

**IMPROVING FLOOD
MANAGEMENT, PREDICTION AND
MONITORING**

This page intentionally left blank

COMMUNITY, ENVIRONMENT AND DISASTER RISK
MANAGEMENT VOLUME 20

IMPROVING FLOOD MANAGEMENT, PREDICTION AND MONITORING: CASE STUDIES IN ASIA

EDITED BY

ZULKIFLI YUSOP

Universiti Teknologi Malaysia, Malaysia

AZMI ARIS

Universiti Teknologi Malaysia, Malaysia

NOR ELIZA ALIAS

Universiti Teknologi Malaysia, Malaysia

KOGILA VANI ANNAMMALA

Universiti Teknologi Malaysia, Malaysia

WILLIAM L. WAUGH, JR

Georgia State University, USA



United Kingdom – North America – Japan
India – Malaysia – China

Emerald Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2019

Copyright © 2019 Emerald Publishing Limited

Reprints and permissions service

Contact: permissions@emeraldinsight.com

No part of this book may be reproduced, stored in a retrieval system, transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without either the prior written permission of the publisher or a licence permitting restricted copying issued in the UK by The Copyright Licensing Agency and in the USA by The Copyright Clearance Center. Any opinions expressed in the chapters are those of the authors. Whilst Emerald makes every effort to ensure the quality and accuracy of its content, Emerald makes no representation implied or otherwise, as to the chapters' suitability and application and disclaims any warranties, express or implied, to their use.

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-1-78756-552-4 (Print)

ISBN: 978-1-78756-551-7 (Online)

ISBN: 978-1-78756-553-1 (Epub)

ISSN: 2040-7262 (Series)



ISOQAR certified
Management System,
awarded to Emerald
for adherence to
Environmental
standard
ISO 14001:2004.

Certificate Number 1985
ISO 14001



INVESTOR IN PEOPLE

CONTENTS

<i>Editor Biographies</i>	vii
<i>About the Authors</i>	ix
<i>Acknowledgement</i>	xvii

Adaptation Strategies for Flood Mitigation in Pahang River Basin	
<i>Nor Diana Mohd Idris, Chamhuri Siwar, Rospidah Ghazali and Nurul Ashikin Alias</i>	1

Application of Interactive Dam Safety Decision Support System (INSPiRE) for Flood Emergency Response Plan (ERP) of Sultan Abu Bakar Dam Malaysia	
<i>Lariyah Mohd Sidek, Hidayah Basri, Hairun Aishah Mohiyaden, Nur Farazuieen Md. Said, Mohd Ruzaimi Yalit, Hamdan Basri and Rashidi Sibri Muda</i>	13

Burden of Health-related Issues and Community Empowerment in Malaysia's East Coast Flood	
<i>Sharifa Ezat Wan Puteh, Chamhuri Siwar, Rozita Hod, Azmawati Mohammed Nawi, Idayu Badilla Idris, Izzah Syazwani Ahmad, Nor Diana Mohd Idris, Nurul Ashikin Alias and Mohd Raihan Taha</i>	19

Derivation of Region-specific Curve Number for an Improved Runoff Prediction Accuracy	
<i>Lloyd Ling and Zulkifli Yusop</i>	37

Environmental Forensics: A Multi-catchment Approach to Detect Origin of Sediment Featuring Two Pilot Projects in Malaysia	
<i>Kogila Vani Annammala, Anand Nainar, Abdul Rahim Mohd Yusoff, Zulkifli Yusop, Kawi Bidin, Rory Peter Dominic Walsh, William H. Blake, Faizuan Abdullah, Dhinesh Sugumaran and Khuneswari Gopal Pillay</i>	49

Evaluating Transportation Modes and Routes for Disaster Relief in Kelantan Using Geographical Information System <i>Muhammad Wafiy Adli Ramli, Nor Eliza Alias and Shazwin Mat Taib</i>	63
Experimental Investigation on Lightweight Composite Slab for Floating Structures <i>Jun Xiu Low, Poi Ngian Shek and Mahmood Md Tahir</i>	73
Facts and Trends of Urban Exposure to Flash Flood: A Case of Kuala Lumpur City <i>Tariqur Rahman Bhuiyan, Mohammad Imam Hasan Reza, Er Ah Choy and Joy Jacqueline Pereira</i>	79
Flood Disaster Management in Sungai Pahang Basin: Case of Temerloh <i>Nurul Ashikin Alias, Chamhuri Siwar, Mohd Khairi Ismail and Nor Diana Mohd Idris</i>	91
Flood Disaster Prediction Model Based on Artificial Neural Network: A Case Study of Kuala Kangsar, Perak <i>Nurul Syarafina Shahrir, Norulhusna Ahmad, Robiah Ahmad and Rudzidatul Akmam Dziauddin</i>	103
Flood Monitoring System Using Mobile SCADA Based on Multiple Environment Indications <i>Nurul Iman Mohd Sa'at, Salwani Mohd Daud and Teddy Mantoro</i>	113
Kelantan Daily Rainfall Datasets: Persistence in Nature <i>Siti Mariam Norrulashikin, Fadhilah Yusof, Zulkifli Yusop, Ibrahim Lawal Kane, Norizzati Salleh and Aaishah Radziah Jamaludin</i>	121
Performance of Time-based and Non-time-based Clustering in the Identification of River Discharge Patterns <i>Nur Syazwin Mansor, Norhaiza Ahmad and Arien Heryansyah</i>	133
<i>Index</i>	141

EDITOR BIOGRAPHIES

Series Editor

William L. Waugh, Jr is a Professor of Public Administration, Urban Studies and Political Science. He is internationally recognized for his work on disaster policy and local and regional capacity-building. He is the author of *Living with Hazards, Dealing with Disaster: An Introduction to Disaster Management (2000)* among others.

