

**COMMUNITY PREPAREDNESS FRAMEWORK FOR
DISASTER RISK REDUCTION OF HYDROELECTRIC
DAMS IN CAMERON HIGHLANDS**

BY

RAHSIDI SABRI BIN MUDA

**A thesis submitted in fulfilment of the requirement for the
degree of Doctor of Philosophy (Built Environment)**

**Kulliyyah of Architecture and Environmental Design
International Islamic University Malaysia**

JULY 2021

ABSTRACT

Dam Related Disaster (DRD) occurrences are an unexpected event that might occur suddenly without warning, which seriously impacts people's lives that exceed their ability to survive. It has become very alarming, resulting in a catastrophic break followed by a flood wave at high speed with considerable loss of life, and the eventual catastrophic damages to infrastructure and the environment. The surrounding communities are an integral part of disaster management efforts to increase their knowledge to respond toward the disaster. Given these circumstances, the appropriate community preparedness for Disaster Risk Reduction (DRR) is important to strengthen disaster response strategies. It helps the community to understand the situations to face disaster and interact with present conditions with efficient manners. The research aims to investigate the community awareness and preparedness and the effectiveness of early warning systems toward dam-related disaster. The research is exploratory research that employs qualitative and quantitative methods in eliciting the data. This research engages the case studies method of collecting data, including questionnaire surveys, focus group discussion (FGD) and aerial-mapping analysis of the selected sites. In this research, two dams in Cameron Highland have been selected: Sultan Abu Bakar (SAB) Dam and its vicinity in Lembah Bertam; and Susu Dam and its vicinity in Pos Telanok. The Statistical Package for Social Science Software (SPSS) (Version 25) was used to analyse data from survey questionnaires. The content analysis was used to analyse data from the FGD. The mapping analysis was used to analyse and quantify the disaster impact in the study areas. The findings indicate that the community's awareness is affected by seven factors: disaster experience; causes and indicators of disaster; recognition of hazardous disaster; response towards DRD; disaster knowledge; information on safe location; and signage and mode of transportation. There is a strong contribution of the relationships between community characteristics with their awareness and preparedness towards dam-related disaster. Community participation and involvement in the DRR program, such as awareness program and evacuation drill exercises are very important in developing better community resilience to face disaster. Subsequently, it was discovered that education, experience, and training significantly influenced people's preparedness. These factors need to be nurtured based on local knowledge, experience on the disaster, emergency warning and simulation exercises, and emergency action plan. The mapping analysis proved that the assessment of the potential hazard at both dams becomes another indicator particularly for the dam's owner to alert the communities in advance when there is a potential of flood risks and other emergency calls. This proved that not only for the dam's owner, but the information will be shared directly to the community involved and also the local agencies and authority of Cameron Highlands. These factors have been put forward as the requirement for developing an emergency preparedness framework for dam-related disasters. The framework developed helps the dam owners and local agencies in enhancing community preparedness and building a resilient community to withstand the DRD. The frameworks displayed community-based programs' continuations to ensure community preparedness's sustainability. The framework can assist local agencies and dam owners in formulating strategic DRR programs. These can be done by establishing effective early warning and planning appropriate evacuation strategies to increase people's preparedness toward DRD. The identification of these pertinent factors and framework enables a greater understanding of the community's preparedness for DRR in both dams of Cameron Highlands.

