordination systems for disaster preparedness is a timely necessity in the Sri Lankan context, while it is imperative to overcome technological, financial and human resource barriers for ensuring successful implementation.

5.5 Framework for a digitally enhanced information and coordination system for disaster preparedness

As per the user requirements for a digitally enhanced information and coordination system that can be utilised for disaster preparedness, the framework of such a system has been developed as per Figure 5.1.

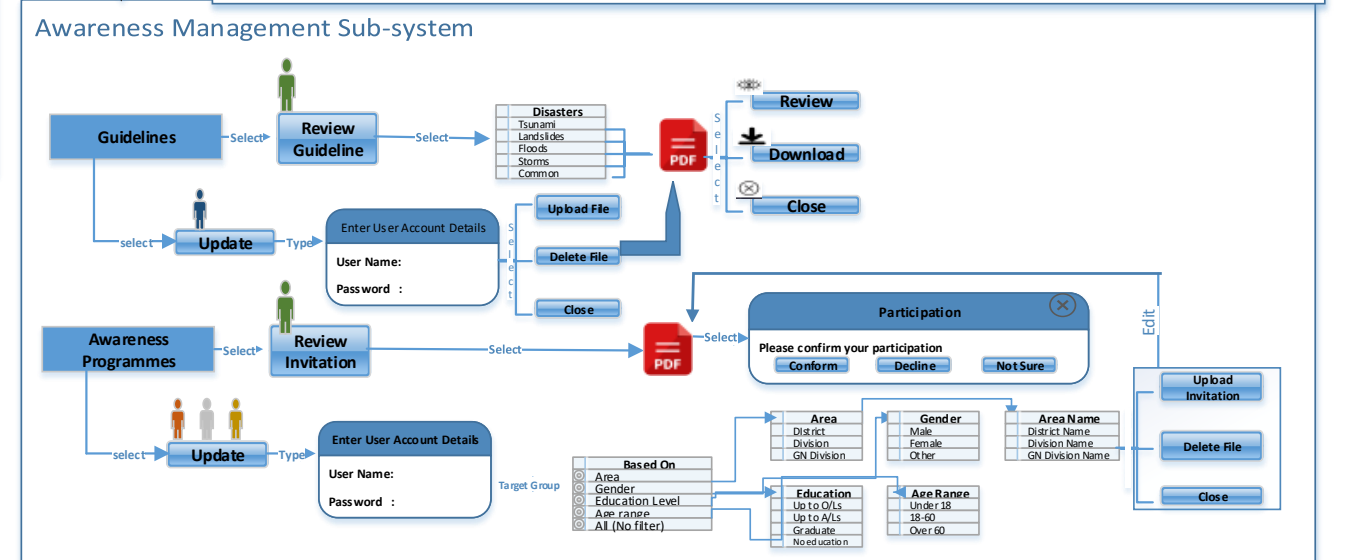
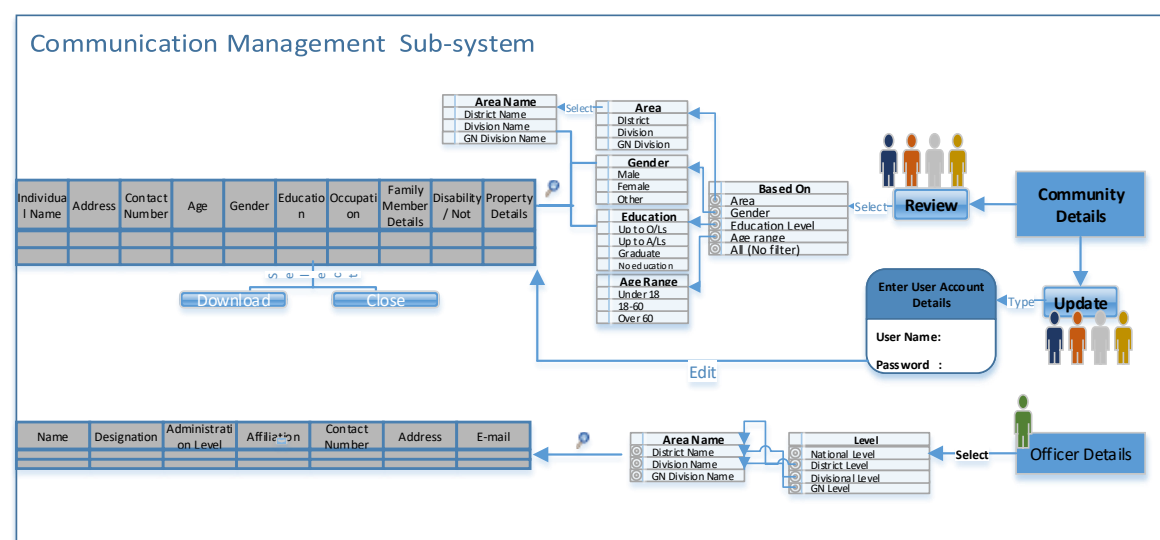
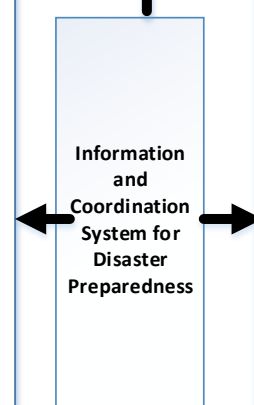
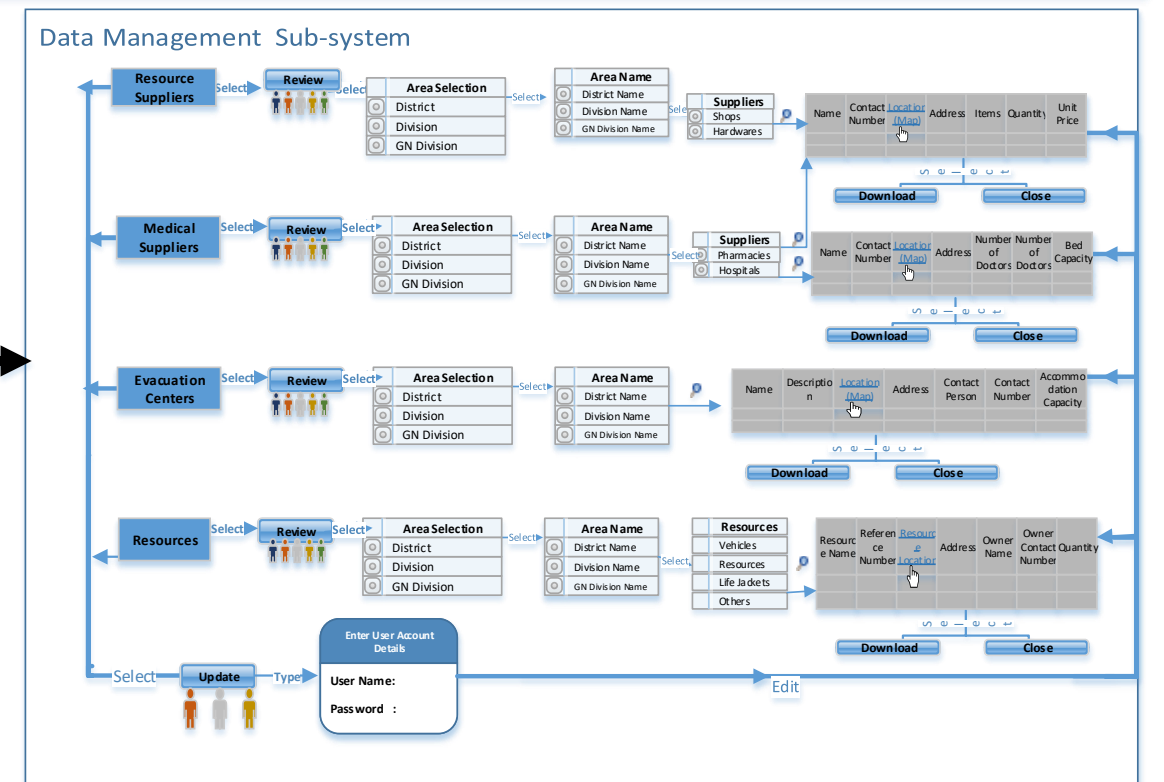
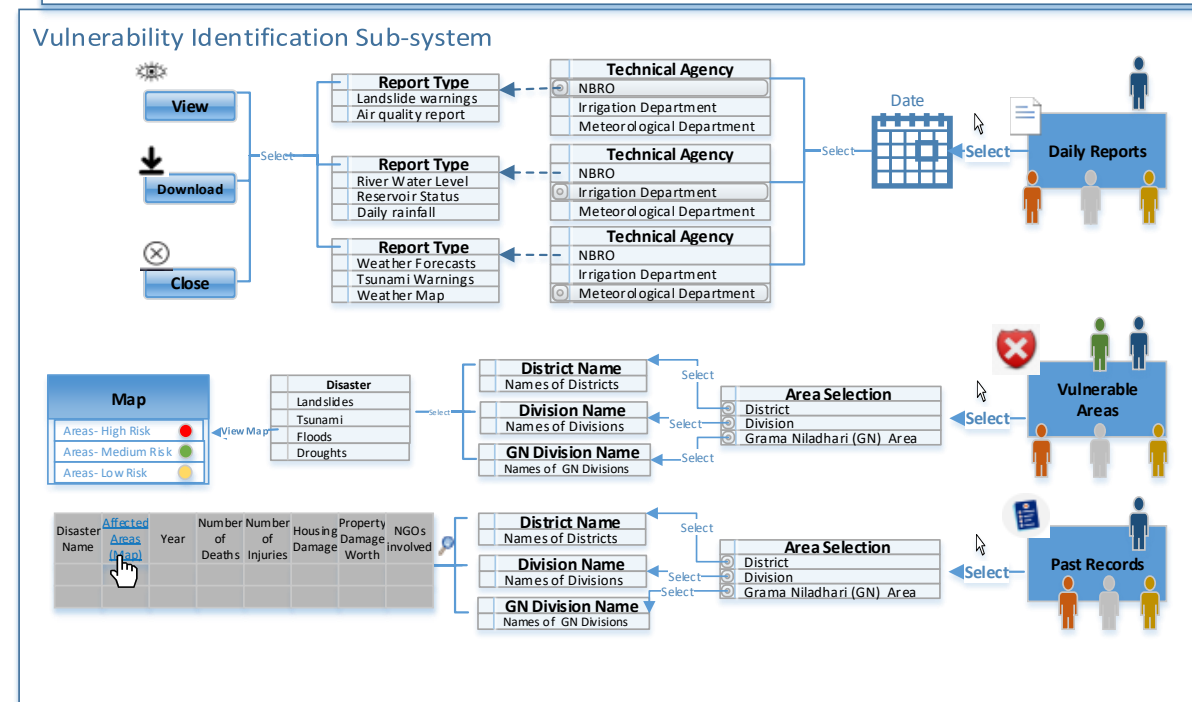
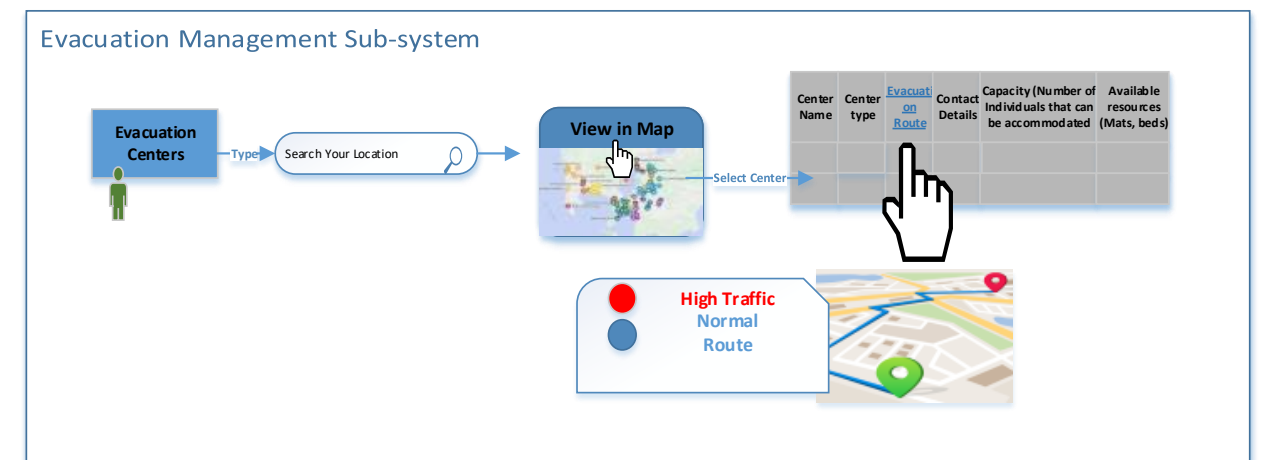
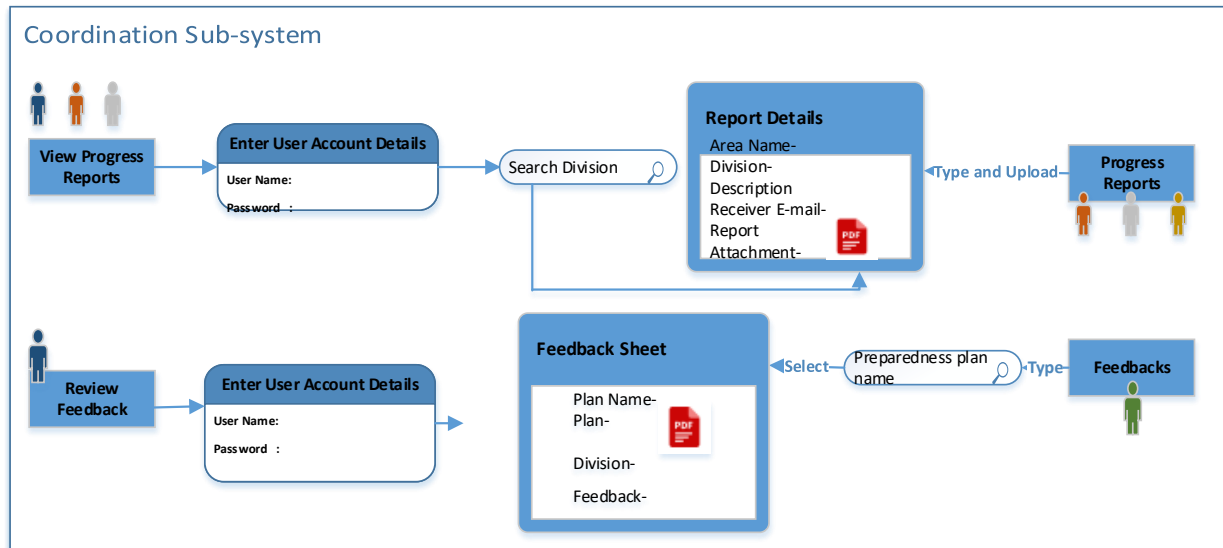




Figure 5.1- Framework for digitally enhanced information and coordination system for disaster preparedness in Sri Lanka

This framework has been designed based upon the user story map (Figure 4.19) and the detailed user stories with 3Cs (Sub-section 4.5 and Appendix B). The user requirements that enhance the overall disaster preparedness approach are integrated into a single frame demonstrating all the system features. Therefore, the reader can get the overall image of the nature of a digitally enhanced disaster preparedness system from the framework.

As per the framework, the information and coordination system, which has been developed for disaster preparedness was sub-categorised into six sub-systems as communication management sub-system, awareness management sub-system, data management sub-system, vulnerability identification sub-system, coordination sub-system and evacuation management sub-system. Under each sub-system, the functionalities that are offered have been demonstrated. The path for each function is shown with arrows and the users who have the access to each function are demonstrated by the different coloured actors. Accordingly, disaster management officers at national, district, divisional, Grama Niladhari levels and the community members were considered as the main users of the system (Sub-section 4.2.2) and separate colour codes were given to symbolise each user (refer Legend).

