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14th-18th January 2019
Cinnamon Lakeside | University of Moratuwa | University of Colombo
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This book brings together the full research articles presented as a part of the International Conference on Capacity Building for Research and Innovation in Disaster Resilience, Colombo, Sri Lanka from 14th to 18th of January 2019, which was organised in conjunction with ASCENT, a three year EU-Asia collaborative project that aims to address R&I capacity strengthening for the development of societal resilience to disasters.

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University of Moratuwa, Sri Lanka
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University of Colombo

CAPACITY BUILDING IN RESEARCH AND INNOVATION IN DISASTER RISK REDUCTION

NATIONAL SCIENCE FOUNDATION

CAPACITY BUILDING FOR RESEARCH AND INNOVATION IN DISASTER RESILIENCE

Selected papers from the
International Conference on
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Programme Lead: ascent, cabaret
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Editors:
Dr. Nishara Fernando
Dr. Chandana Siriwardana

April 2019

Capacity Building for Research and Innovation in Disaster Resilience

Dr. Nishara Fernando, Dr. Chandana Siriwardana, (edited by)
Mr. Malith De Silva, Ms. Belinda Wise, Mr. Chameera Randil, Mr. Chamal Perera, (support editing team)
Capacity Building for Research and Innovation in Disaster Resilience Book Volume

CONTENTS

FOREWORD

This book comprises of number of selected papers that have been developed based on the peer review of the abstracts that were presented at the International Conference on CAPACITY BUILDING FOR RESEARCH AND INNOVATION IN DISASTER RESILIENCE, which was jointly organised by University of Moratuwa and University of Colombo in Sri Lanka and Advancing Skill Creation to Enhance Transformation (ASCENT), an EU Erasmus+ project partners. Our world is increasingly subject to hazards that challenge conventional wisdom, both in anticipating natural and human-made hazards, and in responding to them. The event was held from 14th to 18th January 2019 at University of Colombo, University of Moratuwa and at the Cinnamon lake side Hotel in Colombo, Sri Lanka.

ASCENT project aims to strengthen research and innovation capacity for the development of societal resilience to disasters. ASCENT is co-funded by an EU Erasmus+ programme grant, which was commenced in February 2016 and will run for three years and is led by the University of Huddersfield's Global Disaster Resilience Centre, based in the UK. They are joined by a consortium of 13 European and Asian higher education institutions from the Bangladesh, Estonia, Lithuania, Sri Lanka, Sweden, Thailand and the UK. Other programme institutions include: University of Huddersfield, United Kingdom (Lead Partner); University of Central Lancashire, United Kingdom; Lund University, Sweden; Mid-Sweden University, Sweden; Vilnius Gediminas Technical University, Lithuania; and Tallinn University of Technology, Estonia. The Asian partner institutions include: University of Moratuwa, Sri Lanka; University of Colombo, Sri Lanka; University of Ruhuna, Sri Lanka; Naresuan University; Thailand; Chiang Mai University, Thailand; University of Dhaka, Bangladesh; BRAC University, Bangladesh; and Patuakhali Science and Technology University, Bangladesh.

The project was inspired by the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) , signed by 187 UN member states in March 2015, as a 15-year, voluntary, non-binding agreement which recognises that the State has the primary role to reduce disaster risk, but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. The Framework identifies that international, regional, sub-regional and transboundary cooperation remains pivotal in supporting the efforts of States, their national and local authorities, as well as communities and businesses, to reduce disaster risk. In line with this global framework, the development of capacity is vital in empowering the handling of disaster risk.

Higher Education Institutions (HEIs) are environments primed to aid in the development of capacity. As centres of education and research, these institutions are involved in the dissemination and development of knowledge. They often have access to specialised infrastructure, funding sources, and aggregate skills and experience in the overall human resources unified within their organisational hierarchy. Disaster resilience capacity development, as a subject influenced by sharing and development of Research and innovation (R&I) practices, is linked heavily with the HEIs that house these efforts. The SFDRR highlights the importance of academia in developing disaster resilience, characterising the role HEIs play as stakeholders of capacity development.

The ability of R&I to contribute to capacity development demonstrates the significance of these activities to the development of disaster management. The SFDRR itself highlights capacity as a component of the multi-faceted nature of disaster risk. In order to contribute to the SFDRR goals and further the global drive for disaster risk reduction, HEIs must maximise the efficiency and effectiveness of their R&I activities in order to achieve the greatest possible capacity. Not only will R&I allow existing methods to be improved upon, it may also facilitate the introduction of new paradigms and approaches that best suit the evolving disaster risk and resilience environment bespoke to the communities at risk themselves.

The shift towards acknowledging the role and aid of other stakeholders in developing capacity for disaster resilience, especially HEIs, has highlighted the lack of understanding of the nuance these institutions play in aiding capacity development. Whereas States and macroeconomic considerations of disaster risk are well understood, a clearer examination of the interplay of influences that shape capacity development for disaster resilience is required to understand fully the role HEIs can play.

In this context, during the past three years, the ASCENT consortium has identified research and innovative capacity needs across Asian higher education institutions in Bangladesh, Sri Lanka and Thailand in particular, to tackle the development of societal resilience to disasters. It has developed research infrastructure, prepared researchers to undertake advanced, world-class and innovative, multi- and interdisciplinary research, and increased international cooperation among higher education institutions. It has also explored, promoted and initiated opportunities for fruitful university / industry partnerships. In doing so, ASCENT has provided a link between the research and the public, helping to reinforce the connection between education and society.

The work on advancing disaster resilience capacity that is expressed through the record of this conference comes at a time when leading scientists across the world are arguing that our planet has entered a new era, in which humans have supplanted natural forces as the primary determinant of the Earth's future. There can be no doubt that resilience to catastrophic disruptions will come to be one of the major themes in research and practice.

In this context, this book volume has brought together expertise, across a wide range of disciplines and fields of study, around the central theme of resilience and represent some of the selected themes that were presented at the International Conference on CAPACITY BUILDING FOR RESEARCH AND INNOVATION IN DISASTER RESILIENCE. By looking at the capability of systems to withstand change, this approach has informed capacity development of HEIs, both research, practice and the development of links between the education and society. This is both timely and urgent; getting resilience to disasters right has the potential of preventing loss of life on a massive scale, and of mitigating the

suffering that has been all too evident in the string of recent disasters across the world.

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FROM THE EDITORS

It is with great satisfaction that we write the Editor's Note for the book volume containing selected papers presented at the International Conference on "CAPACITY BUILDING FOR RESEARCH AND INNOVATION IN DISASTER RESILIENCE" as part of the "ASCENT Festival", held in Cinnamon Lakeside, University of Colombo and University of Moratuwa Colombo, Sri Lanka, from the 14th to the 18th of January, 2019. The ASCENT Festival was the project dissemination activity of the Advancing Skill Creation to Enhance Transformation (ASCENT) Project. ASCENT aimed to enhance and improve the capacities of academics engaged in research and innovation activities related to disaster resilience since its inception in 2016. ASCENT is co-funded by an EU Erasmus+ programme grant, led by the University of Huddersfield's Global Disaster Resilience Centre, based in the UK with a consortium of 13 European and Asian Higher Education Institutions from Bangladesh, Estonia, Lithuania, Sri Lanka, Sweden, Thailand and the UK.

The conference continues the tradition of bringing together researchers, academics and professionals from all over the world who are experts in Disaster Resilience. In addition to the papers which were presented, the "ASCENT festival" was graced with the presence of keynote speakers. Mr. Abhilash Panda, Deputy Chief for Europe and Central Asia, United Nations Office for Disaster Risk Reduction, spoke on 'Localization as key to resilience and sustainability'. Ms. Bindu Urugodawatte, Deputy Director of SAARC Cultural Centre Sri Lanka, expounded her thoughts on "Heritage and Disaster Resilience' and Dr. Senaka Basnayake, Department Head of the Climate Change and Climate Risk Management unit of Asian Disaster Preparedness Center (ADPC), Thailand expressed his views on the 'Nexus on Climate & Disaster Risk Management'. In addition, a series of special events were organized in line with the conference, which captured a complete

spectrum of activities and dialogue related to Disaster Risk Reduction. These special sessions were well facilitated with world-renowned subject and field experts.

The papers published in this book volume were selected using double blind peer review from over 100 abstracts submitted under seven themes and presented at the conference, which have contributed to the most recent scientific knowledge in the field of Disaster Resilience, Industry-University partnerships and Policy Reforms.

The conference particularly encouraged interaction of young and middle level academics with the more established academic community in an informal setting to present and discuss new and current work.

We trust that this collection of research work will be an impetus to stimulate further study and research in all such areas. We thank all authors for their contribution to the book volume. We would like to specially acknowledge the financial support extended by the National Science Foundation, Sri Lanka to print this book volume and for their contribution towards the advancement of research activities in the country. In conclusion, we appreciate the efforts of everyone who contributed in diverse ways to make this publication successful.

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SCIENTIFIC PAPERS

Capacity Building for Research and Innovation in Disaster Resilience 2019

A review of existing laws and policies applicable to disaster induced resettlement in Sri Lanka

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Abstract

Resettlement has been recognized as an inevitable result of disasters such as landslides and floods, given the large-scale property damage it causes. Both the legislative and policy backgrounds are important in order to understand the process of involuntary relocation. The main objective of the present study is to examine various legal and administrative policies introduced in contemporary Sri Lanka to involuntarily relocate people who have been displaced due to natural hazards. This paper discusses livelihood security of the displaced as well as safeguarding them from future hazards as a disaster risk reduction strategy. Data suggests that even though the existing institutional framework has advantages such as importance given to compensation and litigation procedure, they tend to have various gaps such as the non-legal nature of policies. In conclusion, suggestions have been made to implement a holistic institutional arrangement with further disaster risk management strategies to address the adverse impact on disaster-induced displaced.

Keywords:

Disaster Induced Relocation; Disaster Risk Reduction; Institutional Framework; Livelihood Security; Natural Hazards

1. Introduction

Having been ranked 63rd of the World Risk Report (2017) on natural hazards vulnerability, Sri Lanka is a well-known disaster-prone country. According to the National Disaster Relief Service Centre (2018), 49, 364 families and 188,328 individuals have been affected by flooding and landslides during the year 2018. It further reports that 186 houses were entirely damaged and 551 infrastructure facilities were affected due to the said hazards. Given the amount of property and human damages the said hazards cause, relocation has been recognized as an inevitable result in the aftermath of a hazard in most circumstances (Fernando, 2012). However, research studies have shown that resettlement efforts following a natural disaster are often uncoordinated, sluggish and inefficiently managed. According to Oliver Smith (2009) in general, resettlement or relocation processes are poorly planned, inadequately financed and incompletely implemented turning these projects into "Development Disasters''. Therefore, an evaluation of existing post-disaster resettlement strategies is a timely requirement which would enable the development of a more effective and efficient resettlement mechanism. In this context, it is relevant to understand the legislative and administrative protocols which are to be followed to implement the said resettlement strategies.

According to the Oxford Modern English Dictionary (1995) Resettlement is defined as "Settle again" (P. 920) and Relocation is defined as "locate in a new place" (P. 912). Fernando (2012) has pointed out that the definitions of the terms consider physical movement of people to a new place to live other than the previous place. According to Turton, forced relocation is where "people are forced to leave their homes or home lands for whatever reason and have been allocated specific areas for them to settle down in their own country with at least minimum resources and services to reestablish their lives" (Turton, 2006, P. 13). In the present study, both concepts of relocation and involuntary relocation are relevant, provided that a natural hazard can be sudden (Tsunami, flooding and landslides) as well as slow on sight (drought).

In reviewing the existing laws and policies applicable for disaster induced relocation in Sri Lanka, it is important to conduct the

evaluation based on the conceptual frameworks introduced by Thayer Scudder (2005)[7] and Michael Cernea (2000).

Thayer Scudder's stress and settlement process (2005) *considers physiological (diseases), psychological (anxiety, depression) and socio-cultural (cultural identity) stress people have to deal with throughout the relocation process and this could be overcome through a proper resettlement plan. The resettlement plan could be explained in four stages: 1. Planning and recruitment, 2. Coping and Adjustment, 3. Community formation and economic development, and 4. Handing over and incorporation*

Micheal Cernea's impoverishment Risks and Reconstruction Model for resettling displaced population (2000) model discusses eight possible risks that could influence the resettlement process rather than considering different stages. These risk patterns were identified by comparing empirical studies (Cernea, 1999). The said risks are; *1. Landlessness, 2. Joblessness, 3. Homelessness, 4. Marginalization: 5. Food Insecurity, 6. Increased morbidity & Morality, 7. Loss of access to common property and services, and 8. Social Disarticulation.*

2. Objective of the study (Model, Process, Device, Sample preparation etc.)

The main objective of the present study is to review the existing legal and administrative policies related to involuntarily relocation of people who have been displaced due to natural hazards; the following sub objectives are utilized in attaining the main objective:

1. Identify shortcomings and gaps, in applying the same for resettlement of vulnerable populations to safe areas.
2. Make recommendations for strengthening policy content and laws conducive for efficient planning and implementation of disaster induced relocation.

3. Methods

In order to achieve the main objective, both primary and secondary data were collected. Relevant policies and practices related to land resettlement and land acquisition were gathered and reviewed.

Stakeholder consultative meetings were held with relevant government officials and they expressed their views and experiences on relocation policies adopted at the District Secretariat level, the positive/negative outcomes and recommendations. In addition, primary data was collected though focus group interviews with officials from the National Building Research Organisation (NBRO) and Disaster Management Centre (DMC) to get in-depth knowledge on existing policies on relocation and to determine their experiences and recommendations while implementing these policies.

4. Results and Discussion

4.1 Review of the existing laws and policies

The existing laws and policies relatable to disaster induced relocation in the Sri Lankan context can be mainly recognized under the themes of Land Acquisition, Involuntary Resettlement, Environment and Disaster Management.

4.1.1. Laws and policies for land and acquisition

4.1.1.1 Land Acquisition Act No 9 of 1950 (LAA) and Land Acquisition Regulation of 2008 (LAR)

LAA looks at private land acquisition for public purposes, with the latest amendment Act No 13 of 1986. The LAR 2008 provides a framework for land acquisition; it guarantees that no person is deprived of land unless under the provisions of LAA. The law discourages unnecessary land acquisition.

The land acquisition framework under LAA covers a wider area of the acquisition process. The framework covers a long procedure of noticing the affected people, calculating compensation and referring to the courts. It is evident that based on the requirements given under each provision, the land acquisition process is very time consuming. A cause for delay often arises with legal proceedings relevant to the compensation procedure. Another inadequacy in the act is the obligation to prove ownership of the land. Gathering relevant information and submitting a compensation claim is on the Affected People (AP). Often APs are not aware of their rights as well as how to

deal with complex procedures which entails paperwork. Due to those enquiries on ownership, the acquisition process is further delayed. Compensation is determined based on the market value and LAR amended that this value shall be calculated considering the whole plot of land. Failure to recognize people who might lose their income is another drawback.

Compensation is given only to legal owners as the act does not recognize squatters who have no legal title to land. The LAA has an adverse impact on squatters with no legal ownership to their land.

LAR was introduced to mitigate the gaps in relation to the calculation of compensation in LAA. However, LAR has introduced provisions for the loss of income and other impacts which can be compensated on furnishing of other evidence in lieu of documentary evidence and it does not cover people who cannot produce evidence to claim benefits towards loss of income.

4.1.1.2 Recovery and repossession of State Lands

The state lands (recovery of possession) Act no 7 of 1979 contains provisions for the recovery of state land from unauthorized possession or occupation. Section 10 further stipulates that an appeal cannot be maintained against an order of ejectment by the magistrate. Section 13 provides reasonable compensation for any damages sustained by the aggrieved because they have been compelled to give up occupation.

Chapter VII of the Land Development Ordinance 1935 (LDO) sets out the procedure for the cancelation of state land given on a permit or grant due to non-compliance. Section 106 gives notice to the permit holder when there has been a breach of the conditions of the permit. Section 109 provides an order to cancel the permit if the permit holder fails to appear. Section 110 details the procedure when the permit holder appears and pleads cause. Under section 112 the order of government agent will be served to the permit holder displayed on the land. An appeal can be made to the land commissioner under Section 113.

The procedure to eject a person occupying a state-owned land is detailed in chapter IX of the Land Development Ordinance. Section 168

of the LDO stipulates the offences with regard to state land. If a person cultivates, erects a structure, cuts down trees or encroaches any state land without the permission of the government agent, they are subject to a fine and imprisonment. Thus, the rights of a mala fide possessor are not recognized for compensation for improvement under the laws of Sri Lanka.

4.1.1.3 National Policy on Payment of Compensation (NPPC) 2008

This policy was passed to establish a uniform system of adequate compensation, based on the LAA, NIRP and several other laws applicable to land acquisition and resettlement. It was also designed to supersede all other ad hoc compensation packages used by various government agencies such as the Road Development Authority. The Land Acquisition (LA) Regulations of 2008 which was ratified by the Parliament of Sri Lanka in 2009 gave effect to both NIRP and NPPC. It created a union between the local regulatory framework for land acquisition and resettlement while using international best practices for involuntary resettlement.

With regard to the compensation scheme adopted in the said policy, is the scheme which had been developed by the Road Development Authority (RDA) in 2000 as an attempt to amend the LAA. Despite the failure of the said objective, the RDA established a Land Acquisition and Resettlement Committee (LARC) in 2001. The developed compensation scheme consisted of the following key features: 1. The officials from different authorities who are attached with the given project should work together to negotiate in estimating the compensation for issues such as loss of earning, loss of residence and disturbance, 2. Previously, valuations of buildings were based on depreciated value. Compensation for severance, injurious activities, and disturbance was limited to 20% of market value which resulted in a low compensation payment for those aspects, 3. The LARC enabled the acquiring officer to interact directly with the affected people, and the LARC gave the first ever opportunity for the affected person to participate in the compensation calculation process.

In 2008, the National Policy on Compensation was formulated by the treasury based on the schemes of the LARC. According to a gazette notification in 2013, compensation should be based on market value on

the principle of "not a separate entity" and regulations existed side by side with LAA and LARC. The Mahaweli water security investing

program and Resettlement action plan for Dharmashoka Mawatha are some projects where the said policy was applied.

4.1.2 Laws and policies applicable to involuntary resettlement

4.1.2.1 National Involuntary Resettlement Policy (NIRP)

Since the national legal framework was not supportive towards illegal squatters, the NIRP was introduced in 2001. The newly adopted policy has recognized the following eight social-cultural impacts in involuntary resettlement: 1. Impoverishment of displaced persons due to homelessness and landlessness, 2. Unemployment, 3. Economic marginalization, 4. Increased morbidity, 5. Food insecurity, 6. Lack of access to common property and public services, and 6. Disruption of existing community networks (Ministry of Defense and Urban Development, 2011). They have adopted Cerenea's (2000) risk patterns in identifying those impacts.

The main objectives of the policy are very much similar to the policy of the World Bank on involuntary resettlement. This tries to mitigate or minimize the negative impact of involuntary resettlement rather than avoiding it. The main objectives of NIRP could be listed as: 1. Avoid, minimize and mitigate negative impacts of involuntary resettlement by facilitating productive and self-sustaining establishment for the affected people. The policy should also enrich the development of the affected people and the project, 2. Ensure that the affected people are fully and promptly compensated and successfully resettled. The livelihoods of any and all displaced persons should be re-established and their standard of living improved, 3. Ensure that impoverishment shall not occur as a consequence of compulsory land acquisition for development purposes by the state, 4. Assist affected people in dealing with psychological, cultural, social and other stresses caused by compulsory land acquisition, 5. Make all affected people aware of the processes available to address grievances and to make those services easily accessible and immediately responsive, and 6. Have in place a consultative, transparent and accountable involuntary resettlement process according to a pre-agreed timeframe by the project executing agency and affected people (MOD, 2011).

NIRP was adopted based on the policy frameworks developed by the World Bank (WB) on involuntary resettlement. WB is one of the main organizational bodies to introduce a policy framework for involuntary resettlement. The initial policy was introduced in 1980 and the latest revised policy was published in 1990. As involuntary resettlement should be avoided or minimized based on feasibility, the policy consists of three main objectives. Resettlement activities should be executed as substantial development programs and displaced persons (DP) should be assisted to improve their livelihoods (World Bank, 2012).

The policy emphasizes the importance of a community participatory process where displaced people can provide their input from planning of the project to monitoring and evaluation. Additionally, vulnerable groups among the displaced such as the poor, the elderly, women, children and indigenous communities have been given particular attention. Compensation criteria has been designed irrespective of whether the people have legal rights to the land or not.

The WB follows ten safeguard policies to eliminate or reduce the adverse effects of development projects. They are as follows; 1. Environmental assessment, 2. Involuntary resettlement, 3. Natural habitats, 4. Pest Management, 5. Cultural property, 6. Indigenous people, 7. Forestry, 8. Safety of dams, 9. Projects on international waters, and 10. Projects on dispute areas (World Bank, 2001)

The Ministry of Defense and Urban Development in 2011 has recognized the following as relevant policies in the resettlement process: 1. Involuntary resettlement, 2. Environmental assessment, 3. Physical cultural resources, and 4. Natural habitats (Ministry of Defense and Urban Development, 2011).

The WB further requires a resettlement plan complete with a socio-economic study of the displaced people along with a review of gaps between the policy and the national legal framework. The main drawbacks of this policy framework are the lack of a strong compensation framework and legally enforceable penalties in case of non-conformity.

Even though one of the main objectives in introducing NIRP in 2001 is to provide necessary amendments to LAA, no such amendments have been made up to date.

4.1.3 Laws and policies applicable to the environment

4.1.3.1 National Environment Act (1980)

The National Environmental Act (NEA) was introduced in 1980 as an umbrella legislation that provides a holistic framework for the protection and improvement of the environment. The National Environmental Act No 47 of 1980 also refers to involuntary resettlement. Gazette notifications 772/22 published on 24th June 1993 and no 859/14 of 23rd Feb 1995 determined the types of projects for which an environmental impact assessment is required under part IV (c) of the act. The 1988 amendments vested legal authority to the Central Environmental Authority (CEA) to protect, manage and enhance the environment, and to specifically control pollution. CEA introduced an environmental licensing scheme to reduce pollution and helped establish pollution mitigation regulations (1990) by fulfilling the statutory requirement for an Environmental Impact Assessment (EIA) (Government of Sri Lanka, 2014). The act requires environmental clearances to be sought for specific types of new projects.

The EIA requires development projects to be screened to assess their potential impact. Legal provisions for EIA in Sri Lanka was first included in the coastal conservation Act no 57 of 1981 but these provisions were restricted to the coastal zone. EIA was mandated island wide by the 1988 amendments to the National Environment Act (NEA) and the CEA was assigned regulatory functions. Accordingly, the EIA process in Sri Lanka applies only to "prescribed projects", which have been gazetted under section 23 Z of the NEA. This order lists two kinds of projects that require an EIA clearance before they can be implemented. Part IVC of the amended act of 1988 mandated that the CEA carry out an EIA for "prescribed" development project proposals. Any adverse impact to the environment by the proposed projects would be identified and measures would be taken to minimize such impacts. Based on the initial screening the nature of assessment will be decided. The prescribed project schedules which require an EIA refers to "…involuntary resettlement exceeding 100 families, other than

resettlement resulting from emergency situations" under item 12. The gazette specifies which approval should be obtained from the Project Approving Agency (PAA) (Government of Sri Lanka, 2014). Typically,

the PAA is the project proponent who prepares an IEE or EIA according to CEA guidelines.

4.1.4 Laws and Policies applicable to disaster management

4.1.4.1 National Policy on Disaster Management (NPDM) – 2013

The objective of this policy was to formulate a framework to manage disasters such as floods, Tsunami, droughts, and tornados. The vision statement of the policy was 'towards a safer Sri Lanka' and the mission was to create effective disaster management for safety and resilience of lives and properties. The policy incorporated the following objectives:

To achieve sustainable and resilient disaster management through: i. Appropriate institutional, legal and implementation mechanisms; ii. Informed, scientific, multi-hazard risk reduction approaches mainstreamed in development and reconstruction based on national priorities; and, iii. Participatory, multi-agency, multi-stakeholder engagement in line with national and international standards for effective disaster relief and response.

The positive aspect of this policy is the establishment of the National Council for Disaster Management. On the other hand, drafting the legislative document of Disaster Management Act No. 13 2005 took place right after the Tsunami and it was a requirement of the Act to have a National Disaster Management Policy and National Emergency Policy.

The National Council for Disaster Management (NCDM) is the supreme body for the management of disasters in the Sri Lankan context under the Disaster Management Act No. 13 of 2005. The President of Sri Lanka is the Chairperson and the Prime Minister is the Vice-Chairman. Leader of the opposition and the Ministers of various Ministries such as Disaster Management, Health, Irrigation and Housing have the membership of the Council. As per Article 9 of the Disaster Management Act of 2005, Disaster Management Centre can appoint a technical Advisory Committees with regard to various technical aspects of a given disaster who has the technical knowledge of the given aspect.

4.2 Gaps of the existing laws and policies and recommendations

The recognized gaps and recommendations can be discussed based on the following themes:

Gaps related to the relocation process: One of the main drawbacks of the existing policies is that resettlement of vulnerable families are regarded not as a process for building disaster resilient communities as emphasized by Scudder (2005). On the other hand, there is a lack of accountability and transparency of resettlement project implementing agencies and a lack of a proper monitoring mechanism for maintaining the environmental reservation areas. The present system grants the utilization of land and does not restrict the use of reservation areas for various other purposes. It is a common practice of community members to encroach the said reservation areas dedicated to natural resources (such as rivers, streams, environmental sensitive areas, forests, etc.) and engage in illegal activities which will increase the risk of hazards. The existing frameworks also promote an unusual delay in land acquisition procedures which is problematic in a sudden disaster situation. On the other hand, the existing legal framework is very biased toward the task of land acquisition, not considering the aftermath context of land acquisition. During resettlement of vulnerable families, the usual practice is to provide a single storied house with suitable land for cultivation. However, in semi-urban or urban areas it is difficult to find suitable land to resettle large communities with provision for cultivation. Non-availability of a mechanism or a system for handling complaints and claims for compensation due to acquisition of the land, common structures destroyed due to disaster events, and crops or economic losses is another drawback in the process. It is essential to assist the affected people to submit their claims for compensation due to acquisition of their land, structures, crops or economic losses incurred during the process. This can be undertaken through a reliable government or non-governmental organization. It is also important to assist the displaced people to properly manage their compensation. Establishing a Grievance Committee or a Mediation Board under the leadership of other relevant Governmental officials may be a possibility. The land acquisition procedure should be made efficient and land allocation should be completed within a short period. Once owners can ensure that they will be able to move to the new land, the deeds could be issued. It is more beneficial to have a common compensation scheme similar to compensation schemes applied in the case of development projects and allow resettled families to make their own decisions.