Volume Editors

Zulkifli Yusop is a Professor of Environmental Hydrology and Dean of Sustainable Resources Research Alliance at UTM, He has strong national and international linkages with the Malaysian International Hydrological Program, Malaysian Water Association, International Water Association, European Union (EU) and others through research and consultancy services.

Azmi Aris is a Professor of Environmental Engineering and the Director of Centre for Environmental Sustainability and Water Security (IPASA), UTM. He specializes in water pollution control. He works closely with government and private agencies for the protection of the water environment and sustainable management of water resources.

Nor Eliza Alias is a Senior Lecturer in School of Civil Engineering and a research fellow of the Centre for Environmental Sustainability and Water Security (IPASA), UTM. She is involved in national and international research and consultancies projects related to extreme rainfall events, flood, disaster management and climate change.

Kogila Vani Annammala is a Senior Lecturer in School of Civil Engineering and a research fellow of the Centre for Environmental Sustainability and Water Security (IPASA), UTM . Her research focuses on erosion and sediment sources and transport using natural and artificial sediment properties in exploring catchment response to disturbances.

This page intentionally left blank

ABOUT THE AUTHORS

Faizuan Abdullah is a Post-doctoral Researcher in the Faculty of Earth Science at the Universiti Malaysia Kelantan. He completed his PhD and undergraduate studies at Universiti Teknologi Malaysia in the field of Chemistry. His research interests lie in the area of analytical chemistry, ranging from theory to design to implementation.

Izzah Syazwani Ahmad is a Master's Student of Medical Science (Community Health) from Universiti Kebangsaan Malaysia. Her current research is 'Vaping among University Students'. She is involved with several research in the field of public health and an active member in community volunteerism and outreach community health programme.

Norhaiza Ahmad is a Senior Lecturer at the Department of Mathematical Sciences, Universiti Teknologi Malaysia (UTM). Her interest in research includes hydroinformatics and bioinformatics. She is co-author of several books including *Basic Statistics for Science and Education* and *Statistical Modelling in Industrial and Applied Mathematics*.

Norulhusna Ahmad graduated from UTM with Bachelor, Master and PhD in Electrical Engineering. Her expertise is on the area of digital signal processing and wireless communication, and interests are on future communication such as 5G and cognitive radio focusing on error correcting codes, OFDM and resource allocation.

Robiah Ahmad received her BSc Electrical Engineering from the University of Evansville, USA, MSc IT for Manufacture from University of Warwick, UK and PhD in Mechanical Engineering from UTM. She published over 70 peer-reviewed international journal papers/proceedings related to instrumentation, control, system modeling and identification and evolutionary computation.

Nor Eliza Alias is currently a Senior Lecturer in School of Civil Engineering and a Research Fellow of the Centre for Environmental Sustainability and Water Security (IPASA), Universiti Teknologi Malaysia. She is involved in research and consultancies projects related to extreme rainfall events, flood, disaster management and climate change.

Nurul Ashikin Alias is currently a PhD candidate at Institute for Environment and Development (LESTARI), UKM. Her field of research is on the vulnerability and socio-economic impact of flood catastrophes.

Kogila Vani Annammala is a Senior Lecturer at UTM. She obtained her PhD from Universiti Malaysia Sabah in collaboration with Swansea and Plymouth University. Her research focuses on erosion and sediment sources and transport using natural and artificial sediment properties such as fallout radionuclides in exploring catchment response to disturbances.

Hamdan Basri is a Software Developer at Sustainable Technology and Environment Group (STEG), Institute of Energy Infrastructure, UNITEN.

Hidayah Basri is a Lecturer in Civil Engineering Department at UNITEN. Her research area is reservoir inflow forecasting. She has been involved in various dam break modelling and analysis for TNB Hydropower Dam as well as in development of Emergency Response Plan (ERP) under TNB Dam Safety Program.

Tariqur Rahman Bhuiyan obtained his Bachelor and Master of Arts (Finance) from International Islamic University Malaysia. He is a PhD Candidate at the Southeast Asia Disaster Prevention Research Initiative (SEADPRI), Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia. His area of research is in disaster risk reduction.

Kawi Bidin is a Professor in Faculty of Science and Natural Resources of UMS. He holds a PhD from Lancaster University, United Kingdom. His main field of expertise is in environmental hydrology, modelling of forest structure for characterization of tropical hydrological process in different disturbance regime and local hydroclimatic events.

William H. Blake is a Professor in School of Geography, Earth and Environmental Sciences, University of Plymouth. He specialises in the application of sediment tracing technology to examine fine sediment sources and budgets in catchments. His current works are in the UK, Malaysia, Australia, Greece and Canada and Fukushima, Japan.