Vulnerability identification sub-system has three major features as past records, daily record updates and vulnerability area identification. This sub-system enhances the **risk assessment component** of disaster preparedness by maintaining the coordination between all the agencies related to risk assessments as well as the community. Further, the shortcomings of present systems that focus solely on a single hazard with little or no capacity to aggregate the risks from different perils, according to UNISDR (2016), has been resolved by this system since the details are preserved with reference to all of the catastrophes to which Sri Lanka is prone. Moreover, there is enhanced transparency for risk information when all the agencies are using a single platform to acquire daily reports and historical information. This also may help to enhance the efficiency of technical

information sharing and record keeping. On the other hand, the community may establish their trust in information related to vulnerable areas since they have confidence over the reliability of multi-agency collaboration rather than the information provided by organisations independently. This also improves user-friendliness by displaying vulnerability maps in different colour codes to illustrate risk levels (High, Medium, Low), allowing users to quickly capture the essential information.

Through the communication management sub-system, the contact details and other necessary details of all the officers related to disaster preparedness and the community members can be captured. This system will be very useful to enhance the **coordination component** of disaster preparedness. Due to the availability of filtering features based upon the area, gender, education level and so on, the users can easily obtain necessary information without any time waste. This sub-system addresses the lack of well-defined formats at each level to avoid arbitrary data that hampered coordination (Black et al., 2003) by offering pre-defined forms that can only be altered by authorised officials.

Data management sub-system helps to enhance the **information system component and resource mobilisation component**. This system is particularly effective for recording and storing information in a well-organised manner by eliminating the storage issues specially in Grama Niladhari levels. Further, well-focused disaggregate information is provided through this sub-system, where the users can capture most of the details related to resource mobilisation (hospital, pharmacies, shops, evacuation centers) from a single place. Keeney (2014) defined resource mobilisation as the pre-planning strategy to identify resource availability including buildings that can provide shelters at the response phase, pharmacies that can provide medicines, locations of food suppliers and so on. Therefore, it can be deduced that this sub-system may effectively contribute to resource mobilisation since all the aforementioned details are provided from a single platform. Further, the system also provides the locations for the available resources on maps, so that users can easily acquire them.

Awareness management sub-system can be utilised to enhance the components of **education and training and psychological preparedness**. Accordingly, this sub-system provides several functions to detect the awareness programmes around the user and the other details of those programmes. The officers who have the accessibility to update the details can filter the target groups for preparedness programmes and upload the invitations. Further, the participation can be confirmed or rejected by the community members that help the organisers to plan the programme accordingly. Therefore, this system makes it easier for officers to plan awareness programmes, since coordination, which is difficult in traditional methods, can be performed quickly. This sub-system also

provides an alternative solution for those who are reluctant to allocate time for such kind of awareness programmes due to their busy lifestyles as revealed by Shiwaku and Fernandez (2016). Such people can refer to the detailed disaster preparedness guidelines that include visual aids (videos) that have been uploaded into the system considering all the potential disasters separately.

Evacuation management sub-system is directly related to the development of the **evacuation systems component**. From this, the user may be able to detect the evacuation routes in a map and the details of the other people around them. The evacuation routes are separately demonstrated considering each potential disaster with different colour codes. The user-friendliness of the interface ensures that the community functions efficiently during the catastrophe response stage. Since the users have the details of evacuation centers and the people around them in a single system, they can easily connect with others and evacuate together to the particular locations.

The coordination sub-system has been developed to improve the coordination between the officers of each administration level while dealing with reports and other documents. However, the features of this sub-system have to be limited only to share the progress reports of preparedness activities as per the prioritisation of user requirements (Refer Section 4.4). Another feature of this system is sharing feedback from the community about the disaster preparedness plans. Through this, the opinions of the community who is the target group of preparedness plans can be gathered. This creates a bridge between decision-makers at the national level and the community, which will be effective to develop community-sensitive preparedness plans.

On the main, it can be deduced that the proposed information and coordination system has contributed to develop each component of disaster preparedness by resolving most of the existing challenges and thereby it creates a holistic digitally enhanced disaster preparedness approach.

5.6 Chapter summary

The Chapter presented a detailed discussion of the findings from the analysis by revisiting the literature findings. The overall disaster preparedness approach in Sri Lanka was discussed initially with the global preparedness approaches to determine the condition of the country's preparedness. The role of information and coordination for a successful disaster preparedness approach was discovered highlighting the necessity of improvements in existing systems in Sri Lanka compared to the other countries. Thereafter, the findings on existing challenges with reference to the authority as well as the community in the Sri Lankan context were explored, with comparisons and contrasts

made to the global context. Further, the empirical findings on the appropriateness of digital information and coordination system for disaster preparedness in Sri Lanka were discussed in detail. Ultimately, a framework that demonstrates the nature of a digitally enhanced information and coordination system for disaster preparedness from users' perspective was developed and thereby the contribution of the proposed framework to enhance the existing preparedness system is discussed.

6 CONCLUSION AND RECOMMENDATIONS

This Chapter focused on the study's conclusion based on the achievement of objectives through the literature research, data analysis and discussion in the preceding Chapters. Further, the contribution of the research to the knowledge was also highlighted. Recommendations to encourage the digital involvement of the disaster preparedness approach in Sri Lanka have been proposed and further research areas to expand the study in other related directions were presented in this Chapter.

6.1 Accomplishment of objectives

The research aim of enhancing the disaster preparedness approach in Sri Lanka through a digital information and coordination system was achieved through the accomplishment of five main objectives of the study.

Objective 1: To critically review the definitions, components and current technologies used in disaster preparedness

This objective was achieved through three major steps as; definitions related to disaster preparedness (Section 3.4), major components of disaster preparedness (Section 3.5) and current practices and technologies used in disaster preparedness (Section 3.7). The definitions related to disaster preparedness were derived through systematic review in order to acquire a more precise definition (Refer Section 2.4). Accordingly, a working definition for disaster preparedness (Refer Section 3.4) was derived by identifying four definitional attributes as category of disaster preparedness, aim of disaster preparedness, stakeholders related to disaster preparedness and time frame with reference to a disaster. The working definition is established as;

“Disaster Preparedness refers to a set of activities, measures and capacities that are developed by governments, NGOs, communities and individuals prior to a disaster with the aim of helping vulnerable populations to **mitigate** the impact of hazards and to support their effective **response and recovery**.”

The derived definition further indicated the importance of the disaster preparedness phase in disaster management since the aim of disaster preparedness has been identified as ‘**mitigate** the impact of hazard and ensure effective **response and recovery**’. Therefore, it is evident that successful disaster preparedness is the key to accomplishing the success of the mitigation, response and recovery processes and, thereby, achieving the success of overall disaster management.

At the next stage, the key components of disaster preparedness were identified through a traditional literature review (Section 2.4) as risk assessment, coordination systems,

information systems, resource mobilisation, early warning systems, evacuation systems, education and training, psychological preparedness (Section 2.5). All the aforementioned components should be interconnected with each other in order to have a holistic preparedness approach. This interconnection is established by coordination systems and information systems, which offer these two components a higher priority than the rest. Current approaches and technologies used in disaster preparedness were disclosed under each component through the continuation of the traditional literature review. Accordingly, hazard mapping, maintaining risk information, Geographical Information Systems (GIS), satellite systems for risk assessment (Sub-section 3.7.1); electronic organisation registry, gap identification charts, data warehouse systems for coordination systems (Sub-section 3.7.2); wireless application protocols, cell broadcast mobile technology, digital radio alerts, emergency transmitting vehicles for information systems (Sub-section 3.7.3); telemedicine systems, radio frequency identification for resource mobilisation (Sub-section 3.7.4) were identified as the current technologies that are used in the global context. Some of the technologies introduced for the early warning component are remote sensing, artificial intelligence modelling, last-mile models and sirens systems (Sub-Section 3.7.5). Development of evacuation systems at the preparedness phase has been implemented through the technologies such as Open Street Maps, traffic incident management systems, Internet of Things (IoT), mobile cloud computing (Sub-section 3.7.6). Enhancement of education, training and psychological preparedness can be achieved through education websites, virtual academies and virtual reality (Sub-section 3.7.7 and 3.7.8).

Objective 2- To identify the challenges of existing disaster preparedness approaches

The second objective was accomplished by both literature review and empirical findings. The challenges of existing disaster preparedness approaches in the global context were disclosed through the literature review (Section 3.8) while the challenges of existing systems with particular reference to information and coordination in the Sri Lankan context (Sub-section 4.3.3 and 4.3.4) were discussed through empirical findings.

Lack of transparency, focusing on a single hazard, confusions in institutional frameworks, unawareness about technologies, cultural impacts, lack of trust towards these systems among the community, lack of financial and human resource capacities to manage existing systems, usage of outdated data sets are some of the identified challenges in the global context (Section 3.8). Since the study aim is directed to enhance disaster preparedness in Sri Lanka through a digitally enhanced information and coordination system, the empirical investigation carried out in Sri Lanka was focused only on challenges with reference to information and coordination systems. The challenges were identified separately for authority members and the community members. Accordingly, lack of accuracy, lack of transparency, absence of a central coordination system, inefficiencies in record updating,

technical information sharing and monitoring, lack of capacity in information management are some of the reasons of the authority members, that may ultimately lead to the unsuccessful implementation of existing systems (Sub-section 4.3.3). The aforementioned challenges were identified through the officers representing national, divisional, district and Grama- Niladhari levels. Further, Grama Niladhari level was noted as being the most affected by these challenges when compared to the other administration levels. The challenges of existing information and coordination systems for disaster preparedness in the community's viewpoint were the absence of a well-organised systems, lack of user-friendliness, resource shortages, lack of transparency, lack of trust and lack of accuracy (Sub-section 4.3.4). Apart from the aforementioned challenges, lack of awareness about these systems among the community has hindered their usage. As a result of the highlighted challenges in existing systems, the necessity of a digitally enhanced information and coordination system for disaster preparedness was intensified.

Objective 3- To review the role of information and coordination systems in disaster preparedness

This was purely achieved by literature review and provided a base to achieve Objective 4. The importance of the contribution of information and coordination was pinpointed over the other preparedness components (Section 3.9). Accordingly, the literature findings revealed that the information and coordination system is indeed the bridge that connects all the other preparedness components together and forms a holistic preparedness approach. Therefore, the development of a digitally enhanced information and coordination system was identified as a necessity to obtain a successful disaster preparedness approach to the country. In addition, the process of the development of digital information and coordination system was reviewed in five major stages as user requirement analysis, system design, system development, system deployment and system testing (Section 3.11). Further, the user requirement analysis process is described through user stories and user story mapping.

Objective 4- To capture user requirements for digitally enhanced information and coordination system for disaster preparedness

This objective was achieved through empirical findings. Initially, the user requirements were gathered as user stories (Appendix B) separately for each user through in-depth interviews. The users for the proposed system were identified as Disaster Management Officer (DMO) at the national level, DMO at district level, DMO at divisional level, Grama Niladadhari and community member. The user story maps were developed for each user separately considering their requirement and thereby final user story map was demonstrated by combining all the user requirements. The user story prioritisation has

been conducted next through a focus group discussion (Section 4.4). Consequently, the user stories were categorised as ‘Must Have’, ‘Should Have’, ‘Could Have’ and ‘Won’t Have’ and then the ‘Must Have’ user stories were finalised as the user requirement that is intended to fulfill in the proposed information and coordination system for disaster preparedness initially. Accordingly, 25 user stories were identified for the proposed system (Appendix B). Based upon these user stories, the framework has been developed to accomplish objective 5 (Figure 5.1).

Objective 5- To develop a framework for digitally enhanced information and coordination system for disaster preparedness

Based upon the findings of objective 4, the framework was designed for a digitally enhanced information and coordination system for disaster preparedness from users’ perspective that is applicable to the Sri Lankan context (Section 5.5). The proposed system through the framework consists of six sub-systems as vulnerability identification sub-system, data management sub-system, coordination sub-system, awareness management sub-system, evacuation management sub-system and communication management sub-system. All of these sub-systems are contributing to enhance the functionalities of disaster preparedness components effectively. Further, the proposed system addressed the existing challenges such as lack of user-friendliness, lack of transparency, focusing only on a single hazard, insufficient disaggregate information, issues with information storing, absence of central system and trust issues among the community (Sub-section 4.3.3 and 4.3.4). In addition, user-friendly interfaces, a high level of security, usability for multiple users from different education levels (simplicity), facilitating updated information are some of the other advantages of the proposed system. When considering the aforementioned factors it can be deduced that the proposed information and coordination system is ideal for a successful disaster preparedness implementation in Sri Lanka.

6.2 Recommendations

The recommendations to improve disaster preparedness in Sri Lanka through digital integration are as below.

- **Development of community-based preparedness approaches-** It is evident that the community plays a prominent role as the target population of disaster preparedness. Therefore, community requirements should be highly considered while developing disaster preparedness plans or digital systems for disaster preparedness.
- **Increase investments on digitally enhanced systems-** As a developing country, there is an insufficient financial allocation for these innovative systems, which

discourages researchers. Therefore, it is recommended to invest more in digitally enhanced systems designed for disaster management since they may provide multiple benefits through disaster risk reduction.

- **Development of implementation plan for information and coordination systems-** It is recommended that the authorities should pay attention to ensure the effective implementation of digital systems at local levels since there are many issues with resource insufficiency and network barriers.
- **Enhance the awareness among the society-** The importance of digital integration for disaster preparedness should be convinced to the community through awareness programmes and thereby encourage the community to use these digital systems for disaster preparedness in their daily lifestyle.

6.3 Contribution to knowledge

This study primarily contributed to the knowledge on investigating the nature of a digitally enhanced information and coordination system that can be utilised for disaster preparedness in Sri Lanka. The outcomes of the research can be utilised to enhance the knowledge in the following areas.

1. Understanding the concept of disaster preparedness and its key components as risk assessment, coordination systems, information systems, resource mobilisation, early warning systems, evacuation systems, education and training, psychological preparedness
2. Assessment of the influence of digitally enhanced information and coordination systems on the disaster preparedness approach in Sri Lanka
3. Understanding the challenges for successful disaster preparedness implementation in Sri Lanka with reference to national, district, divisional, Grama Niladhari and community administration levels
4. Identifying the features of a digital information system to develop the disaster preparedness approach in Sri Lanka.
5. Understanding the appropriateness of digital systems to be utilised in disaster preparedness in Sri Lanka.

6.4 Contribution to practice

The end results of the study will be beneficial for the practitioners to implement a successful preparedness approach in Sri Lanka. The outcomes of the research can be utilised to enhance the practices in the following areas.

1. Measures can be taken to fulfill the identified user requirements in each administration level and the community
2. Strategies can be identified to enhance disaster preparedness practices in order to overcome identified challenges at each administration level.
3. Development of a digitally enhanced information and coordination system for disaster preparedness through the identified user requirements.
4. Measures can be taken to improve the usage of digital systems for disaster management at local levels.

6.5 Limitations of the study

The study has been limited to the user requirement analysis, which is the initial step of system development due to time constraints.

6.6 Further research directions

The following further research directions were proposed to extend the research further.

