

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:

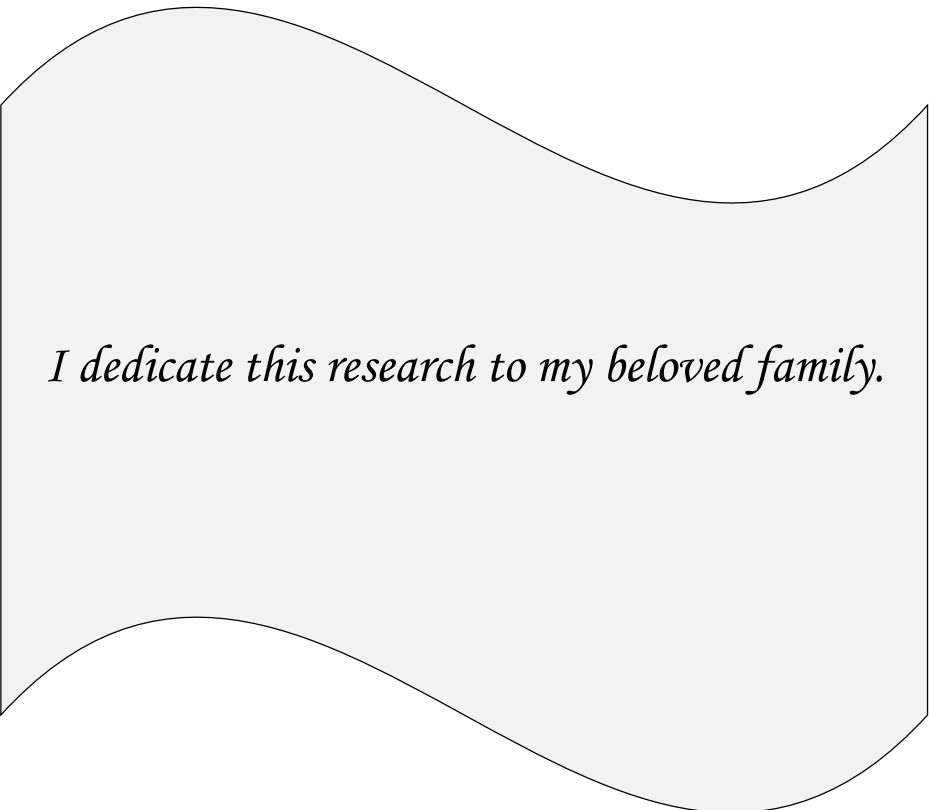
The above candidate has carried out research for the Masters dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

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