ملخص البحث

الكوارث المتعلقة بالسدود هي من الأحداث المفاجئة التي قد تقع بدون أي إنذار مسبق تؤثر سلباً على حياة الناس وتقضي على مقدراتهم على البقاء. وقد أسفرت هذه الحوادث عن انهيار السد يليه موجات فيضان شديدة السرعة تقضي على الحياة إضافة إلى الأضرار في البيئة والمرافق. تعد المجتمعات جزءاً من جهود إدارة الكوارث لتحسين معرفتهم لمواجهة الكوارث. وتحت هذا الضوء، يعد مدى الاستعداد المجتمعي للتخفيف من حدة الكوارث أمراً بالغ الأهمية في تعزيز استراتيجيات لمواجهة الكوارث لأنها من شأنها أن تساعد المجتمع في إدراك الأحوال لمواجهة الكوارث والتعامل تعاملًا فعالاً معها. تهدف الدراسة إلى التحقيق من وعي أفراد المجتمع ومدى استعدادهم وفعالية أنظمة تحذير مبكر في حالة حدوث كوارث السدود. الدراسة دراسة استكشافية تستفيد من الأساليب الكمية والنوعية في جمع بياناتها وتعتمد كذلك على أسلوب دراسات الحالة والاستبانات ومناقشات جماعية مركزة واستخدام رسوم الخرائط الجوية لتلك المواقع المختارة. وقد تم اختيار سدين في مرتفعات كامبيرون: أولهما سد السلطان أبو بكر في وادي "برتام" وسد "سوسو" في "فوس تاندوك". وتستخدم الدراسة برنامج حاسوبية إحصائية للعلوم الاجتماعية (النسخة ٢٥) لتحليل الأجوبة في الاستبانات. كما تستخدم الدراسة طريقة تحليل المحتويات لتحليل البيانات من المناقشات الجماعية المركزة. ويستخدم نتائج الخرائط الجوية لتحليل آثار الكوارث وقياسها في تلك المواقع. تستخلص الدراسة بأن وعي المجتمع متأثر بسبعة عوامل: خبرة التعامل مع الكوارث، أسباب الكوارث ومؤثراتها، التعرف على الكوارث المفجعة، الاستجابة لجهود التخفيف من حدة الكوارث، المعرفة عن الكوارث، توفر المعلومات عن المواقع الآمنة، اللافتات وطريقة النقل. هنالك أثر ملحوظ من العلاقات بين الخصائص الاجتماعية ووعيهم ومدى استعدادهم في مواجهة كوارث السدود. وتعد مشاركة المجتمع في برنامج التخفيف من حدة الكوارث وعقد برامج التوعية وتدريب عمليات الإخلاء مهمة للغاية في تطوير قدرتهم لمواجهة الكوارث. كما تقيدها الدراسة أيضاً أن مدى الاستعداد متأثر أيضاً بالتعليم والخبرة والتدريبات. وينبغي الحرص على هذه العوامل بناء على المعارف المحلية، خبرة مواجهة الكوارث والإنذار المبكر وتمارين المحاكاة وخطة مواجهة الطوارئ. وأثبت تحليل الخرائط الجوية أن تقويم المخاطر المحتملة في كلا السدين يمكن أن يكون مؤشراً أخرى يستفيد منها صاحب السد ليقوم بتحذير المجتمعات المحيطة مسبقاً في احتمال حدوث فيضان وغيرها من الطوارئ. ولقد تمت الاستفادة من هذه العوامل كمطلب في تطوير إطار مدى الاستعداد لمواجهة الكوارث المرتبطة بالسدود. وسيساعد الإطار أصحاب السدود والسلطات المحلية في تطوير مدى استعداد المجتمع لمواجهة الكوارث وتحسين قدرته على التعامل معها. هذه الأطر تعرض استمرارية البرامج الاجتماعية لضمان استدامة إمكانية المجتمع في مواجهة الكوارث. كما تساعد هذه الأطر أيضاً الهيئات المحلية وأصحاب السدود في تنظيم برامج التخفيف من حدة الكوارث بوضع نظام إنذار مبكر تبني خطط الإخلاء الملائمة لزيادة إمكانية استعداد المجتمع. وأخيراً، التعرف على هذه العوامل الخاصة والأطر تُمكن من فهم إمكانية استعداد المجتمع لجهود التخفيف من حدة الكوارث في كلا السدين في مرتفعات كامبيرون.

APPROVAL PAGE

The thesis of Rahsidi Sabri Muda has been approved by the following:

Mohd Ramzi Mohd Hussain
Supervisor

Jasikin Ab. Sani
Co-Supervisor

Noor Suzilawati Rabe
Co-Supervisor

Mazlina Mansor
Internal Examiner

Ahmad Tarmizi Abd Karim
External Examiner

Khamarrul Azzhari Razak
External Examiner

Adibah Abdul Rahim
Chairman

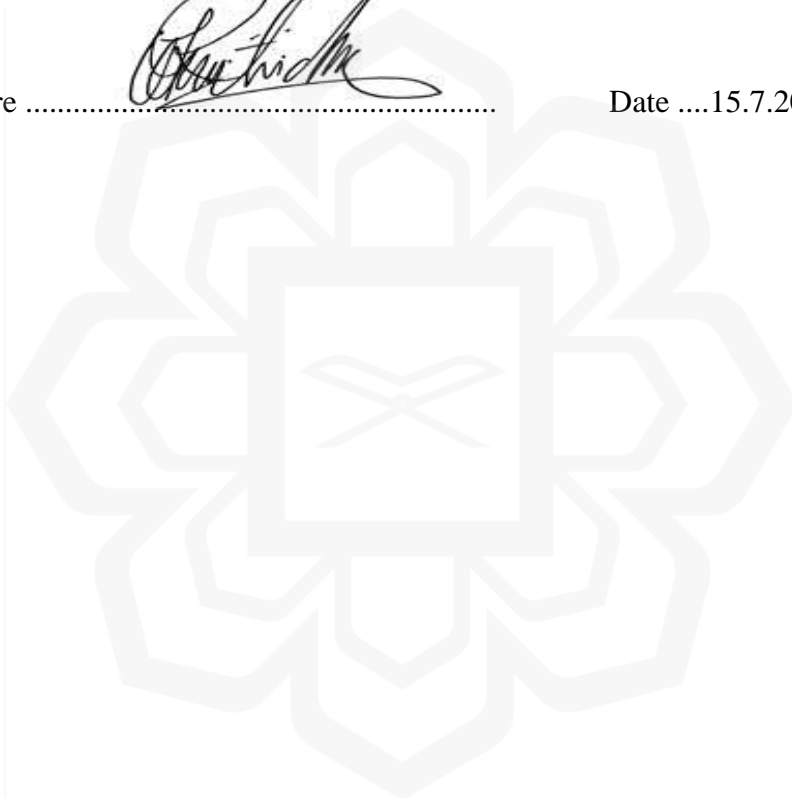


DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Rahsidi Sabri Muda

Signature  Date15.7.2021.....



INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
DECLARATION OF COPYRIGHT AND AFFIRMATION OF
FAIR USE OF UNPUBLISHED RESEARCH

COMMUNITY PREPAREDNESS FRAMEWORK FOR
DISASTER RISK REDUCTION OF HYDROELECTRIC DAMS
IN CAMERON HIGHLANDS

I declare that the copyright holders of this thesis are jointly owned by the student
and IIUM.

Copyright © 2021 Rahsidi Sabri Muda and International Islamic University Malaysia. All rights
reserved.

No part of this unpublished research may be reproduced, stored in a retrieval system,
or transmitted, in any form or by any means, electronic, mechanical, photocopying,
recording or otherwise without prior written permission of the copyright holder
except as provided below

1. Any material contained in or derived from this unpublished research
may be used by others in their writing with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print
or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieved system
and supply copies of this unpublished research if requested by other
universities and research libraries.

By signing this form, I acknowledged that I have read and understand the IIUM
Intellectual Property Right and Commercialization policy.

Affirmed by Rahsidi Sabri Bin Muda

.....

Signature

.....15.7.2021.....
Date

ACKNOWLEDGEMENTS

In the name of Allah, the most gracious and the most merciful. Indeed, there is no action that can be done without the Mercy of Allah s.w.t.

Firstly, I am most thankful and grateful to my main supervisor, Assoc. Prof. LAr. Dr. Mohd Ramzi bin Mohd Hussain for providing me full support and encouragement throughout my journey in completing this research. He has been with me through ups and downs while continuously guiding me to explore my study and not to give up.

My sincere thankfulness also goes to my co-supervisors, Asst. Prof. LAr. Dr. Jasasikin bin Ab. Sani and Asst. Prof. Dr. Noor Suzilawati binti Rabe, for always been a great support system. I am thankful for their willingness in sharing knowledge, opinions, indirectly and directly on uncertainty matters in completing this thesis.

Most importantly, I am grateful to have a very understanding and support from my wife, Izawati binti Tukiman and family members who are always there for me to back me up and are always patience with me.

Finally, I wish to express my appreciation and thanks to those who provided their time, effort and support for this research although their names are not mentioned. May the blessings of Allah s.w.t reach to all of these kind helping hands. Once again, we glorify Allah for His endless mercy on us one of which is enabling us to successfully round off the efforts of writing this thesis.

TABLE OF CONTENTS

CHAPTER.	TITLE	PAGE
	Abstract.....	i
	Approval Page.....	ii
	Declaration.....	iv
	Acknowledgements.....	vi
	Table of Contents.....	vii
	List of Tables.....	xiii
	List of Figures.....	xvii
	Abbreviations.....	xx
1.1	INTRODUCTION.....	1
1.2	Research Background.....	2
1.3	Issues And Problem Statements.....	7
1.4	Research Aim.....	14
1.5	Research Questions.....	14
1.6	Research Objectives.....	14
1.7	Research Gaps.....	15
1.8	Scope Of The Research.....	18
1.9	Structure Of Thesis.....	19
1.10	Summary.....	21
2	LITERATURE REVIEW.....	22
2.1	Introduction.....	22
2.2	Community Awareness and Preparedness.....	22
2.2.1	Importance of Community Preparedness.....	27
2.2.2	Elements in Community Preparedness	29
2.2.3	Community Preparedness and Emergency Response.....	32
2.2.4	Community Perception of Risk.....	36
2.2.5	Culture Perception in DRR.....	37
2.2.6	Community Belief and Fate of Disaster	39
2.3	Community Engagement and Emergency Preparedness For Dam Related Disaster.....	43
2.3.1	Community-Based Disaster Risk Reduction (CBDRR)	45
2.3.2	Disaster Preparedness Plan for the Community	47
2.3.3	Factors Influencing Preparedness in Disaster Risk Reduction	50
2.3.4	Community Participation and Capacity Building.....	52
2.4	Understanding Disaster Risk Management (DRM)	55
2.4.1	Disaster Risk Terminologies.....	56