- Extend the research to develop the proposed information and coordination system for disaster preparedness based on the user requirements
- Assess the success of proposed system implementation among the authority members and the community in Sri Lanka
- Identify strategies to enhance the digital involvement of disaster preparedness in the Sri Lankan context
- Identification of features of digitally enhanced information system that can be utilised for other disaster management phases (Disaster mitigation, disaster response, disaster recovery)

REFERENCES

- Administration for Children and Families. (2016). Multi-hazard mapping using Geographic Information System (GIS). In *Community-based DRR Project Bicol, Region, Philippines*. https://www.preventionweb.net/files/13932_ACF1.pdf
- Aguilar, R., Flacke, J., & Pfe, K. (2020). Towards supporting collaborative spatial planning : Conceptualization of a map table tool through user stories. *International Journal of Geo-Information Article*, 9(29).
- Ainuddin, S., & Routray, J. K. (2015). Institutional framework, key stakeholders and community preparedness for earthquake induced disaster management in Balochistan. *Disaster Prevention and Management*, 21(1), 22–36. <https://doi.org/10.1108/09653561211202683>
- Al-azawi, Z. A. A. S. (2014). *Transportation evacuation strategies based on vehicular disaster management system in urban network environment*.
- Al-Dahash, H., Thayaparan, M., & Kulatunga, U. (2016). Challenges during disaster response planning resulting from war operations and terrorism in Iraq. *12th International Conference of the International Institute for Infrastructure Resilience and Reconstruction*, October 2017, 87–95. <https://www.researchgate.net/publication/320288552>
- Alexander, D. (2014). *Principles of emergency planning and management*. Oxford Press.
- AlHinai, Y. S. (2020). Disaster management digitally transformed: Exploring the impact and key determinants from the UK national disaster management experience. *International Journal of Disaster Risk Reduction*, 51, 101851. <https://doi.org/10.1016/j.ijdr.2020.101851>
- Aliyu, A. A., Singhry, M. I., Adamu, H., & Abubakar, M. muhammad A. (2017). Ontology, epistemology and axiology in quantitative and qualitative research: elucidation of the research philosophical misconception. *Proceedings of The Academic Conference: Mediterranean Publications & Research International on New Direction and Uncommon*, July, 27. https://www.researchgate.net/profile/Aliyu-Aliyu-2/publication/318721927_ONTOLGY_EPISTEMOLOGY_AND_AXIOLOGY_IN_QUANTITATIVE_AND_QUALITATIVE_RESEARCH_ELUCIDATION_OF_THE_RESEARCH_PHILOSOPHICAL_MISCONCEPTION/links/59798097aca27203ecc63de3/ONTOLOGY-EPISTEMOLO
- Amaratunga, N., Haigh, R., & Ingirige, B. (2015). Post-Disaster housing reconstruction

- in Sri Lanka: What methodology? *SAGE Open*, 5(3).
<https://doi.org/10.1177/2158244015583072>
- American Association of Physics Teachers. (2000). *Introduction to disaster preparedness*.
<http://perusersguide.org/>
- Amyan, M. M. (2016). The role of information in disaster management: Case study on disaster management in the general directorate of civil defense of Jordan. *Indian Journal of Applied Business and Economic Research*, 14(10), 6657–6681.
https://reliefweb.int/sites/reliefweb.int/files/resources/UNDAC_SL_Report_Final_Email.pdf
- Aromataris, E., & Riitano, D. (2014). Constructing a search strategy and searching for evidence. *American Journal of Nursing*, 114(5), 49–56.
<https://doi.org/10.1097/01.NAJ.0000446779.99522.f6>
- Asian Development Bank. (2017). *Disaster risk assessment for project preparation: A practical guide*. <https://www.adb.org/sites/default/files/institutional-document/388451/drm-project-preparation-practicalguide.pdf>
- Asian Disaster Preparedness Center. (2011). *ICT for disaster risk management Asian disaster preparedness center*.
https://www.preventionweb.net/files/47520_ictfordisasterriskmanagement.pdf
- Ayeb-Karlsson, S., Kniveton, D., Cannon, T., van der Geest, K., Ahmed, I., Derrington, E. M., Florano, E., & Opondo, D. O. (2019). I will not go, I cannot go: cultural and social limitations of disaster preparedness in Asia, Africa and Oceania. *Disasters*, 43(4), 752–770. <https://doi.org/10.1111/disa.12404>
- Badruddin, A. R. (2012). Issues of disaster management preparedness : A case study of directive 20 of national security council malaysia. *Int. Journal of Business and Social Science*, 3(5), 85–92.
- Baker, N. (2018). Role of explicit and implicit practices in the production of situated preparedness for disasters. *Natural Hazards Review*, 14.
[https://doi.org/10.1061/\(ASCE\)NH.1527-6996.0000127](https://doi.org/10.1061/(ASCE)NH.1527-6996.0000127)
- Barakat, S. (2015). *Housing reconstruction after conflict and disaster* (Issue October).
- Baskerville, R., Spagnoletti, P., & Kim, J. (2014). Incident-centered information security: Managing a strategic balance between prevention and response. *Information & Management*, 51(1), 138–151.
<https://doi.org/https://doi.org/10.1016/j.im.2013.11.004>
- Benson, C., Twigg, J., & Tiziana, R. (2015). Tools for mainstreaming disaster risk

- reduction: Guidance notes for development organisations. In *ProVention Consortium Secretariat*.
- Benssam, A., Nouali-Taboudjemat, N., & Nouali, O. (2016). An e-readiness assessment model for disaster management. *International Journal of Information Technology and Management*, 15(2), 118–143. <https://doi.org/10.1504/IJITM.2016.076412>
- Berau of Child Care Licensing. (2017). Disaster Emergency Evacuation Preparedness. In *Berau of Child Licensing*.
- Beura, D. (2016). Preparedness programme in disaster management : A structural model. *International Journal of Recent Scientific Research*, 7(11), 14494–14497.
- Beydoun, G., Dascalu, S., Dominey-Howes, D., & Sheehan, A. (2018). Disaster management and information systems: Insights to emerging challenges. *Information Systems Frontiers*, 20(4), 649–652. <https://doi.org/10.1007/s10796-018-9871-6>
- Bharosa, N., Lee, J., Janssen, M., & Rao, H. R. (2012). An activity theory analysis of boundary objects in cross-border information systems development for disaster management. *Security Informatics*, 1(15), 17. <https://security-informatics.springeropen.com/track/pdf/10.1186/2190-8532-1-15.pdf>
- Bik, N., Lucassen, G., & Brinkkemper, S. (2017). A reference method for user story requirements in agile systems development. *Proceedings - 2017 IEEE 25th International Requirements Engineering Conference Workshops, REW 2017, September*, 292–298. <https://doi.org/10.1109/REW.2017.83>
- Bilau, A. A., Witt, E., & Lill, I. (2015). A framework for managing post-disaster housing reconstruction. *Nordic Conference on Construction Economics and Organisation*, 21(15), 313–320. [https://doi.org/10.1016/S2212-5671\(15\)00182-3](https://doi.org/10.1016/S2212-5671(15)00182-3)
- Billing, M. (2004). Methodology and scholarship in understanding ideological explanation. In C. Seale (Ed.), *Social Research Methods: A Reader* (pp. 13–18).
- Black, L. J., Cresswell, A. M., Pardo, T. A., Canestraro, D. S., Cook, M., Luna, L. F., Martinez, I. J., andersen, D. F., & Richardson, G. P. (2003). A dynamic theory of collaboration: A structural approach to facilitating intergovernmental use of information technology. *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03)*, January, 13. <https://doi.org/10.1109/HICSS.2003.1174222>
- Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27–40. <https://doi.org/10.3316/QRJ0902027>
- Brazzola, N., & Helander, S. E. M. (2018). Five approaches to build functional early

- warning systems. In *United Nations Development Programme (UNDP)*.
- Brenda, B., & Elizabeth, D. P. (2016). The future of accessibility in disaster conditions: How wireless technologies will transform the life cycle of emergency management. *Futures*, 35. <https://doi.org/10.1016/j.futures.2016.05.004>
- Brouwer, T. (2016). *Potential of twitter derived flood maps: comparing interpolation methods and assessing uncertainties*.
- Brower, D., & Schwab, A. (2000). *Planning to Mitigate the Impacts of Natural Hazards in the Caribbean* (Issue December).
- Bruette, V., & Fitzig, C. (2014). The literature review. In *Research Methods for Business and Management* (pp. 37–40). <https://doi.org/10.4324/9781351156127-9>
- Burak, A. (2019). *Software development life cycle explained*. <https://relevant.software/blog/7-steps-for-effective-software-product-development/>
- Bureau for Crisis Prevention and Recovery. (2010). *Disaster risk assessment*. https://doi.org/10.1007/978-981-13-6689-5_5
- Burling, W. K., & Hyle, A. E. (2016). Disaster preparedness planning: Policy and leadership issues. *Disaster Prevention and Management: An International Journal*, 6(4), 234–244. <https://doi.org/10.1108/09653569710179075>
- Burrell, G., & Morgan, G. (2019). *Sociological paradigms and organisational analysis*. Routledge.
- Burt, B. A., Lundgren, K., & Schroetter, J. (2017). Learning from within: a longitudinal case study of an education research group. *Studies in Graduate and Postdoctoral Education*, 8(2), 128–143. <https://doi.org/10.1108/sgpe-d-17-00002>
- Cannon, T., & Schipper, L. (2014). *World disasters report: Focus on culture and risk*.
- Carla, F., & Da Silva, M. M. (2013). Requirements elicitation with focus groups: Lessons learnt. *ECIS 2013 - Proceedings of the 21st European Conference on Information Systems*, 12. <https://core.ac.uk/download/pdf/301360941.pdf>
- Carter, W. N. (2018). *Disaster management handbook*. Asian Development Bank.
- Caruana, E. J., Roman, M., Hernández-Sánchez, J., & Solli, P. (2015). Longitudinal studies. *Journal of Thoracic Disease*, 7(11), E537–E540. <https://doi.org/10.3978/j.issn.2072-1439.2015.10.63>
- Carver, L. (2018). Human-computer interaction: The human and computer as a team in emergency management information systems. *Communications of the ACM*, 7. <https://doi.org/10.1145/1226736.1226761>

- Chakraborty, A., Kanti Baowaly, M., Arefin, A., & Bahar, A. N. (2012). The role of requirement engineering in software development life cycle. *Journal of Emerging Trends in Computing and Information Sciences*, 3(5), 723–729. <http://www.cisjournal.org>
- Chanawongse, K. (2013). ICT for disaster management. In *Persepsi Masyarakat Terhadap Perawatan Ortodontik Yang Dilakukan Oleh Pihak Non Profesional* (Vol. 53, Issue 9). United Nations Development Programme.
- Chang-richards, A., Richards, J., & Bubb, J. (2018). Measuring the level of disaster preparedness in Auckland. *7th International Conference on Building Resilience*, 212, 419–426. <https://doi.org/10.1016/j.proeng.2018.01.054>
- Check, J., & Schutt, R. K. (2012). Survey research. In J. Check & R. K. Schutt (Eds.), *Research Methods in Education* (pp. 159–185). Thousand Oaks.
- Choudhury, M., Uddin, M. S., & Haque, C. E. (2019). “ Nature brings us extreme events , some people cause us prolonged sufferings ”: the role of good governance in building community resilience to natural disasters in Bangladesh. *Journal of Environmental Planning and Management*, 1–21. <https://doi.org/10.1080/09640568.2018.1513833>
- Cohn, M. (2000). *User stories applied*.
- Collins, M. L., & Kapucu, N. (2011). Early warning systems and disaster preparedness and response in local government. *Disaster Prevention and Management: An International Journal*, 17(5), 587–600. <https://doi.org/10.1108/09653560810918621>
- Covington, J., & Simpson, D. M. (2006). *An overview of disaster preparedness literature : Building blocks for an applied bay area template an overview of disaster preparedness literature : Building blocks for an applied bay area template* (Issue August).
- Crossley, J., & Jansen, D. (2021). *Saunders’ research onion: Explained simply*. GRAD COACH. <https://gradcoach.com/saunders-research-onion/>
- Cutter, S. L., & Derakhshan, S. (2019). Implementing disaster policy: Exploring scale and measurement schemes for disaster resilience. *Journal of Homeland Security and Emergency Management*, 16(3), 1–14. <https://doi.org/10.1515/jhsem-2018-0029>
- Dee, D. K. (2011). *Evacuation considerations for the elderly , disabled and special medical care issues*.
- Deeny, P., & McFetridge, B. (2005). The impact of disaster on culture, selfand identity: Increased awareness by health care professionals is needed. *Nursing Clinics of North*

- America*, 40(3), 431–440. <https://doi.org/10.1016/j.cnur.2005.04.012>
- Dekens, J. (2007). *Local knowledge for disaster preparedness: A literature review* (M. G. Eriksson, G. M. Rana, A. B. Murray, & D. R. Maharjan (eds.)). International Centre for Integrated Mountain Development G.P.O. <http://lib.icimod.org/record/22470>
- Demeyin, W. (2016). *Traditional reviews Vs. systematic reviews*. Students for Best Evidence. <https://s4be.cochrane.org/blog/2016/02/03/traditional-reviews-vs-systematic-reviews/>
- Department of Homeland Security. (2016). *Plan and prepare for disasters*.
- Dharmasena, G. I., Department, Toledano, M., & Weaver, C. K. (2020). The role of public relations in building community resilience to natural disasters: perspectives from Sri Lanka and New Zealand. *Journal of Communication Management*, 24(4), 301–317. <https://doi.org/10.1108/JCOM-11-2019-0144>
- Disaster Management Center. (2014). *Sri Lanka national disaster management plan 2013-2017*.
- Disaster Management Center. (2017). *Impacts of Disasters in Sri Lanka-2016*.
- Disaster Management Center. (2020). *What is disaster information management system?*
Disaster Information Management System.
http://www.desinventar.lk/des_html/what_disas_info/what_des.html
- Disaster Preparedness and Mitigation Summit. (2002). *Confederation of Indian industry and United Nations development program*.
- Dodgen, D., Donato, D., & Kelley, N. (2016). Mental health and well-being. In *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (pp. 46–217).
- Doria, N., Condran, B., Boulos, L., Curtis Maillet, D. G., Dowling, L., & Levy, A. (2018). Sharpening the focus: Differentiating between focus groups for patient engagement vs. qualitative research. *Research Involvement and Engagement*, 4(1), 6–13. <https://doi.org/10.1186/s40900-018-0102-6>
- Dudovskiy, J. (2018). *The ultimate guide to writing a dissertation in business studies: A step-by-step assistance*. <https://research-methodology.net/about-us/ebook/>
- Dunnette, R. (2006). Radio and TV broadcasting for disaster relief and public warning. *Pacific Telecommunications Council '06 Proceedings*.
- Easterby-smith, M., Jackson, P. R., Jaspersen, L. J., Easterby-smith, M., Thorpe, R., Jackson, P. R., & Jaspersen, L. J. (2018). *Management and business research*. Sage

Publications. https://us.sagepub.com/sites/default/files/upm-assets/118458_book_item_118458.pdf

- Economic and Social Commission for Asia and the Pacific (ESCAP). (2015). *Building e-resilience: Enhancing the role of ICTs for Disaster Risk Management (DRM)*. [http://www.unescap.org/sites/default/files/Enhancing the role of ICTs for DRM.pdf](http://www.unescap.org/sites/default/files/Enhancing%20the%20role%20of%20ICTs%20for%20DRM.pdf)
- Elo, S., & Kyngas, H. (2007). The qualitative content analysis process. *Advanced Nursing*, 62(1), 107–115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>
- Eriksen, M. B., & Frandsen, T. F. (2018). The impact of PICO as a search strategy tool on literature search quality: A systematic review. *Journal of the Medical Library Association*, 106(4), 420–431. <https://jmla.pitt.edu/ojs/jmla/article/view/345/726>
- Fajardo, J. T. B., & Oppus, C. M. (2010). A mobile disaster management system using the Android technology. *WSEAS Transactions on Communications*, 9(6), 343–353.
- Federal Emergency Management Agency. (2016). *The four phases of emergency management*.
- Fisher, C. W., & Kingma, B. R. (2012). Criticality of data quality as exemplified in two disasters. *Information & Management*, 39(2), 109–116. [https://doi.org/https://doi.org/10.1016/S0378-7206\(01\)00083-0](https://doi.org/10.1016/S0378-7206(01)00083-0)
- Foehrenbach, S. (2017). *User story mapping: The hands-on course*. <https://www.nngroup.com/articles/user-story-mapping/>
- Formetta, G., & Feyen, L. (2019). Empirical evidence of declining global vulnerability to climate-related hazards. *Global Environmental Change*, 57(May), 9. <https://doi.org/10.1016/j.gloenvcha.2019.05.004>
- Gautam, D. K., & Bhandari, D. (2019). *Institutional arrangements for disaster management in federal countries: Lessons for Nepal* (Issue October 2018). <https://doi.org/10.13140/RG.2.2.10008.85761>
- Geekiyanage, D., Fernando, T., & Keraminiyage, K. (2020). Assessing the state of the art in community engagement for participatory decision-making in disaster risk-sensitive urban development. *International Journal of Disaster Risk Reduction*, 51(May). <https://doi.org/10.1016/j.ijdrr.2020.101847>
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal*, 204(6), 291–295. <https://doi.org/10.1038/bdj.2008.192>
- Gillis, A. (2020). *System development life cycle*. Programming.