Lack of considering the various impacts of relocation: As pointed out by Cernea (2000), relocation is a process with various physiological, psychological and sociological impacts. Therefore, it should be kept in mind that relocating a population entails loss of land, housing, livelihood and break down of social and economic networks that are necessary for survival. Therefore, efforts should be made to analyze the implications of resettlement before implementing and after implementing the programs by implementing agencies or the government. Assessment similar to the Social Impact Assessment (SIA) and Environment Impact Assessment (EIA) should be conducted as part of the process. Such reports have to be examined by a multi-disciplinary expert group. Conducting a vulnerability assessment to consider not only factors such as physical abilities, ethnicity, gender, caste, and income earning activities, but also other socioeconomic, demographic and environmental factors of the affected families is useful for further improvement. This will further be helpful in identifying different levels of vulnerabilities that families face. The data suggests that there is lack of effort from the implementing agencies or the government to analyze the implications of resettlement before implementing or after implementing such programs. In particular, such initiatives are essential to understand the relationship between the host communities and the displaced communities. Sometimes due to social, cultural and ethnic differences, the host communities are reluctant to accept the newly resettled families. Also resettled families have difficulties in adapting to the new environment. Therefore, absence of in-depth research for identifying resettlement related socio-economic issues and resettlement induced risks faced by different communities, unplanned livelihood restoration programs and lack of quality assurance of constructions, services, facilities and material seems to be major drawbacks in the existing frameworks. It is suitable to implement programs to conduct in-depth research on the implications of resettlement programs beforehand, covering displacement related socio-economic issues and resettlement induced risks and to organize awareness programs to address research findings on displacement related socio-economic issues and matters related to the resettlement process. Economic enhancement and livelihood restoration should be promoted during the implementation of resettlement programmes, paying more attention to private public

partnerships, community level skill training, and providing basic resources to restore livelihoods.

Lack of proper legal background: As mentioned earlier, the intended amendments on LAA have not been implemented until now, and this has been one of the major drawbacks in implementation and monitoring of relocation programmes. On the other hand, Sri Lanka's disaster management and resettlement action plans and policies are governed by various ministries, line ministries and authorities and are indirectly influenced by almost all the ministries. Other than the ministry of Disaster Management, there is no other authority responsible to address multiple issues pertaining to victims of displacement due to disasters. Non-availability of a mechanism for handling complaints and claims for compensation, and land titles being provided to resettled families immediately after relocation are also some of the major burdens faced by people due to the lack of a strong legal background in the field of relocation. These results in a situation of unavailability of national standards in the construction of temporary, transitional and permanent shelters provided to affected families as well as provision of common infrastructural facilities and other essential facilities such as road, drainage and garbage disposal in and around the settlement which will further lead into adverse impact on the affected people. It is suitable to have a designated organization with the necessary legal authority and capacity to handle disaster induced resettlement action plans; develop related policies; monitor compliance with policy; payment of compensation; looking into the grievances of beneficiaries; maintenance of newly built settlements and conducting research on implications of resettlement. It is essential to assist the affected people to submit their claims for compensation due to acquisition of their land, structures, crops or economic losses. It is also important to assist displaced people to properly manage their compensation. When constructing permanent shelters, it is advisable to make it mandatory to use disaster resilient house and settlement plans prepared by governmental authorities to ensure a disaster resilient community. Some flexibility should be allowed to facilitate the sound implementation of relocation programs because the availability of resources such as material, land and labor depends on the location. Land that is given up should be replaced by new land of comparable value. Deeds should be granted promptly for the new land. In the absence of land, cash compensation should be paid to all affected

persons. Compensation for all other lost assets (movable and immovable) should be paid promptly. Families who do not have secure

land titles should receive fair and just treatment in order to prevent marginalization.

Role of the affected people: As pointed out by Scudder (2005), Cernea (2000) and Oliver-Smith (2009), it is of utmost importance to involve affected people in the relocation process as it is an act which deals with their lives. However, relocation processes are dominated by the government and donor perspectives and often the voices of the affected people are drowned out. Seeking people's perspectives and active participation in development have the capacity of enhancing the quality of the total outcome and build ownership. It was further observed that coordination committee meetings at national, district and divisional levels, are being organized to discuss resettlement project implementation issues of vulnerable people living in high hazard areas, and these meetings lack participation of some of the essential partners and implementing agencies (and donors). This will have a disrupted information flow and disturb the proper coordination of activities and provision of services for resettling communities. The said settings promote reluctance for sharing data which keeps the affected people in darkness of not knowing the real repercussions of the relocation process. This has led to promoting a method that lacks of community participation in recovery program implementation. In many cases, they are passive observers and no role is given to them during implementation. There is also a misconception that when such programmes are implemented with community involvement, the programmes are delayed. Duly trained taskforces should be established at various levels during the resettlement project implementation as a mandatory requirement in order to avoid red-tape which will negatively impact affected population. Such taskforces should be involved in all stages of the resettlement project. The responsibilities of each stakeholder of the taskforce should be identified and their duties and tasks should be well documented. Another noticeable gap is the lack of participation of the community leaders. It is essential that beneficiary families should be given a chance to express their views and officials in-charge should respond positively to them. Community Based Organizations and the community members should be encouraged to participate in each and every step of the relocation process.

5. Conclusion

Even though Sri Lanka has national policies in place for involuntary relocation and disaster management, the lack of a legal background in the field of relocation seems to be problematic in putting the visions of the policies into action. Therefore, there is a vital need of a legal framework to govern the relocation process with the principles of having a mechanism to maintain a good flow of critical information related to natural hazards, assisting the affected people to submit their claims for compensation due to acquisition of their land, structures, crops or economic losses, nationally accepted standards been developed when constructing temporary, transitional and permanent shelters covering settlement level infrastructure facilities and also provision of services such as livelihood restoration programmes and consultation of affected people to encourage a participatory relocation process with special reference to identify vulnerable groups such as the disabled and children.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

An investigation into root causes of sabotage and vandalism of pipes: A major environmental hazard in Niger Delta, Nigeria

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Abstract

Human activities are seen as the root causes of almost all environmental hazards due to the different actions currently affecting the ozone layer, unusual environmental changes and extreme weather conditions in recent times. Activities such as vandalism and sabotage have contributed significantly to the environmental issues within the Nigerian, Niger Delta context due to the presence of oil and gas activities, perceived marginalisation and neglect on the community aspect and the quest for sustainable livelihood support. This study explores the influencing causes associated with sabotage and vandalism through a desk-based research and primary data collection across communities and related oil spill agencies including oil and gas key personnel. Accordingly, the study has uncovered different influencing factors ranging from institutional to community factors, thereby, establishing some strategic recommendations for the reduction of such acts of sabotage and vandalism.

Keywords:

Environment; Sabotage; Vandalism; Oil Pipelines; Impacts; Oil Spill Hazards; Niger Delta; Nigeria

1. Introduction

Nigeria was previously the fifth largest oil producing nation in the world, but, currently is the 13th largest due to different technological disasters that keep disrupting its production output coupled with the global decline of oil and gas prices since the third quarter of 2014 (CIA, 2018). The decline in the output of Nigerian petroleum product due to sabotage and vandalization activities has posed major challenges to the external balance and federal finances in recent time. These two constructs (vandalism/sabotage) of oil facilities are considered a major problem that significantly affects the sources of revenue in Nigeria. Statistically, the Nigerian government is considered to be losing nearly 300,000 barrels of oil per day as a result of oil pipeline vandalism (Umar & Othman, 2017). Hence, this loss runs into billions of dollars, while negatively affecting the socio-economic development of the region.

This paper attempts to outline the causes of oil pipeline sabotage/vandalism acts in the Niger Delta region of Nigeria. The paper discusses different misconceptions associated with vandalism and sabotage within the context of environmental degradation and oil and gas production activities. Such dimensions are; Oil Terrorism (OT), Oil Bunkering (OB), Oil Scooping/ Vandalization (OS), and Environmental Terrorism (ET). However, the paper starts with a conceptual clarification of the connotation of oil vandalism (OV) and Oil Sabotage (OS) in relation to environmental degradations. The aspect and construct in this paper is discussed with the view of highlighting the players of the deliberate act of sabotage and vandalism and to symbolize the root influencing factors and causes of the act, while, ignoring the positive benefit of the outcomes on the community's livelihood structure.

2. Methods

This study adopts a desk-based approach, key community interviews and representatives of environmental expertise from the oil and gas sectors and representatives from an oil spill-related agency to answer the question; What are the root causes, influencing factors of sabotage, vandalism and oil theft in the Niger Delta, Nigeria? As it is established, a majority of environmental damages in South-South Nigeria are as a

result of third-party activities (i.e., approximately 60% of oil spills are resulting from third party-interference) (Shell, 2017). The key community members, the oil and gas and the oil spill-related agency representatives, were purposively selected for the interview discussions. The participants include; environmental expertise, engineers, community welfare officers, environmental activists, scientists, and community elders who possess relevant experience for the research question under investigation and deem appropriate. The next section presents the literature synthesis.

3. Literature Synthesis

3.1 Conceptual Clarification of Vandalism and Sabotage

The concept of oil pipeline vandalism and oil sabotage are vital to discourse in this piece of work and as such to highlight details of their meaning for proper understanding. First, oil pipelines are the medium through which crude oil, natural gas, and industrial chemicals are transported (Chibuzor, Chukwujekwu, & Ekene, 2014). Oil pipelines are vital and sensible facilities that could cause unconceivable catastrophes during operation, transportation of petroleum product or maintenance without a deliberate act of vandals or saboteur. The concept of vandalism according to Chibuzor et al. (2014), is an illegal or unauthorised activity carried out jointly with different entities in the destruction of gas, petroleum, and chemical pipelines. Umar and Othman (2017) describe vandalism as a thoughtful antagonistic behaviour of unsatisfied and corrupt individuals aimed directly to an environmental object with a destructive motive of damaging properties and causing harm. Also, Christensen, Johnson, and Brookes (1992) describe oil vandalism as a "productive force that fought against the exploration of a capacity system" across the world. Even though different people or nations may have a contrary opinion to the concept of vandalism and what 'acts' constitute vandalism, the concept could be applied to different scenarios such as; play vandalism, for example, breaking of window panels, cars, and other people's facilities, tactical vandalism which includes, sabotage at the workplace or organisational facilities (Umar & Othman, 2017), vandalism as a source of revenge, where individuals feel cheated (vindictive behaviour) and vandalism out of frustration, anger and exasperation (malicious vandalism) (Umar

& Othman, 2017). Also, Aishatu, Chukwudi, and Hauwa'u (2016) describes vandalism from the civil realm as the wilful destruction of public or government property in keeping with criminal or political intent. While vandalism in the oil and gas industries implies the breaking of oil pipelines with the aim to scoop petroleum product for personal and or group use.

However, vandalism in most developing countries is aimed to sabotage the government and or oil and gas operating companies (Aishatu et al. 2016), when felt neglected as the case may be. The concept of sabotage of product, workplace sabotage, government and or company's facilities sabotage are increasingly emphasised due to the consequences that come after the act. Thus, sabotage is a behaviour envisioned to "damage, disrupt, or subvert the organisations' operations from the personal purpose of the saboteur (sabotage) by creating unfavourable publicity, embarrassment, delays in production, damage to property, destruction of working relationship, or the harming of employees or customers" (Ambrose, Seabright, & Schminke, 2002). In a developing country such as Nigeria, oil (pipeline) or sabotage is prohibited under the law of the Petroleum Production and Distribution Act (Act 355 of 1990) section 1. However, the Act stipulates and describe a saboteur as "any person who does; aids another person; or incites, counsels or procures any other person, to do anything with intent to obstruct or prevent the production or distributions of petroleum products in any part of Nigeria. Or, any person who wilfully does anything with intent to obstruct or prevent the procurement of petroleum product for the distribution in any part of Nigeria or, wilfully does anything in respect of any vehicle or any public highway with the intent to obstruct or prevent the use of that vehicle or that public highway for the distribution of petroleum products" the person found to be guilty of sabotage will be convicted to be sentenced either to death or 21 years' imprisonment (Onuoha, 2008).

This unauthorised act of destruction of pipelines to disrupt the supply of petroleum product for self-purpose and or specific group intent for black-market sales in any dimension are prohibited under the Nigerian law. Hence, any person or company involved in such activities is considered to be guilty of economic sabotage (Onuoha, 2008). The

question is, has the existing laws worked positively on the intended aim? Notwithstanding, the incidents of oil pollutions related to sabotage increases on a daily basis in spite of the existing laws and agencies responsible for monitoring and checking the environmental performance of operating organizations in Nigeria (Shell, 2017).Thus, this amplifies why scholars and writers have frequently stressed on its global negative impact (nations reputation), socio-economic impacts and effects on the environment (Albert, Amaratunga & Haigh, 2018; Elum, Mopipi, & Henri-Ukoha, 2016; Ndimele et al., 2018). However, the environment remains a tangible and an aggregate of all external dimensions that affects both living and non-living things and therefore, draws attention to any adverse effects (Olujobi, Oyewunmi, & Oyewunmi, 2018). The effects of sabotage and vandalism activities affects but not limited to the soil; which is used for daily agricultural purposes in a country such as Nigeria, the air, water as significant sources of living for both animals, plants, fish production, human existence (Mogaji, Sotolu, Wilfred-Ekprikpo, & Green, 2018; Ndeh, Okafor, Akpan, & Olutoye, 2017; Olujobi et al., 2018), and other subsystems associated with the entire global system and our eco-system. According to Chibuzor et al. (2014), 40% of the world's oil flows through pipelines which run thousands and or millions of kilometres across unstable areas of the globe. Hence, that influence the access to facilities and trait of damages (Aishatu et al., 2016). Vandalism and sabotage cases have tremendously and continuously impacted the Nigerian environment and other subsystems through the local refining process (oil bunkering) and its related waves.

3.2 Oil Bunkering and Illegal oil bunkering

The term 'bunker' is derived from a Scottish word, which means a 'reserved seat' and is widely used in a different sector to describe an area that safeguards or stores products which could be ammunition, fuel, diesel or lube oil. Thus, in the context of this paper, which focuses on the oil and gas petroleum product and the environmental effluence, linking to shipping companies or oil and gas industries, a fuel bunker is described as a means of storing fuel products on a ship and used for machinery operation, while the process of dealing with bunker fuel is known as bunkering, for example, the process of fuelling the ship with fuel or lube oil product. Thus, bunkering can be described as the

legitimate process whereby a duly licensed operator provides fuel, water and lubricants for marine services or request (Mogaji et al., 2018; Onuzuruike, 2008). Hence, making oil bunkering grip a constructive meaning in an over-all logic, even though, there is a misconception of the word used to describe oil theft, especially, in Nigeria. According to Vreÿ (2012), oil bunkering is misinterpreted within the Nigerian context due to political, economic and social controversies embedded in criminal practices. Notably, the practice of oil bunkering which is the process of transporting the filled ship with fuel/oil from one shore to another is categorically different from the process of vandalising equipment for the bunkering activities. Thus, oil bunkering becomes illegal when unlicensed individuals, groups or organisation scoop/ vandalise the petroleum product in diesel forms, fuel, etc. for its personal gains.

Accordingly, Onuoha (2008) within the Nigerian context divulged that 'bunkering' is an ironic word used to describe oil theft. However, oil bunkering and oil theft is ingeniously the most lucrative private business in the Nigerian petroleum industries in recent times, even though, the activities previously started in the early 1980s (Igbinovia, 2014). Illegal oil bunkering, which is the act of drilling oil pipelines to scoop petroleum product for personal gain is a perpetrated act largely engaged by unlawful groups who are driven by the desire to loot oil product indirectly aiming to sabotage the oil and gas industries or the government (Aishatu et al., 2016). Notably, illegal oil bunkering activity is proven to account for several losses of revenue for both the oil and gas industries and the government since its boom in early 2000 (Igbinovia, 2014; Onuoha, 2008; Shell, 2017).

Nevertheless, Vreÿ (2012); Adishi and Hunga (2017), describes bunker activities in three major levels; small-scale operations that flourish at the local community levels, where the petroleum product is condensate for domestic use and further tapped off for distributions at local usable form. The second practice is where the crude oil product is destined for commercial delivery to barges and ocean traveling tankers for further foreign distribution and destinations (Boris, 2015), while, the third practice is where operating and or delivery companies exceed their legitimate allocations (Adishi & Hunga, 2017). Onuoha (2008) and Vreÿ (2012), stipulate that well-organised operations of oil bunkers

perpetrated by organisations are irreparable. In arguing about illegal oil bunkering activities, Adishi and Hunga (2017) stipulates: "there is a large scale of illegal international trading on crude oil, which is more sophisticated with the use of advanced technologies to tap crude oil and to navigate through the maze of hundreds of creeks, rivers, and streams. This practice has also graduated from ordinary boats and barges to ships and tanker in the high seas which has become extensive and on a large scale since the late 1990s". Vreÿ (2012) in response to Onuoha (2008) and Adishi and Hunga (2017) connotation highlights that the corruption surrounding oil bunkering activities stretches deeply into the local society, government fabric, and the oil and gas industry and thereby threatens security actions of the citizens. Thus, these illegal activities are now on an industrial scale and involve international traders and or, which could be termed criminals, commodity traders and a different network of people within and outside the shoes and boundaries of Nigeria (Adishi & Hunga, 2017; Olateju, 2013).

Chibuzor et al. (2014) calls for radical action to be taken by a none corrupt governmental regulatory agencies and international oil companies (IOC's) to provide a preventive mechanism for the reoccurrences of the act due to frequent occurrences, given that, in 1999 alone, there were a total of 497 vandalism cases for oil bunkering purposes (Okoli & Orinya, 2013). Further, between 2010 and 2012, a total of about 2,787 pipeline breaks were reported by the Nigerian National Petroleum Commission (NNPC). Thus, these incidents resulted in a loss of approximately 12.53 billion Naira for the nation. Likewise, in 2008 an estimated loss of about 250,000 barrels of oil was lost per day due to 'theft' activities, a loss amounting to $22.5 million US Dollars (Vreÿ, 2012). Also, between 2009 and 2011, the Nigerian Extractive Industry Transparency Initiative (NEITI) reported a loss of 10.9 billion US Dollars to oil theft (Aishatu et al., 2016). Also, Vreÿ (2012) stipulates that in 2012 there were drops in vandalism and sabotage/thief activities with the estimated loss of 3 million barrels per month compared to preceding years. The reduction, however was perceived and credited to a particular government security task force deployed against illegal oil bunkering activities (Vreÿ, 2012), even though it lasted for a short period. Likewise, Aishatu et al. (2016); Adishi and Hunga (2017) stipulates that the activities of oil pipeline vandals for

international and or local refining (oil bunkering) resulted in a massive cost of over 174.57 billion Naira in the product losses and repairs of pipelines within ten years, as it increasingly became popular and practiced within Nigeria. Thus, within ten years, a total of 16, 083 pipelines breaks were recorded, adding that while 398 pipelines break representing 2.4 percent were due to rupture, 15,685 breaks which interpreted to about 97.5 % were the activities of unpatriotic vandals (Okoli & Orinya, 2013). However, the growth of this hazardous business and the scramble for access to oil and gas related benefits are considered to underpin an environment conducive to the proliferation of an illegal conflict economy and one that operates extensively in the part of the country (Vreÿ, 2012). Also, activities have fuelled long-insurgency and have increased armed conflict groups providing militant groups with funds for its operations.

According to Igbinovia (2014), the activities of Nigerian illegal oil bunkering has increased the instability in the world energy markets and also position threat not only on the Nigerian States but to international and oil-bearing communities. Thus, the losses in both production output and financial loss have not been without death incidents of the actors in the process, environmental consequences, and human consequences (Aishatu, Chukwudi, & Hauwa'u; Okoli & Orinya, 2013). Thus, the section below discusses how oil terrorism and environmental terrorism further contributes to environmental devastations.

3.3 Oil terrorism and environmental terrorism

Terrorism is an "unlawful use of force or violence against property or persons to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives"(Chalecki, 2002). Hence, the word describes such persons who indulge in such activity a "terrorist." The word terrorism began to have publicity in the 20th century, making terrorist groups wishing to avoid bad publicity who began calling themselves "freedom fighters" and "militias "or "militants." The reform of the word and the concept have been perceived to exist even in the governance system where a government employed terrorist tactics against opponents by calling it "police action" (Chalecki, 2002). According to Section 2656 of Title 22

of the United State code, terrorism means premeditated, politically motivated violence perpetrated against non-combatant targets by subnational groups or clandestine agents, usually intended to influence an audience" these definitions emphasised the connotation of the motive, means and the target imbibe terrorist believe. Undoubtedly, terrorism activities are extensively carried out across the globe either against the government for economic reasons, against cooperation's, natural resources facilities terrorisation or oil terrorism and environmental terrorism in both developed and developing countries.

In a developing country such as Nigeria, different types of terrorism exist which is out of the scope of this paper, as such, not discussed here. The relevant types of terrorism to this paper include environmental terrorism and facility or oil terrorisms. The concept of environmental terrorism and oil or facilities terrorisms are described in a different context depending on the field, motive of discussions and the relevance. However, the two constructs are vital when the environmental and deliberate act of petroleum product destructions are involved. Oil terrorism and environmental terrorism are two terminologies introduced by security analysts, journalists and scholars to describe the deliberate act of pipeline system attacks in Iraq and Nigeria (Onuoha, 2008). This paper describes environmental terrorism as the "unlawful use of force against environmental or natural resources" to deprive public benefit (Chalecki, 2002). While, oil terrorism involves such acts of blowing up oil facilities such as; installations, pipelines and oil platforms with damaging explosive devices, and the act of capturing oil barges, flow stations, support vessels and oil wells to prevent distributions of petroleum product or refining of the product (Onuoha, 2008).

Notwithstanding, the act of oil terrorism and environmental terrorism in the Nigerian context became apparent in early 2005 when the Movement of the Emancipation of the Niger Delta (MEND) blew up a pipeline in Delta state after the arrest of the then leader of the group Alhaji Asari Dokubo (Onuoha, 2008). Since then, oil terrorism and environmental terrorism has increased and influenced environmental damages. The call for the Nigerian Nations natural resources (oil wealth) sharing formula has increased with the view to have a greater share for the Niger Delta communities. Also, Onuoha (2008) stipulates

that the activities of freedom fighters or militants are with the aim to call for preceding environmental, social, political and economic justices.

Hence, the approach has substantially and further damaged the environment (Aishatu et al., 2016), and the socio-political and economic activities of the local communities (Adishi & Hunga, 2017), even though, there are more significant losses on the national revenue. Thus, examples of some blew up by the freedom fighters that have in decades damaged the environment are; the 2005 January blow up of the Forcades export terminal which cut the supply of the petroleum product of about 100,000 barrels per day. The March 2005 oil pipeline blow up operated by the Italian company reducing the flow by 65, 000 barrels per day, the 2006 militant struck at an oil vessel at Cawthorowe Channel, killing five soldiers who were escorting the vessel, and later sank the vessels.

Thereafter, the 2007 dreaded attack of three oil pipelines by MEND at the territory of Akassa and Twon-Brass (Onuoha, 2008), where some significant attacks recorded. Even though, the people continuously quest for employment into the oil and gas business to reduce the desperate and frustrated act of destructions. Furthermore, unemployment amongst youth has also created a massive population of idle, frustrated and desperate young people who are easily manipulated to criminal activities.

4. Result and Discussions

The incidents of vandals, sabotage, and oil theft have fundamentally damaged the environment, local economy and the socio-cultural dimension of the people across Nigerian communities. Hence, the question was to identify the major and or the root and influencing causes of the high increase of such acts of sabotage, oil theft, and vandalism. Thus, upon the transcription of the interviews conducted amongst the community members and key environmental expertise, empirical evidence shows that abject poverty and lack of employment; shallow laying of pipeline and insecurity; sense of marginalisation and neglect; corruption and bad governance are some infusing and influencing factors across communities. Thus, the below section

presents the preliminary results with quoted statements from the interviewees.

4.1 Corruption, weak and bad governance

The corrupt practice in the oil gas distribution sectors, the government sectors, and the security agencies are alarming, making it difficult to curtail the act of oil sabotage and the destruction of oil facilities. This theme, when discussed with the oil spill-related agency, reinforced that, *"though there is corruption in the oil and gas sector as it is elsewhere, weak institutional structures are factors to the corrupt practice. Corruption is everywhere depending on how its defined, presented and managed (oil spill agency participants)".* Accordingly, a majority of the respondents opined that the foundation of the government is wrong due to different impunity (culture of criminal impunity) as such will influence every other sector. On the other hand, communities responding to corrupt practices and bad governance described the act as *"Governance terrorism".* Reasons were that the Nigerian government in both past and present administrations had done things specifically for their interest, hence not contributing positively to oil and gas producing communities. Also, some respondents stated that, *"most corrupt security agents are hugely involved in the sabotage, vandalism, and oil theft business and as such making things further difficult for curtailment (communities respondents)."* Categorically, a majority of the community participants reinforced that sabotage/vandalism will progressively increase, considering that communities are relatively into local oil bunkering within the local capacities. This view is contrary to Vreÿ (2012) study which established that the Nigerian security operates either independently or working along private contractors in conjunction with different arrangements between the oil multinationals and the private security contractors to combat illegal activities. Arguably, Adishi and Hunga (2017) stipulate that there has been alleged involvement of the security force in illegal businesses thereby making difficult in curtailing of activities. This finding is in line with Umar and Othman (2017); Albert, Amaratunga, and Haigh's (2018) study, which found that legal factors influence vandalism, that the weak institutions and inadequate compensation to victims of oil spills can encourage crime, vandalism, oil theft or sabotage. This finding also supports Umar and Othman (2017) in their confirmatory study of

relationships between different constructs and vandalism, which they found that poor governances have a significant contribution to crude oil pipeline vandalism in the Niger Delta, Nigeria.