Er Ah Choy obtained a PhD from Wageningen University, Netherlands, and Bachelor and Master of Arts (Economics) from Universiti Kebangsaan Malaysia (UKM). Her research interests are on sustainable development and environmental management. She is a Professor at the Faculty of Social Sciences and Humanities, UKM.

Salwani Mohd Daud has a degree in Electronics Engineering from University of Liverpool and Master and PhD degrees in Electrical Eng. from UTM. Her main expertise is in intelligent, computer and biomedical systems engineering and engineering education. She is a Professor in Razak Faculty of Technology and Informatics, UTM, Kuala Lumpur.

Rudzidatul Akmam Dziyauddin is a Senior Lecturer in Universiti Teknologi Malaysia. She graduated from Universiti Sains Malaysia with a BEng in Electrical and Electronics. She received her MSc in Information Technology and Science Qualitative from Universiti Teknologi MARA and PhD from University of Bristol, UK.

Rospidah Ghazali has expertise in economic development. Her publications include *Pembangunan Lestari di Malaysia: Harapan dan Kenyataan* (2014) and *Linking Rural Poverty and Environment: Governance and Sustainable Development Policies* (2008) in which she is a co-author.

Arien Heryansyah is a Senior Lecturer at the Department of Civil Engineering, Faculty of Engineering, Universitas Ibn Khaldun Bogor (UIKA Bogor). His research interest includes hydrology modelling, hydro informatics, watershed and water management. He has co-authored several books related to water management, eco-hydrology, integrated water resource management and climate change.

Rozita Hod is a Public Health Physician. She specialises in Environmental Health and holds a PhD in Environmental and Development. She is also a consultant to the Ministry of Health and Department of Environment, Malaysia. Her research interest is on health impacts of climate change.

Idayu Badilla Idris is a Medical Doctor with a PhD in Health Sciences from Warwick University, UK. She is the Head of Research of the Emotional and Behavioural Problems among Adolescents in Malaysia and currently an Associate Professor at the Department of Community Health, Faculty of Medicine, UKMMC.

Nor Diana Mohd Idris has expertise in environmental economics and development, poverty studies, sustainable livelihood, poverty alleviation, sustainable livelihood and socio-economic impacts studies. She involves in research projects in natural hazard socio-economic impacts, poverty and sustainability, rural development and sustainable livelihood funded by Ministry of Higher Education and UKM.

Nurul Iman Mohd Sa'at is a Post-graduate Student in faculty of Advanced Informatics School, Universiti Teknologi Malaysia, Kuala Lumpur. She obtained her first degree in Mechatronics Engineering from International Islamic University Malaysia in 2012. She was a research member of IOT devices development lab at Advanced Informatics School, UTM Kuala Lumpur and currently the faculty changed to Razak Faculty of Technology and Informatics.

Mohd Khairi Ismail is a PhD Candidate at Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia. His research interests are economic development and agriculture economic.

Aaishah Radziah Jamaludin received her BSc in Science (Health Physics) in 2008 and Master of Philosophy (Mathematics) in 2017. She is currently a PhD Candidate in Mathematics. Her research interests include time series, pollution-related diseases, count data analysis and climate change.

Ibrahim Lawal Kane is currently Head of the Department of Mathematics and Computer Science, Umaru Musa Yar'adua University, Nigeria. He received his

Doctor of Philosophy (PhD) in Statistics from Universiti Teknologi Malaysia (2014). His research interests include applied statistics and time series analysis.

Lloyd Ling is the Deputy Chair of the Centre for Disaster Risk Reduction and an Assistant Professor of Civil Engineering Department at Universiti Tunku Abdul Rahman, Malaysia. He is an active consultant of National Hydraulic Research Institute of Malaysia, housing developer and building material manufacturer in Malaysia.

Jun Xiu Low is a Master's Student at School of Civil Engineering, UTM.

Nur Syazwin Mansor is a Postgraduate Student pursuing her doctorate degree in Mathematics at Universiti Teknologi Malaysia.

Teddy Mantoro is currently with USBI-Sampoerna University. He received his PhD from the Australian National University and master degree from School of Advanced Technologies, the AIT, Bangkok. His research interests focus on intelligent environment, pervasive/ubiquitous computing, context aware computing, mobile computing, information security, wireless sensor network and intelligent environment.

Shazwin Mat Taib is a Senior Lecturer at School of Civil Engineering, Universiti Teknologi Malaysia. Her research works are established in resource recovery niche area mainly focus on co-benefits of solid waste management and sustainable consumption approach. She is also active in disaster management research and consultancies.

Hairun Aishah Mohiyaden is a Research Engineer at Sustainable Technology and Environment Group (STEG), Institute of Energy Infrastructure, UNITEN. She is actively working for various research and consultancy projects related to dam break modelling and dam safety.

Rashidi Sibri Muda is a Senior Researcher from TNB Research Sdn Bhd. He has over 15 years of experience working with Tenaga Nasional Berhad (TNB). His research area is in dam break modelling, emergency response plan and community-based disaster management.

Anand Nainar has been studying hydrology, sediment and morphology of different land-uses (natural forests, logged, plantations) in Sabah, Malaysian Borneo. He is now based in the Ecohydrology Research Institute, University of Tokyo, investigating hydrological and erosional dynamics as well as management practices in various Japanese forests.