https://www.researchgate.net/publication/220422934_Human-Computer_Interaction_the_human_and_computer_as_a_team_in_Emergency_Management_Information_Systems

- Global Humanitarian Assistance (GHA). (2019). *Global humanitarian assistance report*. <http://www.globalhumanitarianassistance.org/report/gha-report-2015>
- Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European Journal of Information Systems*, 21(2), 135–146. <https://www.diva-portal.org/smash/get/diva2:515141/FULLTEXT01.pdf>
- Goles, T., & Hirschheim, R. (2000). The paradigm is dead , the paradigm is dead ... long live the paradigm : the legacy of Burrell and Morgan. *The International Journal of Management Science*, 28, 249–268.
- Goniewicz, K., & Burkle, F. M. (2019). Disaster early warning systems: The potential role and limitations of emerging text and data messaging mitigation capabilities. *Disaster Medicine and Public Health Preparedness*, 13(4), 709–712. <https://doi.org/10.1017/dmp.2018.171>
- Gonzalez, R. A., & Bharosa, N. (2009). A framework linking information quality dimensions and coordination challenges during interagency crisis response. *Proceedings of the 42nd Hawaii International Conference on System Sciences*, 1–10. https://www.academia.edu/22099022/A_framework_linking_information_quality_dimensions_and_coordination_challenges_during_interagency_crisis_response
- Goodyear, E. J. (2009). *The state of disaster risk reduction in Iraq*.
- Grix, J. (2019). *The foundations of research*. Red Globe Press. https://books.google.lk/books?hl=en&lr=&id=eqZyDwAAQBAJ&oi=fnd&pg=PR1&dq=the+foundations+of+research&ots=gJECuRKrzl&sig=AySYPM2P6niHeE_d rSByu4cfFFo&redir_esc=y#v=onepage&q=the foundations of research&f=false
- Gryszkiewicz, A., & Chen, F. (2010). Design requirements for information sharing in a crisis management command and control centre. *Proceedings of the 7th International ISCRAM Conference*, 1–10. http://idl.iscrum.org/files/gryszkiewicz/2010/550_Gryszkiewicz+Chen2010.pdf
- Haddow, G., Bullock, J., & Coppola, D. (2015). The disciplines of emergency management: Preparedness. In *Introduction to Emergency Management* (p. 97).
- He, Q., Wang, G., Luo, L., Shi, Q., Xie, J., & Meng, X. (2017). Mapping the managerial areas of Building Information Modeling (BIM) using scientometric analysis. *International Journal of Project Management*, 35(4), 670–685.

<https://doi.org/10.1016/j.ijproman.2016.08.001>

- Hidayati, D. (2008). Kesiapsiagaan masyarakat. *Jurnal Kependudukan Indonesia*.
- Hsieh, H.-F., & Shannon, S. E. (2015). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277–1288. <https://doi.org/10.1177/1049732305276687>
- Hu, H., Lei, T., Hu, J., Zhang, S., & Kavan, P. (2018). Disaster-mitigating and general innovative responses to climate disasters: Evidence from modern and historical China. *International Journal of Disaster Risk Reduction*, 28(January), 664–673. <https://doi.org/10.1016/j.ijdrr.2018.01.022>
- Ibarra, V. A. (2015). *Pivots- A bottom-up approach to enhance resilience* (Issue December).
- International Federation of Red Cross and Red Crescent Societies (IFRC). (2000). *Improving coordination - Participant resource & training module*. 21.
- International Federation of Red Cross and Red Crescent Societies (IFRC). (2015). *Preparing for disasters*.
- International Organisation of Supreme Audit Institutions (INTOSAI). (2015). *Disaster preparedness for supreme audit institutions*. <https://www.google.com/search?q=intosai&oq=INTOSAI&aqs=chrome.0.0i512j0i20i263i512j0i512l4j69i60l2.2550j1j7&sourceid=chrome&ie=UTF-8>
- International Strategy for Disaster Reduction. (2015). *Progress and challenges in disaster risk reduction*.
- International Strategy for Disaster Reduction (ISDR). (2008). *Disaster preparedness for effective response*. https://www.unisdr.org/files/2909_Disasterpreparednessforeffectiveresponse.pdf
- International Strategy for Disaster Risk Reduction (ISDR). (2014). *Progress and challenges in disaster risk reduction*. https://www.preventionweb.net/files/40967_40968progressandchallengesindisaste.pdf
- International Telecommunication Union. (2017). *Broadcasting for public warning , disaster mitigation and relief* (Vol. 2).
- Ishiwatari, M. (2021). Institutional Coordination of Disaster Management: Engaging National and Local Governments in Japan. *Natural Hazards Review*, 22(1), 04020059. [https://doi.org/10.1061/\(asce\)nh.1527-6996.0000423](https://doi.org/10.1061/(asce)nh.1527-6996.0000423)

- Izumi, T., Shaw, R., Djalante, R., Ishiwatari, M., & Komino, T. (2019). Disaster risk reduction and innovations. *Progress in Disaster Science*, 2, 100033. <https://doi.org/10.1016/j.pdisas.2019.100033>
- James, E. (2008). Getting ahead of the next disaster: Recent preparedness efforts in Indonesia. *Development in Practice*, 18(3), 424–429. <https://doi.org/10.1080/09614520802030607>
- Jankowski, T. A. (2008). *The medical library association essential guide to becoming an expert searcher: Proven techniques, strategies and tips for finding health information*. Neal-Schuman Publishers. <https://doi.org/10.1080/003467682000000022>
- Johnson, N., Behe, C., Danielsen, F., Krümmel, E. M., Nickels, S., & Pulsifer, P. . (2016). *Community-based monitoring and indigenous knowledge in a changing arctic: A review for the sustaining arctic observing networks* (Vol. 1, Issue 1). http://iccalaska.org/wp-icc/wp-content/uploads/2016/05/Community-Based-Monitoring-and-Indigenous-Knowledge-in-a-Changing-Arctic_web.pdf%0Ahttp://www.inuitcircumpolar.com/community-based-monitoring.html%0Ahttps://iccalaska.org/wp-icc/wp-content/uploads/201
- Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2000). Rethinking construction: The generic design and construction process protocol. *Engineering, Construction and Architectural Management*, 7(2), 141–153. <https://doi.org/10.1108/eb021139>
- Kaley, A. (2021). *Mapping user stories in Agile*. Nielsen Norman Group. <https://www.nngroup.com/articles/user-story-mapping/>
- Kapucu, N. (2008). Collaborative emergency management: Better community organising, better public preparedness and response. *Disasters*, 32(2), 239–262. <https://doi.org/10.1111/j.1467-7717.2008.01037.x>
- Kar, N. (2011). Psychological impact of disasters on children: Review of assessment and interventions. *World Journal of Pediatrics*, 5(1), 5–11. <https://doi.org/10.1007/s12519-009-0001-x>
- Kawulich, B. (2004). *Qualitative data analysis techniques*. January 2004, 96–113.
- Keeney, G. B. (2014). Disaster preparedness: What do we do now? *Journal of Midwifery and Women's Health*, 49(4), 2–6. <https://doi.org/10.1016/j.jmwh.2004.05.003>
- Khan, F., Amatya, B., Gosney, J., Rathore, F. A., & Burkle, F. M. (2015). Medical rehabilitation in natural disasters: A review. *Archives of Physical Medicine and Rehabilitation*, 96(9), 1709–1727. <https://doi.org/10.1016/j.apmr.2015.02.007>

- Khawaja, S. W., & Xinhai, L. (2013). A Case Study of Telemedicine for Disaster Management in Underdeveloped Remote Districts of Balochistan , Pakistan. *Journal of Economics and Sustainable Development*, 4(20), 1–14.
- Khorram-Manesh, A. (2017). Handbook of disaster and emergency management. In *Disasters* (Vol. 34, Issue 2).
- Kim, H. J., & Zakour, M. (2018). Exploring the factors associated with the disaster preparedness of human service organisations serving persons with disabilities. *Human Service Organisations Management, Leadership and Governance*, 42(1), 19–32. <https://doi.org/10.1080/23303131.2017.1380737>
- Kirac, E., & Milburn, A. B. (2018). A general framework for assessing the value of social data for disaster response logistics planning. *European Journal of Operational Research*. <https://doi.org/10.1016/j.ejor.2018.02.011>
- Kliem, R. L., & Richie, G. D. (2016). *Business continuity planning*. Taylor & Francis Group.
- Kondracki, N. L., Wellman, N. S., & Amundson, D. R. (2002). Content analysis: Review of methods and their applications in nutrition education. *Journal of Nutrition Education and Behavior*, 34(4), 224–230. [https://doi.org/https://doi.org/10.1016/S1499-4046\(06\)60097-3](https://doi.org/https://doi.org/10.1016/S1499-4046(06)60097-3)
- Kothari, C. R. (2000). *Research methodology: Methods and techniques* (2nd ed., Vol. 148). New Age International (Pvt.) Ltd.
- Krasniqi, Z. (2015). Application of information technology in emergency and natural disaster management. *The Asian Conference on Disaster Response and Management*, 1–7.
- Krumay, B. (2015). The role of information systems to support disaster management. *Disaster Management and Human Health Risk IV*, 1(May 2015), 301–313. <https://doi.org/10.2495/dman150271>
- Kuester, A., Niemeyer, H., & Knaevelsrud, C. (2016). Internet-based interventions for posttraumatic stress: A meta-analysis of randomized controlled trials. *Clinical Psychology Review*, 43, 1–16. <https://doi.org/10.1016/j.cpr.2015.11.004>
- Kulatunga, U. (2010). Multi-faceted nature of managing disasters. *International Journal of Strategic Property Management*, 14(4), 283–286. https://www.researchgate.net/publication/241731998_Guest_Editorial_Multi-faceted_nature_of_managing_disasters
- Laaser, U., & Beluli, F. (2016). A Global Public Health Curriculum ; 2nd Edition (2016

-) Edited by Ulrich Laaser and Florida Beluli Jacobs Verlag. *South Eastern European Journal of Public Health*, January, 31. <https://doi.org/10.4119/UNIBI/SEEJPH-2015-106>
- Lakoff, A., & Collier, S. (2008). *Biosecurity interventions: Global health and security in question*.
- Lango, B. (2020). *Procedure for writing a background study for a research paper* (Issue September). <https://doi.org/10.13140/RG.2.2.18093.92644>
- Lauriola, P., Leonardi, G., Righi, E., Malilay, J., & Louca, S. (2018). Natural disaster — Environmental health preparedness. In *Encyclopedia of Environmental Health* (2nd ed.). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-409548-9.11140-6>
- Lee Hughes, A., & Palen, L. (2009). Twitter adoption and use in mass convergence and emergency events. *International Journal of Emergency Management*, 6(3–4), 248–260. <https://doi.org/10.1504/IJEM.2009.031564>
- Lee, J., Agrawal, M., & Rao, H. R. (2015). Message diffusion through social network service: The case of rumor and non-rumor related tweets during Boston bombing 2013. *Information Systems Frontiers*, 17(5), 997–1005. <https://doi.org/10.1007/s10796-015-9568-z>
- Lemyre, L., & Osullivan, T. (2013). *Enhancing community resilience: a matter of multi-level framework, mixed methods and multi-sectoral tools*.
- Lerman, K., & Ghosh, R. (2010). Information contagion: An empirical study of the spread of news on Digg and Twitter social networks. *ICWSM 2010 - Proceedings of the 4th International AAAI Conference on Weblogs and Social Media*, 90–97.
- Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine*, 6(7). <https://doi.org/10.1371/journal.pmed.1000100>
- Lin, C. K., Nifa, F. A. A., Musa, S., Shahron, S. A., & Anuar, N. A. (2018). Challenges and opportunities of disaster education program among UUM student. *AIP Conference Proceedings*, 7. <https://doi.org/10.1063/1.5055440>
- Lin, L. (2018). Integrating a national risk assessment into a disaster risk management system: Process and practice. *International Journal of Disaster Risk Reduction*, 27, 625–631. <https://doi.org/10.1016/j.ijdr.2017.08.004>
- Lindell, M. K., & Prater, C. S. (2003). Assessing community impacts of natural disasters.

- Natural Hazards Review*, 4(4), 176–185. [https://doi.org/10.1061/\(ASCE\)1527-6988\(2003\)4:4\(176\)](https://doi.org/10.1061/(ASCE)1527-6988(2003)4:4(176))
- Lipscomb, M. (2012). Original article abductive reasoning and qualitative research. *Nursing Philosophy*, 13, 244–256. <https://scihub.se/https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1466-769X.2011.00532.x>
- Lucassen, G., Dalpiaz, F., van der Werf, J. M. E. M., & Brinkkemper, S. (2016). The use and effectiveness of user stories in practice. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 9619(March), 205–222. https://doi.org/10.1007/978-3-319-30282-9_14
- Ludlow, B. L. (2011). Technology and teacher education in special education: disaster or deliverance? *The Journal of the Teacher Education Division of the Council for Exceptional Children*, 24(2), 143–163. <https://doi.org/10.1177/088840640102400209>
- Madan, A., & Routray, J. K. (2015). Institutional framework for preparedness and response of disaster management institutions from national to local level in India with focus on Delhi. *International Journal of Disaster Risk Reduction*, 14, 545–555. <https://doi.org/10.1016/j.ijdr.2015.10.004>
- Mahjom, N., Razak, A. A., Muhammad, F., Hussin, M. Y. M., & Mansor, S. S. S. B. (2019). Economic development resiliency: Mobilized disaster's readiness among higher learning students in Malaysia. *Research in World Economy*, 10(5), 81–88. <https://doi.org/10.5430/rwe.v10n5p81>
- Maiers, C., Reynolds, M., & Haselkorn, M. (2005). Challenges to effective information and communication systems in humanitarian relief organisations. *IEEE International Professional Communication Conference Proceedings*, 82–91. https://www.sdmi.lsu.edu/sdmi/wp-content/uploads/2011/12/challenges_to_ics.pdf
- Man Ha, K. (2018). Applying indigenous knowledge to natural disaster preparedness. *Journal of Social Sciences Research*, 4(12), 383–389. <https://doi.org/10.32861/jssr.412.383.389>
- Maqbool, M. Y., & Hussain, S. (2017). Institutional framework for disaster risk management in Pakistan : Issues , challenges and policy recommendations. *Abasyn Journal of Social Sciences*, 10(Special Issue November 2017).
- Masnoon, N., Shakib, S., Kalisch-ellett, L., & Caughey, G. E. (2017). *What is polypharmacy? A systematic review of definitions*. 1–10. <https://doi.org/10.1186/s12877-017-0621-2>