2.4.2	Hazard Vulnerability in Malaysia.....	60
2.4.3	Disaster Risk Reduction (DRR) Process	62
2.4.4	Disaster Risk Management (DRM)	64
2.4.5	Institutional, Legislative and Policy on Disaster Management	71
2.4.6	Disaster Risk Governance.....	75
2.4.7	Framework in Disaster Risk Reduction	77
2.5	Dam Related Hazard.....	81
2.5.1	Definition of Dam.....	82
2.5.2	Purpose of Dam Construction.....	85
2.5.3	Types of Dams in Malaysia	85
2.5.4	Potential Dam Related Disaster and Flood Hazard	89
2.5.5	Risk Assessment within Dam Failure Flood Risk	92
	2.5.5.1 Socio-Economic Impact Assessment.....	94
	2.5.5.2 Risk of Dam to Human Being.....	94
2.5.6	Past Historical Events and Statistics of Dam Failure	95
	2.5.6.1 Sedimentation Problems	99
	2.5.6.2 Alteration of River Morphology and Ecology	100
2.5.7	Dam Failure Modes	100
	2.5.7.1 Overtopping	102
	2.5.7.2 Foundation Defects	103
	2.5.7.3 Piping and Seepage.....	104
	2.5.7.4 Other Reasons	105
2.5.8	Disaster Occurrence Trend in Lembah Bertam, Cameron Highlands	108
2.6	Knowledge Management in Dam Related Disaster.....	113
2.6.1	Importance of Knowledge Disaster Risk Reduction.....	115
2.6.2	People-Centred Risk knowledge in Society.....	116
2.7	Education in Disaster Risk Reduction	117
2.7.1	Education and Training for Disaster Preparedness.....	118
2.7.2	Education in Disaster Risk Reduction (DRR)	119
2.8	Early Warning System (EWS) and Community Preparedness	122
2.8.1	Community-Centric Early Warning Systems	125
2.8.2	Relationship between EWS and DRR	126
2.8.3	Early Warning System (EWS) for the Community	130
2.9	Information And Communication In Dam Related Disasters (DRD)	136
2.9.1	Information and Communication for Resilient Community.....	137
2.9.2	Challenge of Communication during Emergency Disaster Response	138
2.10	Summary.....	139

3	RESEARCH METHODOLOGY.....	140
3.1	Introduction.....	140
3.2	Research Design.....	140
3.3	Case Study Approach.....	143
3.3.1	Justification of Selected Case Studies	143
3.3.2	Overview of Sites Study	145
3.3.2.1	Sultan Abu Bakar Hydroelectric Dam Scheme (SAB Dam), Lembah Bertam.....	151
3.3.2.2	Susu Hydroelectric Dam (Susu Dam), Pos Telanok.....	153
3.4	Aerial Mapping Approach.....	155
3.4.1	Flood Hazard Assessment and Aerial Mapping	155
3.5	Questionnaire Survey Approach.....	159
3.5.1	Questionnaire Design.....	159
3.5.2	Sampling Technique	164
3.6	Focus Group Discussion (FGD) Approach.....	167
3.7	Method of Data Analysis.....	169
3.7.1	Mapping Analysis	169
3.7.1.1	Vulnerability Analysis	172
3.7.2	Descriptive Analysis	176
3.7.3	Content Analysis for FGD	177
3.8	Triangulation Design.....	178
3.9	Summary.....	179
4	COMMUNITY PREPAREDNESS FOR DISASTER RISK REDUCTION: COMMUNITY'S RESPONSES.....	180
4.1	Introduction.....	180
4.2	General Background of Respondents.....	181
4.3	Community Awareness on Dam Related Disaster.....	184
4.3.1	Respondent's Experience towards Disaster	184
4.3.2	Caused and Indicators of Disaster	189
4.3.3	Recognition of Hazardous Disaster	191
4.3.4	Response towards Dam Related Disaster	194
4.3.4.1	Response Time to Evacuate.....	195
4.3.4.2	Response during Emergency	198
4.3.4.3	Preferable Action to Face Disaster	199
4.3.5	Disaster's Responsive Knowledge.....	201
4.3.6	Information on Safe Location.....	204
4.3.7	Signage and Mode of Transportation.....	205
4.3.7.1	Signage for Safe Location.....	205
4.3.7.2	Mode of Transportation	206
4.4	Community Preparedness On Disaster Risk Reduction (DRR) Program	208
4.4.1	Participation Dam Related Disaster Preparedness.....	209

4.4.2	Preparedness towards Dam Related Disaster.....	212
4.4.3	Drill Exercises and Emergency Response Plan (ERP)	215
4.4.4	The Obstacle in Participating in Disaster Risk Reduction (DRR) Program.....	218
4.4.5	Response on Drill Exercise Program	221
4.4.6	Influence Factors for Drill Exercises	223
	4.4.6.1 Experience with Disaster	223
	4.4.6.2 Gender and Marital Status	224
4.4.7	The Effectiveness of Disaster Risk Reduction (DRR) Program.....	225
4.5	The Early Warning System (EWS)	230
	4.5.1 Awareness of Early Warning System (EWS)	230
	4.5.2 Medium of Early Warning System (EWS) Provision.....	232
	4.5.3 Establishment of Early Warning (EW)	236
	4.5.4 Preference and Improvement on the Implementation of EWS	240
	4.5.5 Response Factors on Emergency Warning	242
	4.5.6 Hazard Mapping for Emergency Warning.....	246
4.6	Summary.....	249
5	COMMUNITY PREPAREDNESS FOR DISASTER RISK REDUCTION: FOCUS GROUP DISCUSSION (FGD) AND MAPPING ANALYSIS.....	250
5.1	Introduction.....	250
5.2	Analysis on Focus Group Discussions (FGD).....	250
	5.2.1 Background of Respondents	251
	5.2.2 Knowledge and Experience on Disaster	252
	5.2.2.1 Managing the Disaster	253
	5.2.2.2 Search and Rescues Operation	254
	5.2.2.3 Standard Operating Procedure (SOP) for Emergency	255
	5.2.2.4 Community Leader’s Concerned.....	256
	5.2.3 Emergency Warning and Simulation Drill	257
	5.2.3.1 Emergency Warning	257
	5.2.3.2 Emergency Training and Data Management	260
	5.2.3.3 Simulation Drill Exercise	262
	5.2.4 Emergency Action Plan	265
	5.2.4.1 Safe Location	265
	5.2.4.2 Evacuation route	268
	5.2.4.3 Improvement and Suggestions.....	269
5.3	Mapping Analysis for Dam Break Disaster in Relation to Community Preparedness.....	271
	5.3.1 Dam- Break Flood Hazard Analysis.....	272
	5.3.1.1 Dam Break Flood Boundary Map	272
	5.3.1.2 Flood Hazard Map	275