4.2 Abject poverty and unemployment

The poverty and unemployment rate within and amongst Nigerian youth is alarming. Thus, when discussing the issues of vandalism and oil sabotage relating to environmental degradation. Majority of the participants attributed the causes to poverty and unemployment, given that some actors of such acts are commited by unemployed youth. Accordinly, participants pointed that the poverty level of these communities are damaging and the fact that some of the community households find it difficult to afford one square meal per day is "worth " doing anything for survivals. Accordingly, participants stressed, *"Now, the issues of oil bunkering exists, most communities were never into such business but when you discovered that, that is an alternative livelihood support, you tend to engage to survive (Community Respondents)."*

The researcher in the process of making meaning from the data rigorously selected graduate respondents and cross-checked their response to the unemployment issues. It was evident that almost all the graduate participants are into oil bunkering businesses, affirming that there were no employment opportunities, as such, oil bunkering becomes an alternative. According to a majority of the participants, *"employment comes with whom you know and not because your community produces petroleum product, employment in this part of the world is not by merit, capabilities, and potentials but most likely godfatherism (Community Respondents)."* On the contrary, majority of the experts from the oil and gas participants disagree with the concept that "poverty and unemployment" were the root causes of sabotage and vandalism. Thus, implying that most vandals/ actors are wealthy and educated persons and that the acts are deliberately carried out to sabotage oil multinationals and the government, and not necessarily acts of poverty. The oil and gas participants added, *"Communities are never satisfied with any provision offered by the oil multinationals and as such, will want to blame the oil operating companies and the government by indulging in the act of vandalism (oil and gas respondents)."*

4.3 Shallow laying of pipeline and insecurity

The oil-related agency opines that most of the pipelines are above the ground and as such attracts criminal motive even though the vandals from the communities carry out the activities in conjunction with other higher officials and international bodies. The community members have conceived some sense of neglect and marginalisation and as such will use every opportunity to destroy the government and or multinationals facilities, even though, some basic necessities are occasionally provided. Contrarily, a majority of the participants from the oil and gas opposes the view of shallow pipeline structures, while, maintaining that communities act of sabotage and vandalism are a deliberate act. Accordingly, the oil and gas sectors respondents opine that pipelines be buried below, above or beneath the water and as such should not create an avenue for any vandals. While, on the contrary, a majority of the community participants maintained that oil bunkering will ever increase given that it contributes to livelihood support for the communities. The participants believe that shallow laying of a pipeline is not an influencing factor for sabotage while community respondents and agency respondents revealed that shallow laying of some pipes across and within communities without maximum security influences vandalism/sabotage. However, the community perspective supports the literature of (Akinleye, 2018), who revealed that most communities have felt marginalised and neglected for decades and as such, oil bunkering becomes a 'share' for the communities irrespective of any form of a treatment to health and environment.

4.4 Sense of Marginalisation and Neglect

Marginalisation and neglect issues in South-South Nigeria are bitterly and glamorously pronounced and emphasised. The bitterness and the glamour of neglect and marginalisation are with the fact that 90% of the revenue derived from the region and yet have received little or nothing in comparison to the living standard, other than environmental damages and pollution of different kinds from the exploration and production of the petroleum product. The participants opined that the two constructs (marginalisation and neglect) are a deliberate act from the Nigerian government and oil and gas multinationals. Emphasising on neglect, a majority of the participants reinforced that, *" the act of*

vandalism, oil theft or bunkering will never stop until the Nigerian Government takes appropriate steps to compensate the natives or communities across the region (Community respondents).” The incidents will continue as far as the natives of the region still feel marginalised and neglected, as added by participants. Likewise, when the communities or natives of the region feel some sense of belonging through the action of the Nigerian government or the oil cooperation, then oil sabotage, oil terrorism, and vandalism will stop, otherwise not in recent time. This result conforms Umar and Othman (2017); Adishi and Hunga (2017); Boris (2015) where they mention that denial, and exclusion from societal and or natural resources utilisation by primary owners may influence the formulation of groups among aggrieved persons and as such increase the frequency of stress and emotional outburst. Also, increasing the activities of oil bunkering and theft. The table below summarises other influencing factors of sobatage/vandalism.

Table 1. Other Influencing factors of sabotage, vandalism

Community Factors	Institutional / Legal Factors
Widespread poverty, Ignorance/ illiteracy, Poor Protection of oil pipelines, inordinate ambition for wealth	Political sabotage (Niger Delta Militancy), Poor policing oil pipelines, Scarcity/ high cost of petroleum product within communities, corruption, and sabotage in the oil and gas sector
Culture of criminal impunity, corruption and greed, unemployment, neglect of the region by the government and the oil and gas, frustration,	Poor/ bad governance, incompetency, Weak institutional structures, Ineffective law enforcement, marginalization, Neglect,
A Sense of neglect and marginalization	Oil derivation sharing principle, Shallow laying of pipelines
A Quest for resources control, community industry mismatch, political deprivation	Evolving culture of impunity

Sources: Primary Data

5. Conclusion and recommendations

Based on the findings of the study, the researcher concludes that corruption, weak and bad governance are major causes influencing sabotage, vandalism and oil theft, from an institutional perspectives. While, abject poverty and unemployment, neglect and some sense of marginalisation are factors influencing the act of sabotage, vandalism and oil bunkering and oil theft. Even though, majority of the community

participants justified the act by implying that its an alternative means for livelihood support due to the damages to original livelihood structures, the study concludes that easy access to pipelines is a major factor influencing sabotage, vandalism and oil theft. As such, this needs more of the community involvement in the security aspects for pipelines, given that most pipes are layed crisscrossed between and within community topography. The study recommends the following critical strategies to reduce the act of sabotage, vandalism, oil bunkering, and oil theft. Such recommendations are; To provide profound security initiatives which include 24 hour monitoring devices entrusted in community security agents in collaboration with the oil and gas and oil spill-related agencies concerned. Establish a profound inclusion mechanism for oil producing communities in security plans. A good governance and fair distribution of oil wealth and political prioritisation across communities of the region in such a way that includes the natives of oil-bearing communities. Likewise, a good philosophy where a worthy and appropriate infrastructural development are put in place to enhance societal needs, irrespective of the present situations.

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Assessment of community resilience to disasters: A case study at Chotto Bighai Union in Patuakhali District, Bangladesh

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Abstract

Chotto Bighai Union of Patuakhali District is one of the most disaster-prone areas in coastal Bangladesh. The study is conducted to assess major climatic hazards at Chotto Bighai. This study focuses on the assessment of community resilience to disasters. A number of hazards including cyclones, river bank erosion, tidal floods, thunderstorms, heavy rainfall, waterlogging and salinity intrusion were predominant in the study area. The study is designed mainly considering responses and perceptions of respondents. Both primary (Sixty Household Questionnaire Survey, Four Focus Group Discussions, Ten Key Informants Interviews) and secondary data was collected for the research, correlated and interpreted. Interaction between hazards, physical, environmental, social and economic vulnerability is discussed. It reveals that cyclones, river erosion, tidal floods and thunderstorms are major natural hazards in the locality and the risk of cyclone (2.91) is prioritized compared to others existing risks related to the hazards experienced in this area. The community has achieved maximum

resilience in heavy rainfall (0.56). Resilience status of this community for waterlogging is (0.76), tidal flood (0.88) and salinity intrusion (0.83) which means that the community has below-average exposure, below-average damage, and average or slightly above-average recovery. The community is susceptible to cyclones (0.97), river bank erosion (0.96) and thunderstorms (1.04). They have achieved minimum levels of resilience in thunderstorms because there is no risk reduction practices available. People have achieved minimum resilience to cyclones due to its high frequency and intensity. The community has managed to reduce risks through indigenous practices and by social bonding. However, to reduce vulnerability and enhance resilience to disasters, proper action should be taken and strengthened in the near future.

Keywords:

Assessment; Capacity Enhancement; Hazard Frequency; Vulnerability; Resiliency

1. Introduction

Bangladesh has been identified as one of the most vulnerable countries due to its exposure to frequent and extreme climatic events such as cyclones, associated storm surges and other disasters (Field, Barros, Stocker, & Dahe, 2012). Frequent cyclones (i.e., Sidr in November 15, 2007; Aila in May 25, 2009; Mohasen in May16, 2013; Komen in July 31, 2015) gave an early indication of increasing natural calamities and supports the latest observation of the Intergovernmental Panel on Climate Change (IPCC) that frequency of climate change induced extreme disaster will increase in the future (Mirza Ali Ashraf, 2016). Disaster Resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses - such as earthquakes, drought or violent conflict - without compromising long-term prospects (Department for International Development, 2011). Bangladesh is the world's 6th most disaster-prone country (Ahmed, Kelman, Fehr, & Saha, 2016). Chotto Bighai Union in Patuakhali Upazila experiences several hazards such as floods, cyclones, storm surges, heavy rainfall, salinity, river bank erosion, thunderstorms etc. every

year. Structural, non-structural measures and social safety net programs for disaster preparedness play an important role in creating a resilient community (Mirza Ali Ashraf, 2016). Proper training and participation of women can increase family's economic resilience, food security and nutrition in the long term (Lipper, et al., 2014). Chars Livelihoods Program improves disaster resilience of households through a variety of its livelihood's activities (Barrett, Hannan, Alam, & Pritchard, 2014). Mainstreaming disaster risk reduction among the community for building resilience is a sustainable pathway for Bangladesh (Ha & Ahmad, 2015). Ultra-poor households and poor economic conditions impact physical resilience of the community and breaks the cycle of reliance on negative coping strategies for the reoccurrence of shocks (Ahmed, Kelman, Fehr, & Saha, 2016). Chotto Bighai Union in Patuakhali Upazila is a coastal area and is highly vulnerable to different natural hazards. Hazards cause a huge disruption in human life, damage to settlement and infrastructure; creates economic losses, human displacement and change in the patterns of livelihood in this area due to rapid climate change. As a result, lives and livelihood, economy, households, infrastructure and human health is threatened by such natural phenomenon at Chotto Bighai. This study is designed to identify frequently occurring disasters, community vulnerabilities to disasters, vulnerable sectors and community resilience to disasters by analyzing hazard frequency, vulnerability, capacity, risk and resilience.

2. The objective of the study

i. To assess present hazards and frequently occurring disasters of the study area.
ii. To categorize vulnerabilities to disasters.
iii. To assess community resilience to disasters.

3. Methods

3.1 Study Area

Chotto Bighai Union (Patuakhali Upazila) is located between 22°17´and 22°20´ North latitudes and between 90°12´ and 90°16´ East longitudes. It is bounded by Payra River on the North and Northwest, Baro Bighai

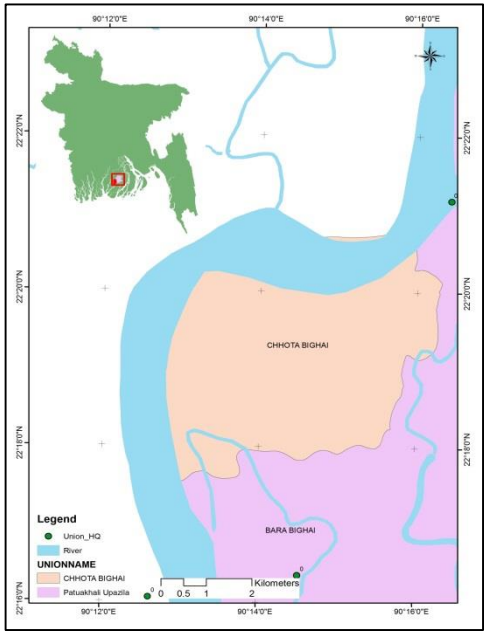

Figure 1. *Study area map, (Source: LGED, 2017)*

khal on the South, Guabari River on the East and Patuakhali pourashova on the West (Bangladesh Bureau of Statics, 2011). Under Chotto Bighai Union Chotto Bighai, Fultola and Mati Vanga villages were selected for the current research.

3.2 Data Collection

Both primary and secondary data were collected, analyzed and triangulated to fulfill the objectives, 60 household questionnaire surveys were conducted to collect community perceptions using semi-structured questionnaires, 04 focus group discussions (FGD) and 10 key informant interviews (KII) were conducted for triangulation and correlation of the collected data.

4. Results and Discussion

4.1 Assessing Community Resilience to Natural Hazards

The framework defines resilience as "the ability to prepare and plan for, absorb and recover from and more successfully adapt to adverse events". The three dimensions of the framework are the exposure of a community to hazards (such as cyclone frequency), the damage a community suffers from the exposure (such as property damage), a more successfully adaptation to adverse events and the recovery after disasters (such as population return). Vulnerability and resilience capacity are two latent relationships between the three dimensions and are indicated by both vulnerability and capacity. Vulnerability refers to the latent relationship between exposure and damage, whereas capacity indicates the latent relationship between damage and recovery. If a community has high exposure to a hazard but sustains low damage, then the community is considered to have low vulnerability. Similarly, if a community sustains high damage but has a favorable recovery, then the community should be considered to have high

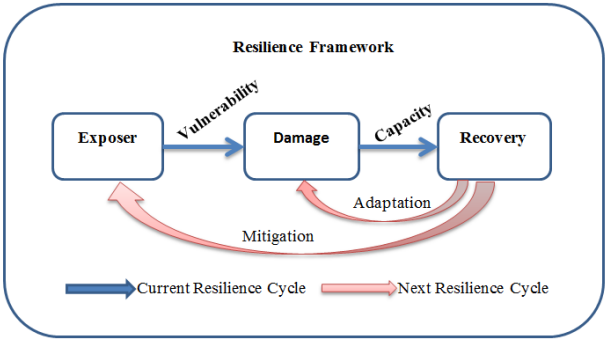

Figure 2. Resilience Framework (Source: Heng Cai, 2016)

capacity (Cai, Lam, Zou, Qiang, & Li, 2016). This phenomenon is illustrated in Figure 2.

A high vulnerability/capacity ratio reveals low resilience, whereas a low ratio reflects high resilience. This model borrows the concept from resilience literature and classifies resilience into four states; from low to high resilience they are called susceptible, recovering, resistant, and

usurper. Adaptation refers to the measures applied to lessen impacts that result from disastrous events so that the community can recover, such as raising the housing structures above the flooding level to avoid serious damages from the next disaster (Cai, Lam, Zou, Qiang, & Li, 2016). Social, economic, physical, and environmental issues were considered as community resilience indicators after Susan L.Cutter, 2008 (Cutter, et al., 2008).

4.2 Community Exposer to Hazard

Due to the geographic location and high intensity of frequently occurring hazards, the Chotto Bighai community is highly exposed to natural hazards. 58.33% of respondents live inside the embankment, 26.66% live outside and 15% live above the embankment of the area. Most of the respondents are vulnerable to different natural hazard such

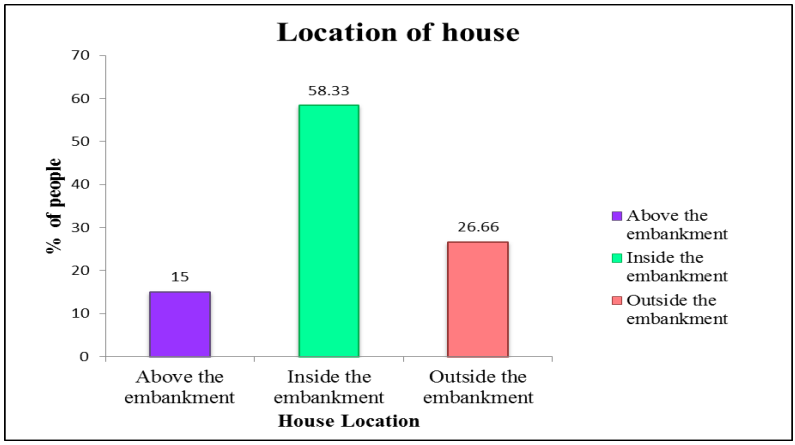

Figure 3. *Location of the house of the respondent (Source: Field Survey Data, 2017)*

as flooding, cyclones, salinity, river bank erosion, heavy rainfall, water logging etc.

4.3 Natural Hazards of the Study Area

The people of the area are affected by different natural hazards of different intensity, frequency and damages. The most common natural phenomenon of the area are cyclones, river bank erosion, floods,

salinity intrusion, heavy rainfall, water logging and thunderstorms. Each hazard type was therefore initially calculated on the basis of combined frequency and intensity. The hazard priority index is based on disaster management experts, professionals and community opinions (Table 1). Cyclone frequency and intensity is high and hazard value is 3. However, the last priority was Thunderstorm and hazard value is 1.48.

Table 1. Hazard priority index after Heng Cai, 2016 (Source: Based on survey data, 2017)

Hazard Types	Hazard Priority Index							
	No (0)	Low (1)	Medium (2)	High (3)	Very High (4)	Respondent Frequency	Priority Index	Ranking
Heavy Rainfall	7	13	24	9	7	60	1.93	IV
River Erosion	4	8	19	17	12	60	2.41	II
Cyclone	0	8	10	16	26	60	**3**	**I**
Water Logging	10	23	15	8	4	60	1.55	VI
Tidal Flood	0	17	21	13	9	60	2.23	III
Salinity Intrusion	13	18	14	9	6	60	1.67	V
Thunderstorm	18	11	19	8	4	60	**1.48**	**VII**

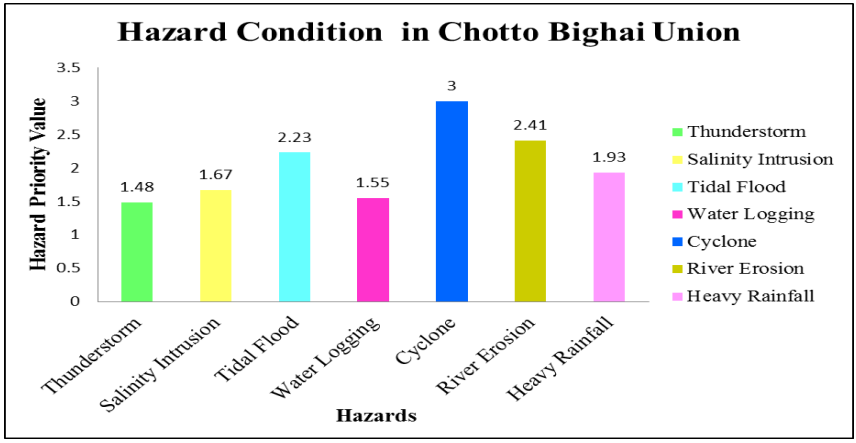

Figure 4. *Natural hazards of Chotto Bighai Union (Based on Survey Data, 2017)*

4.4 Community Vulnerability Assessment

The aforementioned frequent natural hazards affect different sectors; primarily agriculture in addition to livelihood, education, public health, infrastructure and transportation. These cause a huge disruption in human life, damage to settlement and infrastructure, create economic problems, human displacement and change in the pattern of livelihood in Chotto Bighai. About 70% of respondents opined that great damage occurs to agriculture during any disaster. Cyclone vulnerability is greater than other disasters here. The area suffers mostly due to cyclones and its coastal characteristics. The sector-based vulnerabilities with priority indexes are shown in table 2.

Table 2. Vulnerable sectors by hazards with their priority index after Heng Cai, 2016 (Source: Based on survey data, 2017)

Sectors	Sector affected by frequent hazards							
	No (0)	Low (1)	Medium (2)	High (3)	Very High (4)	Total Frequency	Priority Index	Ranking
Agriculture	0	6	11	22	21	60	2.96	I
Livelihood	8	13	16	15	8	60	2.03	II
Education	9	14	23	11	3	60	1.75	V
Public health	6	16	19	14	5	60	1.93	III
Infrastructure	7	21	16	11	5	60	1.76	IV
Transportation	11	18	14	11	6	60	1.71	VI

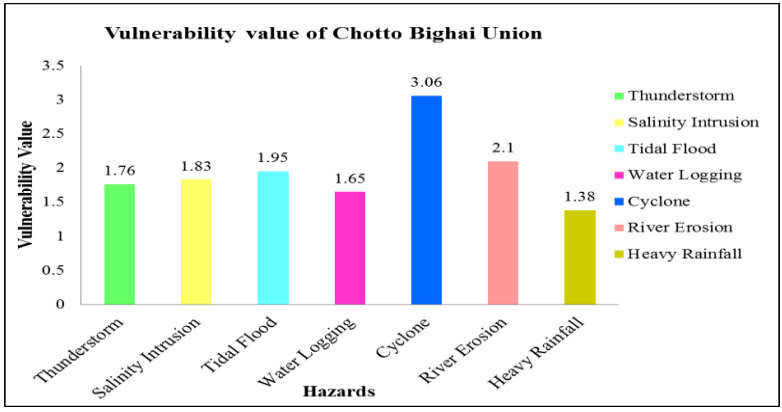

Figure 5. *Vulnerability value index by natural hazards (Based on Survey Data, 2017)*

4.5 Communities Capacity Assessment

Capacity means the combination of all strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals. Community capacity may include the domains of stakeholder participation, problem assessment capacities, developing local leadership, empowering organizational structure, resource mobilization, establishing links with other organizations or people and enhancing stakeholder ability. It is not just one way to perform individual responsibility to community but vice versa also (Ziaul, 2014). In the findings, Cyclones have a greater capacity compared to other natural hazards. The overall capacity index to natural hazards are shown in table 3.

Table 3. Capacity index to hazards after Heng Cai, 2016 (Source: Based on survey data, 2017)

Hazards	**Capacity Index**							
	No Capacity	Environmental	Economic	Physical	Social	Total Frequency	Priority Index	Ranking
	(0)	Low (1)	Medium (2)	High (3)	Very High (4)			
Heavy Rainfall	6	9	12	17	16	60	2.46	II
River Erosion	9	12	11	15	13	60	2.18	IV
Cyclone	0	5	9	18	28	60	**3.15**	**I**
Water Logging	9	12	12	14	13	60	2.16	V
Tidal Flood	10	12	9	14	15	60	2.2	III
Salinity Intrusion	7	16	10	13	14	60	2.18	IV
Thunderstorm	17	13	11	10	9	60	1.68	VI

4.6 Community Risk Assessment

Risks can be defined as the probability of negative consequences that may arise when hazards interact with vulnerabilities. Community Risk Assessment is a method to identify community risks in different sectors by analyzing hazard and vulnerabilities. Risk= (Hazard X Vulnerability)/Capacity. Calculations have been made by calculated data from hazard, vulnerability and capacity assessments. Chotto Bighai risk values to the different hazards are shown in table 4**.**

Table 4. Community risk index after Heng Cai, 2016 (Source: Based on survey data, 2017)

Hazard	Community Risk Index				
	Hazard Value (H)	Vulnerability Value (V)	Capacity Value (C)	Risk (R)=(H*V)/C	Ranking
HEAVY RAINFALL	1.93	1.38	2.46	1.08	VII
River Bank Erosion	2.41	2.1	2.18	2.32	II
Cyclone	3	3.06	3.15	**2.91**	**I**
Water Logging	1.55	1.65	2.16	1.18	VI
Tidal Flood	2.23	1.95	2.2	1.97	III
Salinity Intrusion	1.67	1.83	2.18	1.40	V
Thunderstorm	1.48	1.76	1.68	1.55	IV

4.7 Status of Hazard, Vulnerability, Capacity and Risk Value of Chotto Bighai

Community cyclone capacity is high. But values are also high in terms of hazard frequency, intensity and vulnerability. This can be identified as the reason why the community is still at a high risk of cyclones. The overall scenario of hazards, vulnerability, capacity and risk of the study area are shown in figure 6.

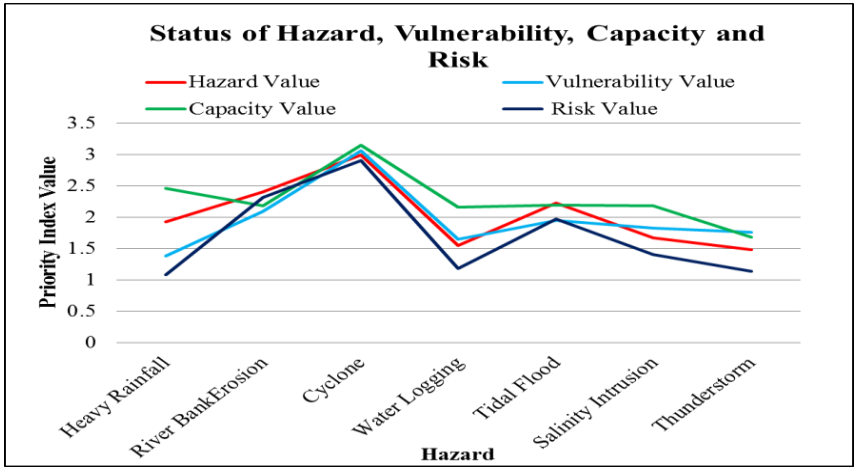

Figure 6. *Status of hazard, vulnerability, capacity and risk in Chotto Bighai Union (Source: Based on Survey Data, 2017)*

4.8 Community Resilience Scenario

According to the value of Vulnerability/Capacity ratio, the model depicted by figure 2 classifies resilience into four states; (from low to high resilience) namely susceptible, recovering, resistant, and usurper. In identifying the resilience status of the community to disasters (Table 5), the overall values of resilience were classified into four categories. 0.25-0.49 represents very high resilience to hazards or usurper community, 0.50-0.74 represents resistance of community to hazards, 0.75-0.99 represents recovering communities and 1 represents low level of resilience to hazards, which was not identified as an adaptive capacity to disasters. People of this area have achieved maximum resilience in heavy rainfall with a value of 0.56 and very low resilience is seen in terms of thunderstorms.