- McEntire, D. A. (2008). A critique of emergency management policy: recommendations to reduce disaster vulnerability. *International Journal of Public Policy*, 3(6), 302–312.
- Md Hassan, A. A. (2015). *Role of ICT in natural disaster management if Bangladesh*.
- Mehta, R. (2019). *How can ICT help in disaster preparedness and response?* Devidiscourse. <https://www.devidiscourse.com/article/technology/597329-how-can-ict-help-in-disaster-preparedness-and-response>
- Meier, D. (2000). *The accelerated learning handbook: A creative guide to designing and delivering faster, more effective training programs*.
- Meissner, A., Luckenbach, T., Risse, T., Kirste, T., & Kirchner, H. (2012). Design challenges for an integrated disaster management communication and information system. *IEEE Workshop on Disaster Recovery Networks (DIREN)*, 7. https://omidi.iut.ac.ir/SDR/2009/88_M.Nazarpour_SDR_final_project/htmlfile/references/8.pdf
- Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Futures Studies*, 23(2), 29–44. [https://doi.org/10.6531/JFS.201812_23\(2\).0003](https://doi.org/10.6531/JFS.201812_23(2).0003)
- Menon, S. (2017). *Key elements for an effective early warning system*. <https://www.linkedin.com/pulse/key-elements-effective-early-warning-system-sanjeev-s-menon>
- Ministry of Mahaweli Development and Environment. (2016). *National adaptation plan for climate change impacts in Sri Lanka*. [https://www4.unfccc.int/sites/NAPC/Documents NAP/National Reports/National Adaptation Plan of Sri Lanka.pdf](https://www4.unfccc.int/sites/NAPC/Documents/NAP/National%20Reports/National%20Adaptation%20Plan%20of%20Sri%20Lanka.pdf)
- Ministry of National Policies and Economic Affairs. (2008). *Floods and Landslides. In Reduction And Predictability Of Natural Disasters* (Issue May). <https://doi.org/10.4324/9780429492549-6>
- Morelli, R., Silva, C., Lanerolle, T., Curzon, R., & Mao, X. S. (2010). Collaboration to deploy help to China. *Communications of the ACM*, 53(12), 142–149. <https://doi.org/10.1145/1859204.1859235>
- Muldoon, N. (2020). *The ultimate guide to user story mapping* (p. 42).
- Muranganwa, R., & Thinyane, M. (2015). Design of a multi-agent opportunistic grid computing platform. *Multiagent and Grid Systems*, 10(4), 199–212. <https://doi.org/10.3233/MGS-140223>

- Naghdi, K., Mansourian, A., Valadanzoej, M. J., & Saadatseresht, M. (2012). Evacuation planning in earthquake disasters, using RS & GIS. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 1671–1676.
- Naoum, S. G. (2007). *Dissertation research and writting for construction students*. Elsevier Ltd.
- Nasreen, M., Hossain, K., Azad, A., & Hassan, K. (2014). *Best practices of strengthening resilience and safety in schools and communities in Bangladesh*.
- National Disaster Management Office. (2015). *National progress report on the implementation of the Hyogo Framework for action (2013-2015) - Interim* (Issue December 2014).
- National Fire Protection Association. (2008). *Standard on disaster/emergency management and business continuity programs*.
- Nguyen, D. N., Imamura, F., & Iuchi, K. (2018). Barriers towards hotel disaster preparedness: Case studies of post 2011 Tsunami, Japan. *International Journal of Disaster Risk Reduction*, 28, 585–594. <https://doi.org/10.1016/j.ijdr.2018.01.008>
- Nishida, S., Nakatani, M., Koiso, T., & Atoji, Y. (2013). Information filtering for emergency management. *Cybernetics and Systems*, 34(3), 193–206. <https://doi.org/10.1080/01969720302838>
- Novak, J., Lozos, J. C., & Spear, S. E. (2019). Development of an Interactive Escape Room Intervention to Educate College Students about Earthquake Preparedness. *Natural Hazards Review*, 20(1), 06018001. [https://doi.org/10.1061/\(asce\)nh.1527-6996.0000322](https://doi.org/10.1061/(asce)nh.1527-6996.0000322)
- Nunes, N., Roberson, K., & Zamudio, A. (2014). *The MEND guide- Comprehensive guide for planning mass evacuations in natural disasters*.
- O'Reilly, K. (2009). *Inductive and deductive*. <http://dx.doi.org/10.4135/9781446268308.n19>
- Ogie, R. I., Forehead, H., Clarke, R. J., & Perez, P. (2018). Participation patterns and reliability of human sensing in crowd-sourced disaster management. *Information Systems Frontiers*, 20(4), 713–728. <https://doi.org/10.1007/s10796-017-9790-y>
- Pamidimukkala, A., Kermanshachi, S., & Karthick, S. (2020). *Impact of natural disasters on construction projects: Strategies to prevent cost and schedule overruns in reconstruction projects*. 49–57. <https://doi.org/10.3311/cc2020-054>
- Parker, J. (2019). Emergency preparedness through community cohesion: An integral

- approach to resilience. In *Emergency Preparedness through Community Cohesion: An Integral Approach to Resilience*. <https://doi.org/10.4324/9780429441271>
- Patton, J. (2014). User story mapping. In *Wiener Medizinische Wochenschrift* (Vol. 154, Issues 19–20). O'Reilly Media. <https://doi.org/10.1007/s10354-004-0110-z>
- Patton, M. Q. (1987). *How to use qualitative methods in evaluation*. Sage Publications. https://books.google.lk/books/about/How_to_Use_Qualitative_Methods_in_Evalua.html?id=0co1ESOVJHkC&redir_esc=y
- Peek, L., & Fothergill, A. (2009). Using focus groups: Lessons from studying daycare centers, 9/11 and Hurricane Katrina. In *Qualitative Research* (Vol. 9, Issue 1). <https://doi.org/10.1177/1468794108098029>
- Perry, M. (2010). Natural disaster management planning: A study of logistics managers responding to the tsunami. *International Journal of Physical Distribution and Logistics Management*, 37(5), 409–433. <https://doi.org/10.1108/09600030710758455>
- Phillips, B. D. (2015). *Disaster recovery*. CRC Press.
- Ponto, J. (2015). Understanding and evaluating survey research. In J. M. Brant, M. L. Haas-Haseman, S. H. Wei, & R. Wickham (Eds.), *Translating Research into Practice* (pp. 168–171).
- Prizzia, R. (2008). The role of coordination in disaster management. In *Disaster Management Handbook* (pp. 75–98). <https://dspace.lib.hawaii.edu/bitstream/10790/3357/1/prizzia.r-2008-0036.pdf>
- Queensland Government. (2021). *Prevention preparedness, response and recovery disaster management guideline*. <https://www.disaster.qld.gov.au/dmg/Pages/DM-Guideline.aspx#4.1>
- Quero, R. A. (2017). Reframing coordination challenges for public-private partnerships in disaster preparedness. *Procedia - Social and Behavioral Sciences*, 57, 440–447. <https://doi.org/10.1016/j.sbspro.2012.09.1209>
- Quero, R. A. (2012). Reframing coordination challenges for Public-Private Partnerships in disaster preparedness. *International Conference on Asia Pacific Business Innovation and Technology Management Reframing*, 57, 440–447. <https://doi.org/10.1016/j.sbspro.2012.09.1209>
- Ragsdell, G. (2009). Participatory action research: A winning strategy for KM. *Journal of Knowledge Management*, 13(6), 564–576. <https://doi.org/10.1108/13673270910997196>

- Rahman, K. M., Alam, T., & Chowdhury, M. (2012). Location based early disaster warning and evacuation system on mobile phones using OpenStreetMap. *2012 IEEE Conference on Open Systems, ICOS 2012*. <https://doi.org/10.1109/ICOS.2012.6417627>
- Raithatha, Y. (2017). *Understanding the economic impact terrorism has on the destination decision making : Northern Irish tourists*. <https://www.semanticscholar.org/paper/Understanding-the-economic-impact-terrorism-has-on-Raithatha/77230393f2129e390308412b783125ef5eb7b8a8>
- Rajen, G. (2021). *Stages of software development process*. SynapseIndia; SynapseIndia. <https://www.synapseindia.com/article/6-stages-of-software-development-process>
- Randil, C., Siriwardana, C., & Hewawasam, K. (2019). Framework to analyze Sri Lanka disaster management mechanism. *International Journal of Disaster Resilience in the Built Environment*, 11(2), 289–307. <https://doi.org/10.1108/IJDRBE-07-2019-0044>
- Rao, R. R., Eisenberg, J., & Schmitt, T. (2007). Improving disaster management: The role of IT in mitigation, preparedness, response and recovery. In *Improving Disaster Management*. National Research Council. <https://doi.org/10.17226/11824>
- Reser, J. P., & Morrissey, S. A. (2009). *The crucial role of psychological preparedness for disasters*.
- Response, H. (2016). *What is preparedness?* OCHA. <https://www.humanitarianresponse.info/en/coordination/preparedness/what-preparedness#:~:text=The term “preparedness” refers to,current hazards%2C events or conditions>.
- Reyes, J. A. L., Ayo, K. A. R., Baluyan, M. P. M., & Balaguer, A. S. R. B. (2020). Indigenous knowledge in disaster risk reduction: The tales of three islands (San Miguel, Camotes and Alabat) in the Philippines. *Copenhagen Journal of Asian Studies*, 37(1), 103–132. <https://doi.org/10.22439/CJAS.V37I1.5908>
- Robeer, M., Lucassen, G., Van Der Werf, J. M. E. M., Dalpiaz, F., & Brinkkemper, S. (2016). Automated extraction of conceptual models from user stories via NLP. *Proceedings - 2016 IEEE 24th International Requirements Engineering Conference, RE 2016*, 196–205. <https://doi.org/10.1109/RE.2016.40>
- Rodriguez-Espiindola, O., Albores, P., & Brewster, C. (2017). Disaster preparedness in humanitarian logistics: A collaborative approach for resource management in flood. *European Journal of Operational Research*, 37. <https://doi.org/10.1016/j.ejor.2017.01.021>

- Rodríguez, O., Albores, P., & Brewster, C. (2017). Disaster preparedness in humanitarian logistics: A collaborative approach for resource management in flood. *European Journal of Operational Research* Received, 36. <https://doi.org/10.1016/j.ejor.2017.01.021>
- Ronan, K. R., Alisic, E., Towers, B., Johnson, V. A., & Johnston, D. M. (2015). Disaster Preparedness for Children and Families: a Critical Review. *Current Psychiatry Reports*, 17(7), 1–9. <https://doi.org/10.1007/s11920-015-0589-6>
- Rono-bett, K. C. (2018). Erratum : A political economy analysis of decision-making on natural disaster preparedness in Kenya. *Journal of Disaster Risk Studies*, 10(1). <https://jamba.org.za/index.php/jamba/article/view/722>
- Rosselló, J., Becken, S., & Santana-Gallego, M. (2020). The effects of natural disasters on international tourism: A global analysis. *Tourism Management*, 79(December 2019). <https://doi.org/10.1016/j.tourman.2020.104080>
- Rudestam, K. E., & Newton, R. R. (2007). *Surviving your dissertation: A comprehensive guide to content and process* (3rd ed.). Sage Publications. <https://psycnet.apa.org/record/2007-15383-000>
- Safaie, S., Stepanyan, M., Houdijk, R., & Onur, T. (2017). National disaster risk assessment. In *United Nations Office for Disaster Risk Reduction*.
- Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). Understanding research philosophy and approaches to theory development. In *Research Methods for Business Students* (8th ed., Issue January, pp. 128–171). Pearson Education Limited. www.pearson.com/uk
- Schempp, T., Zhang, H., Schmidt, A., Hong, M., & Akerkar, R. (2019). A framework to integrate social media and authoritative data for disaster relief detection and distribution optimization. *International Journal of Disaster Risk Reduction*, 39(April), 101143. <https://doi.org/10.1016/j.ijdr.2019.101143>
- Schreier, M. (2012). *Qualitative content analysis in practice*. Sage Publications. <https://us.sagepub.com/en-us/nam/book/qualitative-content-analysis-practice>
- Schul, F. (2019). *How to improve your user stories and the efficiency of your team*. Ambient-Digital. <https://medium.com/ambient-innovation/how-to-improve-your-user-stories-and-the-efficiency-of-your-team-bf7d59f2f2d0>
- Scotland, J. (2012). Exploring the philosophical underpinnings of research : Relating ontology and epistemology to the methodology and methods of the scientific , interpretive and critical research paradigms. *English Language Teaching*, 5(9), 9–16.

<https://doi.org/10.5539/elt.v5n9p9>

- Sena, L., & Woldemichael, K. (2010a). Disaster prevention and action. In *USAID* (Vol. 30, Issue 4).
- Sena, L., & Woldemichael, K. (2010b). *Disaster prevention and preparedness* (Vol. 30, Issue 4). USAID. SCMRE
- Setia, M. S. (2016). Cross-sectional studies. *International Journal of Dermatology*, 61(3), 261–264. <https://www.e-ijd.org/printarticle.asp?issn=0019-5154;year=2016;volume=61;issue=3;page=261;epage=264;aulast=Setia>
- Shahid, W., Xinhai, L., & Muhammad, R. (2014). Issues and challenges in inter-organisations ' disaster management in underdeveloped coastal areas of Pakistan. *International Journal of Academic Research in Business and Social Sciences*, 4(5), 140–155. <https://doi.org/10.6007/IJARBS/v4-i5/844>
- Sharma, S., Jerripothula, S., Mackey, S., & Soumare, O. (2014). Immersive virtual reality environment of a subway evacuation on a cloud for disaster preparedness and response training. *IEEE Symposium Series on Computational Intelligence - Computational Intelligence for Human-Like Intelligence, Proceedings*, 978–984. <https://doi.org/10.1109/CIHLI.2014.7013380>
- Shaw, R., Izumi, T., & Shi, P. (2016). Perspectives of science and technology in disaster risk reduction of Asia. *International Journal of Disaster Risk Science*, 7(4), 329–342. <https://doi.org/10.1007/s13753-016-0104-7>
- Shiwaku, K., & Fernandez, G. (2016). Innovative approaches in disaster education. In *Disaster Education* (Vol. 7, pp. 115–136). [https://doi.org/10.1108/S2040-7262\(2011\)0000007012](https://doi.org/10.1108/S2040-7262(2011)0000007012)
- Simons, A., Brocke, J. vom, Niehaves, B., Niehaves, B., & Reimer, K. (2009). Reconstructing the giant: On the importance of rigour in documenting the literature search process. *European Conference on Information Systems*. <https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1145&context=ecis2009>
- Singleton, R. A., & Straits, B. C. (2009). *Approaches to social research* (5th ed.). Oxford University Press.
- Sinha, A., Pal, D. K., Kasar, P. K., Tiwari, R., & Sharma, A. (2008). Knowledge, attitude and practice of disaster preparedness and mitigation among medical students. *Disaster Prevention and Management: An International Journal*, 17(4), 503–507. <https://doi.org/10.1108/09653560810901746>
- Siriwardana, C. S. A., Jayasiri, G. P., & Hettiarachchi, S. S. L. (2018a). Investigation of