Azmawati Mohammed Nawi is a trained Medical Doctor from Universiti Kebangsaan Malaysia. She obtained her master's in Public Health (Epidemiology and Statistics) from Universiti Kebangsaan Malaysia. Her research interest is more on non-communicable disease and clinical prediction model using traditional statistic and machine learning.

Siti Mariam Norrulashikin obtained a Bachelor of Science in Industrial Mathematics from Universiti Teknologi Malaysia and Master of Applied Statistics from Universiti Putra Malaysia. Currently a PhD candidate in Mathematics from Universiti Teknologi Malaysia, her research interest includes multivariate time series analysis and climate change.

Joy Jacqueline Pereira obtained a PhD from University of Malaya in 1996, Master of Science from The University of Leicester in 1991 and Bachelor of Science from Universiti Kebangsaan Malaysia in 1989. She is a Professor and Principal Research Fellow at the Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM).

Khuneswari Gopal Pillay obtained her BSc (Mathematics with Economics) from Universiti Malaysia Sabah and doctorate in Statistical Modeling from University of Glasgow, United Kingdom. She is a Lecturer in the Faculty of Applied Science and Technology, Universiti Tun Hussein Onn Malaysia. Her major field of study is Statistical Modelling.

Sharifa Ezat Wan Puteh is a trained Medical Doctor. Her PhD was on Health Economics from the United Nations University-International Institute for Global Health. She was a consultant to the Ministry of Human Resource on occupational diseases related burden and Ministry of Higher Education on prevalence of electronic cigarette among university students.

Muhammad Wafiy Adli Ramli received his BSc in Geoinformatics in 2014 and Master of Engineering in Environmental Management in 2016. He is currently a PhD candidate in Civil Engineering. His research interest includes disaster management, geographical information system (GIS) and environmental management.

Mohammad Imam Hasan Reza obtained a PhD from Universiti Kebangsaan Malaysia (UKM) in 2012. He obtained his Bachelor and Master of Science from Chittagong University, Bangladesh. He is a Fellow at the Southeast Asia Disaster Prevention Research Initiative (SEADPRI), Institute for Environment & Development (LESTARI), UKM.

Nur Farazuien Md. Said is a Research Engineer at Sustainable Technology and Environment Group (STEG), Institute of Energy Infrastructure, UNITEN. She is actively working for various research and consultancy projects related to dam break modelling and dam safety.

Norizzati Salleh received her Master of Philosophy in Mathematics from Universiti Teknologi Malaysia in 2017 and is currently providing services as Foundation Assistant Lecturer in Multimedia University, Malaysia.

Nurul Syarafina Shahrir received her Bachelor of Engineering (Computer and Communication Systems from Universiti Putra Malaysia in 2014 and Msc (Systems Engineering from Universiti Teknologi Malaysia in 2016. Her area of

studies and interest are wireless communication and optical communication systems.

Poi Ngian Shek is currently a Senior Lecturer and a research head for R&D and Commercialization in UTM Construction Research Centre (UTM-CRC). His primary research interests are in the field of steel connection, multi-storey steel frame, light steel framing system, steel and composite structure and load bearing interlocking block system.

Lariyah Mohd Sidek is a Professor of Civil Engineering Department at UNITEN. She has been involved in numerous researches and consultancy services in water resources, dam safety, hydrodynamic modelling, dam break analysis, reservoir sedimentation and flood forecasting. She has published over 300 articles and been awarded for various design inventions.

Chamhuri Siwar has expertise in environmental economics, poverty studies and sustainable livelihoods, agricultural and rural development. He has authored various publications such as *Pembangunan Lestari di Malaysia: Harapan dan Kenyataan* and *Linking Rural Poverty and Environment: Governance and Sustainable Development Policies* among others.

Dhinesh Sugumaran obtained his BSc (Industrial Chemistry) from UTM in year 2017, majoring in Polymer Chemistry and Analytic Chemistry. He is currently a fast track PhD researcher in Department of Water and Environmental Studies at UTM focusing on environmental forensics using trace elements and radio-nuclide tracers.

Mohd Raihan Taha is currently the Director of LESTARI, UKM. His expertise is in civil engineering, geotechnical engineering, environmental issues and assessment, groundwater contamination and nanotechnology. He played role as a Project Leader in the research entitled 'Integrated Water Resources Management Approach for Supporting Integrated Flood Disaster Management Decisions'.

Mahmood Md Tahir is a Professor in Department of Structures and Materials, Faculty of Civil Engineering and a Senior Director of UTM's Institute for Smart Infrastructures and Innovative Construction. He specialized in research and consultancies related to the interlocking block construction, composite beam construction and structural steel design.

Rory Peter Dominic Walsh is a Professor in Physical Geography at Swansea University. His main research foci include drainage networks and hydro-geomorphological processes in the humid tropics; sediment fingerprinting, forest fires and land management. He has carried out researches in the Caribbean, Sudan, Sarawak and Sabah, as well as Thailand, Indonesia, Vietnam and Portugal.

Mohd Ruzaimi Yalit is a Research Engineer at Sustainable Technology and Environment Group (STEG), Institute of Energy Infrastructure, UNITEN. He

is actively working for various research and consultancy projects related to dam break modelling and dam safety.

Fadhilah Yusof is currently an Associate Professor in the Department of Mathematical Sciences, Faculty of Science. She is currently the Head, Department of Mathematical Sciences, and the Group Leader for climate change research under Resource Sustainability Research Alliance. Her research interest includes modelling drought episodes and rainfall events using statistical, stochastic and time series analysis.