Table 5. Community resilience to hazards after Susan L. Cutter, 2008 (Source: Based on survey data, 2017)

Hazards	**Community Resilience Scenario to disasters**				
	Value of Vulnerability (V)	Value of Capacity (C)	Ratio of (V:C or V/C)	Value of Resilience (R)	Resilient Type
Heavy Rainfall	1.38	2.46	1.38/2.46	0.56	Resistant
River Bank Erosion	2.1	2.18	2.1/2.18	0.96	Susceptible
Cyclone	3.06	3.15	3.06/3.15	0.97	Susceptible
Water Logging	1.65	2.16	1.65/2.16	0.76	Recovering
Tidal Flood	1.95	2.2	1.95/2.2	0.88	Recovering
Salinity Intrusion	1.83	2.18	1.83/2.18	0.83	Recovering
Thunderstorm	1.76	1.68	1.76/1.68	1.04	Susceptible

5. Conclusion

Cyclones, river erosion, tidal floods and thunderstorms are the major natural hazards that occur and the risk of cyclones (2.91) was significant compared to others existing risks due to high frequency and intensity. The community shows maximum resilience to heavy rainfall (0.56). Resilience status of this community is recovering for waterlogging (0.76), tidal floods (0.88) and salinity intrusion (0.83) which means that the community has below-average exposure, below-average damage, and average or slightly above-average recovery. The community is susceptible to cyclones (0.97), river bank erosion (0.96) and thunderstorms (1.04). They have achieved a minimum level of

resilience in thunderstorms because people are not capable of predicting thunderstorms and because it has no risk reduction practices yet. Early warning systems and information dissemination for every hazard should be developed, proper adaptive techniques like increasing stable embankments, construction of levees, pre-disaster preparedness, emergency management and post recovery to respective disasters should be taken and government and non-governmental organizations should establish initiatives for awareness building, sheltering during disaster, capacity building and regular monitoring for enhancing community resiliency to disasters of Chotto Bighai Union.

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Creating an enabling environment in compliance with policies and practices for landslide risk management in Sri Lanka

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Abstract

Currently, mountainous areas prone to landslides are subjected to serious changes in land use and land management practices and hence high landslide risks are clearly evident within an area covering more than 10 administrative districts of Sri Lanka. Due to the impact of climate change, climate variability and consequent extreme weather conditions, current trends are likely to increase to a sizeable extent in the near future. The National Building Research Organization (NBRO), is the mandated agency for landslide risk management in Sri Lanka. NBRO has recently carried out a Training Needs and Gaps Assessment (TNGA) survey, in order to understand the capacity needs for promoting Research & Innovation (R&I) for the management of landslide risk and to identify gaps in technical competency, policy & practice, knowledge & skills. According to the survey, while there has been a notable progress in the development of general capacities to manage disaster risks within the country, gains have lagged in relation to specific technical areas. Some of the capacity gaps are connected with the general understanding of concepts. The consultative process undertaken through the survey has uncovered several key gaps in policy, legal, regulatory and the institutional set up for creating an

enabling environment for the application of engineering and nature-based solutions. Lack of measures to ensure compliance with policies and practices is also found to be a notable challenge. Results of the assessment would help NBRO in promoting R&I for landslide risk management by building capacities of stakeholders to undertake innovative approaches. NBRO is in the process of conducting training programmes in the future, which will essentially focus on theoretical and practical understanding on the subject, knowledge gaps, skills and technical competencies needed for R&I in undertaking and promoting landslide risk management interventions. Additionally, they will take measures to strengthen policy compliance in development practices in landslide prone areas.

Keywords:

Landslide Risk Management; Training Needs and Gap Assessment

1. Introduction

Landslides are increasingly frequent and turning into a major threat for infrastructure development in the hilly areas of Sri Lanka. Essentially mountainous areas are becoming more popular for living and leisure, agriculture, tourism etc. Hence, those lands are being converted rapidly in to urban and semi-urban settlements. The current urbanization trends, population growth and scarcity of suitable land for various developments in such areas force people to move in to vulnerable slopes, thus increasing the potential danger further. Currently the impact of landslides is clearly felt within a significant area in central highlands, covering more than 10 administrative districts of the country. Due to the impact of climate change, climate variability and consequent extreme weather conditions, the current trends in landslide events and subsequent impact are likely to grow to a sizeable extent in the near future. Hence, there is a need to have a systematic approach for landslide studies, conducting analysis, and determining the associated risk levels and identifying the most appropriate interventions to reduce the risk in a cost-effective manner. Without adequate capacity and mechanisms for R&I, it will be impossible for the country to achieve the targets set up under the Sendai Framework for landslide and other DRR endeavours. The common finding in this

regard, is the need to have a strategic approach to develop required capacities to meet targets and to initiate more collaborative and coordinated efforts.

When implementing efforts in promoting R&I for landslide risk management, it is necessary to understand the gaps and hindering factors in relation to general policy and practice and therefore, policy related factors should be considered in designing capacity building programs. The primary focus of this paper is to present the findings of the study in relation to the aspects of creating an enabling environment for R&I in landslide risk management in sustaining the associated capacity of building efforts, institutional development and improving coordination among stakeholders.

2. Objectives of the Training Needs and Gap Assessment (TNGA) Survey

As highlighted in the Capacity Assessment Practice Note of UNDP (2008), capacity is defined as 'the ability of individuals, institutions and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner. In the same way, capacity development is regarded as a process obtained, strengthened, adapted and maintained over time. Systematic training and capacity building to become a process-oriented task require development of an understanding of existing government and non-government policies and programs. That way capacity development and associated R&D plans could be contextualized to suit the vision & objectives, operational systems and implementation strategies of respective ministries in addition to the focal ministry, which is the Ministry of Disaster Management (MoDM).

In this regard, the Asian Disaster Preparedness Center (ADPC), Thailand in partnership with the focal agency for landslide risk management in Sri Lanka, the NBRO, has undertaken a Training Needs and Gaps Assessment survey in order to:

a) Identify and document the needs in R&I for management of landslide risk and gaps in associated technical competency, knowledge & skills.

b) Understand key gaps in policy, legal, regulatory and institutional set up for creating an enabling environment for the application of engineering and non-engineering solutions for landslide risk management.
c) Recognize an appropriate coordination mechanism and a knowledge management strategy to sustain the capacity of individuals, institutions and society to manage the landslide risks successfully.

3. Discussion on key findings

The TNGA survey was carried out through a consultative process involving representatives from multi-stakeholder agencies and respondents were selected randomly. The questionnaire survey instrument contained 07 fields, namely:

Section I – Institutional Arrangement for landslide risk management training & leadership; Section II – Policy Environment; Section III– Current Gaps; Section IV– Awareness creation; Section V – Existing Training programs and content; Section VI - Subject areas that can be suggested for inclusion in future training and capacity building programs; Section VII - Preferred duration and method of training.In relation to each major field, the survey instrument contained a number of statements.

The respondents were asked to select the statement that can be considered to be the most suitable answer as per his/her personal 'best judgment'.

The consultative process undertaken through the TNGA survey has focused on two areas:

a) Identification of needs in capacity development for R&I.
b) Understanding the policy environment so that the complementary factors related to both aspects could be used to develop capacity building programs.

In terms of capacity needs, the study has uncovered several key gaps and challenges, which stakeholders consider as main apprehensions.

Some of them are common to landslide risk management capacity development. According to the survey, while there has been a notable progress in the development of general capacities to manage disasters within the country in recent years, gains have lagged in relation to specific technical areas. It has also become a concern that the landslide disaster risk management related to capacity development is not carried out as a regular endeavour, covering the capacity development needs for R&I of all stakeholders.

In terms of the policy environment, several facts, which are of particular importance in creating an enabling environment for application of R&I for landslide risk management have been revealed through the study and are described in detail in this paper. One of the key findings of the survey in this regard, is the availability of laws, regulations and policies related to protection and conservation of natural environmental resources, but none of them have any reference to landslide risk management until now. It is also revealed that most of them are connected with overlapping responsibilities and approaches that can have a direct relationship with some of the landslide risk management functions.

3.1 Methodology used to review of policies, legal mandates and institutional mechanisms

The team has carried out the study of policies, legal mandates and institutional mechanism through

a.) a desk study on relevant acts, ordinances and policies
b.) a survey using a questionnaire survey instrument
c.) institution level meetings and key informant interviews.

Key areas considered under the policy review are Conservation of forest and upper watershed areas (Forest Conservation Act, 2009; Forest Conservation Ordinance, 2009); Land use planning and land management (Land Development Ordinance, 1935); Protection of environment and natural resources (Fauna and Flora Protection Act, 2009; Fauna and Flora Protection Ordinance, 1907; Soil conservation, prevention of soil erosion and land degradation (Soil Conservation Act, 1996); Water resource management and conservation of water sources (Forest Conservation Ordinance, 2009); Disaster management (Sri

Lanka Disaster Management Act, 2005). Among them, main aspects related to landslide risk management, which can be positively linked to capacity building to promote Research and Innovations in landslide risk management, are discussed below.

3.2 Gaps identified in Policy and Practice

3.2.1 Disaster management related policies

The main legal instrument for Disaster Risk management in the country is Sri Lanka Disaster Management Act No 13 of 2005, which is supposed to address the subject of disaster management holistically and to provide the legal framework for disaster management activities. It recognizes landslide as one of the major types of natural hazards, from which the country had significant impacts such as physical, social, environmental and economic aspects. Several agencies undertake various functions related to disaster risk management under the purview of the Ministry of Disaster Management.

Currently the NBRO which was established in 1986 functions as the focal agency for Landslide risk management. NBRO as per its mandate, provided through a cabinet decision (Cabinet Paper No.07/0435/343/002, 1986), continues to develop landslide hazard maps covering all landslide prone districts and undertakes landslide investigations. Additionally, they perform few other essential functions through subsequent directives and cabinet memorandums such as loss and damage assessment, forecasting and providing technical assistance to DMC to issue landslide early warning, issuing land clearance certificates, provide guidance on human settlement planning, conducting socio-economic studies in landslide prone areas etc.

There are also certain gaps in the policy, legal and institutional set up, which are not covered adequately under the provisions of the act. It is now vital to regularize the mandate covering all functions and responsibilities by introducing new acts or incorporating necessary amendments to the existing act such as;

i. Provide legal provisions for NBRO to function as the mandated institution for landslide risk management (this can be done through

a new act to provide for the establishment of NBRO for such purposes but not limited to)

ii. Provide more powers to district authorities to enforce regulations, ensure compliance and increase the accountability and declaration of high-risk areas as reservation areas that are not suitable for any infrastructure development when and where necessary.

3.2.2 Policy gaps related to management of environment and natural resources

Environmental Impact Assessment (EIA) is a current process used in Sri Lanka to assess the likely environmental impacts of a development proposal and to identify options to minimize environmental damage. The main purpose of EIA is to inform decision makers of the potential impacts of a proposal before an implementation decision is made. EIA provides an opportunity to identify key issues and stakeholders early in the life of a proposal so that potentially adverse impacts can be addressed before the final approval or the decisions are made. A notable shortcoming in the current EIA process is the inadequacy for incorporation of hazard specific concerns during the implementation of development projects in landslide prone districts. Recently there was a suggestion to replace EIA with a Strategic Environment Assessment process (ADPC, 2018), where factor maps related to various aspects will be considered in assessing environment impacts in a holistic way. Landslide hazard maps can be used for such purposes only in a limited way. Usually Landslide hazard maps are available in 1:10,000 and 1:50,000 scales and can be used to identify high hazard prone areas for large scale development projects and regional level planning. However, since landslides are localized events, there is a need to have a special location of specific landslide risk assessment to understand the possible consequences due to potential landslide occurrences. It was also found that less attention is paid to make recommendations to reduce potential hazard impact. This inadequacy will prevent incorporation of landslide hazard risk mitigation aspects into the final project proposal.

The other issue relates to the issuance of licenses for sand extraction, earth and rock excavation for construction purposes, reclamation of lands etc. This is one of the key functions executed by the Geological

Survey & Mines Bureau (GSMB) under the powers vested in regulating the exploration of mineral deposits and mining operations, minerals and processing, trading and export. During the issuance of licenses for sand extraction, earth and rock excavation they are supposed to follow the guidelines to satisfy EIA conditions. However, currently the requirements of EIA are only practiced for bigger commercial level mining operations. Minor and medium scale operations, which are most widespread does not cover adequately, within the current provisions associated with environment impact assessment (ADPC, 2018). Thus, the mitigation actions for landslide occurrence, cutting failures or potential slope destabilizations associated with such operations are not included under conditions of licenses issued by GSMB to majority of licensees involved in small or medium scale opencast mining operations, excavation of earth and rock etc.

3.2.3 Common gaps related to other policy areas.

One of the other findings of this study is the availability of laws, regulations and policies related to protection and conservation of the natural environmental resources in Sri Lanka, but none has any reference to landslide risk management in its content. It was also revealed that most of these laws, regulations and policies are connected with overlapping responsibilities and approaches to address the issues of environmental protection and conservation although there is no scope for hazard risk management except floods. These policies also have a main focus on ensuring sustainability of the natural environment but concerns in relation to landslide risk is not mentioned adequately in any of the current policies. Some of the prominent policies to list in this regard are: National Policy on Watershed Management (National Watershed Management Policy, 2004), National Land Use Policy (Land Use Policy Planning Department, 2019), National Forest Policy (Forest Act, 2009), National Environment Policy (National Environmental Act, 1980) etc. The main principle of all such policies is to protect and conserve natural environmental resources. It is advisable to integrate the subject of landslide disaster risk management in an appropriate way into the scope of the subject areas described in various ordinances such as Land Use Planning (Land Use Policy Planning Department, 2019), Forest Conservation (Forest Act, 2009), Soil Conservation (Soil Conservation Act, 1996), State Land Ordinance (Land Development

Ordinance, 1935), Urban Development, Town and Country Planning Ordinance (Town and Country Planning Ordinance, 1946), etc. for unifying the efforts, for getting maximum benefits as well as to control development activities which may increase landslide risks during execution of permissible activities under the respective regulations.

Therefore, the positive aspects of the above-mentioned policies is that if arrangements can be made to incorporate minor amendments to relevant ordinances, many national policies mentioned above could be used to create an enabling environment for promoting landslide risk management in addition to addressing the major subject areas of their focus.

3.2.4 Addressing the accountability issue while implementing projects by the stakeholder institutions

The studies undertaken by some agencies (such as upper watershed land use planning division of Mahaweli Authority, LUPPD, NRMC etc.) (ADPC, 2018) have shown that erosion related to engineering practices and landslides due to manmade interventions have increased significantly. It is necessary to take up such issues with relevant agencies such as the Road Development Authority, Divisional Secretaries, Local Authorities etc. for policy changes to introduce improved practices to adhere to current regulations applicable to others. In the meantime, there is also a need to develop guidelines for social and environmental safeguards covering all such major projects to address the grievances of the public. Essentially there is a gap in policies and regulations to make all stakeholder agencies accountable towards the outcome of their interventions and services within landslide prone districts.

3.3 Improving the Institutional framework

3.3.1 Controlling development activities which can increase the landslide risk

The study also revealed that, there is a number of existing institutional arrangements created by the government to promote a multi task policy dialog and undertake appropriate actions in order to minimize policy overlaps and duplication of tasks. Additionally, it is meant more

importantly to share information freely and to optimize resource allocation to relevant government agencies. Some of these high-level task forces are being chaired by H.E. the President of Sri Lanka while some are chaired by relevant ministers or secretaries in order to ensure an integrated and effective decision making process (ADPC, 2018). Examples for some of these institutional arrangements and such high-level mechanisms are: National Council for Disaster Management, Soil Conservation Board, National Platform for Solid Waste Management, National Physical Planning Council etc. In addition such high-level mechanisms can be used to control activities which are not recommended and/or are detrimental in creating new risks or enhancing the effect of landslide triggering factors.

3.3.2 Building resilience through resettlement of vulnerable families

Since 1990, the NBRO implements a landslide hazard zonation mapping programme covering landslide prone districts of the country and as a result, high hazard prone settlement areas have been delineated in most districts to date. At present, as one of the strategies to mitigate and manage landslide risks, the government intends to carry out systematic resettlement of the communities currently living in critical high landslide hazard areas to safe locations.

In the absence of a specific policy for hazard induced relocation, the National Involuntary Resettlement Policy (NIRP) that was formulated and approved around two decades ago has been used by governments to resettle people who were displaced due to past disaster events. Clear examples can be drawn from the experience of resettlement of people affected due to the Tsunami event in December 2004 and landslides in Meeriyabedda, Aranayake etc. However, since the NIRP is formulated to address the involuntary resettlement associated with development projects such as expressways, highways, free trade or industrial zones etc. there seems to be many challenges and limitations. Hence, suitability of the same for landslide induced resettlement is questionable. In particular the effectiveness of such resettlement programmes needs to be evaluated in terms of provision of effective social protection to beneficiaries as resilience building should be considered as a priority of the strategy. Therefore, in addition to providing housing and infrastructure there is also a need for providing attention to the livelihood security of the displaced, security of the most

vulnerable segments etc. as well as safeguarding them from future hazards.

It is essential that the government take action to designate an appropriate organization with necessary technical competency, legal authority and capacity to handle disaster induced resettlement; prepare action plans, develop related policies, monitor compliance with policy, payment of compensation, look after grievances of beneficiaries and proper maintenance of newly built settlements and slope areas abandoned due to landslide occurrence or due to relocation of people.

3.3.3 Improvement of landslide early warning system (EWS) to make it a people centered, end- to -end landslide early warning system

An EWS is described as an end-to-end if it connects the technical (upstream) and societal (downstream) components of warning through an identified set of institutions responsible for dissemination. Comprehensive EWS should have an "end-to-end" approach, addressing all stages of early warning from forecasting, initial hazard impact area detection, formulation of warning and dissemination to community-level and appropriate decisions to respond to warning messages. The effectiveness of an early warning system will depend on the detection technology, as well as socioeconomic factors that dictate the manner in which people at the local level can understand and react to disaster events. Advanced preparedness planning will help creating better community understanding and community organization to respond to early warning efficiently. The current operational set up for landslide early warning needs some revisions to make it a more people centered end-to-end landslide early warning system. It is necessary to review policy mandates, roles and responsibilities of involved institutions in the EW process at each stage and to propose a better institutional framework that will ensure an effective People Centric Landslide Early Warning System in place.

3.3.4 Developing a data sharing platform for sharing data internally and externally

Overall data plays a critical role with all the emerging trends such as data science, analysis and essentially will help improve the general decision-making process. There is an enormous benefit in application

of such advancements in to the landslide risk management decision making process. Importance of having all data in one place and displaying them converted into information and presenting them in a more meaningful way, invariably will help NBRO and other associated stakeholders in their decision-making processes. Hence, there is a priority need to collect, collate perform data inventorization etc. and set up a comprehensive geo-information database management system for data sharing internally and externally. It is necessary for increased security, efficiency, productivity, and easy management as well.

3.3.5 Initiate setting up of technical resource centers to promote Community Based Disaster Risk Management (CBDRM) process

The guiding principle of the Sendai Framework for Disaster Risk Reduction (SFDRR) recognizes that "Preventive measures are most effective when they involve participation at all levels, from the local community through the national government to the regional and international levels." Whatever the scale of hazards, big or small, it is the community that either suffers the devastation or survives from disaster impacts. The community is the first to be affected and as such becomes the first/initial responders who manage the emergencies at the household and at community levels. By managing emergencies well, it prevents the escalation of these emergencies into disasters. This is true for landslide hazard prone areas as well, as landslides are a local level emergency. Landslides differ from other type of hazards such as earthquakes and floods as impact of such disasters spread over a larger area, whereas landslides are confined to a relatively smaller area. Local communities need to take measures to manage landslide risk in order to ensure safety. This can be practically achieved by setting up technical resource centers to promote CBDRM process (in partnership with DMC, NBRO and NDRC etc.) at District and Divisional Secretariat levels and to initiate collaborative actions to develop prepared communities. It is advisable to initiate actions for incorporating the same in to ongoing key government programmes such as the Samurdhi programme, Housing programmes etc. and other local level development projects;

3.4 Improving the legal mandates to create an enabling environment

3.4.1 Legal mandate for the focal agency, NBRO

NBRO is one of the leading Government sector R & D institutions charged with the responsibility for providing technical services in identifying technical areas including geotechnical engineering. Established in 1986[44] through a cabinet paper initially to provide technical services to the housing sector, NBRO was subsequently recognized to be the national focal point for landslide risk management in the late eighties.

The current legal status of NBRO is a significant weak point and a hindering factor for NBRO to function as the mandated institution for landslide risk management. This also will have some limitations for expanding its research activities, developing partnerships with external links (in particular international agencies), entering in to agreements etc. There is a pressing need to have legal provisions for NBRO to operate as an independent research entity. In addition, such legal mandates should provide scope for functioning as the mandatory institution for landslide risk management in Sri Lanka to identify areas prone to landslides, conducting mapping for delineating landslide hazard prone areas, assessment of risk, issuing related EW, undertaking landslide related risk reduction measures, monitoring slopes and issue land clearance certificates in granting approvals for development purposes and conducting research related to landslide risk management.

3.4.2 Make the Land Clearance process mandatory for all local government areas.

The circular of the Secretary of the Ministry of DM dated 2011.02.10 issued consequent to a cabinet decision on 2011.01.05, provides directives to restrict development and execute development control in highly vulnerable areas to landslides. As per the same, it is mandatory before any type of construction, to obtain a Land Suitability Certificate (LSC) with necessary recommendations of NBRO. NBRO has been designated as the mandated institution that is equipped with the necessary technological know-how and the expertise for issuing LSC.

The above-mentioned circular is applicable to the areas subjected to landslide risks and this directive is taken with a view to reduce impeding danger, triggering of new landslides and thereby reducing the potential for the occurrence of landslides. The intended objective of the directive is to minimize the loss of life and property of dwellers in these areas. According to the circular, it will be obligatory on the part of local governments and other institutions granting permission for various projects to obtain the relevant technical advice from the NBRO, prior to granting permission for any type of construction within landslide prone districts.

However, many of the developers including house owners do not obtain any permits for such projects from the respective local authorities and controlling such activities is a challenge at present. Even when NBRO provides the technical advice during the process of issuing land suitability certificates to reduce vulnerability, there is no authority for NBRO to intervene in the process and monitor. Hence, it is better to introduce necessary policy regulations to strengthen the process for improving the accountability of local authorities for monitoring, development control and compliance, mitigating unstable slopes etc. It is also necessary to take action to build the capacity of involved technical officials attached to local authorities, divisional secretaries etc.

3.4.3 Mainstreaming the building and construction control process in landslide prone areas

Haphazard development activities on hill slopes and inadequate attention to safer and resilient construction practices have led to a considerable increase in landslide induced property damage and losses of life in the recent past. Studies carried out in several areas in Sri Lanka suggest that occurrence of small-scale landslides is due to construction activities on vulnerable slopes and this could be easily avoided by the introduction of better slope protection measures. Most landslides or potential failures can be predicted if proper investigations are performed before deciding to construct on vulnerable slopes. On the other hand, landslide induced losses can be prevented if resilient features could be integrated in an appropriate way, addressing possible vulnerabilities associated when designing houses. It is necessary to

mainstream the construction control process in landslide prone areas by incorporating the procedure into necessary ordinances such as local government ordinance, Town and Country Ordinance, Urban development Authority act, National Hosing policy, Bye Laws of local governments etc (Town and Country Planning Act, 2000; Town and Country Planning Ordinance, 1946).

3.4.4 Create provisions to introduce outcomes of Landslide Research and Development work to address technological gaps

When unsafe conditions associated with development initiatives are identified with indicators of slope instability, urgent measures have to be undertaken for rectification by initiating necessary modifications, special slope stabilization and management measures. There is a need to introduce cost effective measures as otherwise the general public may not show an interest in undertaking action to introduce such measures. There is a need to undertake innovative research to come up with such cost-effective solutions and provide know-how to build the knowledge of construction workers, property developers etc. It is a recognized factor to have a meaningful contribution of built-environment professionals (BEPs), particularly architects and engineers to improve the design of safe housing as well as slope stability measures in landslide prone areas. They should be encouraged to undertake more research and introduce innovative construction techniques suitable to improve the resilience of vulnerable slopes. Already NBRO has published a Disaster Resilient Construction Manual (NBRO, 2015) and currently NBRO is taking actions to promote the same among technical officers in local government authorities, home builders and construction professionals by distributing copies and by conducting training courses. Such initiatives should be taken by others including academia so that many cost effective techniques could be introduced in the future.

4. Conclusions

a. One of the key findings of this study is the availability of laws, regulations and policies related to protection and conservation of the natural environmental resources. It is also revealed that most of them are connected with overlapping responsibilities and

approaches. Most of them also have a direct relationship with landslide risk management functions. The positive aspects of such policy environment are that it can be converted into an opportunity for multiple stakeholders to undertake research and Innovation for landslide risk management if relevant ordinances can be amended in a suitable way to include landslide risk management in the scope; NBRO also can form partnerships with other like-minded institutions to undertake applied research in future.

b. There is a number of existing institutional arrangements created by the government to have multi-task policy dialog and take appropriate action in order to minimize policy overlaps, duplication of tasks, share information and to optimize resource allocations to government agencies.

c. Currently there are limited attempts of undertaking joint research programs with other institutions. There is a priority need for better coordination arrangements between NBRO and other agencies for research, awareness creation, capacity building etc. Where possible, efforts should be made to initiate integration across programs undertaken by such government agencies.

d. Private investors including the general public has little interest in undertaking slope stability measures as part of development projects, shelter and infrastructure projects. The government should introduce new policies and encourage government institutions as well as the academia, private sector etc. to conduct innovative research so that cost effective solutions for improving the stability of slopes can be presented to investors and to the general public.

e. In recent years while there has been a notable progress in the development of general capacities to manage disasters within the country, gains have lagged in relation to specific technical areas such as management of landslide disaster risk. In addition, it has become a concern that the landslide disaster risk management related capacity development is also not carried out as a regular endeavor. It is preferable if the government can provide a mandate with appropriate allocations of resources to NBRO or any other

suitable agency for capacity building and awareness creation covering the needs of all stakeholders in landslide risk management.

f. To bridge the capacity gaps, it is useful to develop knowledge products and disseminate them widely. Specific knowledge products related to landslide risk management should be shared with others and it is essential to organize forums (such as seminars, landslide symposium etc.) to share the experience. Mostly such forums are being organized in Colombo but it is also essential to have such forums organized outside Colombo particularly in landslide prone districts.