- efficiency and effectiveness of the existing disaster management frameworks in Sri Lanka. *Procedia Engineering*, 212(2017), 1091–1098. <https://doi.org/10.1016/j.proeng.2018.01.141>
- Siriwardana, C. S. A., Jayasiri, G. P., & Hettiarachchi, S. S. L. (2018b). Investigation of efficiency and effectiveness of the existing disaster management frameworks in Sri Lanka. *Procedia Engineering*, 212(2017), 1091–1098. <https://doi.org/10.1016/j.proeng.2018.01.141>
- Smilowitz, K., & Dolinskaya, I. (2011). *Decision-making tools for distribution networks in disaster relief*. http://ccitt.northwestern.edu/documents/Smilowitz_Dolinskaya_DisasterRelief_FinalReport.pdf
- Sridarran, P. (2018). *A Framework to enhance post-disaster resettlement process through adaptable built environment in Sri Lanka* (Issue February).
- Srivastava, N., Bharti, N., Tyagi, B., Saluja, S., Aslam, S., & Aggarwal, V. (2017). Effects of various disaster management approaches: an evidence summary. In *Social Science Research Unit* (Issue January). <http://eppi.ioe.ac.uk/>
- State Government of Victoria. (2019). *Teach with digital technologies*. <https://www.education.vic.gov.au/school/teachers/teachingresources/digital/Pages/teach.aspx#:~:text=Digital technologies are electronic tools,across all curriculum learning areas.>
- Steele, P., Wickramasinghe, K., & Knight, M. (2017). *Disaster management policy and practice in Sri Lanka : Sharing lessons among government , civil society and private sector* (Issue October 2016).
- Stock, A. (2012). *What is content analysis: Quantifying the qualitative*. ProfileTree. <https://profiletree.com/what-is-content-analysis-quantifying-qualitative/>
- Subhan, Z., & Bhatti, A. T. (2015). Requirements analysis and design in the context of various software development approaches. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 3(6), 812–820.
- Susi, T., Johannesson, M., & Backlund, P. (2015). Serious Games Effects: An Overview. *Procedia - Social and Behavioral Sciences*, 174(November), 2240–2244. <https://doi.org/10.1016/j.sbspro.2015.01.881>
- Sutton, J., & Tierney, K. (2006). Disaster preparedness : Concepts , guidance and research. In *Disaster Preparedness* (Issue March). <http://www.colorado.edu/hazards>
- Swati, A., Raveendran, J., & Shaheen, M. (2014). Conflict management strategies used

- by Indian software companies : A Summative Content Analysis. *The IUP Journal of Soft Skills*, 8(4), 47–61. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%253A%252F%252Fwww.researchgate.net%252Fprofile%252FMusarrat-Shaheen%252Fpublication%252F272086633_Conflict_Management_Strategies_Used_by_Indian_Software_Companies_A_Summative_Content_Analysis%252F
- Sympson, G. (2020). *The Definitions Book: How to Write Definitions*. <https://commoncontrolshub.com/education/how-to-write-definitions/>
- Tabish, S. A., & Syed, N. (2015). Disaster preparedness : Current trends and future directions. *International Journal of Science and Research (IJSR)*, 4(6), 227–252.
- Taranaki Emergency Management. (2018). *Readiness*.
- Tech, A., & Money, E. (2019). *Benefits of Digital Technology*. Ten Benefits Editorial.
- The United Nations Office for Disaster Risk Reduction (UNDRR). (2019). *Disaster risk reduction in Sri Lanka*.
- The United Nations Office for Disaster Risk Reduction (UNISDR). (2015). *Sendai framework for disaster risk reduction 2015 - 2030 1*. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
- Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). Facing the unexpected. In *Facing the Unexpected*. <https://doi.org/10.17226/9834>
- Toloie-eshlaghy, A., Chitsaz, S., Karimian, L., & Clarkhchi, R. (2011). A classification of qualitative research methods. *Research Journal of International Studies*, 20(20), 106–124.
- Tonkiss, F. (2004). Using focus groups. In S. Clive (Ed.), *Researching Society and Culture* (pp. 193–206). Sage Publications. <http://eprints.lse.ac.uk/id/eprint/9766>
- Torpan, S., Hansson, S., Rhinard, M., Kazemekaityte, A., Jukarainen, P., Frislid, S., Schieffellers, A., Lovasz, G., & Orru, K. (2021). Handling false information in emergency management : A cross-national comparative study of European practices. *International Journal of Disaster Risk Reduction*, 57, 102151. <https://doi.org/10.1016/j.ijdrr.2021.102151>
- Transitional Government of Ethiopia. (2015). *National policy on disaster prevention and management*.
- Tsai, C. H., & Chen, C. W. (2011). The establishment of a rapid natural disaster risk assessment model for the tourism industry. *Tourism Management*, 32(1), 158–171.

<https://doi.org/10.1016/j.tourman.2010.05.015>

- Turoff, M. (2019). Past and future emergency response information systems. *Communications of the ACM*, 45(4), 39–32. <https://doi.org/10.1145/505248.505265>
- Twigg, J. (2004). Disaster risk reduction: Mitigation and preparedness. In *Disaster Risk Reduction* (Vol. 1). http://undmtp.org/english/disaster_preparedness/disaster_preparedness.pdf.%0Ahttps://goodpracticereview.org/9/
- United Nations (UN). (2009). *Terminology of disaster risk reduction*.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015a). *Disaster risk reduction & disaster risk management*. PreventionWeb. <https://www.google.com/search?q=undrr&oq=UNDRR&aqs=chrome.0i355i512j46i199i465i512j0i10i433j46i10i433j0i10i433j46i10i433j0i10i433j46i10i199i291j0i10.2132j0j7&sourceid=chrome&ie=UTF-8>
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015b). *Proposed updated terminology on disaster risk reduction : A technical review*.
- United Nations Office for Disaster Risk Reduction (UNISDR). (2016). Risk assessment and management. In *United Nations Office for Disaster Risk Reduction* (Issue January). <https://doi.org/10.1002/9783527619658.ch77>
- Villagrán de León, J. C., Bogardi, J., Dannenmann, S., & Basher, R. (2009). Early warning systems in the context of disaster risk management. In *Entwicklung und Ländlicher Raum* (Vol. 2). <http://www.unisdr.org/eng/sasakawa/>
- Vincent, D. S., Sherstyuk, A., Burgess, L., & Connolly, K. K. (2008). Teaching mass casualty triage skills using immersive three-dimensional virtual reality. *Acad Emerg Med*, 15(11). <https://doi.org/10.1111/j.1553-2712.2008.00191.x>
- Visual Paradigm. (2021). *Requirement analysis techniques*. <https://www.visual-paradigm.com/guide/requirements-gathering/requirement-analysis-techniques/>
- Vitalii, S., Khorram-Manesh, A., & Nyberg, L. (2017). Disaster cycle and management. In *Handbook of disaster and emergency management* (pp. 23–29).
- Walle, B. Van De, Turoff, M., & Hiltz, S. R. (2009). *Information systems for emergency management*. M.E.Sharpe. <https://dl.acm.org/doi/10.5555/1823194>
- Warfield, C. (2017). *The disaster management cycle*. https://www.gdrc.org/uem/disasters/1-dm_cycle.html
- Wattegama, C. (2017). *ICT for disaster management*.

- Wautelet, Y., Heng, S., Kiv, S., & Kolp, M. (2017). User-story driven development of multi-agent systems: A process fragment for agile methods. *Computer Languages, Systems and Structures*, 50, 159–176. <https://doi.org/10.1016/j.cl.2017.06.007>
- World Health Organisation (WHO). (2019a). A strategic framework for emergency preparedness. In *WHO* (Vol. 53, Issue 9).
- World Health Organisation (WHO). (2019b). *Thematic Paper on the Status of Country Preparedness Capacities* (Issue September). https://apps.who.int/gpmb/assets/thematic_papers/tr-2.pdf
- Xu, X., Zhang, L., Sotiriadis, S., Asimakopoulou, E., Li, M., & Bessis, N. (2018). CLOTHO: A Large-Scale Internet of Things-Based Crowd Evacuation Planning System for Disaster Management. *IEEE Internet of Things Journal*, 5(5), 3559–3568. <https://doi.org/10.1109/JIOT.2018.2818885>
- Yin, R. K. (2014). *Qualitative research from start to finish*. Guilford Press.
- Ying, E., & Chan, Y. (2020). *Disaster public health and older people*. Newgen Publishing UK.
- Yun, H.-C., Kim, J.-B., Jung, K.-Y., & Kim, M.-G. (2012). *Application of disaster information system for disaster management* (T. Kim, C. Ramos, H. Kim, A. Kiumi, S. Mohammed, & D. Ślęzak (eds.)). Springer Berlin Heidelberg. https://link.springer.com/chapter/10.1007/978-3-642-35267-6_53
- Zou, H., Li, N., & Cao, L. (2017). Emotional response–Based approach for assessing the sense of presence of subjects in virtual building Evacuation studies. *Journal of Computing in Civil Engineering*, 31(5), 04017028. [https://doi.org/10.1061/\(asce\)cp.1943-5487.0000679](https://doi.org/10.1061/(asce)cp.1943-5487.0000679)
- Žukauskas, P., Vveinhardt, J., & Andriukaitienė, R. (2018). *Philosophy and paradigm of scientific research*. <https://doi.org/DOI: 10.5772/intechopen.70628>
- Zulch, H. (2019). Psychological preparedness for natural hazards – Improving disaster preparedness policy and practice. In *Griffith University School of Psychology revue* (Issue Gar 2019). <https://www.unisdr.org/we/inform/publications/66345>
- Zurich Insurance Company Ltd. (2018). *Extreme weather events—How hard lessons strengthen resilience against the next big event*. Risk Insights.

APPENDIX A - DEFINITIONS OF SYSTEMATIC REVIEW

Definition Number	Definition	Source
[1]	“Disaster preparedness refers to measures that are developed either by government agencies, nongovernmental organisations (NGO), communities or individuals in advance of an imminent threat with the aim of reducing loss of life, injuries and property damage”	(United Nations Office for Disaster Risk Reduction [UNDRR], 2015)
[2]	“The continuous establishment of measures and controls to ensure a greater likelihood of recovery. These measures and controls include taking corrective action to provide reasonable assurance that a critical business process is resilient.”	(Kliem & Richie, 2016)
[3]	“Disaster preparedness is one of the core elements of disaster management which includes activities and measures taken in advance to ensure effective response to a disaster, including early warnings and quick shifting of people and their property from the endangered locations”	(Phillips, 2015)
[4]	“Disaster preparedness defines as actions that enable government, organisation, society, community and individuals to be able to respond to a disaster situation quickly and efficiently. Included in preparedness measures are preparation of disaster management plans for resource maintenance and personnel training”	(Hidayati, 2008)
[5]	“Disaster Preparedness is practiced by enhancing the capacities of government and nongovernment organisations, as well as communities, in light of possible negative impacts of disasters.”	(Reyes et al., 2020)
[6]	“Disaster preparedness involves the activities undertaken to prepare the relief agencies and communities for the disaster they are about to respond. Disaster preparedness comprises of activities intended for improving response activities and coping capabilities.”	(Rodríguez et al., 2017)

[7]	“Disaster preparedness can be defined as the knowledge and capacities developed by various institutions, including governmental, non-governmental and professional organisations, as well as communities and individuals, to effectively anticipate, respond to and recover from any imminent hazards or emergencies. Preparedness includes understanding and analysing the hazards particular to a community, learning about community warning systems and response plans, knowing the designated evacuation route and shelter and maintaining adequate supplies, thus allowing for a smooth transition from response to recovery”	(United Nations [UN], 2009)
[8]	“Disaster preparedness refers to activities undertaken by health professionals to ensure timely and efficient response systems when disasters strike, as well as actions taken at the community and individual levels to maximise resilience and protect against and minimise physical and emotional damage resulting from disasters. Mitigation involves measures deployed to reduce the health risk posed by hazards.”	(Ying & Chan, 2020)
[9]	“Preparedness means a state of readiness and capability of human and material means, structures, communities and organisations enabling them to ensure an effective rapid response to a disaster, obtained as a result of action taken in advance.”	(Lauriola et al., 2018)
[10]	“Readiness is an element of disaster management process specifically involving natural disasters as it is an important element of proactive disaster risk reduction management activities, before the actual disaster occurs. The readiness concept is focused more on the ability to take emergency action in a timely and timely manner.”	(Mahjom et al., 2019)
[11]	“Preparedness is defined as the knowledge, capabilities and actions of governments, organisations, community groups and individuals to effectively anticipate, respond to and recover from, the impacts of likely, imminent or current hazard events or conditions”	(The United Nations Office for Disaster Risk Reduction [UNISDR], 2015)
[12]	“Preparedness is a series of activities undertaken to anticipate disasters through organising and through appropriate and efficient measures. The importance of	(Meier, 2000)

	preparedness is one of the key elements of proactive active disaster risk reduction prevention activities, prior to a disaster”	
[13]	“Preparedness, in the context of disaster risk management, focuses on building capacity to ensure the efficient management of emergencies and building sustainable systems for resilience and recovery.”	(Rono-bett, 2018)
[14]	“Disaster preparedness refers to the steps and activities that are planned and undertaken prior to the onset of a disaster aiming to enhance the capacity of individuals, households or communities to respond effectively to an emergency, crisis, or disaster.”	(Baker, 2018)
[15]	“Disaster preparedness is often referred to as the measures taken prior an event that lessen or may help mitigate and eliminate the severity of natural disasters by preparing the community or people through development of emergency plans for response and recovery, translation of these plans quickly and effectively and continuous public awareness regarding hazards and risks.”	(Chang-richards et al., 2018)
[16]	“Disaster preparedness refers to the capacities and knowledge developed by governments, professional response organisations, communities and individuals to anticipate and respond effectively to the impact of likely, imminent, or current hazard events or conditions.”	(Humanitarian Response, 2016)
[17]	“Developing operational systems and capabilities before an emergency happens, including making arrangements with emergency services, lifeline utilities and other agencies and developing self-help and response programmes for the general public.”	(Taranaki Emergency Management, 2018)
[18]	“Disaster preparedness is a state of readiness to respond to a disaster, crisis, or any other type of emergency situation.”	(Haddow et al., 2015)
[19]	“Disaster preparedness fosters resilience, which is the capacity of individuals and communities in maintaining adequate functioning and returning to normalcy post-disaster.”	(Lemyre & Osullivan, 2013)

[20]	“Disaster preparedness is defined as comprising any measures to predict and—where possible—prevent [disasters], mitigate their impact on vulnerable populations and respond to and effectively cope with their consequences.”	(IFRC, 2015)
[21]	“Disaster preparedness includes any activities involved in “developing plans for what to do, where to go, or who to call for help before an event occurs, which will improve chances of successfully dealing with an emergency.”	(Federal Emergency Management Agency, 2016)
[22]	“A continuous cycle of planning, organizing, training, equipping, exercising, evaluating and taking corrective action in an effort to ensure effective coordination during incident response. This cycle is one element of a broader National Preparedness System to prevent, respond to and recover from natural disasters, acts of terrorism and other disasters.”	(Department of Homeland Security, 2016)
[23]	“Preparedness according to which it engages in the activities to enhance the disaster response by highlighting the role of training and education, evacuation plan, simulating a disaster, emergency kits and resource allocation.”	(Novak et al., 2019)
[24]	“Disaster preparedness means preparing for unknown emergent threats through the enactment of future emergency events with their urgency in the present.”	(Lakoff & Collier, 2008)
[25]	“The concept of preparedness implies that specific efforts are made to identify potential hazards so as to decrease the number of variables that can lead to disasters, while at the same time increasing the ability of individuals, organisations and nations to prevent, prepare for and react to them effectively.”	(McEntire, 2008)
[26]	“Disaster preparedness refers to measures taken to prepare for and reduce the effects of disasters. That is, to predict and—where possible—prevent them, mitigate their impact on vulnerable populations and respond to and effectively cope with their consequences.”	(American Association of Physics Teachers, 2000)
[27]	“Disaster preparedness refers to a combination of short- and long-term strategies that help minimise or reduce the negative effects of natural hazards, prevent their	(Dekens, 2007)

	impacts on assets and escape certain peak values (e.g., during periods of excessive rainfall, etc) or their consequences.”	
[28]	“The systematic process of using administrative measures, organisations and operational skills to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and to minimise the opportunity for development of emergencies (disasters) is called emergency (disaster) preparedness.”	(Laaser & Beluli, 2016)
[29]	“Emergency preparedness encompasses actions undertaken before disaster impact that enable social units to respond actively when disaster does strike.”	(Tierney et al., 2001)
[30]	“Activities, programs and systems developed and implemented prior to a disaster/emergency that are used to support and enhance mitigation of, response to and recovery from disaster/emergencies.”	(National Fire Protection Association, 2008)
[31]	“Preparedness can be defined as the leadership, training, readiness and exercise support and technical and financial assistance to strengthen citizens, communities, state, local and tribal governments and professional emergency workers as they prepare for disasters, mitigate the effects of disasters, respond to community needs after a disaster and launch effective recovery efforts.”	(Sutton & Tierney, 2006)
[32]	“The capacities and knowledge developed by governments, professional response organisations, communities and individuals to anticipate and respond effectively to the impact of likely, imminent or current hazard events or conditions.”	(International Strategy for Disaster Reduction [ISDR], 2008)
[33]	“Disaster preparedness is building up of capacities before a disaster situation prevails in order to reduce impacts. Its measures include inter alia, availability of food reserve, emergency reserve fund, seed reserve, health facilities, warning systems, logistical infrastructure, relief manual and shelves of projects.”	(Transitional Government of Ethiopia, 2015)
[34]	“Disaster preparedness is defined as a state of readiness to respond to a disaster, crisis, or any other type of emergency situation.”	(Sena & Woldemichael, 2010)

APPENDIX B - USER STORIES

User Story Number	US-01
User Story (Card)	As a GN/Divisional/District Officer, I need to receive the details of vulnerable areas for each disaster from technical agencies so that I will be able to develop the preparedness plans accordingly
Conversation	Technical Agencies- Irrigation department, NBRO, Meteorological department Details- Irrigation Department- Areas vulnerable to floods around river basins, NBRO- which areas are vulnerable for landslides, meteorological department- areas vulnerable to winds, heavy rainfalls
Confirmation	User needs to select the technical agency from a drop-down and search for their updated daily reports on the disaster risks.