Abdull Rahim Mohd Yusoff is a Professor in Chemistry and Senior Director of Ibnu Sina Institute for Scientific and Industrial Research in UTM. He is a well-experienced consultant for many government and non-government projects. His research foci are on environmental chemistry, water quality, dyes and wastewater treatments.

Zulkifli Yusop is a Professor of Environmental Hydrology and Dean of Sustainable Resources Research Alliance at UTM, Malaysia. He has strong national and international linkages with the Malaysian International Hydrological Program, Malaysian Water Association, International Water Association, European Union (EU) and others through research and consultancy services.

This page intentionally left blank

ACKNOWLEDGEMENT

This volume of the *Community, Environment and Disaster Risk Management* book series focuses on improving flood management, prediction and monitoring based on case studies particularly in Malaysia. The chapters included in the volume consist of research papers presented at the Conference on Flood Catastrophes in a Changing Environment jointly co-organized by the Centre for Environmental Sustainability and Water Security (IPASA), Universiti Teknologi Malaysia, Asian Network on Climate Science and Technology (ANCST), Southeast Asia Disaster Prevention Research Institute (SEADPRI) – Universiti Kebangsaan Malaysia, and Malaysia-Japan International Institute of Technology (MJIT) on 15–16 November 2016 at Universiti Teknologi Malaysia City Campus, Kuala Lumpur, Malaysia.

The theme of this volume is unique and rather peculiar ‘Integrating EVERYTHING’. This does not mean that there is paucity in focus, but it is to reflect the complexity involved in order to deal with issues regarding calamity or catastrophes. This volume is aimed to cover three main phases that may be simplified as triple Ps: Pre-disaster, Present/during disaster and Post-disaster. These processes involve immense planning, formulation of strategy, preparedness at all levels including the community, early warning system, rescue operation and dealing with the traumatized victims. The volume is hoped to broadly cover various disciplines and matters related to flood management. It is fortunate to have authors and contributors who are expert in flood disaster related fields to share experiences, ideas and view of and solutions that can be implemented to improve flood management and flood risk reduction in Asia particularly in Malaysia.

This page intentionally left blank

ADAPTATION STRATEGIES FOR FLOOD MITIGATION IN PAHANG RIVER BASIN

Nor Diana Mohd Idris, Chamhuri Siwar,
Rospidah Ghazali and Nurul Ashikin Alias

ABSTRACT

This chapter explores the ways in which residents in Pekan, Kuantan and Temerloh districts dealt with extreme floods in the Pahang River Basin. The data were based on a survey of 602 respondents who were affected by the floods, using a set of questionnaire in a face-to-face interview conducted in June 2015. Results of the study show that the flood has destructed the livelihood, crops and small business activities of the affected communities. Vulnerabilities of the communities are linked to the lack of flood warning, landlessness, unstable housing and food insecurity, in addition to female-headed households with financial burden. Community empowerment is necessary for recovering and reducing the loss and damages incurred and improving the quality of life. The prevention and coping measures aim to reduce risk of disasters for the communities in areas that are most vulnerable and less resilient. Flood preparedness is a good preventive measure to limit the negative impacts of extreme flooding in the future. Upgrading of communication system, diversification of income and strengthening of social institution networks are most appropriately recommended for flood adaptation and mitigation strategies.

Keywords: Flood; flood mitigation; adaptation strategies; Pahang River Basin; vulnerability; preparedness

INTRODUCTION

River flood poses a serious threat to millions of people living in river basins worldwide. It is one of the effects of climate change that brings about damage and destruction of large and/or significant loss of human life (Chan, 2012). Malaysia exhibits annually increasing trends in temperature per decade, by 0.15–0.25°C, lower than the global average which is 6°C by 2100 (Tangang et al., 2012). However, the rates of warming for the last 40 years were as high as 4°C per decade for several locations in Malaysia (Tangang, Juneng, & Reason, 2007). The increasing temperatures have led to significant impact on the livelihood of locals due to the resulting high rate of melting ice, glacier retreat, drought and floods. Climate events related to the disasters and shocks are even more prominent if we look back at the records in Malaysia. Large numbers of human lives have been affected by the floods, namely in Kelantan, Terengganu and Pahang. Similarly, greater numbers of livelihood assets of the poor have been severely damaged by climate-related disasters which are found to be still unreported. Therefore various adaptation and vulnerability reducing projects are urgently needed to cope with the highly precarious state of the victims and their livelihoods throughout Malaysia. For this, it is first essential to identify the socio-economic, health and well-being impacts of floods on vulnerable places, communities as well as the magnitude and aspects of livelihood vulnerability in Malaysia. Flooding is a recurring seasonal event in Malaysia. About 29,800 km² or 9% of the total of land are located in flood-prone areas and it affects almost 4.82 million people, which are around 22% of the total population of Malaysia (Sani et al., 2012). In fact, floods are mostly associated with climate variability whereby flooding is speculated to become more serious in the future and its occurrence is expected to increase in duration, number and frequency. The most immediate and serious consequence of heavy rain is the flooding of river basin through both inundation and recession. Flooding creates many risks, including impacts on health and well-being, damage of ecosystems and disruption of people's lives. The severity of flood impacts may further increase in the future due to climate change. In many places, climate change will not only be exhibited as a gradual change in average condition, but also as a change in the frequency and intensity of extreme events, such as heavy rainfall or drought, or periods of extreme cold or heat (IPCC, 2007). The most severe natural disaster that is experienced in Malaysia is flood (Sani et al., 2012). Pahang River Basin is subjected to flood almost every year, but the 2014 flood incident was one of the worst flood disasters that have ever occurred. River flood exposes the population to multiple risks, namely physical, mental, health and their related threats. The aim of the study was to explore the ways in which the residents of Pekan, Kuantan and Temerloh districts dealt with the extreme floods in the Pahang River Basin. Adaptation and mitigation strategies to deal with the climate change and climate variability can help identify and characterise actions that can ameliorate the adverse impacts