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De-stabilization of the estuarine sand bar of river "Kalu" in relation to the scenario of flooding in the Kalutara District of Sri Lanka

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Abstract

"Kalu Ganga" or River Kalu is one of the major four rivers in the country which starts from the "Sripada" mountain of Sri Lanka. It covers a basin area of approximately 2,766 sqkm and being located in the wet zone of Sri Lanka, both monsoon and convectional rains nourish the river. "Kalu Ganga basin will receive the highest rainfall from the South West Monsoon (SWM) from May to September and during this period, the river will accumulate much water from the upper streams which resulted in devastative floods in the lower valleys. "Kalu Ganga" estuary had a shifting behavior due to the deposition of sand and erosion of sand during the monsoon and inter-monsoon seasons. Therefore, nearly a one and half kilometer-long sand bar was stabilized by introducing plant species like pine trees, Pandanus and bay hop plants more than three decades ago. In 2017 due to extreme floods in the lower "Kalu Ganga" Basin, a decision was taken to blast the lower section of the sand bar to maximize the discharge of the river. The main objective of this study therefore, is to identify changes in wave dynamics and to identify the changes in spatio-temporal behaviors of floods after 2017. Under the methodology of the study, primary and secondary data were used. Field observations, aerial maps, interviews and a semi structured questionnaire survey was conducted as primary sources of data collection and secondary data were obtained from the

Department of Meteorology, the Disaster Management Centre and the Department of Irrigation, Sri Lanka. A questionnaire survey was conducted in the flood prone areas of the "Kalu Ganga" catchment area. More than 100 households were selected as the sample among the people who live within the flood inundation area which was determined based on previous floods. Interviews were conducted with key informants of the area like local government agents, government officials and building owners of the coastline. Continuous monitoring was conducted every three months to observe shoreline changes as well as the erosional and depositional patterns of the sand. Descriptive statistics and spatial analysis were the main analysis techniques adopted and GIS based software applications were used as tools of analysis. As a result of de-stabilization of the sand bar, within three months the entire sand bar was eroded resulting in heavy erosion on the coasts. Continuous field observations have revealed that erosion and deposition patterns are also changing along with rainfall seasons. High erosion was detected near the Kaluthara South railway station as soon as the sand bar was disturbed, but towards the end of the year new sand deposition was detected. At the same time the "Kalido" beach had entirely disappeared from the map. This was the stabilized section of the sand bar and currently wave processes have reshaped the beach into a typical estuary with no sand bar formation. The main reason for this phenomenon is the change of rainfall patterns. The questionnaire survey revealed that floods have being minimized in many parts of the area, but rainfall data pointed out to the fact that rainfall is less in 2018 compared to 2017. People's attitude therefore, is directed towards the positive side of the action taken to de-stabilized the sand bar. According to the aerial photo interpretation it is clear that the "Kalu Ganga" estuary has a highly dynamic depositional and erosional pattern which is the main reason for authorities to take a decision of stabilizing it in the past. Therefore, continuous monitoring of the estuary is essential to predict any future scenarios. The Kalu Ganga estuary in the past was not populated but currently it is historically, religiously and economically important. Many public service entities like railway, schools, and main roads are located adjacent to the coastline. So the question remains as to whether the current decision de-stabilize actually has an impact on reducing floods or if it creates another issue which may result in disastrous events in the near future.

Keywords:

Coastal Erosion; Flood; Kalu Ganga; Sand Bar

1. Introduction

Being a tropical country, Sri Lanka is more prone to disasters related to hydro-meteorological origin. According to statistics the most prominent disaster types are floods, landslides and droughts. Apart from them there are few others which have in the recent past due to the climate change under the same origin, and coastal erosion is one of them. Coastal Erosion in the present situation has been given more focus since many parts of the Western and Southern coastal belts have been under the risk of been eroded. The risk has increased the vulnerability of coastal belts since more anthropogenic activities have been conducted rather than utilizing them as natural habitats. Most of the highly populated cities like Colombo, Kaluthara, Galle, Matara are located as coastal cities and urbanization is therefore considerably high in the area. Infrastructure like rail roads, main roads, private and state-owned buildings along with many service centers like schools, hospitals and government institutes are also located within these coastal regions. Therefore, the impact of coastal erosion in this region is significant both socially as well as economically. Many coastal erosion prevention and mitigation strategies have been undertaken by relevant stakeholders and yet some parts still get eroded despite all prevention strategies. Some of the most common measures that can be identified are construction of breakwaters, groins, revetments and seawalls. In some regions these measures have been successful and in others they are not

Coastal erosion has created many adverse impacts on both man and the environment. Coastal habitats are degenerating and many of these coastal ecosystems have set back or disappear from the coastal regions. Compared to the impact on anthropogenic activities, the environmental impact is considerably low. One of the main reasons for the degeneration of the coastal ecosystems is anthropogenic activities itself. Coastal erosion is a natural process yet humans have disturbed the equilibrium of nature by interfering with the natural order. There are two main reasons which can be identified here.

Beaches get their sand from the sediments transported by rivers and the sediment load is released to the sea through the estuaries and longshore currents transport it along the shoreline. Especially in Sri Lanka during the South West monsoon period erosion takes place due to the wave action, yet during the inter-monsoon period the system will deposit sand along beaches and balance the process. In the present scenario sand mining has disturbed this natural process by extraction of sand from river beds before they reach the ocean. The amount of sand as the sediment left will not be enough to nourish the beaches after the monsoon period. This is one reason that accelerates the process of coastal erosion. All the rivers in the Southern and Western province have severe sand mining activities all over the basins. This was the first reason and the second is sea level rises due to climate change. Though it has not been scientifically confirmed, many scholars have discussed the fact that sea level rising can be one of the major reasons for coastal erosion.

This study is focused on the river "Kalu" or "Kaluganga" in local language which is the second largest river basin in the country. The basin is about 2766 km^2 and the catchment is located in the wet zone of the country, which reflects high annual rainfall. The annual rainfall in the basin is an average of 4000mm and leads to 4000 million m3 of annual flow according to the Departmet of Irrigation. One of the major issues related to "Kaluganga" is the flood hazard. Each year due to the heavy rainfall, flood incidents are visible. Based on the amount of rainfall, the flood impact varies. Authorities have pointed out that if the discharge of "Kalugnga" is at its full capacity the impact of flooding can be minimized. They have pointed out that it will reduce the spatial distribution of flood inundated areas in the Kaluganga river basin. Hence decisions have been taken by the authorities to widen the river mouth by de-stabilization of the existing sand bar.

The sand bar was 1.4 kilometers in length and it was dynamic in nature. Three decades ago bay hops and government authorities have decided to stabilize the sand bar using soft engineering methods. They have invented pine trees, pandanus and ipamoea plants to prevent the sand bar from being eroded. The main purpose of the stabilization process is to reduce the saline intrusion and also minimize the threats of coastal erosion of the main land. The project was successful and it has created

a separate ecosystem. With the decision taken in the year 2017, the sand bar was cut open from the base of the sand bar as an immediate action to increase the discharge of "Kaluganga". Recently it has created another aspect of disasters where the process of coastal erosion has been accelerated, yet the question remains "Can it be justified for the sake of greater good?"

2. Objective of the study (Model, Process, Device, Sample preparation etc.)

The main objective of this study is to identify changes in wave dynamics and to identify the changes in spatio-temporal behaviors of floods after 2017. Under this objective, the wave process and the changes of wave process were given more focus. Changes of the wave processes can support the argument, whether there is any impact due to climate change. Then rainfall and water discharge of the "Kaluganga" was taken into consideration so that it gives an idea about the rational of the decision taken by authorities to de-stabilize the sand bar. Rainfall variability was also taken into consideration to investigate into the amount of rainfall and people's attitude on the de-stabilization process. Lack of rain gauge stations as well as water gauge stations were the main issue in collecting data. There were limited stations and some of the spatial analysis techniques were unable to be executed due to this reason. The study also focused on spatial dynamics of the sand bar formation and temporal changes of the sand bar as well. Evaluating the current methods and the situation were also another objective of the study.

3. Methods

This study was based on both primary and secondary data along with both quantitative and qualitative approaches. Secondary data was obtained for rainfall, water level and discharge of the river. Rainfall data was obtained from the Meteorological Department of Sri Lanka for the main flood occurrence period on a daily basis. Water level and discharge of the "Kaluganga were obtained from the Department of Irrigation for the same time period for comparison purposes. To identify the geomorphological variation of the sand bar, both aerial photographs as well as satellite images were used. Aerial photographs were used to

examine the morphological characteristics in the years of 1956, 1967, 1983 and 1994 due to the absence of satellite data. Aerial photographs of the area were obtained from the Survey Department of Sri Lanka. To identify the recent changes of the sand bar, satellite images were used. Satellite images were obtained from online sources mainly from the USGS Earth Explorer website. These satellite images were collected from December 2017 to January 2019.

Primary data was collected in order to evaluate the current scenario of the area and three data collection methods were used. Among them field observations were one of the main data collection methods. Field observations were conducted from March 2017 and after every three months, there was at least one field visit. Through field visits continuous monitoring of the sand bar formation and its related processes was made possible. Photographs, sketch diagrams and basic measurements of the sand bar were kept as field records. Several interviews were conducted with key informants of the area such as the local government agent, building owners (Station Master, Monks of the Temple, Shop owners and Officers of the Navy Training Center) and government officials. A questionnaire survey was conducted with the aim of investigating the qualitative aspect of the situation and its impact on people and their activities. For the questionnaire survey a sample of 32 were selected based on the purposive sample method where people who live adjacent to the river mouth or the shoreline were selected.

Data analysis of the study was based on both quantitative and qualitative frameworks. Overlay analysis and spatial statistical techniques were mainly used as the method of spatial data analysis and the main tool of data analysis was Arc GIS 10.1. All aerial images obtain from the Survey Department of Sri Lanka were scrutinized using the screen digitizing process and converted to digital format. Satellite images were also converted using tools in Arc GIS. Apart from the qualitative analytical technique statistical analysis methods like measures of central tendency and dispersion were commonly used. Correlation and regression methods were also used to identify the relationships between variables. Visualization of data was mainly based on maps and diagrams. Charts and graphs were also included where necessary.

4. Results and Discussion

According to the analysis the shifting behavior of the sand bar was clearly identified based on maps, aerial photographs and satellite images of the area. The land use map given in imperial scale (1:63360) illustrating the land use pattern of 1947 shows that the opening of the river mouth is located towards the southern art of the lagoon. Aerial photograph of the area in 1956 illustrates that the opening has shifted towards the northern part of the lagoon. It has been located very close to the river mouth. Again in 1963 the mouth opening indicates more shifting patterns towards the Northern part of the lagoon and the opening is wider than the previous time. As it is given in the aerial photographs in 1983, the river mouth was partially closed by the sand bar and the southern part of the islet was fully open to the sea. In 1994 after 11 years, the river mouth has shifted its opening towards the location situated in 1947. This is the shifting behavior of the river mouth which was happening for a long period of time. Figure 1 illustrates the changing behavior of the sand bar during the time.

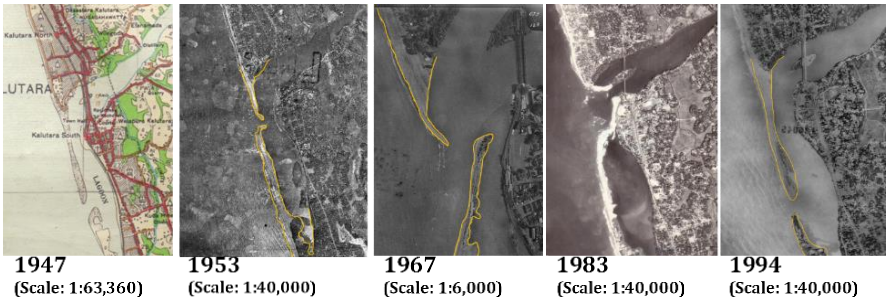

Fig. 1. *Dynamic geomorphology of the estuarine sand bar of "Kaluganga", Source: Survey Department of Sri Lanka, 2018*

Many researches have been conducted on the topic of changing dynamics of the "Kaluganga" river mouth and many of them pointed to seasonal variations of currents as the main reason. After 1994 authorities took a decision to stabilize the sand bar as a method of minimizing the risk of coastal erosion in Kaluthara town as well as to reduce the saline intrusion to certain extents. Based on soft engineering methods the sand bar was stabilized and there was a separate ecosystem on the sand bar. The main tree species was pandanus and

there was a thick layer of pine trees. The total length of the sand bar was nearly 1.4 km and there was a well-established beach where many recreational activities took place. The beach was named "Kalido Beach" and many people spent quality time here. It was one of the most crowded beaches in the Western and Southern coastal belt during weekends and holidays. With the de -stabilization of the sand bar all these activities were stalled and the community has lost one of the important public spaces where many social interactions took place. The following photographs indicate the previous condition of the sand bar.

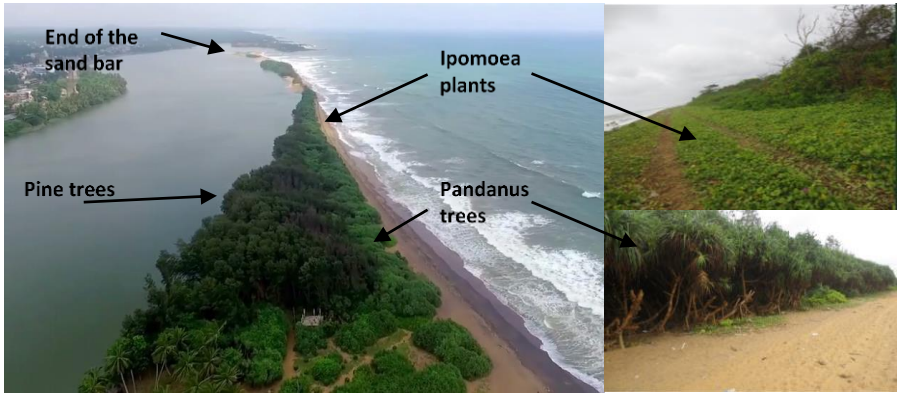

Fig. 2. *Status of the sand bar before the destabilization Source: Field Surveys, 2017/18*

According to figure 02 it is clear that the sand bar has protected the mainland from coastal erosion. Wave activities took place only on the sand bar and the lagoon was a very calm water body. In the mainland adjacent to the beach is the Colombo - Matara main road as well as the Colombo – Matara rail road which are highly important segments in the Sri Lankan transport network system. The Kalutara town is also located at the boundary of the "Kaluganga" estuary and it is one of the most highly populated urban areas of the country. The Kalutara "Bodhi" is a significant temple located within the estuary. Thousands of people visit the temple daily and engages in religious activities. Therefore, all these activities are under threat hence the sand bar is removed. The initial idea of de-stabilization is to create an opening at the point where the river reaches the sea. Since its nearly 1.4 km parallel to the main land before reaching the sea, many people believe that discharge of the river

may not increase to its full potential. They also believed that one of the main reasons for flood retention for a long period of time in the lower basin areas is related to this scenario. Therefore, the purpose of creating an opening is to drain the accumulated water without been retained for a longer period of time.

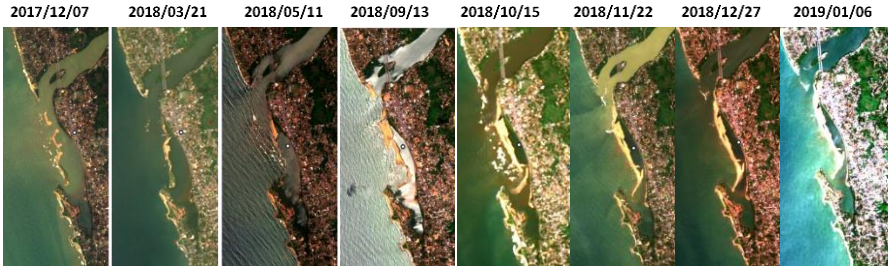

Fig. 3. *Status of the sand bar before the destabilization Source: https://eos.com/landviewer/, 2019*

After the opening was created authorities thought that the water will reach the sea faster and the rest of the sand bar will remain safe. Yet due to wave action the sand bar started to erode rapidly. Figure 3 illustrates the dynamic behavior of the sand bar from December 2017 to January 2019 based on satellite images. Kalutara is located in the Western coastal belt of the country and is directly impacted by the South West monsoon winds. During the monsoon period the erosion increases in the coastal belt regions. After the monsoon period deposition of sand can be identified. Therefore, in the months of November, December 2018 and January 2019, new sand deposition in the coastal region of the mainland is clearly seen. Yet, during the monsoon period it shows high erosion in the same area. Again during the incoming monsoon period heavy erosion can be expected. Therefore, the beach or the coast in the mainland now becomes a highly unstable beach based on wave action.

Figure 4 illustrates the relationship between rainfalls and water level of the catchment. Secondary data were obtained from the Department of Meteorology for four rain gauge stations including Geekiyanakanda, Kalutara, Rathnapura and Raigma which belongs to the “Kaluganaga” catchment and daily data were obtained for the month of May for three flood events. Since the South West monsoon is active from May to September, the month of May records heavy floods in many years.

Fig. 4. *Water level of the river during floods in relation to rainfall. Source: Department of Irrigation, Sri Lanka, 2018*

Three flood events were recorded in May 2003, May 2007 and May 2008. Based on the questionnaire conducted results have shown that people believe that the 2018 flood was not severe compared to the previous flood in 2017. The graphs also indicate that the water level is lower than the previous two years. At the same time the amount of rainfall is also low. In 2003 and 2017 the daily rainfall in Rathnapura rain gauge station increased above 400 mm of rainfall, yet in 2008 the daily rainfall value is less than 200 mm. There was no intense rain during the month of May in 2018. Therefore, the extent of the flood and the flood retention periods is very small compared to 2017. People strongly believe that the main reason for the low impact of flood is the de-stabilization of the sand bar. They do not accept the fact that rainfall is lower than the previous year.

Key informants of the area have different views on the action taken by the authorities. The Kalutara South railway station is one of the most vulnerable buildings in the area. During the south west monsoon period the waves hit the station wall. Field observation also confirmed that the wall was at high risk during the monsoon period. As an emergency action the Cost Conservation Department (CCD) has decided to lay an embankment to prevent heavy erosion. Within three weeks the embankment was breached. According to the people at the railway station, nearly 20 coconut trees have eroded into the sea. With the declining of monsoon winds, erosion has minimized and since recent times there is wider sand deposition that is identified. Some people believe that the risk has now been minimized yet some believe that during the next monsoon period erosion may be severe. Another place or a monument which is religiously significant is the Kalutara "Bodhi" Temple. Authorities have highlighted the same points as per the railway station where the lower wall of the "Bodhi" was almost breached due to wave action. Again, in recent times there is a wider sand deposition where the erosion took place during the monsoon.

Community members who have previous experience before stabilization of the sand bar pointed out another important fact about the river mouth. According to them with the highly dynamic behavior of sand deposition in the area, the river mouth may be blocked due to heavy sand deposition. In such cases the river discharge may be again obstructed by the sand increasing the flood retention period in the

lower basin of the "Kaluganga". Coastal engineers also predict this possibility based on wave action. The river mouth is a place where the river flow meets sea waves. If the sea waves are more powerful than the velocity of the river, sediment transported by the river will start to deposit at the river mouth immediately without reaching the ocean. If such incidents happen, it may block the river mouth and extend the flood retention period of the catchment. Based on the wave parameters it is clear that wave velocity, height and energy increases due to the monsoon winds. Therefore, destructive waves can be witnessed during the time. If the destructive waves are more active during the monsoon, all sand depositions at present will eroded rapidly.

5. Conclusion

River action and the wave process are two different components in two different physical systems. River mouths are places where these two processes are merged together. Mother Nature has her own way of balancing the processes without harming any of the ecosystems present. With human interference all these processes have been altered or changed according to human needs. Yet nature finds a way to balance the process which may have more adverse effects on anthropogenic activities.

The action taken to de-stabilize the sand bar of 'Kaluganga" river mouth is a decision taken as a flood mitigation strategy yet has created another disastrous event; coastal erosion. It is clear that past experiences or studies have not understood the reason why the sand bar was stabilized in the first place. Else the authorities have not studied the wave action or sought the opinion of field experts before taking the decision of de-stabilization. Otherwise it may have been a decision taken as an immediate action to mitigate floods than thinking about the greater wellbeing. However the decision has been made and the action has been executed with communities having to face the consequences. It is not very wise to think that the sand bar has stalled erosion. During the next monsoon period the impact of erosion may be more devastative. Therefore, the question remains, if immediate action can be taken to mitigate such occurrences?

It is important to conduct a comprehensive study on the coastal belt near 'Kaluganga" river mouth and the main focus should be wave climates. Continuous study of the wave climate will enhance the understanding of dynamic behavior of the waves. It is important to understand the current spatial context and its behavioral patterns. Currents are changing according to seasons. Therefore, study of seasonal variation is a must. Continuous monitoring of the geomorphology of the coastal belt is another aspect to study and it should also be conducted continuously to understand seasonal variations. After such studies are conducted necessary action can be taken. Research and studies have become the base of decision making. Decisions taken by authorities have to be more accurate, productive and formulated for the wellbeing of both man and the environment. Therefore, it is important to conduct research before taking further decisions or any temporary action since it may have increased the adversity of the impact for both man and environment.

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Developing herbal based liquid sanitizer to maintain personal and environmental hygiene as a disaster resilience

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Abstract

It is common to experience an outbreak of infectious disease caused by common pathogens due to the prevalence of a poor hygienic environment after natural disasters. Development of an organic based herbal sanitizer is a viable option to overcome such outbreaks. Sri Lanka is rich in plant species comprised with secondary metabolites proved to consist of *in vitro* antimicrobial properties. Acmella, Turmeric, Cinnamon and Lemon are some of the potential medicinal plants with antimicrobial, antiviral and antifungal constituents which could be used to develop liquid sanitizer against common pathogens. Thus this liquid sanitizer can be used in the occasions of washing hands, cleaning food processing areas, in preparation and consumption of food etc. Herbal extract based sanitizing liquid which is highly safe, efficient, convenient and cost effective could be used to mitigate disasters by ensuring personal and environmental hygiene.

Keywords

Disease Spread; Environmental Hygiene; Herbal Extract; Personal Hygiene; Liquid Sanitizer

1. Introduction

All regions of the world experience different kind of disasters caused by natural and man-made factors. Floods, storms, Tsunamis and droughts are frequently recorded disasters in the South Asian region. Management of such disasters include mitigation of hazards within our control, increasing the community resilience capacity and disseminating knowledge of risk reduction. Risk assessment is essential in after-effects of disasters and in the immediate enactment of control measures through resettlement and improvement of basic health care provision is very crucial. Even though there is a lack of pre-disaster surveillance data in any type of unexpected disaster, managing personal and environmental hygiene should be given high priority.

It is common to experience public health and hygiene issues following natural disasters due to outbreaks of infectious diseases caused by common pathogens like *E. coli, Shigella* and *Hepatitis* (Akbari et al., 2004; WHO, 2005). This is caused by the destruction of sanitation systems and displacement of the population which leads to poor hygienic surroundings. Recent studies have shown that it is essential to maintain safe hygienic conditions of people and the environment of the public, which implies the necessity of cleanliness after disasters (Kouadio et al., 2012). An organic based herbal sanitizer is high in demand to overcome issues such as the spread of after-effect diseases including skin irritations. Plants are rich in a wide variety of secondary metabolites, such as tannins, terpenes, and alkaloids (Yadav & Agarwala, 2011; Vaghasiya et al., 2011; Rao & Gan, 2004) which have been proved to consist of *in vitro* antimicrobial properties (Ahmad & Beg, 2001; Uthpala et al., 2018). Sri Lanka is a gifted country rich in plant species with high bioactive compounds (Gunatilaka et al., 1980). Among them Acmella, Turmeric, Cinnamon and Lemon (Rao & Gan, 2004; Uthpala et al., 2018; Nelson et al., 2017; Ikpeama et al., 2014; Rauf et al., 2014) are some of the potential medicinal plants high in antimicrobial, antiviral and antifungal constituents which could be used in developing an effective organic liquid sanitizer against common pathogens responsible for causing diseases. This liquid sanitizer can be utilized in occasions such as washing hands, cleaning skin, cleaning food processing areas, in the preparation and consumption of food etc. Therefore, herbal extract-based sanitizing liquid which is highly safe,

efficient, convenient and cost effective could be used to mitigate disaster related issues by managing ways of ensuring personal and environmental hygiene.

2. Objective of the study

To identify the importance of developing an effective organic liquid sanitizer using phytochemical rich plants against common pathogens that are responsible for causing diseases.

3. Disaster occurrence

All regions of the world experience different kind of disasters (natural or man-made). Recent occurrences reveal that even the most developed countries are vulnerable to natural disasters. Floods, storms, Tsunami, droughts etc. are frequently recorded disasters in the South Asian region. Flood disasters are the most common (40%) natural disasters (Howard et al., 1996) in the world that occurs due to weather and climate changes. According to the Figure 1 shown below, Emergency Events Database (EM-DAT) reveals that floods, storms and earthquakes are the most common disasters that have occurred in 2017. Also 136 out of the 318 globally recorded natural disasters hit Asia, accounting for 58% loss of lives compared to other continents in 2017 (Below & Wallemacq, 2017; ESCAP, 2015).