5.3.1.3	Risk Classification Map.....	278
5.4	Summary.....	283
6	INTERPRETATION AND DISCUSSION.....	285
6.1	Introduction.....	285
6.2	Key Issues of The Community Preparedness for Disaster Risk Reduction (DRR).....	285
6.3	Evaluation of Factors Influencing The Community Awareness and Preparedness Towards Disaster Risk Reduction.....	286
6.3.1	Demographic Factors and Education background.....	287
6.3.2	Community's Knowledge and Experience.....	288
6.3.3	Disaster Education and Risk Knowledge in Dam Related Disaster.....	290
6.3.4	Community's Participation.....	291
6.3.5	Disaster Risk Reduction (DRR) Programs.....	293
6.4	The Importance of EWS Implementation and Disaster Risk Reduction Programs for Community Preparedness.....	295
6.4.1	Emergency Response Plan and Drill Exercises.....	297
6.5	Mapping Impact for The Community Preparedness.....	300
6.6	Community Emergency Framework for Future Dam Related Disaster.....	302
6.7	Summary.....	309
7	CONCLUSION AND RECOMMENDATIONS.....	311
7.1	Introduction.....	311
7.2	Key Findings of The Community Preparedness for Disaster Risk Reduction in Malaysia.....	312
7.2.1	Awareness for Disaster Risk Reduction (DRR).....	313
7.2.2	Community Response toward DRD.....	316
7.2.3	Effectiveness Hierarchy Of Early Warning System (EWS).....	318
7.3	Community Awareness and Preparedness for Dam Related Disaster.....	319
7.3.1	Community Awareness and Preparedness in Study Areas.....	320
7.3.2	Community Preparedness Cycle.....	321
7.3.3	Early Warning System and Emergency Response.....	324
7.4	Recommendations for The Risk Reduction in Malaysia.....	325
7.4.1	Data and Information Management.....	326
7.4.1.1	Data Management.....	326
7.4.2	Communication and EWS.....	328
7.4.2.1	Active Communication Approach.....	328
7.4.2.2	Passive Communication Approaches - Signage system....	329
7.4.3	Human Intervention.....	330
7.5	Summary.....	331
7.5.1	Recomendation for Future Research.....	333

REFERENCES	334
APPENDIX A: SURVEY QUESTIONNAIRE.....	363
APPENDIX B: FOCUS GROUP DISCUSSION (FGD) OUTLINE.....	375
APPENDIX C: HOUSEHOLD SURVEY CHECKLIST.....	384
APPENDIX D: HOUSEHOLD ANALYSES.....	386
APPENDIX E: MAPPING ANALYSES FOR PAR.....	397
APPENDIX F: PUBLISHED PAPERS.....	411



LIST OF TABLES

Table 1.1	Study on community preparedness for disaster risk reduction	5
Table 1.2	Gaps according to variables	17
Table 1.3	Summary of the research scope	19
Table 2.1	Preparedness on the research topic	26
Table 2.2	Previous community preparedness's studies on disaster	28
Table 2.3	Elements in preparedness, disaster risk reduction and early warning	35
Table 2.4	Key indicator people preparedness toward disaster	52
Table 2.5	Development framework for disaster preparedness in different regions	79
Table 2.6	British dam failures that caused loss of life	96
Table 2.7	Some international dam related disaster causing loss of life	97
Table 2.8	Recent dam failure recorded between years 2017-2020	102
Table 2.9	Analysis of the three issues and three gaps concerning the science-policy interface for disaster risk reduction	114
Table 2.10	Education in disaster risk reduction for other countries	121
Table 2.11	Four Elements of people-centred Early Warning System	124
Table 3.1	Exploratory research in disaster preparedness	141
Table 3.2	Detail of SAB Dam's capacity and other features	152
Table 3.3	Purpose behind survey question types	160
Table 3.4	Survey outline for questionnaire survey	160
Table 3.5	Distribution of Sampling according to area	166
Table 3.6	Research associated with a vulnerability analysis	173
Table 3.7	Risk Classification for PAR, Simplified flood depth and velocity categories	174
Table 3.8	The statistical analysis and tests used to correspond to the research objectives	177