User Story Number	US-02
User Story (Card)	As a GN/Divisional/District Officer/ Community member, I need to review the vulnerable areas within the division/district/GN division to identify the disaster risks.
Conversation	All the users need this requirement. Need to search for the disaster and the particular area. Review the vulnerable areas in a map with colour codes (High, medium, low).
Confirmation	User needs to select the disaster (from a dropdown) and whether to search on a district or a division (from a drop-down). Then type the district or division name that user needs to search. Then user will be able to review the areas that are vulnerable to the particular disaster in the selected district or division on a map. User needs to separately identify the vulnerable areas as high, medium and low from three different colours in the map.

User Story Number	US-03
-------------------	-------

User Story (Card)	As a GN/Divisional/District Officer, I need to review the past records of disasters within the selected area so that I can predict future severities of disasters
Conversation	User needs the details such as disaster name, year, date, damage (Number of deaths, injuries, number of houses destroyed, worth of property damage), NGO details engaged (Names and Contact details) within the selected area. The name and the contact number of the officer who updated the records should also be inserted.
Confirmation	User needs to select whether the district or division needs to be selected from the drop-down. Then type the name of the particular district or division. Then user needs to select the past disaster records button. User should have the details of each disaster separately. If the area is disaster free 'No past records could be found' should be prompted. If the selected area is not applicable to the system 'The selection is incorrect' should be prompted.

User Story Number	US-04
User Story (Card)	As a community member, I need to track whether my current location is vulnerable to any kind of disaster, so that I can be better prepared according to the disaster event.
Conversation	Based on the current location. What are the disasters I will be affected? The severity level.
Confirmation	User should receive a message if his current location is vulnerable to any kind of disaster. The message should include the name of the disaster and vulnerability level (Low, medium, high)

User Story Number	US-05
User Story (Card)	As a District/ Divisional/ Grama Niladhari officer, I need to review the details of all the individuals within each administration level, so that I can use them to prepare a communication map
Conversation	Details- Name, Living or Dead, Disabled or not, District, Division, Grama Niladhari Divison, permanent address, temporary address, Contact

	Numbers (Mobile, Landline), family members (Names, marital status, age), Occupation, Available property details (Details of houses owned including address, number of rooms, number of stories)
Confirmation	User needs to review the details of an individual by searching the name from the system. If user can't remember the name he should be able to filter the details based on the district, division, or Grama Niladhari division of the user. After the selection of a particular administrative level (whether district, division, or Grama Niladhari from a drop-down) and the name of the selected administration level, user should be able to review all the details of the individuals who belong to that particular administration level.

User Story Number	US-06
User Story (Card)	As a District/ Divisional/ Grama Niladhari officer, I need to prioritise the details of the community by categories, so that I can use them to prepare a communication map
Conversation	Filter the details of the individuals as per the disability status (Disable or Not), age ranges (less than 18, 18-60, more than 60), Education level (up to O/Ls, Up to A/Ls, Graduate, No education)
Confirmation	User needs to select the category from the drop-down (disability, age range, education level) and then select the sub-category from the next dropdown and review the details with reference to the selected administrative area.

User Story Number	US-07
User Story (Card)	As a community member, I need to review the details of all the officers related to disaster preparedness, so that I can contact them in the necessity.
Conversation	Details- Administration Level (National, District, Division), Designation (National, district, divisional disaster management officer/ Grama Niladhari), Name, Contact Number, Address, e-mail

Confirmation	User should be able to type the name of the administration level and the designation and then the necessary details should be appeared.
--------------	---

User Story Number	US-08
User Story (Card)	As the Divisional, District and Grama Niladhari, I need to update the capacity of available shops, hardwares, hospitals, pharmacies in my area, so that others can review them.
Conversation	Separate detail lists should be there for district, divisional and Grama Niladhari levels. The editing function should be available only for the disaster management officers that represent the particular area (There should be a separate user name and password to that). Details- Shops, Hardwares (Name, Owner contact number, address, good items that can be borrowed at the emergency- name of the good, amount, unit price, total price) Pharmacies (Name, Owner contact number, address, medicines that can be borrowed at the emergency- name of the medicine, amount, unit price, total price) Hospitals (Name, Contact numbers, location, Staff availability- number of doctors, nurses, attendants, Bed capacity,
Confirmation	User should be able to type the administration level that he represents select the edit the details button. Then user needs to type the user name and password to log in to the particular section for the editing. (The user should have the editing ability only for his representing area, other areas details only can be reviewed.

User Story Number	US-9
User Story (Card)	As the Divisional, District and Grama Niladhari officers and community members I need to the review the capacity of available shops, hardwares,

	hospitals, pharmacies in my area, so that I can use them at the response stage.
Conversation	All the details in the US- 09 should be able to be reviewed. Separate administration levels in a dropdown (District, Division, GS). Separate categories in the second drop-down (shops, hardwares, hospitals, pharmacies) Accessible for all registered users
Confirmation	User should be able to select whether the search is from district, division or GS level from the dropdown. Then type the name of the district, division or Grama Niladhari area. After that, he should select the category that he needs the details (shops, hardwares, hospitals, pharmacies) Then the required details should be appeared matching to the searched area.

User Story Number	US-10
User Story (Card)	As the Divisional, District and Grama Niladhari, I need to update the details of the places that can be used as evacuation centers in case of emergency immediately
Conversation	Separate detail lists should be there for district, divisional and Grama Niladhari levels. The editing function should be available only for the disaster management officers that represent the particular area (There should be a separate user name and password to that). Details- name, Description of the place, address, contact person, contact number, number of individuals that can be temporary accommodated
Confirmation	User should be able to type the administration level that he represents select the edit the details button. Then user needs to type the user name and password to log in to the particular section for the editing. (The user should have the editing ability only for his representing area, other areas details only can be reviewed.)

User Story Number	US-11
User Story (Card)	As the Divisional, District and Grama Niladhari officers I need to review details of the places that can be used as evacuation centers in case of emergency immediately.
Conversation	All the details in the US- 11 should be able to be reviewed. Separate administration levels in a dropdown (District, Division, GS). Accessible for all registered users
Confirmation	User should be able to select whether the search is from district, division or GS level from the dropdown. Then type the name of the district, division or Grama Niladhari area. Then the required details of the evacuation centers should be appeared matching to the searched area.

User Story Number	US-12
User Story (Card)	As the Divisional, District and Grama Niladhari officers, I need to update the contact details of vehicles and boats and other resources, so that I can use them in the response stage
Conversation	Separate detail lists should be there for district, divisional and Grama Niladhari levels. The editing function should be available only for the disaster management officers that represent the particular area (There should be a separate user name and password to that). Details- Resource Name (vehicle, Boats, Life Jackets, Others), Resource reference number (Ex- Vehicle number, boat number), Owner name, Owner contact number, Owner address, the address of the place where the resources can be collected
Confirmation	User should be able to type the administration level that he represents select the edit the details button. Then user needs to type the user name and password to log in to the particular section for the editing. (The user should have the editing ability only for his representing area, other areas details only can be reviewed.)

User Story Number	US-13
User Story (Card)	As the Divisional, District and Grama Niladhari officers, community member, I need to review the details of the vehicles and boats and other resources, so that I can use them in the response stage
Conversation	All the details in the US- 13 should be able to be reviewed. Separate administration levels in a dropdown (District, Division, GS). Accessible for all registered users
Confirmation	User should be able to select whether the search is from district, division or GS level from the dropdown. Then type the name of the district, division or Grama Niladhari area. Then the required details of the resources should be appeared matching to the searched area.

User Story Number	US-14
User Story (Card)	As the community member, I need to review the contact details of line departments such as police, electricity board, divisional, water board, divisional secretariat within my area, so that I can call them in an emergency.
Conversation	Separate administration levels in a dropdown (District, Division, GS). Separate categories in the second drop-down (Police station, electricity board, water board, NBRO, divisional secretariat, district secretariat,) Details- Organisation name, Address of the organisation, Telephone number, fax number, organisation e-mail address Accessible for all registered users
Confirmation	User should be able to select whether the search is from district, division or GS level from the dropdown. Then type the name of the district, division or Grama Niladhari area. After that user should select the organisation that he needs the details from the drop-down (Police station, electricity board, water board, NBRO, divisional secretariat, district secretariat) Then the required details should be appeared matching to the searched area.

User Story Number	US-17
User Story (Card)	As the national level officer, I need to send guidelines for every individual indicating how to be prepared for the disaster, so that the awareness can be enhanced.
Conversation	Update the guideline separately for each disaster. The pdf file should be able to upload (leaflet) The editing function should be available only for the national level disaster management officers (There should be a separate user name and password to that).
Confirmation	User should be able to upload the leaflet files for each disaster that is visible to all the users. User should be able to edit the files at any time.

User Story Number	US-18
User Story (Card)	As the community member, I need to search for guidelines to be followed at the preparedness and response, so that I can enhance my awareness
Conversation	Search the disaster and find out the leaflet with guidelines
Confirmation	User should be able to select the particular disaster from the drop-down (Tsunami, landslides, floods, storms) and select the button 'Go to Guideline'. The guideline should be visible to the user

User Story Number	US-19
User Story (Card)	As the Divisional, District and Grama Niladhari officers, I need to invite the target groups for awareness programmes, so that the invitation will be sent to the particular groups of individuals.
Conversation	Attach the invitation

	Select the target group (based on age/ based on education level, based on gender, based on the area- all the individuals in the area) There should be sub-categories for the target groups (age- - less than 18, 18-60, more than 18/ Education- OLs,ALs, Graduate, No education/ Gender- Men, women/ Area- name of the Grama Niladhari Division)
Confirmation	User should upload the invitation. User should select the target group that should be invited. To that user should select the Target Group button. Then select the district and Grama Niladhari division, then select the target group category from the drop-down (age, education, gender, area), select the subcategory from the next dropdown. Then all the recipients will be appeared to that particular sub-category. User should be able to add and remove the list. The final list should be sent.

User Story Number	US-20
User Story (Card)	As a community member, I need to review the invitations for disaster preparedness programmes, so that I can participate and enhance my awareness
Conversation	Can review the invitation. The notification should receive for the invitation
Confirmation	User should receive the notification stating that ‘You received an invitation for a future event’. User either should be able to click the notification to see the invitation or should be able to click the invitations tab and review the new invitation.

User Story Number	US-21
User Story (Card)	As a community member, I need to confirm my participation for the preparedness activities, so that the officers can count me for the arrangements
Conversation	After the invitation there should be three buttons as ‘I will Participate’, ‘I am not sure’, ‘I won’t participate’

Confirmation	User should be able to confirm his participation by pressing one of the three buttons. There should be the statement “Please confirm your participation” and below that, ‘I will Participate’, ‘I am not sure’, ‘I won’t participate’
--------------	--

User Story Number	US-22
User Story (Card)	As a national level disaster management officer, I need to receive the feedbacks for existing disaster preparedness plans, so that I can revise the plans accordingly
Conversation	The feedbacks of the officers and other community members should be received. Name, Preparedness plan, Organisation, designation, Feedback Should be included in the feedback form.
Confirmation	User needs to receive feedbacks for the preparedness plans. User needs to select the feedbacks tab and find out all the feedbacks for the plans. User should be able to filter the feedback based on the disaster preparedness plan.

User Story Number	US-23
User Story (Card)	As a community member, I need to search the closest evacuation center by entering the location, so that I can evacuate in the response stage.
Conversation	The location should be shown in a map. The name, address, contact details and the capacity of the evacuation center could be able to reviewed
Confirmation	User should provide the current location and select the button ‘Search closest evacuation centers’. Then the locations should be appeared in the map. Once user selects the particular locations he will be able to view the other necessary details of the particular evacuation center

User Story Number	US-24
User Story (Card)	As a community member, I need to search the evacuation routes as per each disaster in a map, so that I can evacuate in the response stage.
Conversation	The evacuation routes should be shown in a map.
Confirmation	User should be able to type the location and select the particular disaster from the dropdown and then search the evacuation routes. The map with the evacuation routes and the directions must be appeared.

User Story Number	US-25
User Story (Card)	As a national-level disaster management officer, I need to find out the location of every community member in a map
Conversation	Map should be prepared The location should be based upon the permanent address of the individuals.
Confirmation	User needs to type the name of the individual and press the button ‘Search in the map’. Then the permanent location of the particular individual should be reviewed.

APPENDIX C - PRELIMINARY INTERVIEW GUIDELINE

SECTION I- INTRODUCTION TO THE STUDY

Research Title

Digitally enhanced disaster preparedness approach for natural disasters in Sri Lanka.

Research Aim

The aim of the study is to enhance the disaster preparedness approach in Sri Lanka through a digital information and coordination system

SECTION II- GENERAL INFORMATION

1. Name(Optional):.....
2. Designation:.....
3. Experience:.....
4. Name of the Organisation (Optional):.....

SECTION II- IMPORTANCE OF THE STUDY

5. Do you think the aforementioned study is fruitful to conduct based upon Sri Lanka?
Why?
.....
.....
6. What are the existing challenges in the overall disaster preparedness approach in Sri Lanka?
.....
.....
7. Among the following disaster preparedness components, what components should be given the best priority for the digital enhancement in order to have successful disaster preparedness outcomes in Sri Lanka? Why do you think so?

Risk Assessment	Coordination Systems	Information Systems	Resource Mobilisation
-----------------	----------------------	---------------------	-----------------------

Early Systems	Warning	Evacuation Systems	Education Training	and	Psychological Preparedness
------------------	---------	-----------------------	-----------------------	-----	-------------------------------

.....

.....

APPENDIX D - EXPERT INTERVIEW GUIDELINE

.....
.....
.....

Dear Sir/ Madam,

Data Collection – Expert Interviews

I am a postgraduate from Department of Building Economics, University of Moratuwa following a Master Degree (Major Component by Research). I am currently conducting a research titled "Digitally enhanced disaster preparedness approach to natural disasters in Sri Lanka" as a part of my Masters degree programme. The study aims to **investigate the user requirements of a digitally enhanced information and coordination system that can be utilised by the practitioners who are involved in disaster preparedness activities**. For that, I am expecting to gather the opinions of professionals of multidisciplinary stance.

I believe through your experience and knowledge in this regard, it will be really valuable for me to have this brief interview with you. Approximately, the interview session would proceed for 45 minutes. The interview guideline is attached herewith for your reference.

The information collected through the interview will be kept strictly confidential and will be used only for the purpose of the study. Further, any of your personal information would not be disclosed throughout the study.