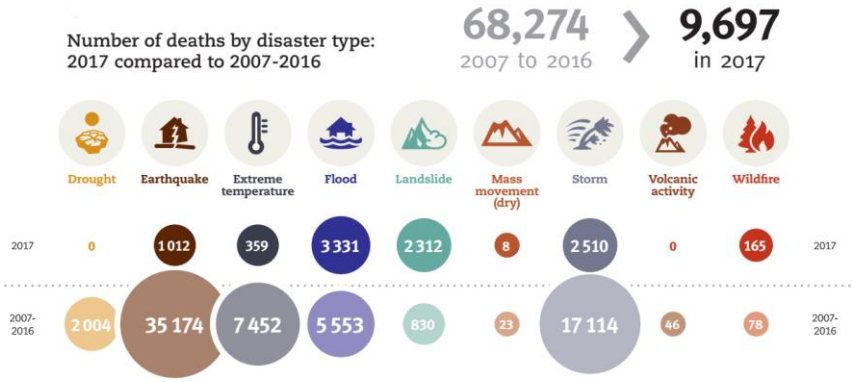

Figure 1. *Comparison of number of deaths by disaster type in year 2017 and average deaths in previous decade. Source: EM-DAT (*Below & Wallemacq, 2017)

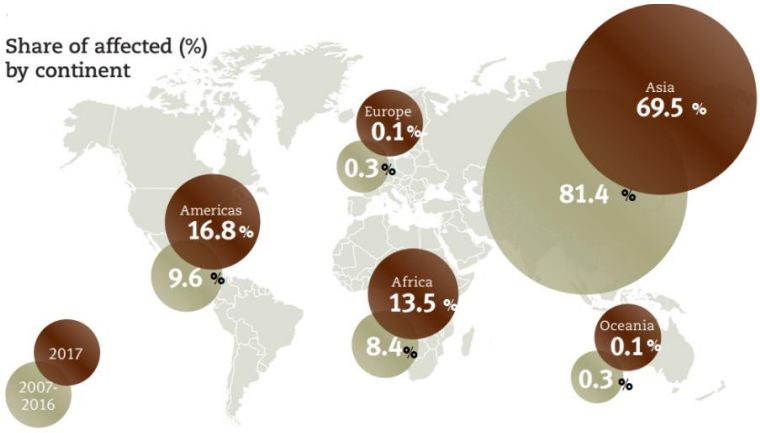

Figure 2. *Comparison share of affected percentage by continent in year 2017 and average deaths in previous decade. Source: EM-DAT (*Below & Wallemacq, 2017)

Among the disasters that have occurred around the world, 69.5% of people are affected in the Asian continent compared to other continents. EM-DAT data reveals that in 2017, Asia seemed to be the most vulnerable continent for floods and storms experiencing 44% of all disaster events, 58% of the total deaths and 70% of the total people affected inhabiting these regions. Therefore, it is highly essential to take measures to control these losses which are within our control. Management of such disasters include mitigation of hazards within our control, increasing the community resilience capacity and disseminating knowledge in risk reduction.

4. Outbreak of Infectious Diseases

Figure 3 shows a disaster which occurred in Barbados, 2018. The image of this Caribbean natural disaster reveals that there is a significant number of property loss that have occurred due to such disasters and also in addition to damage and destruction of physical infrastructure, natural disasters can lead to the outbreak of infectious diseases. This is caused by the destruction of sanitation systems and displacement of the population (Watson et al., 2007) which leads to poor hygienic surroundings. Recent studies have shown that it is essential to safeguard hygienic conditions of people and the public environment, which implies the necessity of cleanliness after disasters.

Figure 3*. Image of people affected by flood in Bridgetown, Barbados, 2018*

As an after-effect of disasters, it is common to experience public health and hygiene issues due to outbreaks of infectious diseases caused by common pathogens like *E. coli, Shigella,* and Hepatitis. Table 1 shows disasters that have occurred in the past few years around the word and the consequent disease outbreaks. It reveals that Diarrhea, Leptospirosis and hepatitis tend to occur after natural disasters. Among those disease outbreaks, diarrheal diseases are the most common potential secondary associated disease which causes over 40 % of deaths (WHO, 2009) in disaster and refugee camp settings. There are a number of pathogens (Table 2) that cause diarrheal disease which eventually leads to death.

Evidence of diarrheal deaths have been reported from several studies in low-income countries. Surveillance data reveals significant mortality rates associated with diarrhoea following floods in Khartoum, Sudan. Routine surveillance data and hospital admissions records also dictate diarrhoea as the most frequent (27 percentage) cause of death following severe floods in Bangladesh (Ahem et al., 2005).

Table 1. Natural disasters and potential associated infectious disease

Disaster Event	Year	Country	Infectious disease outbreak associated to disaster	Source
Flood	2018	India	Diarrhoea	(Below & Wallemacq, 2017).
Earthquake	2011	Japan	Diarrhoea, influenza	(Kouadio et al., 2012;Norio et al., 2011)
Hurricane	2005	USA	Diarrhoea,TB	(CDC, 2005)
Earthquake	2005	Pakistan	Diarrhoea, hepatitis E, Acute respiratory infection tetanus	(WHO,2005)
Flood	2004	Bangladesh	Diarrhoea	(Kouadio et al., 2012)
Tsunami	2004	Indonesia Sri Lanka	Diarrhoea, hepatitis A and E , Acute respiratory infection, measles, meningitis, tetanus	(WHO, 2005;EM-DAT, 2005)]
Tsunami	2004	Thailand	Diarrhea	(Kouadio et al., 2012)
Earthquake	2003	Iran	Diarrhea, Acute respiratory infection	(Kouadio et al., 2012)
Flood	2001	Indonesia	Diarrhoea	(Kouadio et al., 2012)
Hurricane	2001	USA	Diarrhoea	(WHO,2005)
Typhoon	2001	Taiwan	Leptospirosis	(WHO, 2005, 21-28)

Table 2 . Common pathogens involved in Diarrhoea (Kiser et al., 2011)

Pathogen	Fever
Campylibacterspp	Common
Salmonella spp.	Common
Shigella spp.	Common
Escherichia coli	Atypical
Clostridium difficile	Occurs
Entamoeba histolytica	Occurs
Cryptosporidium spp	Variable
Cyclospora	Variable
Viruses	Variable

5. Reasons for outbreak

Infectious disease transmission or outbreaks are common (months) after the onset of disasters and are caused by massive population displacement and aggravation of risk factors for disease spreading, such as increasing size and characteristics of the displaced population within the local disease ecology, lack of food, safe water and functioning

latrines, poor personal hygiene etc. Further, public health consequences of disease outbreaks are listed below;

- Shared water containers and cooking pots.
- Displacement of people into overcrowded camps/ unplanned and overcrowded shelters.
- Scarcity of cleaning material (soap).
- Limited access to safe food.
- Limited access to safe water (cross-contamination of water sources with fecal material and toxic chemicals).
- Pre-existing poor sanitary infrastructures, water supply and sewerage systems [High humidity and damped environment leading to rapid increment of micro flora (log phase)].

It is important to manage the outbreak of diseases due to the severity of loses caused by it. As an example, in the year 2004, Indonesia faced a Tsunami and 85 % of the survivors in the town of Calang experienced diarrheal illness as an after-effect of the disaster.

6. How to overcome disease outbreak as resilience?

It is essential to maintain proper personal and environmental hygiene during disasters. Therefore, herbal extract-based sanitizing liquid can be used to mitigate the outbreak of infectious diseases by maintaining personal and environmental hygiene.

This can be done in several ways;

- Sanitizing and washing hands and body.
- Sanitizing and cleaning food processing and serving surfaces.
- Sanitizing and cleaning food processing areas before preparing or eating food.
- Sanitizing and cleaning house hold floors.

7. Phytochemical rich plants

An organic based herbal sanitizer is high in demand to overcome issues related to the after-effects of disasters due to cross contamination. Plants are rich in secondary metabolites, such as tannins, terpenes, and alkaloids which have been proved to consist of *in vitro* antimicrobial

properties (Uthpala et al., 2018). Sri Lanka is a gifted country rich in plant species with high bioactive compounds (Gunatilaka et al., 1980). An effective organic liquid sanitizer can be developed using herbs that can fight against common pathogens that are responsible for causing diseases. The general public tend to use natural herb-based products rather than artificial products because of its convenience.

Those potential medicinal plants are higher in antimicrobial, antiviral and antifungal constituents (Table 3, 4). Recent studies show evidence that plants which have a higher phytochemical profile are good in controlling harmful microbes (Uthpala et al., 2018; Gupta et al., 2012; Awan et al., 2013; Mauti et al., 2015; Racowski et al., 2017). Therefore, these properties can be used to develop hand sanitizer during disasters. Figure 4 shows images of selected herbs which have higher anti-microbial properties.

Table 3. Anti-microbial properties of plant compounds [MIC- Minimum Inhibitory Concentration which should be used to kill relevant pathogens]

Type of antimicrobial plant	MIC value	Target organism(s)	Reference
Acmella- water extract	20%	*E. coli, S. aureus*	(Uthpala et al., 2018; Gupta et al., 2012)
Turmeric	5.25%	*S. epidermidis, P. aeruginosa* *S. aureus*	(Awan et al., 2013)
Cinnamon- bark ethanoic extract	0.41µg/ml 0.63µg/ml 0.12µg/ml	*E. coli,* *P. aeruginosa* *S. aureus*	(Awan et al., 2013; Mauti et al., 2015)
Lemon- peel ethanoic extract	5% 20%	*E. coli,* *S. aureus*	(Racowski et al., 2017)

Table 4. Phytochemical availability of selected herbs (+ mark indicates the presence of relevant phytochemical, - mark represents the absence)

Selected Plant	Tanin	Terpinoids	Alkaloids	Saponins	Flavonoids	Phenolics	Phlobatanins	References
Acmella	+	+	+	+	-	+	-	(Uthpala et al., 2018; Lalthanpuii et al., 2018)
Turmeric	+	+	+	+	+	+	+	(Nelson et al., 2017; Ikpeama et al., 2007)
Cinnamon	+	+	+	+	-	+	+	(Watson et al., 2007; Hosseins et al., 2009)
Lemon	-	+	+	-	+	+	-	(Rauf et al., 2014; Nascimento,et al., 2000)

Figure 4. *Potential herbs which are having phytochemicals and anti-microbial properties [a-Acmella (Acmella oleracea),b-Lemon (Citrus limon),c-Cinnamon (Cinnamomumverum), d-Turmeric (Curcuma longa)*

8. Advantages of herbal sanitizer

Inventing herbal extract based sanitizing liquid is highly safe with minimum or no skin irritation. Generally Triclosan, Fragrance, Parabens, Formaldehyde and Phthalates (Squance et al., 2015) are used as commercial sanitizing liquids and have been labeled as possible carcinogens. Therefore this product is high in demand for all ages including children. Liquid sanitizer prevents the drying effect that solid soap can have on the skin. Solid soap generally has a higher pH (Nix, 2000) level causing drying (particularly of sensitive skin). Hence the use of liquid sanitizer minimizes the effect of skin irritations. It is efficient because it is in liquid state which is more active than soap. Moreover it is convenient because there are no cross contaminations

by users, ease of usage and is cost effective because the availability of raw materials are high. These sanitizers can be used to control the outbreak of infectious diseases by maintaining good personal and environmental hygiene.

9. Conclusion

Innovation of herbal based organic liquid sanitizer made from phytochemical rich selected plants of Acmella, Turmeric, Cinnamon and Lemon can be used to mitigate the after effects of disasters due to infectious disease outbreak as resilience for personal and environmental hygiene.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

Disaster resilience research in a Thai university: A way forward

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Abstract

This paper investigated the role of higher education institutes in working, creating and constructing knowledge related to disaster resilience research by investigating the enablers that support and barriers that hinder disaster resilience research among academic scholars at different levels. Data were collected by interviewing 26 respondents, and online surveying with 65 respondents. Results showed that the most important enablers for disaster resilience are policies and skills. However, there were still many barriers that hinder disaster resilience research in the Thai university, and it should focus more on its research policy in terms of accessibility, adequacy, continuity, equity, and equality.

Keywords:

Disaster Resilience Research; Research Capacity Building; Research University; Thailand

1. Introduction

Thailand has long been facing hazards such as flooding, tropical storms, droughts, earthquakes, and Tsunamis. Due to its tropical climate, monsoons are normal during the rainy season and floods are common throughout the country. Cities like Bangkok and Chiang Mai have had severe floods in the last few years. The flood in 2011 had caused several socio-economic and political impacts to the whole country. Thailand also experiences more frequent droughts in recent years because of a direct linkage from climate change and higher water demands in the agricultural and industrial sectors. The country has also been facing moderate and small earthquake events mostly in the northern and western parts of the country. Moreover, Thailand was one of the countries hit by the 2004 Indian Ocean Earthquake and Tsunami, and thousands had been reported dead, injured, and missing (Center for Excellence in Disaster Management & Humanitarian Assistance, 2018).

Due to the frequencies and severities of the hazards/disasters, and particularly the impact from the 2004 Indian Ocean Earthquake and Tsunami, and a flood that affected almost the whole country of Thailand in 2011, interests in disaster risk reduction and disaster resilience have been increasing during the past two decades among several government and non-government sectors. The studies on building capacity in education and research are mostly found at school level across Europe and the USA (for example, the study by King and Newmann, 2001; Lane *et al.*, 2006; and Murray *et al.*, 2009) but not at a university level and in Asia in particular. This study, therefore, investigates the roles of higher education institutes in working and researching about disaster resilience.

2. The object of the study

This paper, aimed to study the roles of higher education institutes in working, creating and constructing knowledge related to disaster resilience research by investigating the enablers that support and barriers that hinder disaster resilience research among academic scholars at different levels. Since 2009, Thailand has set up the National Universities Development Project, aiming to increase the educational standard and increase research capacity. Nine universities have been

selected under 2 categories: 1) one of the 500 universities under the university world ranking; and 2) produced at least 500 research papers within the past 5 years and within the 500 papers, covering 5 major subjects with at least 2 of 5 subjects defined as outstanding subjects and 40 % of the academic staff should be PhD degree holders. In this study, a case study in a Thailand research university have been chosen.

3. Methods

Data were collected in one of the research universities in Thailand by interviewing 26 respondents, and surveying 65 respondents online. The population sample was selected by purposive sampling technique which included the university research directors/managers from the office of the University, research centers and institutes, academic staff and research staff who have been involved in disaster resilience research projects from several academic areas including science, engineering, health science, geology, geography, sociology and anthropology, political science and public administration. Questions in the interviews included the importance of R&I (Research and Innovation) for the university, current context and gaps in R&I capacity building, policies to promote R&I, available research infrastructure, the current context of enablers that support R&I and barriers that hinder R&I in the university and, finally, suggestions to improve R&I in the university. Questions in the online survey focused on barriers that hinder R&I in the university.

4. Results and Discussion

Results of this study were analysed based on the opinions from the interviews and answers were divided into 3 categories of respondents: research directors/managers (D); academic full-time staff (A); and researchers (R). Results from the online survey had been added in the last part of this section.

It was clear that all of the respondents have seen the importance of R&I for higher education institutions, and for the university (85 % of the respondents has seen it as very important while 15 % has seen it as important). All categories D, A, and R have similar opinions and agreed that R&I has helped to build and create new knowledge and transfer knowledge to societies and communities, to help solving problems in

both local, national and regional levels, particularly new and emerging problems. In addition, R&I also facilitated the learning and teaching process from research experiences of academic staff and researchers.

The following subsections discuss the current context and gaps regarding R&I in the university.

4.1 Current context and gaps

This section investigates the current context and gaps in R&I capacity building, policies to promote R&I and the available research infrastructure.

4.1.1 R&I capacity building

In terms of the requirements for R&I capacity building for the university, respondents have listed 13 factors related to R&I capacity building. The most important factor was budget, followed by policies and facilities, depicted by (Table 1).

Study results showed that budget was the most important factor for R&I capacity building (65.4 %) as it affected R&I directly. Respondents in category R have a strong supporting opinion on this factor, followed by category A and D, accordingly. Another important factor for R&I capacity building was policies (46.2 %) both at the national and University levels. Respondents in category R have a strong supporting opinion of this factor due to the fact that policies in these levels will help to support further development in R&I. Facilities (IT equipment and other equipment) were also factors that the respondents have mentioned (38.5 %), particularly by respondents in category A.

Table 1. Factors related to R&I capacity building in the university

Factor	Category			Total	Percentage
	D	A	R		
Budget	2	7	8	17	65.4
Policies	3	3	6	12	46.2
Facilities	2	7	1	10	38.5
Skills	-	3	3	6	23.1
personnel	2	1	2	5	19.2
Knowledge	-	2	2	4	15.4
Networking	-	2	2	4	15.4
Environment	1	2	-	3	11.5
Self-motivation	-	1	1	2	7.7
Research Integration	1	-	1	2	7.7
English skill	1	-	-	1	3.8
Publication	1	-	-	1	3.8
Mentor	-	1	-	1	3.8

Source: Own Source

Apart from the three most important factors mentioned above, there were also other factors. These included: 1) skills – 23.1 % of all the respondents mentioned this factor, particularly among respondents in categories A and R; 2) personnel – 19.2 % of all the respondents mentioned this factor, particularly in respondents of categories D and R. Most of them said that personnel who were efficient and well-prepared for R&I were important for R&I capacity building; 3) knowledge – 15.4 % of all the respondents mentioned this factor. This percentage was from respondents in group A and R, they thought that the knowledge of staff was important for R&I capacity building; 4) networking – 15.4 % of all the respondents mentioned this factor. The respondents thought that these networking included personal, university, national and international networking; 5) environment – 11.5 % of all the respondents (categories D and A in particular) mentioned this factor. This included the working environment and workplace environment; 6) self-motivation and research integration – these two factors were mentioned by 7.7 % each. Respondents thought that staff/researchers should have self-motivation themselves in building capacity for R&I. Research integration means several sub-fields or sciences should be integrated with one another for specific research issues; and 6) English skills, publication and mentor - these three factors were mentioned by 3.8 % for each factor.

Overall, the respondents suggested that the most important factors required for R&I were budget, followed by policies and facilities,

respectively. Other factors such as skills, personnel, networking (at personal, university, national and international levels) and environment were also mentioned by respondents. Although research budget was one of the main research strategies of the university, the results reflected that these factors should be further developed or improved.

4.1.2 Policies to promote R&I

Questions related to policies to promote R&I in the university included availability, accessibility, adequacy and timeliness of policies.

1) The availability of the policies

Most of the respondents (42.3 %) thought that the government and higher education institutions already have clear policies to promote R&I. This can be seen from funding channels such as the National Research Council of Thailand and the Thailand Research Fund, but did not really cover much of the disaster resilience related research. Such funding would sometimes give funding when disasters existed or happened which had affected the continuity of research development in disaster resilience in a long term. In addition, there was inequality among the support to Health Science, Technology Science, and Social Sciences research. About 23.1 % held that to some extent, the HEIs had policies, and 23.1 % thought that HEIs did not have a policy to promote R&I.

2) Accessibility of policies

Although most of the respondents thought that policies were available, almost half of them (46.2 %) thought that policies were accessible only to some extent and the same proportion (46.2 %) thought that policies were not easily accessible at all. Only 3.8 % thought that policies were easily accessible and another 3.8 % did not express an opinion about this issue. Most of the respondents thought that because the government had no clear policies, particularly on disaster resilience related-issues, it affected the policies of the university.

3) Adequacy of the policies

Most of the respondents (65.4 %) thought that the policies were not adequate. Therefore, other supporting factors such as funding and facilities were also not adequate. Only 11.5 % of the respondents thought that policies were adequate while 7.7 % of the respondents thought that they were adequate to some extent. Another 15.4 % did not give an answer on this issue.

4) Timeliness of the policies

Almost half of the respondents (46.2 %) thought that the policies were not up-to-date. However, they thought that it was up to the research interests of each staff/researcher whether it went in the same direction of the policies of the government and HEIs or not. About 30.8 % thought that the policies were up-to-date, to some extent, particularly in emergency problem-solving policies related to disasters. About 23.1 % of respondents did not give answer on this issue.

Results on policies to promote R&I showed that less than half of the respondents found that HEIs have clear policies to promote R&I through the funding of research agencies like National Research Council of Thailand and Thailand Research Fund, although the policies on disaster resilience research is not quite clear. However, among this group, half of them agreed that policies were accessible to some extent and another half agreed that there were not easily accessible. Moreover, majority of respondents agreed that polices were not adequate and not up-to-date.

However, one of the strategic plans of the University was to support R&I and aimed at research excellence. The indicators for this plan included the number of published research papers, the number of cited research papers, the number of R&I projects that have social and economic benefit, economic value added and the number of communities that have been supported by the area based and/or topic-based research. Results from this section indicated that R&I policy and strategy of the university plan had not been widely recognized, neither by its academic nor research staff members.

4.1.3 Available research infrastructure

The availability of research infrastructure discussed here will be divided into 1) facilities and related services, 2) human resources (academic), 3) human resource (administrative), and 4) funding.

1) Facilities and related services

About 40 % of all respondents, particularly respondents in categories A and R, thought that there were not enough facilities related to services, 32 % thought that it was enough and 28 % thought it was enough to some extent. It should be noted that 80 % of the respondents in category D thought that the facilities and related services including ICT (Information and Communications Technology) were enough.

2) Human resources (academic)

Half of the respondents (50 %) thought that human resources (academic) was enough, most of the academic staff have the knowledge and ability to develop their own potential according to specialization and interests. However, 37.5 % of respondents thought that academic staff who were specialized in disaster resilience are not enough because disaster-related R&I need to have integration of knowledge. Therefore, academic staff from several fields were needed. Another 12.5 % of respondents said the academic staff was enough to some extent, but not enough for problem-solving in current disaster situation.

3) Human resources (administrative)

Most of the respondents (57.1 %) believed that human resources (administrative) is not enough. Some of them thought that most in the administration did not have a research vision and therefore, do not see the importance of R&I as much as it should be including the initiative of policies that were related to research support. Another 23.8 % thought that the administrative was enough, to some extent, while only 19.1 % thought that it was enough.

4) Funding

Most of the respondents (79.2 %) said that funding was insufficient, particularly funding within the University. There was a limitation in supporting funds available to new researchers in the sense that they had less research experience. On the other hand, the amount of supporting funds available to the senior researchers was not enough and most senior researchers had to look for funding outside the University. About 12.5 % said that the funding was enough, to some extent, and only in some research areas. Only 8.3 % said that the funding was enough, most of the respondents in this group was in category R.

In sum, majority of the respondents strongly agreed that the research infrastructure have to be improved, particularly the research funding within the University, followed by human resources (administrative) and research facilities. Although half of the respondents mentioned that human resources (academic) was enough in general, the University had only a few academic staff who were specialized in DI related research. Results from this section indicated that the university research strategic plan in reforming the overall research management has to be further enhanced.

4.2 Enablers that support R&I

When questioned about the enablers that can enhance R&I capacity in the university, majority of the respondents mentioned, equally (57.7%) for each factor, two factors namely policy and skills. Table 4 presents the enablers that support R&I.

As shown in Table 2, policy has been mentioned most as the factor that supports R&I. These policies were: firstly, the specific and prioritized research topics/issues that the university should focus upon so that staff from several disciplines could use their knowledge and specialization to integrate knowledge so that research results could actually give some benefits and help solve problems of communities. Secondly, the university policy should give equality to research in Science and Social Sciences. Currently, majority of grants and other support were mainly for Science (Health Science and Technology Science) research. Thirdly, the university policy should aim to combine

research and teaching, either by encouraging staff to do research so that the research could be combined with the teaching.

There were also the same proportion of respondents (57.7 %) who thought that skills and knowledge management of the academic staff and research staff should be enhanced. This could be done by short course training, or, most importantly, skill transfer from senior staff to the young staff. As mentioned by one of the respondents,

> "…*skills and experiences of the senior researchers are very important for the enhancement of R&I capacity in our University, therefore the mentor system in the research project would help a lot for young staff to learn from the senior ones*…" (University Director, May 2016)

In addition, knowledge in research and research project management was also important for research capacity.

Table 2. Enablers that support R&I in HEIs by each category

Enablers	Which category mentioned the particular enabler			Frequency of mentions	Percentage
	D	A	R		
Policy	3	5	7	15	57.7
Skills	2	6	7	15	57.7
Researchers/resources	3	3	4	10	38.5
Grant	2	3	2	7	26.9
IT facility	-	2	1	3	11.5
Financial personal	-	1	-	1	3.8

Source: Own Source

The second most mentioned factor that supports R&I was researchers and resources (38.5 %). It was important for the university to balance the load for teaching and research. Most respondents found that the teaching load as well as other related-teaching load (i.e., prepare documents/annual reports for quality assessment) had lessened time to do research, particularly those of a satisfactory quality. It is also important to note that the university should increase foreign/international researchers. For the resources, most respondents found that if there were enough research-related resources, R&I at the university would improve significantly.

About 27 % of respondents said that grants for research was important for the R&I capacity, particularly grants to purchase research

equipment and also grant management in terms of the appropriate payment for researchers and research staff. About 12 % mentioned about the IT facility stating that the Wi-Fi signals should be improved in some places and should cover the entire university. In addition, only 4 % mentioned about the importance of financial personnel that would help to improve the R&I capacity at the University.

Results suggested that both policy and skills were the main enablers that support R&I in the university. The most important policy issues raised by the respondents were research integration across different fields and equality between science and social sciences research support. Moreover, skills and knowledge management of the staff should be enhanced, and skill transfer from senior to young staff should also be facilitated. Although it had been mentioned in the university plan that it would give continued support to retired staff, it has to facilitate more in knowledge/skill transfer from the senior to young staff.

4.3 Barriers that hinder R&I

Most of the respondents found that there were many barriers that hinder R&I in the University. There are as follows:

1) *Unclear/discontinued/inadequate policies as well as the unequal access to policy between different disciplines (such as science and social sciences)*

Most of the respondents (54 %) thought that policy was the most important barrier that hinders R&I in the university. This included policy and strategy that focused on certain/important and interesting issues and that the university should take responsibility to use knowledge and expertise to help in serving the community and society. As a norm, each researcher would seek their own grant from outside sources, both at national and international levels. The university only supports research grants each year for young and mid-career academic staff (with a limited numbers), and research that help to serve the surrounding communities and the most-needed districts in Chiang Mai.