on the socio-economic, health and well-being status of communities along the Pahang River and their households.

STUDY AREA

Pahang River Basin is in the central part of the Peninsular Malaysia sandwiched by the Titiwangsa Range in the west and Timur range in the east, both of which expand in the north-northeastern direction, at latitude N2° 48'45"–N3° 40'24", E 101° 16'31"–E103° 29'34". With the length of 435 km, it covers about 29,300 km² of catchment area, of which 27,000 km² is in Pahang and 2,300 km² in Negeri Sembilan and provides ecosystem services to 1.9 million residents who live along the river to sustain their livelihood (JICA, 2011). The annual rainfall varies from 1,700 to 2,800 mm within the basin (mean annual rainfall obtained across 10 years). The high intensity of rain (>60 mm/hour, 200–450 mm/day) at the upstream river increases the quantity of water in the river and causes it to overflow. Most of the residential areas are located at the lowland and the floodplain region and amidst the bad irrigation system, especially in big residential areas. Temerloh faces a larger magnitude of flooded area because it is located at the confluence of main tributaries (Sg. Jelai and Sg. Tembeling) at the mid-stream area. Pekan is located within the lowland area and experiences larger magnitude of flood at the downstream area. Meanwhile, Kuantan is irrigated by the Kuantan River and several other small rivers such as Belat River, Tiram River and Pandan River. It is located at a downstream area. These three districts are flood-prone areas and experience the recurring seasonal event during the period of October to December.

MATERIAL AND METHOD

To investigate the ways in which residents in Pekan, Kuantan and Temerloh districts dealt with the extreme floods in the Pahang River Basin community, the present study utilised a mixed-method of quantitative and qualitative techniques. Data were collected using of a structured socio-economic questionnaire containing both open and close-ended items. The questionnaire administration was cross-sectional in nature. It was designed, tested and administrated at the household level. The study employed mainly primary data sources from respondents in Temerloh, Pekan and Kuantan districts. These are the most flood-affected areas in Pahang and encountered the adverse impacts of the 2014/2015 flood. The study was conducted within the period of six months after the aftermath which was in June 2015. Face-to-face interviews were conducted with 602 residents who were chosen through the stratified random sampling technique. Data obtained were analysed using Statistical Package for Social Science (SPSS) for Windows version 21. Descriptive statistics such as frequency distribution, observation scale as well as range and percentage value are widely used to quantitatively discuss and justify arguments.

RESULTS AND DISCUSSION

Demographic Characteristics

The discussions of the results begin with the profiling of demographic characteristic of the respondent in terms of strata, gender, age, ethnicity and education level to portray the socio-economic status of Pekan, Kuantan and Temerloh residents who live in the study area. Altogether, 610 questionnaires were successfully distributed among the respondents, with a total return of 602 usable questionnaires. This indicates a response rate of 97%.

As illustrated in Table 1, in terms of strata, the result shows that the distributions of respondents are mainly in the rural areas, with 75% of respondents

Table 1. Demographic Characteristic, Perception of Respondents to Prevention Measures and Resilience Indicators by Districts.

(1) Demographic Characteristic of Respondent by District			
Item	Pekan (<i>n</i> = 200)	Kuantan (<i>n</i> = 200)	Temerloh (<i>n</i> = 202)
<i>Strata</i>			
Urban	50 (25.0%)	145 (72.5%)	74 (36.6%)
Rural	150 (75.0%)	55 (27.5%)	128 (63.4%)
<i>Gender</i>			
Male	167 (83.5%)	103 (51.5%)	114 (56.4%)
Female	33 (16.5%)	97 (48.5%)	88 (43.6%)
<i>Age</i>			
19–40 years	39 (19.5%)	99 (49.5%)	44 (21.8%)
41–65 years	143 (71.5%)	88 (44.05)	119 (58.9%)
> 65 years	18 (9.0%)	13 (6.5%)	39 (19.3%)
Mean	50.2	42.6	51.2
<i>Ethnic</i>			
Malay	199 (99.5%)	191 (95.5%)	199 (98.5%)
Chinese	–	4 (2.0%)	–
Indian	–	–	2 (1.0%)
Orang Asli	1 (0.5%)	–	1 (0.5%)
Others	–	5 (2.5%)	–
<i>Level of education</i>			
Degree	4 (2.0%)	23 (11.5%)	9 (4.5%)
Certificate	–	2 (1.0%)	1 (0.5%)
STPM/Diploma	6 (3.0%)	19 (9.5%)	11 (5.4%)
SPM	86 (43.0%)	81 (40.5%)	79 (39.1%)
SRP/PMR	44 (22.0%)	33 (16.5%)	38 (18.8%)
Primary school	54 (27.0%)	32 (16.0%)	62 (30.7%)
No schooling	6 (3.0%)	10 (5.0%)	2 (1.0%)