Table 4.1	Summary of the background of respondents	182
Table 4.2	Distribution of respondents according to village/ residential area	183
Table 4.3	Respondents' experience with disaster	184
Table 4.4	Respondents' experience with disaster with their residential area	185
Table 4.5	Cross-tabulation test between respondents' length of stay and disaster experience	186
Table 4.6	Respondents' residential area with the duration of stay	187
Table 4.7	Chi-square test between respondents' preference on area/place to go when disaster strike with their experience on disaster	188
Table 4.8	Chi-square test between respondents' preference on area/place to go-when disaster strike with a residential area	188
Table 4.9	Respondents' perceived disaster sign/ indicators	189
Table 4.10	Pearson tests between respondents perceived sign of disaster happening versus age and duration of stay	190
Table 4.11	Respondents' perceived signs of disaster happening with their residential area/village.	191
Table 4.12	Perceived factors that were influencing disaster to happen	192
Table 4.13	Respondents' perceived sign of disaster happening with their experience of handling disaster	193
Table 4.14	Spearman Rho test between respondents' perceived factors of disaster happen with age, duration of stay and education level	193
Table 4.15	Affected Location under Scenario SAB and Susu Dam PMF Failure...	195
Table 4.16	Estimated time required by the respondent to evacuate to a safe location	197
Table 4.17	Action taken when disaster is expected to strike	198
Table 4.18	Chi-square results between respondents' preferred action with their experience on disaster strike	199
Table 4.19	RII Rank on Action taken when disaster expected to strike	200
Table 4.20	Area/Place respondents' preferred to go when disaster strikes.	201
Table 4.21	Response on the safe area identified/ designated by the local agency	202
Table 4.22	Source of information about the safe location	202

Table 4.23	Chi-square result between sources of information about the safe location with their experience with disaster	204
Table 4.24	Necessary to place signage at a safe location	205
Table 4.25	Cross-tabulation test between mode of transportation to reach the safe location and residential area	206
Table 4.26	Other mode of transportation to reach a safe location	208
Table 4.27	Respondents' participation with DRR program exercise	209
Table 4.28	Chi-square test between respondents' participation with DRR program exercise with their experience with disaster	210
Table 4.29	Spearman Rho test between respondents' participation with DRR programs exercise with their duration of stay and education level	211
Table 4.30	RII rank on precaution measures by respondents in facing disaster	213
Table 4.31	RII ranking on precaution measures in facing disaster taken with family	215
Table 4.32	Responses on drill exercise program	216
Table 4.33	Attended drill exercise program	216
Table 4.34	Responses on DRR program with respondent's profile	217
Table 4.35	Reasons why respondents decline to attend the exercise drill program	219
Table 4.36	Chi-square results between respondents decline to attend the drill exercise program with their experience and gender.	219
Table 4.37	Spearman Rho test between respondents' decline to attend the drill exercise program with the estimated time for disaster to reach respondents' village and time taken to reach a safe location	220
Table 4.38	Responses on drill exercise program for dam related disaster	222
Table 4.39	Chi-square result between responses on drill exercise program and experience with disaster	224
Table 4.40	Chi-square results between responses on drill exercise program and information given with gender and marital status	225
Table 4.41	RII Rank on responses on the conducted drill exercise program	226
Table 4.42	Comments and suggestion to motivate and improve drill exercise	227
Table 4.43	Information needed to be provided in the next drill exercise	229

Table 4.44	Preferred number of Exercise drill to be conducted in a year	230
Table 4.45	Responses on the effectiveness of the warning system (EWS)	231
Table 4.46	RII ranking on medium to receive information on early warning (EW)	232
Table 4.47	Medium used to obtain EW information with respondents' education level.	234
Table 4.48	RII ranking for the medium used to obtain EWS information with respondents' education level	235
Table 4.49	Preferred system for early warning system (EW)	236
Table 4.50	Respondent's acceptance of the siren provision	238
Table 4.51	Response on appropriate timing of the siren to be activated	239
Table 4.52	Suggestion on the improvement of early warning system (EWS)	241
Table 4.53	Respondent's responses toward emergency warning with their experience on disaster	243
Table 4.54	Spearman Rho test between responses on the effectiveness of siren/warning system with the duration of stay and time taken to reach safe location.....	244
Table 4.55	Spearman Rho test between responses on the effectiveness of siren/warning system with age	245
Table 5.1	Respondents in FGD session	252
Table 5.2	FGD's finding of local knowledge and experience on disaster	256
Table 5.3	FGD's findings on emergency warning and drill exercise	264
Table 5.4	FGD's findings on safe location, evacuation plan	270
Table 5.5	Affected areas due to dam break	274
Table 5.6	Affected key Location under scenario SAB and Susu Dam	277
Table 5.7	PAR in each risk class	280
Table 5.8	Identified PAR according to risk category for each location in the study area	282
Table 6.1	Contributing factors toward dam related disaster	299