2) Lack of budget for research equipment and facilities

According to the government's regulations, funding from the government agencies did not include equipment, especially big equipment. Therefore, lack of research equipment became a big barrier to R&I capacity of the university. Moreover, there was no database about equipment at the faculty or university level. Therefore, many researchers did not know exactly whether there were equipment they needed for their research within the faculty or the university. As one of the respondents said:

"*…I didn't realise if there is any equipment I want to use for my research within the faculty or the University. As the equipment is expensive and cannot use a grant budget to buy, I have to find all over the country… before. I later realised that the staff next room has it!*" (Academic staff, May 2016)

3) Work burden of the researchers (academic staff)

The work load for academic staff at the University has to cover 4 main tasks, including teaching (18 hours per week), student's development, academic services, and socio-cultural activities. Moreover, many academic staff are also apart of the programme committee that routinely conducts meetings, and prepares documents for quality assessment. Therefore, many academic staff found that with this work burden, they have less time to do a good quality research.

4) Lack of funding

There was limited funding for research projects at the university level. For the national level, it has a very high competition. Moreover, at the national level, research issues were fixed and sometimes did not cover the research interests of some of the staff. In addition, funding aimed to go for scientific rather than social sciences research.

5) Lack of research skills

Many respondents found that their research skills had not been improved as they did not have the opportunity to go for training. This was because most research skill training fees were expensive and they have no funding to attend, let alone the travel cost as most of them take place in Bangkok. However, this reason varied from faculty to faculty.

Apart from the above barriers, there were also other barriers. These included insufficient databases, lack of research networking, lack of integration between disciplines, lack of awareness for R&I initiatives, lack of access to mentor system, lack of researchers in the field of disaster risk reduction, and lack of skills in project management such as writing progress report, financial matters and management.

Results from the online survey which had been carried out among 65 university professors, lecturers, research assistants, and research fellows who had been involved in disaster resilience research and innovation showed that there were many barriers that hinder research and innovation in the university. Over 60 % agreed and strongly agreed that there was a lack of access to facilities such as journals and libraries (65.2 %), lack of peer mentoring and support (64.8 %), and lack of support from the administrative staff (60.2 %). While half of the respondents (51 %) agreed and strongly agreed about the lack of sharing resources and inadequate infrastructure to carry out R&I activities, almost half of the respondents agreed and strongly agreed about lack of resources such as tools, laboratories, and equipment, lack of staff, lack of technical assistance for methodology/experimental design/data analysis, lack of funding, and lack of motivation to carry out R&I activities.

Findings from the interviews and online surveying suggested that there were many barriers that hinder R&I at the university, particularly in research supporting mechanism from policies, funding, facilities and equipment. Although the speciality and expertise of academic staff and researchers were not the main problem for this research university, this study has pointed out that the supporting scientific and non-scientific skills of academic staff and researchers were still very important and are needed, for knowledge integration between disciplines in particular.

4.4 Suggestions to improve R&I

Most of the respondents (65.4 % of all the respondents) thought that the university policy was an important factor to improve R&I. Among these respondents, there were 8 respondents in category A, 8 respondents in category R, and 1 respondent in category D. They suggested that the University should have an explicit policy for budget

and resource allocation. As a research university, it should have clear and accessible policy in research and build a research culture/environment within the organisation, with equity in all disciplines.

The second factor that has been suggested by respondents was the researchers' network and the provision of skills acquisition (8 respondents or 30.8 % of all the respondents for each factor). For the respondents who suggested about researchers' network, 2 of them were from category D, 2 of them were from category A, and 4 of them were from category R. They suggested that the university should improve the network between the researchers, particularly at the international level. Among respondents who suggested about the provision of skills acquisition, 4 of them were from category A, and 4 of them were from category R. They suggested that a mixed research method, particularly software training, should be introduced to the staff and students and that would help to improve R&I in the university.

The third factor that has been suggested by respondents is tools and resources (5 respondents or 19.2 % of all the respondents for each factor). Among the respondents who suggested about tools, 1 of them was from category D, 1 of them was from category A, and 3 of them were from category R. They suggested that the university should help (by providing budget) or allow researchers to buy equipment and hardware. Among respondents who suggested about the resources, 1 of them was from category D, 2 of them were from category A, and 2 of them were from category R. They suggested that the university should help and support human resources that were related to research projects, financial officers and administrative officers should understand and support research projects.

Another factor suggested by 4 of the respondents (15.4 % of all the respondents); 1 respondent from category D, 2 respondents from category A, and 1 respondent from category R, was the need for multi-disciplinary research. They thought that if the University supports academic and research staff from several disciplines to do a research projects together, it would help to improve R&I in the university. This has been strongly suggested by one of the academic staff:

"…I think multi-disciplinary is very important especially for a research that help to solve community problem. However, the University has failed to put together the researchers from several fields and work closely together in one research project. It's not that they haven't got any multi-disciplinary project….they have, but it didn't actually work…the work is like a layer…" (Academic staff, May 2016)

Other factors that have been suggested by the respondents are databases, research budgets, and work burden (3 respondents or 11.5% of all the respondents for each factor). For the respondents who suggested about the database, all of them are from category R. They opined that the database for research (researchers, field of interest, tools and equipment) was very important and would help to improve R&I in the university. For the respondents who suggested about research budgets, all of them were from category A. They stated that the university should provide more research funding to all levels of academic staff and researchers, with equity to every field (particularly between science and social sciences). All respondents who suggested about the work burden are from category A. This reflects that the academic staff thought that they had several works to do at the same time, and reducing the teaching load would help them to have more time to do research.

Other factors suggested by respondents (less than 10 % of the respondents for each factor) included networking for equipment use, the state/national policy, promotion and clear career path for research staff, research environment, support to the staff involved in DI, international policy, mentor system, and classification of researchers' expertise.

The study results showed that the most important factors suggested by respondents to improve R&I were the University's research policy, followed by the researchers' network and the provision of skills acquisition, tools and human resources, multi-disciplinary research, database, research budgets, and work burden of the academic staff, respectively. More importantly, communication between university policy makers and its academic and research staff needs to be enhanced.

5. Conclusion

Although this particular university is a research university and efforts have been made to facilitate its staff to do research, the respondents have raised many barriers that hinder R&I. The university has to focus more on its research policy in terms of its accessibility, adequacy, continuity, and equality. Moreover, a budget should be provided specially to cover expenses of research equipment. Most of the academic staff respondents felt that their heavy teaching load had affected time needed to do research. Therefore, the overall policy related to research, teaching, academic and community services should be well balanced.

The university's research policy is definitely the most important factor to improve R&I. The university should have a policy that is accessible, adequate, continuous, and equal for both academic and research staff in all disciplines. Moreover, it should create a research integration community and improve the research environment within the university as well as research networks at local, regional, national and international levels.

The study results have indicated that research strategies of the university in its recent plans have facilitated R&I to a certain level over the past few years. However, some strategies have not been widely recognized, at least by the academic and research staff in this study. Therefore, communication and information within the university should be further enhanced.

In addition, it should be noted that the university's current plan has focussed on R&I integration, as suggested by this study, and integrates research for systematic and efficient learning/teaching development. Since 2016, the government has restructured the roles of national research organisations and established the National Research and Innovation Policy Council (NRIC) which aims to determine the unity of research policies and strategies and foster important and urgent R&I. This organization could also authorize a holistic budget allocation plan for tertiary education, research, and innovation of the Country (Thai Royal Gazette, 2016). By 2019, the Ministry of Tertiary Education, Sciences, Research, and Innovation will be established to integrate

teaching, research, and innovation in science, technology, and other disciplines following Thailand 4.0 policy which focuses on producing new knowledge and innovation to progressively develop national competitiveness and quality of life of the population and society (National Legislative Assembly, 2017). In the near future, all public funding for research and innovation must be endorsed by the National Science, Research, and Innovation Promotion Fund before distributed through various government agencies and researchers in universities, research institutes, government bodies, and in the private sector depending on specialization. Even though it seems to be an advantage for a more explicit R&I policy and direction, skepticism in balancing and integrating interdisciplinary research and equity across knowledge arenas still becomes obvious.

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Effect of global warming on dry mass loss of paddy stored in gunny bags

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Abstract

The objective of this study was to assess the dry mass loss (DML) of paddy stored in gunny bags at different temperatures in simulation with global warming and to suggest adaptation techniques for minimizing DML. Five kilograms of paddy were packed in gunny bags and stored in temperature-controlled chambers for 6 months. Results revealed that the DML of raw paddy was increased with the elevated storage temperature and it can be expressed by a multiple regression equation. It could be recommended that varietal selection and parboiling are best practices when storing paddy to cope with global warming.

Keywords:

Dry Mass Loss; Global Warming; Respiration; Storing Paddy; Temperature

1. Introduction

Global warming has become a major concern in the world today. Increasing temperature is the instant and most obvious effect of global warming. A scenario of comparatively high greenhouse gas emissions called RCP 8.5 predicted that global mean surface temperature will increase from 2.6 to 4.8°C by the end of the 21st century (IPCC, 2014). Similarly, analysis of data on temperature from 1961 to 1990, has revealed that mean temperature in Sri Lanka may rise by approximately 0.9 - 4°C by the year 2100 (Eriyagama, Smakhtin, Chandrapala, & Fernando, 2010). Consequently, many problems will have to be faced by the global community such as rising sea levels, altering local climatic conditions, affecting forests, crop yields and water supplies. However, global warming will continue to exert its influence not only on crop production, but also on the increasingly valuable harvested commodity and post-harvest activities (Stathers, Lamboll, & Mvumi, 2013).

Recorded average day time maximum temperature of countries in the tropical belt area is around 32°C and may exceed to 35ºC (OneStat.com, n.d). Rice is the major crop which can be influenced by elevated temperature in this area. Therefore, production of rice will be a challenging issue in rice-growing areas. Quality degradation and reduction of paddy yield within the period from planting to harvesting are major issues that have faced due to high ambient temperature (Peng et al., 2004). Besides the yield, rising temperature can be a huge economic threat even on post-harvest operations including harvesting, drying, processing, pest and disease management, packaging and storage (Stathers et al., 2013). Among the different post-harvest activities, rising temperature can cause detrimental effects during storage because storing paddy appropriately for a long time is of urgent need. For instance, Sri Lankan farmers tend to stock about 50% of harvested paddy for their consumption, seeds and future sale for a period of 6-12 months (Stathers et al., 2013).

One of the prominent issues on harvested commodities in many developing countries is deterioration of food sources due to hot and humid climates (Faure, 1987). It was revealed that storage temperature is closely related to changes in quality and mass loss of paddy, the higher the temperature, the faster the deterioration, the faster the

decline of vitality and shorter safe storage period (Gao et al., 1999). Global warming and increment of corresponding temperature affects respiration of harvested foods. Since structural carbohydrates of foods combust in the respiration process, dry mass loss (DML) can occur with quality degradation of harvested foods. Therefore, respiration is the main process to be controlled after crops have been harvested. It was found that respiration rate increases with temperature up to a certain point and then begins to decline. For an example, as an indicator of DML, soluble sugar content of corn stored at 45°C over a six-month period decreased until its moisture content was 20.4% (Rehman, Habib & Zafar, 2002). In perishables, rate of deterioration increases by 2 or 3-fold for each increase of 10˚C above optimum (Kader, 2002). Similarly, as durables, corn stored at 10°C to 30°C with 14 to 22% moisture, showed around doubled respiration rate with each 10°C increase in temperature. (Huang, Danao, Rausch, & Singh, 2013). However, post-harvest physiologists and food scientists have restricted alternatives that interfere with the respiratory process, since majority of them depend on specific characteristics of harvested commodities (Moretti, Mattos, Calbo, & Sargent, 2010).

2. The object of the study

Although there are numerous evidences to prove the negative effects of increasing temperature on paddy yield, a little is recorded about its effects on stored paddy. Moreover, as storage temperatures of paddy depend on the influence of external factors such as radiation, conduction and convection depending upon the climactic condition (Chidan & Shanmugasundaram, 2016), understanding the effect of global warming on quality deterioration of stored paddy is vitally important. Therefore, the main objectives of this study were to assess the DML of paddy stored in gunny bags at different temperatures in line with global warming and to identify adaptation techniques for minimizing DML of paddy at storage.

3. Methods

3.1 Fabrication of temperature controlling device

Four wooden chambers were fabricated as storage structures under controlled conditions of temperature. Selected temperature levels for

the study were 26°C, 30°C, 34°C and 38°C. The most appropriate distances to keep paddy bags in chambers were observed by changing the distances of upper most shelves and making holes at the bottom. These chambers were equipped with bulbs (100W) to supply heat energy and an electric sensor board was developed to maintain the stipulated temperature consistently. The Arduino Micro controller system was equipped using DHT 11 temperature and relative humidity sensors to record temperature and relative humidity data inside and outside the chambers during the experiment.

3.2 Sample preparation

The study was conducted at Faculty of Agriculture, University of Ruhuna, Sri Lanka. AT-362 (an improved paddy variety) and Kuruluthuda (a traditional paddy variety) were selected for the experiment considering the abundance in the designated experimental area. Two hundred and forty kilograms of fresh paddy harvested in the Maha season (2016/2017) were collected, cleaned and dried to get 14% of the moisture content as this moisture content assured safe storage for a long period. Half of the paddy was parboiled using the IPHT parboiling process (IPHT, n.d.). Then the paddy was disinfected using chloroform (CHCl3) vapour for 12 h in a gastight chamber to avoid the attack of possible pests and microbes during the storage period (Prasantha, Hafeel, Wimalasiri, & Pathirana, 2014).

3.3 Storing paddy

About 50 ml of Phirimiphos methyl (500g/L EC) was dissolved in 4.5L of water and the prepared solution was sprayed on packing materials (IPHT, n.d.). Five Kilograms of paddy were packed in prepared gunny bags to build a sample unit. The length and width of a bag was 0.45m and 0.3m respectively. Gunny bags were closed with 5 mm wide PVC cable connectors. Packed paddy was stored under 4 different temperatures, namely 26°C, 30°C, 34°C and 38°C for 6 months.

3.4 Experimental Design

The study was conducted according to the split-split plot design while replicating all treatment thrice. The variety is the main plot factor with 2 levels (AT-362, Kuruluthuda), the processing technique is the sub plot

factor with 2 levels (raw, parboiled) and temperature is the sub-sub plot factor with 4 levels (26, 30, 34 and 38°C).

3.5 Data collection

Samples were drawn at 4-week intervals for a period of 6 months and subjected to determine moisture content and 1000 grain weight, as these two parameters are important to calculate dry mass loss of grains against the period of storage and stored temperature. Dry mass loss was calculated using equation 3.1 (Gao et al., 1999).

$$L(\%) = \frac{[G_1 (1- W_1) - G_2 (1- W_2)]}{G_1 (1- W_1)} \times 100\% \quad \text{Eq.1}$$

Where: L = mass loss rate (dry- basis)
G_1 = Initial 1000 grain weight (g);
G_2 = 1000 gram weight after storage (g);
W_1 = Initial grain moisture content of the sample (%);
W_2 = The grain moisture content in the sack after storage (%)

3.6 Data analysis

All the analyses were performed in triplicates and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by analysis of variance (ANOVA) followed by LSD tests using statistical analysis System (SAS). The level of significance was considered at $P < 0.05$. Furthermore, multiple regression analysis was conducted to develop equations.

4. Results and Discussion

4.1 Changes in DML of raw paddy

Results revealed that DML depends on the combined effects of levels of all 3 factors rather than that of their individual effects, because 3 factor interaction was significant in the third ($F_{3,24}=3.97$, $P<0.05$), fourth ($F_{3,24}=3.2$, $P<0.05$) fifth ($F_{3,24}=5.44$, $P<0.05$) and sixth month ($F_{3,24}=3.03$, $P<0.05$). As shown in Figure 4.1, the rate of DML steadily increases with time for both paddy varieties. A positive correlation between storage time and DML of raw paddy ($r=0.76$; $P<0.05$) was found for a period of six months. The highest DML was shown by the raw AT-362 variety (2.27 ± 0.156%) when stored at 38°C after 6

months. The lowest DML occurred at 26°C after a month in both paddy varieties.

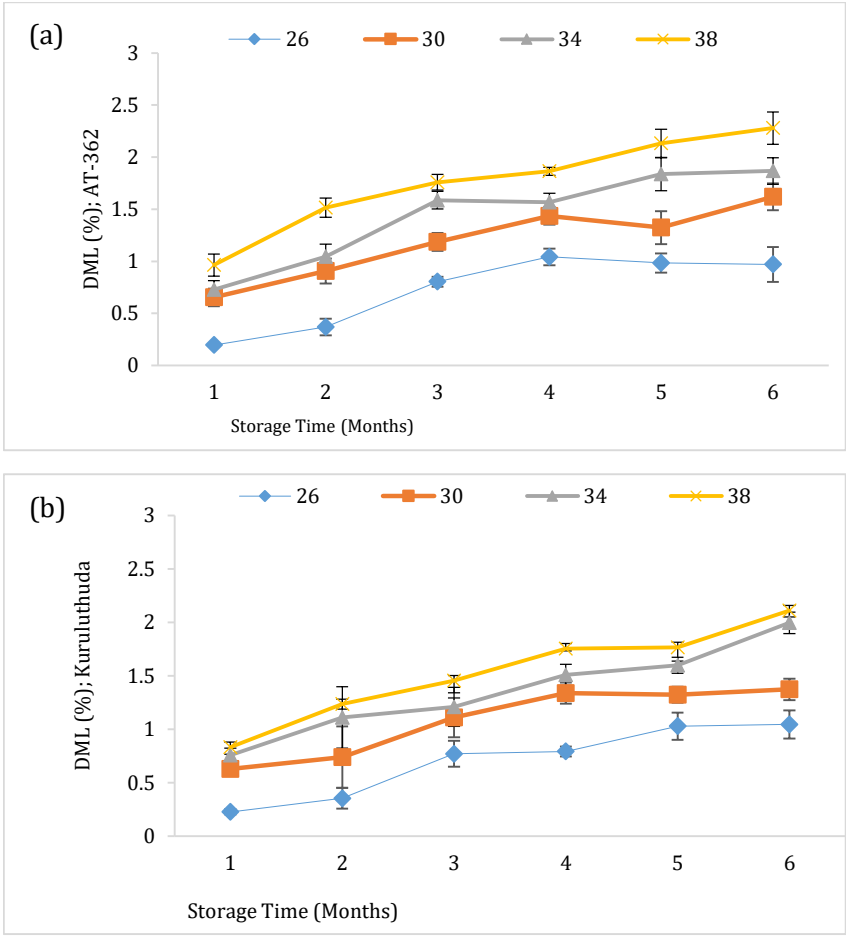

Figure 1. *Changes in DML rate of raw paddy (a) AT-362 and (b) Kuruluthuda stored at 4 temperature levels for 6 months*

The DML was significantly higher ($P< 0.05$) at 38°C compared to the DML at 26°C during the six-month period of storage in both varieties. Similarly, Navaratne et al. (Navaratne & Anjalo, 2013) studied the effects of temperature on DML of paddy, green gram corn and cowpea.

They reported that DML of grains stored at higher temperature (>35°C) for 4 months was higher due to the rapid rate of respiration and it was vice versa when grains were stored at low temperatures, preferably less than 30°C. Furthermore, when storage temperature increased from 26°C to 38°C (by 12°C), the rate of DML was more than double for both types of paddy varieties until the 3rd month of the storage period. Previous studies support this phenomenon as corn stored at 10°C and 30°C with 14% to 22% moisture contents, the rate of respiration was doubled with the increment of temperature by 10°C (Huang, Danao, Rausch, & Singh, 2013).

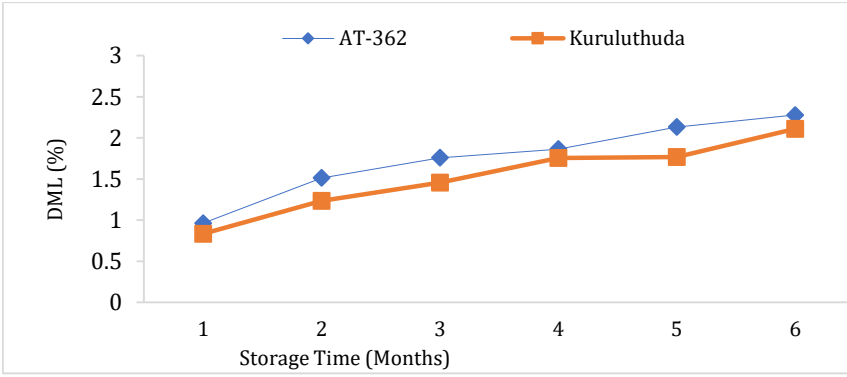

Figure 2. *Changes in DML of raw paddy stored at 38ºC for 6 months*

This research study indicated that AT-362 has a higher DML than Kuruluthuda in raw during storage as indicated in Figure 4.2. This is most probably due to the thickness variation of paddy husk in two paddy varieties. Paddy husk is an excellent insulating material, which can prevent heat flow by conserving energy flow through the gain to loss (Jamil & Bejo, 2014). Sreenarayanan, & Chattopadya, 1986, found that paddy husk can be used as a heat resistant material by using the transient heat flow method. Furthermore, thermal resistance value can be increased with the thickness of the insulating material (Shawyer, & Pizzali, 2003). This study estimated that thickness of husk in Kuruluthuda (0.2 mm) is higher than AT-362 (0.1 mm). Therefore, Kuruluthuda has a high thermal resistance and as a result it may show less dry mass loss compared to AT-362 stored at the same temperature.

4.2 Changes in DML of parboiled paddy

Dry mass loss of parboiled paddy ranged from 0.019±0.003 to 0.084±0.009 for AT-362 and 0.028±0.017 to 0.081±0.010 for Kuruluthuda. The results further revealed that DML of parboiled paddy of both varieties was remarkably lower than ($P<0.05$) that of raw paddy stored at 4 different temperature levels each month. The low DML in parboiled paddy may be due to destroying and conversion of enzymes present in the rice to an inactive form as a result of heat applied during steaming in the parboiling process (Xavier, & Raj, 1995). Therefore, most biological processes, such as germination, respiration, and any other form of biological activities do not occur in parboiled rice. In this study, low DML of parboiled paddy may be strengthened by the fact that their maximum allowable storage time would be more than 6 months. However, no significant difference was found between raw and parboiled paddy on both varieties stored at 26ºC during the first 2-3 months. This may be due to low DML at low temperatures in raw paddy varieties during the early period of storage (Gao et al., 1999), which was almost close to a low rate of DML in parboiled rice

4.3 Determination of maximum allowable storage time in terms of DML

Teter, 1981, suggested that the deterioration of paddy in terms of DML should not exceed 0.8% at the end of the storage period. Furthermore, according to the grading system developed by Sukabdi, 1979, when the rice lost approximately 0.75% dry matter; it can be graded in to U.S No 2. Therefore, maximum allowable storage time was determined by estimating the storage time that required 0.8% of dry matter to be lost during the storage period by this study.

The maximum allowable time for raw paddy stored in gunny bags at different temperature levels are presented in Table 4.1. The longest maximum allowable storage time (120 days) was recorded by raw Kuruluthuda stored at 26°C. Thus, when the storage temperature is increasing, maximum allowable storage time required to lose 0.8% dry matter in raw paddy reciprocally decreases due to increasing respiration rate. Similar findings have been reported by Mutters and Thompson, 2009, who projected that paddy /rice stored at 20°C, 25°C, and 30°C temperatures with 16% initial moisture content would lose 0.5% of its dry matter weight during 13, 5, 1.7 months respectively.

However, similar maximum allowable storage time (40 days) were recorded at 29.5°C and 35°C to lose 0.5% dry matter of paddy with 15% of initial moisture content (Sukabdi, 1979). DML of parboiled paddy were less than 0.8% DML respectively in this study. Therefore, maximum allowable storage time for parboiled paddy would be more than 6 months irrespective of temperature increment.

Table 1. Maximum allowable time of raw paddy stored in gunny bags at different temperature levels

Temperature (ºC)	Maximum allowable storage time (Days)	
	AT-362	Kuruluthuda
26	115	120
30	69	63
34	60	40
38	42	38

4.4 Development of equation to determine the dry mass loss

Equations were developed using multiple linear regression to quantify the DML of two paddy varieties in raw form because there were no correlations in the DML of parboiled paddy. Results revealed that there is a strong positive co-relationship ($p<0.05$, R-Sq = 88.0%) between dry mass loss of raw paddy against 3 variables such as stored temperature, storage time and variety as shown in equation 2. Equations 3 and 4 impart the quantification of DML loss of AT-362 variety ($p<0.05$; R-Sq = 87.2%) and Kuruluthuda variety ($p<0.05$; R-Sq = 89.8%) respectively.

$$DML = - 2.02 + 0.0834\ T + 0.203\ S - 0.107\ V \quad \text{Eq.2}$$

$$DML = -2.37 + 0.0906\ T + 0.206\ S \quad \text{Eq.3}$$

$$DML = - 1.99 + 0.0761\ T + 0.200\ S \quad \text{Eq.4}$$

T = Storage temperature (°C), S = Period of storage (month), V=Paddy Variety (0 for improved/At 362 variety, 1 for traditional/Kuruluthuda variety)

5. Conclusion

The studied high temperature profiles that simulate the upcoming global warming scenarios have adversely affected the quality of stored paddy by means of dry mass losses. Dry mass loss was nearly doubled when storage temperatures is increased from 26°C to 38°C in raw

paddy. Therefore, maximum allowable storage time of paddy decreased drastically with the increment of temperature. The changes of DML in stored raw paddy can be measured using a developed equation as a function of temperature, variety and time. However, DML of parboiled paddy appears to be significantly lower than raw paddy in both varieties at 30°C, 34°C and 38°C. Since raw Kuruluthuda paddy variety showed lower DML than AT-362, selecting appropriate paddy varieties or genetically transforming the properties is the subsequent option available for mitigating the impacts. However, as traditional varieties give low productivities, the practically viable option would be parboiling as an adaptation technique for global warming.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

Emergency food from rice related composite flour with functional ingredients for disaster resilience

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Abstract

This study is based on developing safe and secure, nutritious rice related emergency food with improved structural properties for disaster resilience. Therein, baked crumb slices can be prepared by fermenting and gelatinizing dough under 1 $kgcm^{-3}$ initial air pressure, followed by slicing and baking to obtain a well porous, crunchy and low moisture product with a stable and less breakable structure using rice related composite flour from locally available food sources.