Table 1. (Continued)

(1) Demographic Characteristic of Respondent by District			
Item	Pekan (n = 200)	Kuantan (n = 200)	Temerloh (n = 202)
<i>Household income</i>			
No income	–	–	3 (1.5%)
<MYR1,000	77 (38.5%)	38 (19.0%)	103 (51.0%)
MYR1,001–MYR2,000	74 (37.0%)	104 (52.0%)	65 (32.2%)
MYR2,001–MYR3,000	23 (11.5%)	29 (14.5%)	21 (10.4%)
MYR3,001–MYR4,000	15 (7.5%)	15 (7.5%)	8 (4.0%)
>MYR4,000	11 (5.5%)	14 (7.0%)	2 (1.0%)
(2) Perception of Respondent to Prevention Measures to Reduce the Impact of Flood by District			
Item	Pekan (%)	Kuantan (%)	Temerloh (%)
<i>To protect vehicle from flood damage</i>			
Parking at a high place	63.0	76.5	75.7
Prepare canoe or boat	59.5	46.5	71.8
<i>To prevent inundation/damage of houses</i>			
Build higher-storey houses	44.5	66.5	57.9
Increase floor heights	44.0	62.0	49.0
Build up structures with concrete material	22.0	55.0	39.6
Keep ditches clean	76.5	87.5	68.3
<i>To protect households properties from flood damage</i>			
Elevate (e.g. place under rooftops)	55.0	77.5	81.7
<i>To protect standing crops from flood damage</i>			
Harvest premature crops	40.5	23.0	50.0
Store seedling	40.0	8.5	58.4
<i>To protect livestock</i>			
Move to a high place/hill side	41.0	43.0	80.2
Shift to relative area	24.5	43.0	64.4
(3) Resilience Indicators of Flood of Respondents by District			
Resilience Indicator	Pekan (n = 200)	Kuantan (n = 200)	Temerloh (n = 202)
<i>Know where the nearest evacuation</i>			
Yes	179 (89.5%)	162 (81.0%)	191 (94.6%)
No	21 (10.5%)	38 (19.0%)	11 (5.4%)
<i>Time taken to move to evacuation centre</i>			
Immediately	89 (44.5%)	97 (48.5%)	153 (76.5%)
<1 hour	61 (30.5%)	27 (13.5%)	25 (12.5%)
1–6 hours	24 (12.0%)	35 (17.5%)	9 (4.5%)
7–24 hours	15 (7.5%)	6 (3.0%)	4 (1.9%)

Table 1. (Continued)

(1) Demographic Characteristic of Respondent by District			
Item	Pekan (n = 200)	Kuantan (n = 200)	Temerloh (n = 202)
>24 hours	7 (3.5%)	2 (1.0%)	—
No answer	4 (2.0%)	33 (16.5%)	11 (5.4%)
<i>Ready to be evacuated*</i>			
Immediately	42 (21.0%)	61 (30.5%)	94 (47.0%)
Always prepared	132 (66.0%)	94 (47.0%)	105 (52.5%)
No prepared	6 (3.0%)	5 (2.5%)	3 (1.5%)
<i>Period of recovering from flood</i>			
<1 month	66 (33.0%)	101(50.5%)	40 (19.8%)
1–6 months	128 (64.0%)	62 (31.0%)	90 (44.6%)
7–12 months	3 (1.5%)	23 (11.5%)	21(10.4%)
>a year	3 (1.5%)	14 (7.0%)	51 (25.2%)
<i>Plan to move to other place</i>			
No	134(67.0%)	81 (40.5%)	177 (87.6%)
Will move	6 (3.0%)	8 (4.0%)	4 (1.9%)
Perhaps	25 (12.5%)	23 (11.5%)	4 (1.9%)
Not sure	35 (17.5%)	88 (44.0)	17 (8.4%)

Source: Field Survey, 2015.

Note: *Those who have evacuated.

living in Pekan and 63.4% in Temerloh, while 72.5% of the respondents in Kuantan reside in urban areas. Overall, 55.3% of respondents live in rural areas and 44.7% dwell in urban areas. The male-headed households form 63.8% while female-headed households form 36.2% of all households. The age of the respondents ranged between 19 and over 60 years old. The greatest number of respondents (58.1%) is from the age group of between 41 and 65 years old. The second largest group of respondents (30.1%) are between 19 and 40 years, while 11.1% of the respondents are aged above 66 years. The mean age of respondents by districts ranged between 43 and 51 years old. In terms of ethnicity, almost 98% of respondents are Malay. However, there is a small portion of respondents of other ethnicity such as Chinese (0.7%) and others (0.8%) who are located in the urban area (Kuantan), whereas Indian (0.3%) and Orang Asli (indigenous people) (0.3%) are mostly located in the rural area. In terms of education, 40% of respondents have secondary school certificate. Furthermore, up to 90% of respondents obtained at least primary level of education. Meanwhile, small portions (3.0%) of respondents are illiterate. In terms of income, about 76% of respondents earn less than MYR2,000 per month, which falls under the low-income group. From the socio-economic characteristics and profiling of

respondents in the study areas, it can be concluded that most of the respondents are vulnerable to floods that occur in the Pahang River Basin.