LIST OF FIGURES

Figure 2.1	Disaster and Risk Profile related to Malaysia	61
Figure 2.2	Disaster Risk Reduction Process	63
Figure 2.3	Disaster risk reduction components	64
Figure 2.4	Disaster Management Cycle	66
Figure 2.5	Malaysia's Disaster Management Cycle	67
Figure 2.6	Evolution of disaster management in Malaysia	72
Figure 2.7	Adopted from Disaster Management Committees (NSC), Jabatan Perdana Menteri, (2012)	74
Figure 2.8	Evolution toward Sendai Framework Disaster Risk Reduction (SFDRR).	78
Figure 2.9	Dams in Peninsular Malaysia	83
Figure 2.10	Dams in Sabah & Sarawak	84
Figure 2.11	Earth fill Dam- Mengkuang Dam (Jabatan Bekalan air, KeTTHA)	86
Figure 2.12	Concrete Face Rockfill Dams (CFRD) - Bakun Dam (Sarawak Hidro Sdn Bhd.)	86
Figure 2.13	Core Rockfill Dam- Sultan Mahmud Power Station Kenyir Dam (TNB)	86
Figure 2.14	Concrete Gravity Dam- Klang Gates Dam (Puncak Niaga (M) Sdn Bhd)	87
Figure 2.15	RCC Dam- Susu Dam (TNB)	88
Figure 2.16	Concrete buttress dam- Muda Dam (MADA)	88
Figure 2.17	Flood severity category	93
Figure 2.18	Typical reservoir sediment profile	99
Figure 2.19	Typical defect and potential failure modes	101
Figure 2.20	Photo of the approximate location of Banqiao Dam and its final breach	103
Figure 2.21	St. Francis Dam before and after dam failure resulted from defective foundations	104

Figure 2.22	Breached dam looking downstream of Kelly Barnes Dam	105
Figure 2.23	Before and after pictures of two basins in Val di Stava Dam	106
Figure 2.24	Aerial imagines of the Stava Valley before and after the disaster	106
Figure 2.25	An aerial view of the flooded villages around the failed dam	107
Figure 2.26	Mud flood event chronology in Lembah Bertam, Cameron Highlands	109
Figure 2.27	Timeline of flood events in Cameron Highland	111
Figure 2.28	Flood risk map for District of Cameron Highlands	112
Figure 2.29	Early warning system framework	135
Figure 3.1	Flow chart methodology research framework	142
Figure 3.2	Flood Incident in Lembah Bertam due to water released from SAB Dam in 2013 and 2014	145
Figure 3.3	Tenaga Nasional Berhad (TNB) hydroelectric power stations plan in Cameron Highlands	146
Figure 3.4	Location of SAB Dam (1) and Susu Dam (2) in the Strategic Land Use map of Cameron Highlands	147
Figure 3.5	Bird's eye view of SAB Dam and its vicinity	148
Figure 3.6	Susu Dam and its vicinity	148
Figure 3.7	Sultan Abu Bakar Hydroelectric Dam, Cameron Highlands	149
Figure 3.8	Susu Hydroelectric Dam in Ulu Jelai, Cameron Highlands	149
Figure 3.9	Communities' settlements in the vicinity of SAB Dam and Susu Dam	150
Figure 3.10	Evacuation route map for the study area within SAB Dam	152
Figure 3.11	Susu Dam's Schematic Station Plan	153
Figure 3.12	Susu Dam features	154
Figure 3.13	Evacuation route map for the study area within Susu Dam	154
Figure 3.14	Flood hazard assessment and mapping analyses	156
Figure 3.15	Capturing aerial images using a drone at the site.	157
Figure 3.16	Study area in SAB Dam vicinity from an aerial view	158
Figure 3.17	Study area in Susu Dam vicinity from an aerial view	158

Figure 3.18	Focus Group Discussion	169
Figure 3.19	Overlay technique using ArcGIS application	171
Figure 3.20	Human instability at different water depths and velocities	172
Figure 3.21	Triangulation method	179
Figure 4.1	Flood boundary map with indication of siren and strobe light, safe location and radius which covered by the sound of the strobe light (beacon) at SAB Dam Vicinity	247
Figure 4.2	Flood boundary map with indication of the siren and strobe light, safe location and radius which covered by the sound of the strobe light (beacon) Susu Dam Vicinity	248
Figure 5.1	Evacuation area at Lembah Bertam	268
Figure 5.2	Flood boundary maps at the affected location in the study area.	273
Figure 5.3	Flood hazard map downstream SAB (Depth) in grid (100mx100m)	276
Figure 5.4	Flood hazard map downstream Susu (Depth-) in the grid (100mx100m)	276
Figure 5.5	The transaction of extreme to medium of risk classification is expecting for PAR at downstream SAB Dam	279
Figure 5.6	The transaction of extreme to medium of risk classification is expecting for PAR at downstream Susu Dam	279
Figure 5.7	PAR according to the risk level	281
Figure 6.1	The early warning chain	296
Figure 6.2	DRR Framework for Community Preparedness	303
Figure 7.1	Cycle of phases in DRD Framework	309
Figure 7.2	The Top-Down vs Community-Based in risk knowledge transfer	314
Figure 7.3	Links between variables and influencing factors towards community response	317
Figure 7.4	The effectiveness hierarchy of EWS for DRD	318
Figure 7.5	Community preparedness cycle process diagram for an integrated community-based dam related disaster	321
Figure 7.6	DRR for dam related disaster for community preparedness	326