Thank you,

Yours sincerely,

Senuri Disara Siriwardhana,

Department of Building Economics,

University of Moratuwa.

SECTION I- INTRODUCTION TO THE STUDY

Research Title

Digitally enhanced disaster preparedness approach for natural disasters in Sri Lanka.

Research Aim

The aim of the study is to investigate the **user requirements of a digitally enhanced information and coordination system** that can be utilised for the disaster preparedness in Sri Lanka.

SECTION II- GENERAL INFORMATION

1. Name(Optional):.....
2. Designation:.....
3. Experience:.....
4. Name of the Organisation (Optional):.....

SECTION III- DIGITALLY ENHANCED DISASTER PREPAREDNESS SYSTEM

5. Please explain the disaster preparedness process conducted in Sri Lanka.
.....
.....
6. Please explain your job role within the Disaster preparedness system
.....
.....

Suppose a digitally enhanced **holistic information and coordination system** will be designed for the disaster preparedness process that is specified to Sri Lankan context.

7. What are the tasks and their potential benefits that you are expecting to be conducted through such an information system with reference to your job role?

Task	Benefits	Other requirements	Acceptance Criteria

8. Please mention the strengths and weaknesses of the **existing information and coordination system** while performing the disaster preparedness process.

Strengths	Weaknesses

9. Do you have any significant experiences (challenges) faced while implementing the existing disaster preparedness process due to the **information and coordination issues**? Can you please share your experience?

.....
.....

10. What is your overall opinion about implementing a digitally enhanced **information and coordination system** for disaster preparedness in Sri Lanka?

.....
.....

APPENDIX E - PRELIMINARY INTERVIEW TRANSCRIPT

SECTION I- INTRODUCTION TO THE STUDY

Research Title

Digitally enhanced disaster preparedness approach for natural disasters in Sri Lanka.

Research Aim

The aim of the study is to enhance the disaster preparedness approach in Sri Lanka through a digital information and coordination system

SECTION II- GENERAL INFORMATION

1. Name(Optional):.....
2. Designation: *Director, Disaster Management Center*
3. Experience: 07
4. Name of the Organisation (Optional): *Disaster Management Center*

SECTION II- IMPORTANCE OF THE STUDY

5. Do you think the aforementioned study is fruitful to conduct based upon Sri Lanka?
Why?

Yes of course. There is an unavailability of a holistic disaster preparedness approach that can be collaboratively utilised by all the administration levels as well as the community to successfully implement disaster preparedness processes in Sri Lanka. Even DMC works hard to develop disaster preparedness plans and thereby enhance the disaster preparedness among the community it has become difficult due to different types of implementation issues that occurred mainly due to the unawareness of community and the authorities about the importance of disaster preparedness. However, this can be seen as a critical issue to our country since, we are expecting many extensive disasters in near future including a tsunami. Therefore, it is a timely necessity to have a holistic disaster preparedness approach that can be utilised by the authorities as well as the communities collaboratively.

6. What are the existing challenges in the overall disaster preparedness approach in Sri Lanka?

The main challenge is the unawareness of the populations about the importance of disaster preparedness. This is due to the lack of coordination between resource persons in the responsible authorities with the community members. Apart from that insufficiency of financial and human resource capacities at local levels for enhancing the disaster preparedness is also a critical issue considering the country's economic condition. There are novel technologies that have the ability to establish a high level of disaster preparedness. But the adoptability of such technologies to Sri Lankan context is doubtful. Unavailability of central information and coordination system is another challenge for a successful disaster preparedness system in Sri Lanka. Agencies related to disaster preparedness maintain their own databases, but there is no proper coordination and standard information sharing system between these agencies with proper security system.

7. Among the following disaster preparedness components, what components should be given the best priority for the digital enhancement in order to have successful disaster preparedness outcomes in Sri Lanka? Why do you think so?

Risk Assessment	Coordination Systems	Information Systems	Resource Mobilisation
Early Warning Systems	Evacuation Systems	Education and Training	Psychological Preparedness

Coordination and information systems should be enhanced through digital integration first. When it comes to other components, in Sri Lanka, risk assessments, evacuation systems, training procedures are already functioning upto some extent. But information and coordination systems which are developed specifically for disaster preparedness is lacking in Sri Lanka. Such initiatives have been taken for disaster recovery phase. But it is better if we have digital information and coordination system that can be specially utilized by the disaster preparedness practitioners and the community. In this way, all the components will be properly functioned in the collaborative working environment among the disaster preparedness agencies and thereby Sri Lanka can enhance the status of disaster preparedness.

APPENDIX F - EXPERT INTERVIEW TRANSCRIPT

.....

.....

.....

Dear Sir/ Madam,

Data Collection – Expert Interviews

I am a postgraduate from Department of Building Economics, University of Moratuwa following a Master Degree (Major Component by Research). I am currently conducting a research titled "Digitally enhanced disaster preparedness approach to natural disasters in Sri Lanka" as a part of my Masters degree programme. The study aims to **investigate the user requirements of a digitally enhanced information and coordination system that can be utilised by the practitioners who are involved in disaster preparedness activities**. For that, I am expecting to gather the opinions of professionals of multidisciplinary stance.

I believe through your experience and knowledge in this regard, it will be really valuable for me to have this brief interview with you. Approximately, the interview session would proceed for 45 minutes. The interview guideline is attached herewith for your reference.

The information collected through the interview will be kept strictly confidential and will be used only for the purpose of the study. Further, any of your personal information would not be disclosed throughout the study.

Thank you,

Yours sincerely,

Senuri Disara Siriwardhana,

Department of Building Economics,

University of Moratuwa.

SECTION I- INTRODUCTION TO THE STUDY

Research Title

Digitally enhanced disaster preparedness approach for natural disasters in Sri Lanka.

Research Aim

The aim of the study is to investigate the **user requirements of a digitally enhanced information and coordination system** that can be utilised for the disaster preparedness in Sri Lanka.

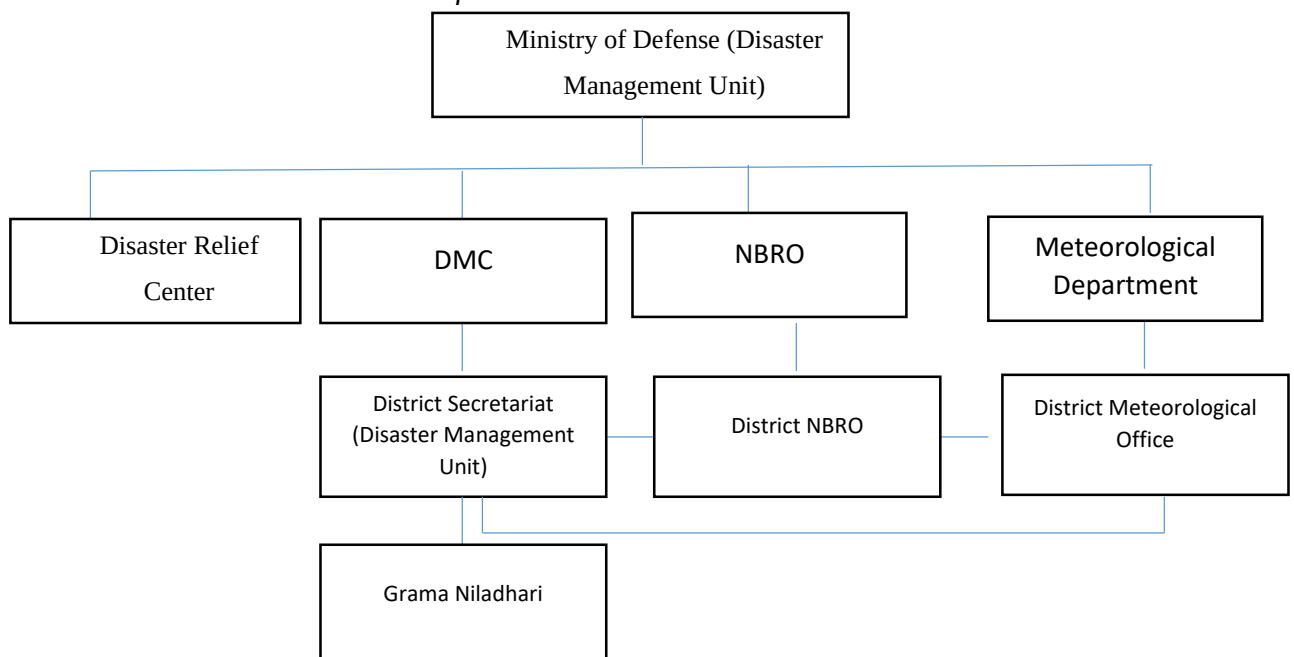
SECTION II- GENERAL INFORMATION

1. Name(Optional):.....
2. Designation: *District Disaster Management Officer*
3. Experience: *7 years*
4. Name of the Organisation (Optional): *District Secretariat- Galle*

SECTION III- DIGITALLY ENHANCED DISASTER PREPAREDNESS SYSTEM

5. Please explain the disaster preparedness process conducted in Sri Lanka.

When it comes to institution framework



As disaster management officers, we are responsible for the management of disasters such as rain, wind, floods, tsunamis, tree fallings, droughts, landslides, lightning under the disaster management circular of 2020 (1). Fire disasters are removed from our scope.

District DM committee consists of (District Level)

District secretary, District DMOs, District Disaster relief officers, Divisional secretaries, NBRO district officer, Irrigation district Officer, Police, Representatives of armed forces, health officers including PHI, (sometimes prison officers), Bank officers, provincial council officers, electricity board, water board

We are working according to the contingency plan introduced by DMC for the preparedness activities.

For every preparedness activity there should be alternative plan at the district level to implement when the main plan at the divisional and village level got failed. We experienced these type of instances in flood in 2017. The main preparedness plan got delayed to implement due to the many of the divisional officers got affected. District secretary took the whole coordination and monitoring of the district and he has to implemented the district plan. This is because we had such kind of preparedness plan at district level.

The preparedness concept is “ If we can spend 1\$ for disaster preparedness, we can save 7\$ at the response.” Sometimes the community is reluctant to spend that 1\$ for preparedness with the hope of having the funds after a disaster that is like 7\$.

The preparedness level decides the success of the disaster response stage.

The thing is that most of the people feels a little about the preparedness and more attention is paid to response that needs to be changed. The community perception is “ Its like making the Vesak Lanterns at January”. They think that without having a warning for a disaster/ clue of a disaster in near future it is useless to get preparedness

6. Please explain your job role within the Disaster preparedness system

I need to find out the suitable food suppliers that can be contacted in case of a disaster. And the transportation medium for the supplies. Actually there should be separate contact list for each divisional secretary as well. But that can't be applied for district level since sometimes all those places at the divisions might be destroyed by the disaster. Therefore, at the district level I should have separate backup contact list broader than the divisional level.

Monitoring the establishment of evacuation centers at divisional level

Progress review of disaster preparedness of each divisions

Coordination of disaster preparedness committee in district level

Supervising disaster preparedness drills at divisional levels.

Building up mental capacity of the community at district levels-There is a loophole in current practice. We need to change the mentality of dependence on aids from the community. Mental capacity building is very necessary for that. (This mainly targets the school children and youths)

Education programmes to convince the importance of preparedness (Participate as a resource person for these programmes)

Directing the divisional level issues to necessary parties to solve down / or at the district DM committee

Disaster management officers have so many responsibilities. Sometimes they may fail to manage his duties. For that it is needed to make their mental readiness initially. I have to conduct such programmes for the all disaster management officers within the district

Suppose a digitally enhanced **holistic information and coordination system** will be designed for the disaster preparedness process that is specified to Sri Lankan context.

7. What are the tasks and their potential benefits that you are expecting to be conducted through such an information system with reference to your job role?

Task	Benefits	Non-functional requirement
<i>I need to have the contact details of food suppliers within the district</i>	<i>To contact at the disaster relief stage</i>	
<i>I need to know the food and other supply transportation methods and contact them</i>	<i>To educate the responsibilities of the owners of transptation at the response</i>	
<i>I need to coordinate the food suppliers and the transportation system</i>	<i>To effective distribution of food and other resources at the response stage</i>	

<i>I need to monitor the establishment of evacuation centers</i>	<i>To report the progress to the district secretary or district disaster management committee</i>	
<i>I need to receive the details of each evacuation center in each division</i>	<i>To keep records and use at the response stage</i>	<i>Locations (GIS,GPS) Owner's details, capacity, Should be visible to every level (District/national)</i>
<i>I need to coordinate NGO's at district levels and direct them to the necessary divisions</i>	<i>To effectively conduct disaster preparedness activities</i>	
<i>I need to select suitable NGO's for the disaster management in our division at the preparedness stage</i>	<i>To involve them in disaster preparedness</i>	<i>Update once in two months</i>
<i>I should have the details and quantity of prisoners in the district level</i>	<i>To use their service for the cooking and other relief activities</i>	
<i>I need to keep records and the details of the places where the helicopters can be landed within the district</i>	<i>To use at the response stage/ to make the necessary authorities aware about their duty in case of a disaster regarding such lands</i>	
<i>I need to remind the divisional DMOs to send their progress of disaster preparedness in each division</i>	<i>To receive their progress report</i>	<i>Once in a two months</i>
<i>I need to review the progress of disaster preparedness of each division</i>	<i>To discover the loopholes/ To report to the district secretary</i>	

<i>I need to direct the divisional level issues to district secretary</i>	<i>To discuss in the DM committee and solve</i>	
<i>I need to send the issues of district level that can't be solved to national level through divisional secretary</i>	<i>To solve them down from national level</i>	
<i>I need to request financial approvals from district secretary</i>	<i>To perform the necessary preparedness activities in district level</i>	
<i>I need to analyse the details of population and vulnerability within the district</i>	<i>To come in to necessary conclusions and report about the current preparedness to top levels</i>	

8. Please mention the strengths and weaknesses of the **existing information and coordination system** while performing the disaster preparedness process.

The information and coordination is very primary at district level. Many of the decisions are taken through the table discussions and the decision and other information sharing is then proceeding with letter communication.

The coordination of village committees is at very low level. The regular monitoring is not conducted. Further there is no encouragement for those committee members through the government. The information sharing in a technical perspective is not active at the village level.

There are some databases at the district level. But they are not familiar and not user-friendly.

Some information that are provided by top levels are not focused properly. Some information reports are provide in a very generic manner without being specific.

There is large amount of information at the district level. But there is an issue with the clarity and we need to develop the proper information analysis system. Without that these information might be useless.

Some approvals getting delayed in terms of finances. For an example, if we got a

suitable proposal for disaster preparedness from bottom level we have to present that to the top level to approve the necessary finances. Then only I can present necessary documents to our financial division and take the money and send to the divisional levels. This procedure is time consuming.

Telephone communication is successfully processing within the district. It is easy. With the collaborative working environment for some approvals telephone conversations has been enough for some instances

9. Do you have any significant experiences (challenges) faced while implementing the existing disaster preparedness process due to the **information and coordination issues**? Can you please share your experience?

As preparedness stage we need to visit the houses with Grama Niladharis to quantify their resource availability and their issues and risk conditions. But some people misunderstand us and reluctant to give true details. For example, some are assuming that we are collecting the details for income taxes and such other purposes. In such cases it is really difficult to collect reliable information

There was an incident where disaster management center advised to conduct a practice tsunami drill. Due to the mistake in communication link the detail transferred to the bottom level was about an actual tsunami. All the officers and the community got panic and it has become a huge issue since the people trying to evacuate.

10. What is your overall opinion about implementing a digitally enhanced **information and coordination system** for disaster preparedness in Sri Lanka?

This is good. But it is necessary to focus on every micro detail from the ground level to top level. The issue with current information and coordination systems is most of the information are generalized (macro details) that is not applicable for the small community groups. Therefore, individual community details should be focused while developing this kind of information and communication system for disaster preparedness