Loss and Damage

Loss and damage is an issue of growing importance for the international community, as no country will escape the impacts of climate change (IPCC, 2014). The complete and irrecoverable loss of some things and the repairable damage of other things due to the impacts of human-induced climate change (Saleemul Huq, 2014) result in the extreme events and slow-onset processes (UNFCCC, 2012; Warner et al., 2012). Although there is no universally agreed definition of loss and damage, a working definition has been proposed, which is 'the negative effects of climate variability and climate change that people have not been able to cope with or adapt to' (Warner et al., 2012). The value of losses in terms of financial by the residents of Pekan, Kuantan and Temerloh due to the flood incidents included the damage to property, collapse of housing and building, damages to crops and livestock and replacement of household items.

About 24% of respondents mentioned that their loss was in the range of RM2,001 to MYR5,000 due to flooding, while 16.4% said their loss was minimal, which is less than MYR100. Overall, more than one-third (72.9%) of the respondents reported facing a total loss of less than MYR5,000. About 27.1% of the respondents faced losses and damages worth MYR5,000 and above. By districts, 54.1% respondents from Temerloh experienced damages and losses totalling between MYR5,000 and MYR50,000. In Pekan, majority of the respondents (85.5%) experienced losses of less than MYR2,000 and the rest incurred losses within the range of MYR2,001 to MYR50,000. Meanwhile, in Kuantan, 87.5% said they lost over MYR5,000 worth of assets and 12.5% of respondent faced total losses of over MYR10,000. The result of this investigation shows that residents in Temerloh district were more disadvantaged in terms of total loss and damage incurred compared to other districts. Houses belonging to 15 respondents (7.4%) were damaged by flood and 10.4% experienced damages to crops such as palm oil and rubber, besides poultry, chicken pens, orchards and vegetables. Loss and damage emanating from climate change impacts can be economic in nature, such as loss of income or damage to property and assets, and non-economic, which include the cultural, social and mental impacts, as well as the loss of biodiversity and ecosystem services, among others (Morrissey & Oliver-Smith, 2013). From these results, it is very obvious that flooding has caused untold hardships to residents of Temerloh, and there is an urgent need to ameliorate the suffering of the people by the appropriate stakeholders. The Ministry of Agricultural and Agro-Based Industry under the Department of Agriculture should take action by providing compensations for damages and losses (including for production means) as an endeavour to reduce serious misery. This could serve as recovery means for the losses incurred and ease the burden of residents who are victimised by flooding. The government should develop a compensation mechanism which includes the cost of

production such as fixed and variable inputs, including labour and technology and damaged value of crops.

Economic Losses

The economic impacts of flooding are identified through the changes observed in income and poverty levels, income groups and the adverse impacts on livelihoods for those relying on nature as their daily source of income. In Malaysia, the method used to measure income poverty is Poverty Line Income (PLI), which categorises poverty groups by certain income levels. By referring to the PLI for 2014, food and non-food poverty line was used to identify the hard-core poor group as those with the household income of below MYR520 per month. Meanwhile, those with household income of less than MYR830 per month are considered as poor, while a non-poor household earns MYR830 and above per month. Furthermore, the distribution of respondents' income for this study was categorising to hard-core poor, poor and non-poor based on PLI ([Economic Planning Unit, 2012](#)). The study shows that more than 50% of respondents earn MYR1,500 and below per month. This indicates that the households affected by the flood are mostly in the low-income category. The floods led to the increase of households in hard-core poor group by 23% overall, and by 1.5%, 0.5% and 6.5% for Pekan, Kuantan and Temerloh, respectively, which are higher than Pahang state hard-core poverty level (0.3%) for the year 2009 ([Economic Planning Unit, 2009](#)). In comparison, overall, the poor category decreased by 9.72%, while the non-poor decreased by 3.2%. For the bottom 40% of the groups, there figures remain unchanged for Pekan, while in Kuantan and Temerloh, there was a reduction of 0.5% and 3%, respectively.

Basically, Pekan and Temerloh residents are located in rural areas, with agriculture and related resources of nature as the main sources of livelihood. The effect of climate change which led to floods has affected their income sources. The sources of income consisted of agricultural income, non-agricultural and other incomes. Agricultural income encompassed incomes from main crops, others crop, livestock and wages for agriculture activities. Non-agricultural income was drawn from wages/salaries and businesses, while other incomes were from items such as spouse's income, remittance, transfer of payment (pension and government assistance), dividends from savings and investments. The flooding has brought about significant impacts on 109 respondents relying on agricultural activities as their source of livelihoods. More than 60% of farmer's incomes are derived from agricultural sources for 49 respondents in Pekan, 57% for 40 respondents in Temerloh and 41% for 15 respondents in Kuantan. This shows that a great and considerable portion of household income for the population under study was derived from agricultural sources. The reduction of incomes in the range of between 24.7% and 31.2% in farmer's average income in these three districts due to the damages of crops such as rubber, oil palm, paddy and short-term crops like chilli, vegetables and maize, caused revenue loss and subsequently reductions in the sources of households income. Loss of livestock, disruption of business activity, loss of jobs and the need for more expenditure to