ABBREVIATIONS

ADPC	Asian Disaster Preparedness Center
APM	Angkatan Pertahanan Awam Malaysia (Malaysia Civil Defense Department)
BOMBA	Jabatan Bomba dan Penyelamat (The Fire and Rescue Department)
CB	Community Based
CBDRM	Community-Based Disaster Risk Management
CBDRR	Community-Based Disaster Risk Reduction
CBMRC	Central disaster management relief committee
CBTAP	Community Based Training and Awareness Program
CDERT	Civil Defence Emergency Response Team Community
CDF	Clear Day Failure
CEMAS	Community Disaster Management and Awareness
CFEDM	Center For Excellence In Disaster Management And Humanitarian Assistance
CFRD	Concrete Face Rockfill Dams
CHBPS	Cameron Highland Batang Padang Hydroelectric Scheme
CIC	Community Information Center
COC	Community Operation Center
DDMRC	District Disaster Management and Relief Committee
df	degrees of freedom
DID	Department of Irrigation and Drainage
DMRC	Disaster Management and Relief Committee
DOE	Department of Environment
DPA	Damage To Physical Asset
DRD	Dam Related Disaster
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DRRE	Disaster risk reduction education
DSERP	Dam Safety Emergency Response Plan
EAP	Emergency Action Plan
EL	Elevation Level
ERP	Emergency Response Plan
ETP	Economic Transformation Program
EW	Early Warning
EWS	Early Warning System

FAT	Flood Arrival Time
FEMA	Federal Emergency Management Agency
FGD	Focus Group Discussion
FSL	Full Supply Level
GCB	Generation Control Building
GIS	Geographical Information system
GSM	Global System For Mobile Communication
HADR	Humanitarian Assistance and Disaster Relief
ICBDM	Integrated Community-Based Disaster Management
ICOLD	International Commission on Large Dams
ICT	Information and communications technology
IPK	Ibu Pejabat Polis Kontinjen
JAKOA	Jabatan Kemajuan Orang Asli
JAS	Jabatan Alam Sekitar
JKM	Jabatan Kemajuan Masyarakat
KeTTHA	Kementerian Tenaga Teknologi Hijau Dan Air
KKM	Kementerian Kesihatan Malaysia
LA	Local Authority
LED	Light Emitting Diodes
LHZ	Landslide Hazard Zonation
LSM	Life Safety Model
MADA	Muda Agriculture Development Authority
MDCH	Majlis Daerah Cameron Highlands
MKN	Majlis Keselamatan Negara
MNSC	Malaysian National Security Council
MOE	Ministry of Education
MPKK	Majlis Pengurusan Komuniti Kampung
MSEP	Multi stakeholder Engagement Program
MSL	Minimum Supply Level
MyCOLD	Malaysian National Committee on Large Dams
MyDams	Malaysia Dam Safety Management Guidelines
MyDAMS	Malaysia Dam Safety Management Guidelines
NADMA	National Disaster Management Agencies
NDMRC	National Disaster Management and Relief Committee
NGO	Non-Government Organization
NSC	National Security Council
PAR	Population at Risk
PDRM	Polis Diraja Malaysia
PDTCH	Pejabat Daerah dan Tanah Cameron Highlands
PEWS	Public Early Warning System

PKTK	Pusat Kawalan Tempat Kejadian
PMF	Probable Maximum Failure
PPE	Personnel Protective equipment
PWDs	People with Disabilities
RCC	Roller Compacted Concrete
RII	Relative Importance Index
RTD	Rancangan Tempatan Daerah
RTU	Remote Thermal Unit
SAB	Sultan Abu Bakar
SDG	Sustainable Development Goals
SDMRC	State National Disaster Management and Recovery Committee
SFDRR	Sendai Framework for Disaster Risk Reduction
SJKC	Sekolah Jenis Kebangsaan China
SK	Sekolah Kebangsaan
SMS	Short Message Service
SOP	Standard Operating Procedure
SPSS	Statistical Package For Social Sciences
SSJ	Stesen-Stesen Janaelektrik
SSJCH	Stesen-Stesen Janaelektrik Cameron Highlands
TNB	Tenaga Nasional Berhad
TNBR	TNB Research
TOT	Training of Trainers
TTP	Time to Peak
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNICEF	United Nations International Children's Emergency Fund
UNISDR	United Nations International Strategy for Disaster Risk Reduction
UNITEN	Universiti Tenaga Nasional
USACE	US Army Corps Of Engineers
USBR	United State Bureau Of Reclamation