***Key words*:**

Bakery Product; Disaster Situations; Emergency Food; Food Safety and Security; Rice Flour

1. Introduction

A Disaster is defined by WHO/EHA (2002) as: "an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community" (p. 3). Disasters can be induced both naturally and due to human activities. The most frequent natural disasters include floods, landslides, droughts and cyclones (Sri Lanka National Report on Disaster Risk, Poverty and Human Development Relationship, 2009). Industrial accidents, terrorism and cyber-attacks can be identified as the most common man made and technological disasters.

Due to natural disasters, food in affected areas can easily get contaminated leading to a mass outbreak of food borne illnesses including diarrhea, cholera, typhoid fever and hepatitis A (World Health Organization). These food safety risks occur mainly due to poor sanitary practices and unhygienic conditions during food processing, storage, distribution and consumption as well as lack of safe water in the affected areas. Hence, supplying secure food that fulfills the nutritional requirements of the affected communities is a significant challenge (Cooper, 2018).

The concept of resilience has been introduced to overcome such challenges (Tendall et al, 2015). Disaster resilience has been defined by the Department for International Development, United Kingdom (2011) as: "the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses such as earthquakes, drought or violent conflict without compromising long-term prospects" (p. 6). In the case of food, certain international organizations have become interested and worked towards introducing the concept of building resilient food systems for disaster situations. A food system that provides a reliable source of safe, nutritious and accessible food even in harsh conditions is called a resilient food system (Biehl, Buzogany, Baja and Neff, 2018), which is mainly focused on building resilient food production systems (mainly focusing on agriculturally resilient), resilient food supply systems (proper supply of secure, valued added food items) and socio-economic resilient (develop food policies and supply of foods from local sources) (Pacific Community, 2015).

Having a good storage of emergency food supply is an important part of disaster resilience. When a sudden disaster occurs, people get isolated due to loss of electricity and communication. An emergency food supply will then help in fulfilling dilatory requirements until recovery from the disaster or until outside help is offered. Simply, emergency food can be identified as food that are high in nutritional and calorie value (Texas A&M AgriLife Extension, 2004), that require no refrigeration, water or special preparation techniques (Texas A&M AgriLife Extension, 2004; The Federal Emergency Management Agency, 2004). These products should not be salty (because that can make the persons thirstier) (University of California, 2009) and should be properly packed in affordable sizes (small serving sizes) (University Of California, 2009; Texas A&M AgriLife Extension, 2004). Further, when planning an emergency food supply system, dilatory requirements, preferences and allergic responses of individuals should also be considered.

In the case of Sri Lanka, having an emergency food supply for disaster resilience is not very common. Hence, the government and institutions can organize different workshops to make the community aware of the importance of having a good storage of disaster resilience emergency foods and educate them to plan such systems.

Mostly at household level, it is recommended to have an emergency food storage for several days. Ready-to-eat canned foods (Ex: meats, fruits, vegetables) are the most recommended emergency food for disaster resilience. In addition, Smoked or dried meats (Ex: beef jerky), Canned, powdered or crystallized juices, Soups, Powdered or canned milk, Staples (Ex: sugar, salt, pepper), High energy foods (Ex: peanut butter, jelly, crackers, nuts, trail mix), Stress foods (Ex: sugar cookies, hard candy, sweetened cereals), Vitamins and other dilatory supplements, Pet food and Water (1 gallon of water per person per day) have also been claimed as emergency foods (University Of California, 2009; Texas A&M AgriLife Extension, 2004; The Federal Emergency Management Agency, 2004).

Product innovations and value additions can be conducted by introducing new products, processing methods or improving the properties of existing products for the purpose of making them ideal for different conditions and/or for a certain group of consumers. As an

example, according to the concepts of building resilient food supply system and building socio-economic resilient, ready to eat low moisture nutritious food products can be developed from locally available underutilized food sources using suitable processing conditions and packed in proper packaging material in affordable portions to store for a period of time without being subjected to spoilage or any quality deterioration to make them suitable for recommending as emergency foods for disaster resilience.

2. The objective of the study

This study is mainly focused on developing baked crumb slices with the application of pressurized conditions to obtain a low moisture product with a well-developed porous crumb structure from rice related composite flour that is easy to handle during storage, transportation and distribution. Further, this study is focused on enhancing the nutritional and functional properties of the developed product for the purpose of introducing a safe and nutritious emergency food for disaster resilience.

3. Materials and Methods

3.1. Sample preparation

Dough was prepared by substituting wheat flour with 50% Rice flour into 100% flour basis according to the straight dough method and approximately 20±0.05g dough portions were loaded into cylindrical containers. Thereafter, the dough samples were subject to fermentation followed by gelatinization at 1kg/cm^2 initial pressure conditions in a closed chamber. The gelatinized crumb samples were cut into slices of 3±0.5mm and baked at 170±1^{o}C for 40 minutes to obtain a crunchy product with moisture content between 1.2-1.6%.

3.2. Sensory evaluation

Sensory evaluation was conducted to evaluate the organoleptic properties of the baked crumb slices that have been developed under pressure (227), with respect to a control (127) (crumb sample prepared without pressure application) using a five-point hedonic scale with 30

panelists by considering five sensory attributes namely crumb appearance, aroma, texture, taste and overall acceptability.

3.3. Crumb Moisture content and storage stability

Baked crumb slices were packed in double lamination (PET(20 µm)/LLDPE (50 µm) packaging material and stored at room temperature conditions (30±1^{o}C, 68±5% RH) for six months and the moisture content of the baked crumb slices were determined using the AOAC official method 925.10 (Official Methods of Analysis of AOAC, 16th ed, 1999) at three months intervals.

3.4. Statistical analysis

The collected non-parametric data were analyzed by the Mann Whitney U test using Minitab 17 Statistical Software. All analyses were conducted at 95% confidence level. Graphical representations were done using Microsoft Excel 2013.

4. Results and Discussion

Figure 1 represents pictures of the baked crumb samples prepared under pressurized (study sample) and unpressurized conditions (control sample) whereas, figure 2 represents the web diagram for sensorial properties of the two samples according to the results obtained from statistical data analysis.

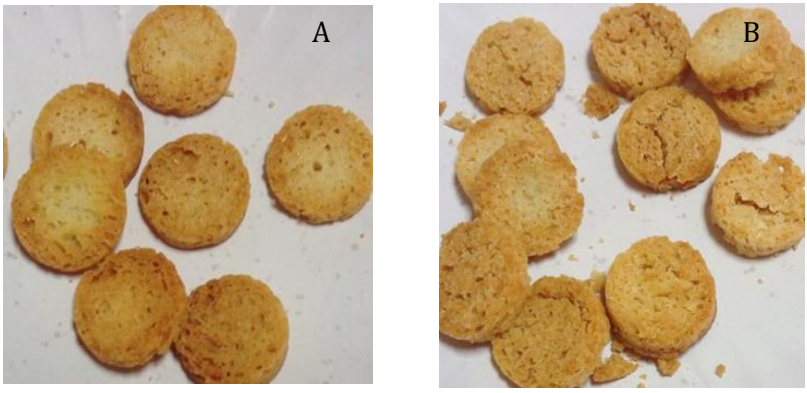

Figure 5. *Baked crumb slices, (A) Study sampple, (B) Control sample*

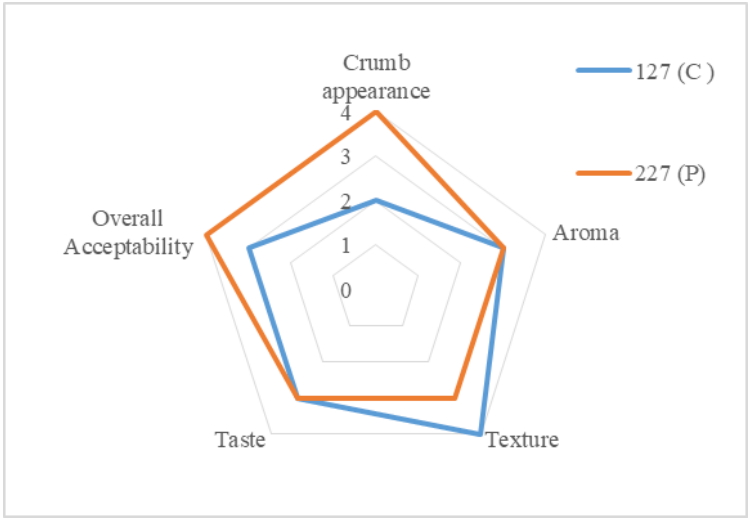

Figure 6. *Sensory evaluation of the two samples, 227 (P) Study sample, 127 (C) Control sample*

According to figure 2, the study sample (227) has better acceptance in terms of crumb appearance due to its uniform and well developed porous crumb structure. Since the study sample has a harder texture, it gained less preference for the texture parameter compared to the controlled group (127). Product aroma and taste represent the presence of different volatile and nonvolatile components. Aroma and taste of the two samples do not show any significant difference ($P \geq 0.05$). When considering the overall acceptability, the study sample has significantly higher ($P \leq 0.05$) preference than the controlled group. Hence it can be concluded that the baked rice crumbs developed under this study shows better consumer acceptance and perception (especially regarding the porous crumb structure) than the controlled sample prepared without the application of pressure (under normal atmospheric conditions).

Certain food additives such as food hydrocolloids/ gums (Ex: Hydroxypropylmethylcellulose, Xanthan gum), emulsifiers, enzymes (Ex: alpha-amylases from different origins such as cereal, fungal and bacterial) have been commonly applied by researchres to improve porous crumb stucture, to enhance crumb texture and to retard crumb staling (Rathnayake, Navaratne and Navaratne, 2018) specially in

developing gluten free bakery products. Hence, those food additives can also be tested with the pressurized product to further enhance the porous crumb structure as well as to reduce crumb hadness.

Table 1 shows the moisture content of the baked crumb slices (developed under pressurized conditions) at three month intervals. Development of well porous crumb structure can be beneficial as it can effectively remove moisture from the product to give a low moisture product. The initial moisture content of the product is 1.43 ± 0.22 %. Hence it can be considered as a low moisture product. Therefore, if packed in proper packaging material with higher barrier properties and stored in optimum conditions, low moisture products have a very low susceptibility of microbial spoilage (Morais et al., 2018) as well as due to the stable structure in pressurized product, it is more convenient for packaging, storage and handling.

Table 5. Moisture content of the product at three months intervals

Time	Moisture Content (%)
Initial	1.43 ± 0.22
After three months	3.78 ± 0.46
After Six months	6.40 ± 0.52

Certain cereal flour types such as Corn, Finger millet, Gram, Green gram as well as flour from certain yams and root crops such as Cassava, Purple yam, Sweet potato etc. can be incorporated into the composite flour mix by further reducing the wheat flour content. In addition, the product can be further improved with locally available under-utilized highly nutritious/functional food sources such as, dehydrated *Moringa olifera* leaves, dehydrated *Murraya koenigii* leaves, *Artocarpus heterophyllus* seed flour, soaked/germinated *Trigonella foenum-graecum* etc. A study conducted by Rathnayake and Navaratne (2017) proved that blanched dehydrated *Moringa olifera* leaves are a good source of protein and beta carotenes and incorporation of 5% blanched dehydrated *Moringa* leaves can improve the nutritional property of biscuits. Drisya, Swetha, Velu, Indrani and Singh (2015) have incorporated 0-15% dehydrated *Murraya koenigii* leaves powder into cookies and obtained that the content of protein, dietary fiber, iron, calcium and β-carotene as well as the radical scavenging activity has been increased with increasing amount of dehydrated *Murraya koenigii*

leaf powder. Further, they have proved that cookies incorporated with dehydrated *Murraya koenigii* leaves up to 10% received better consumer acceptance with respect to sensory evaluation. Wani and Kumar (2018) have described in a review article that the application of germinated *Trigonella foenum-graecum* up to about 10% can improve nutritional and functional properties of biscuits. Further they have mentioned that *Trigonella foenum-graecum* can perform lipid lowering activity and the intake of *Trigonella foenum-graecum* incorporated products can be beneficial for people suffering from iron deficiency anemia.

Finally, the nutritional, antioxidant and organoleptic properties as well as the microbial stability during storage can be determined for the finalized product. Since those low moisture baked crumb slices are ready to eat, are not salty, do not require any refrigerated storage conditions and can be consumed as a safe and nutritious product by consumers in any age, they can be ideal for recommendation as emergency foods for disaster resilience not only for Sri Lankans but also for the global consumers as well.

5. Conclusion

Fermentation and gelatinization under pressurized conditions have improved rice flour incorporation percentage to obtain a low moisture product with better crumb properties. Baked crumb slices can be further developed to a safe, secure, healthy and nutritious product that can be consumed conveniently as an emergency food in disaster situations.

Acknowledgement

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Future flood prediction with artificial neural network model from rainfall grid data at Bangrakam District, Thailand

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Abstract

Artificial neural network models have been widely used in the hydrological area to forecast flood but to predict future flood is very challenging due to the limitation of hydrological data. The main idea of this paper is to predict flood in the future (30 years: 2035-2064) from data in the past (1989-2009) with an artificial neural network model and input variables of this model is rainfall daily grid from the WRF-ECHAM-5 model. The WRF-ECHAM-5 model, which is a climate model, predicts rainfall data in the future. In order to find the most suitable model for flood prediction, three types of rainfall grid data (Moving average time step back-MAT, Moving window average-MWA and Moving window average time step back-MWT), three input determination techniques (Cross correlation-C, Stepwise regression-S and Genetic algorithms-G) and three number of hidden nodes (50%, 75% and 100%) are investigated. The results reveal that 2 models MAT_G_50 and MWT_S_75 are the most suitable and also that between the year 2035-2064, Bangrakam District would be flooded almost every year with the highest flood recording 8.37 meters in the year 2061 by model MAT_G_50 and 10.59 meters in the year 2041 by model MWT_S_75.

Keywords:
Bangrakam; Flood; Neural Network; Rainfall Grid; WRF-ECHAM5

1. Introduction

The keys of predicting flood are fast and accurate, so the Artificial Neural Network model (ANN) is the one that has the ability to process big data within a short time and learning from the past events for predicting future events. Usually the prediction of floods is done with ANN using runoff data from upper gauging stations (Nural et al., 2018) or rainfall data (Falah et al., 2019), however, these data are limited and only up to date in the present time. As a result, we cannot predict floods in the future. Fortunately, the model WRF-ECHAM5, which is a regional climate model, can project the future scenario (year: 2035-2064); rainfall grid, temperature grid etc. (Chotamonsak et al., 2011 & Chotamonsak, 2011). Therefore, if ANN model could use rainfall grid data in the far future as the input variable to predict water level in the river, which would represent the impact of climate change in the next 30 years, then government agencies or people who live in the flood plain area will understand more about flood frequency or the maximum flood level in the future.

2. The objective of the study

Bangrakam District, Phisanulok Province is located in the Lower Yom Basin (Fig.1) and this area has suffered from drainage flood almost every year, so this research focuses on Y.16 station. To reduce the impact from floods, good flood warning systems are needed, also in predicting flood for long term due to climate change. There are 2 main causes of floods in this area; one is due to the heavy rainfall in this area and because of the amount of water from the Upper Yom Basin and also other basins such as the Ping Basin. Currently, the dataset for model prediction is based on past periods until the present, so most of the models can use past data and predict future events but not for a very long time period. Climate change has become a big issue around the world, it involves the extreme natural disaster events i.e. heavy rainfall, large flood or drought.

To predict flood levels in the long time period, such as in the next 30-60 years due to the main issue of climate change, the output from climate models, which are necessary are rainfall, temperature, precipitation etc. Unfortunately, these output data cannot predict the flood levels in the future, and as a result, we need other models that can use the output of climate models and predict flood levels. However, the artificial neural network model has been applied in the hydrology study (Nural, et al., 2018 & Falah, et al., 2019). To improve ANN's model performance, it depends on internal and external parameters. Internal parameters are about computing knowledge such as types of the learning algorithm, type of transfer function, learning rate, momentum rate, also numbers of hidden layer and hidden nodes. External parameters are related to the quality of dataset and the amount of dataset (Abrahart et al., 2010 & Chaipimonplin et al., 2011).

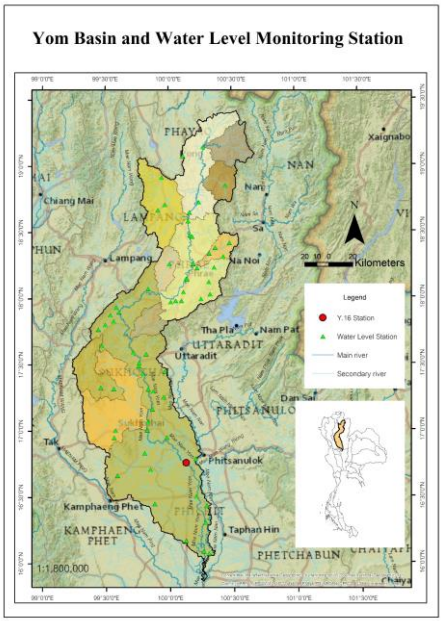


Figure 1. *Yom Basin*

Therefore, there are 2 objectives of this study; to compare 3 types of rainfall grid data with 3 input determination techniques and to investigate the most suitable architecture structure of the ANN model.

3. Modified from: Geo-Informatics and Space Technology Center (Northern Region), 2015 Methods

3.1. Rainfall grids

Fig.2 (a) represents the rainfall grid of the WRF-ECHAM5 model with spatial resolution of 20*20 km. Three types of rainfall grids are compared; (1) Moving Average Time Step back (MAT) technique represents "Time", all 7 grids are used to calculate from time (t), then back from 2 – 7 days (t, MV2, …, MV7) (Fig.3, left), (2) Moving Window Average (MWA) technique represents "Space", using 2*2 windows to calculate the rainfall average from 4 grids (Fig.3 b) to create new rainfall grids; Z1-Z8 (Fig. 2 right) and (3) Moving Window average Time step back (MWT) technique represents "Time and Space" by using 8 new grids from MWA to calculate rainfall average from 2-7 days.

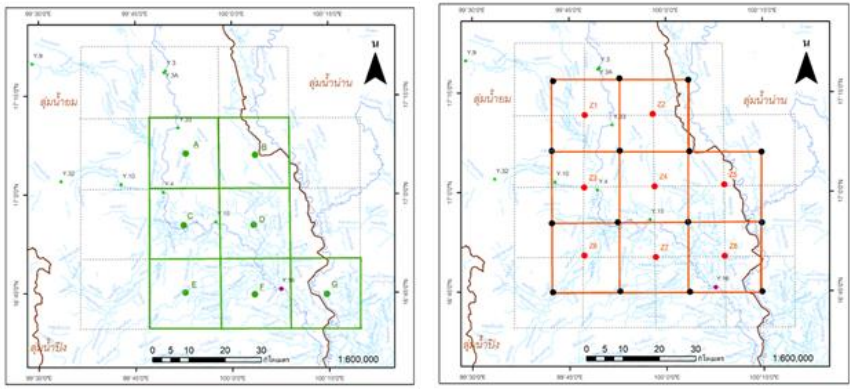
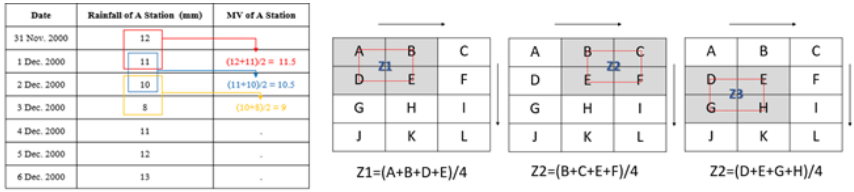


Figure 2. *Rain grid of MAT (a), MWA and MWT (b)*



Date	Rainfall of A Station (mm)	MV of A Station
31 Nov. 2000	12	
1 Dec. 2000	11	(12+11)/2 = 11.5
2 Dec. 2000	10	(11+10)/2 = 10.5
3 Dec. 2000	8	(10+8)/2 = 9
4 Dec. 2000	11	.
5 Dec. 2000	12	.
6 Dec. 2000	13	.

Figure 3. *Moving average (left) and Moving window average (right)*

For the available water level data at Y.16 station is recorded by the hour between the year 1989-2009 with the highest flood recording 10.97 meters. All 21 flood events can be classified into 4 groups; no flood (water level less than 7.28 meter) with 6 events (1989-1993 and 1998), small flood (flood level less than 8 meter) with 2 events (1997 and 2008), medium flood (flood level between 8-10 meter) with 7 events (1999-2001, 2003-2004, 2007 and 2009) and big flood (flood level greater than 10 meter) with 6 events (1994-1996, 2002, 2005-2006). Then, flood events for testing model performance, which are indicated in red (Fig.4), are 6 events; 2 events of no flood (1992, 1998), 2 events of the medium flood (2001, 2009) and 2 events of the big flood (1995,

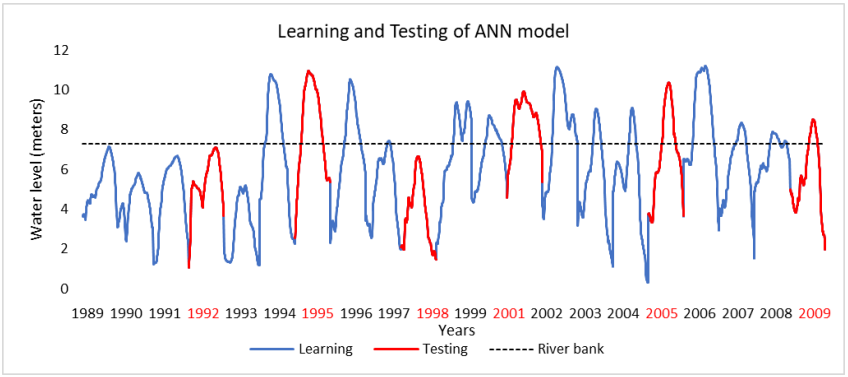


Figure 4. *Hydrographs at Y.16 station between 1989-2009 (August-November)*

2005).

3.2. Input determination techniques

Cross-correlation techniques (C) is the most popular technique of finding the correlation between input and output parameters (Maier et al., 2010), moreover, Chaipimonplin (2010) investigated about 8 input determination techniques and recommended that Genetic algorithm (G) and Stepwise regression (S) seem to be the best technique to predict water level in Upper Ping Basin, Thailand.

MAT technique has a total 42 input variables (6*7) with 6 rainfall grid (A-G) and each rainfall grid has 7 variables (t, MV2, MV3, …, MV7).

Technique C selects all input variables but S and G select 1 and 8 input variables respectively.

The MWA technique has a total of 64 input variables (8*8) with new 8 rainfall grids (Z1, Z2, …, Z8) and each grid has 8 variables (t, t-1, t-2, …, t-7). After selected by C, S and G techniques, 31, 3 and 24 input variables are remaining respectively.

The MWT technique has a total of 56 input variables (8*7) with 8 rainfall grids (Z1-Z8) and each new grid value is calculated with moving average time step back 2 to 7 days (t, MV2 – MV7). The input variables that are selected by C, S and G, are 55, 4 and 16 respectively.

3.3. Model's architecture structure

As numbers of hidden node influence model performance but for the most suitable hidden node for ANN model, it would be difficult to conclude that what the right hidden node is, so the research needs to trial and error (ASCE, 2000). However, Chaipimonplin (2010) did the literature review about the suitability of hidden nodes in hydrology research and he concluded that there are 3 possible groups of how to set hidden nodes. The first group said that hidden node should be 50% of input nodes (Minns & Hall, 1996), the second group recommended that hidden node should be 75% of input nodes (Walczak & Cerpa, 1999) and the third group, the hidden nodes would be 200%+1 nodes of input nodes (Patuwo et al., 1993). The recent study of Chaipimonplin (2016, 2017a) concluded that the number of hidden nodes for flood forecasting at Upper Ping Catchment would be less than numbers of the input node. In addition, Chaipimonplin (2017b), who experimented with different numbers of the hidden node by increasing hidden node from 1 node to 200%+1 node (base from input nodes) and he found that changing number of hidden nodes did not have any effect on model performance.

The number of input variables of 3 types of rainfall grids after selecting from 3 input determination techniques are different, so the number of hidden nodes are based on the number of input variables with 50%, 75% and 100%.

Table 1. Number of hidden nodes

Models	MAT			MWA			MWT		
	50%	75%	100%	50%	75%	100%	50%	75%	100%
A	42:21:1	42:31:1	42:42:1	64:32:1	64:48:1	64:64:1	56:28:1	56:42:1	56:56:1
C	42:21:1	42:31:1	42:42:1	31:15:1	31:23:1	31:31:1	55:27:1	55:41:1	55:55:1
S	-	-	1:1:1	3:2:1	3:2:1	3:31:1	4:2:1	4:3:1	4:4:1
G	8:4:1	8:6:1	8:8:1	24:12:1	24:18:1	24:24:1	16:8:1	16:12:1	16:16:1

To evaluate the model performance, PDIFF, which is peak difference, is used in this research. If the PDIFF is a positive value, it means over prediction, while a negative value means under prediction.

$$PDIFF = max\ A1 - maxA2 \quad \text{Eq.1}$$

Where maxA1 is the peak of modeled value
maxA2 is the peak of observed value

4. Results and Discussion

First of all, there is a need to find out which model is the best in each rainfall grid type and then comparing all 3 best models of each rainfall grid type. Hydrographs in Fig 5 shows that all models of MAT (representing Time) can predict flood level from MAT rainfall grids except model S, which is selecting input variables with a stepwise regression technique, has fewer input variables (Fig.5 top). In addition, PDIFF values show an error value of the models, model G (Genetic algorithm) with 50% hidden nodes (MAT_G_50LM or G_50) seem to be the best model in this rainfall grid type with the small values of PDIFF especially at the biggest flood (1995) (Fig.5 bottom)

In the MWA rainfall grid type (representing Space), all hydrographs are similar to MAT i.e. model S cannot predict flood levels (Fig.6 top). Also, model G with 50% and 75% hidden nodes (MWA_G_50LM and MWA_G_75LM) seem to be the best models in this rainfall grid type as PDIFF values are smaller than other models (Fig.6 bottom).

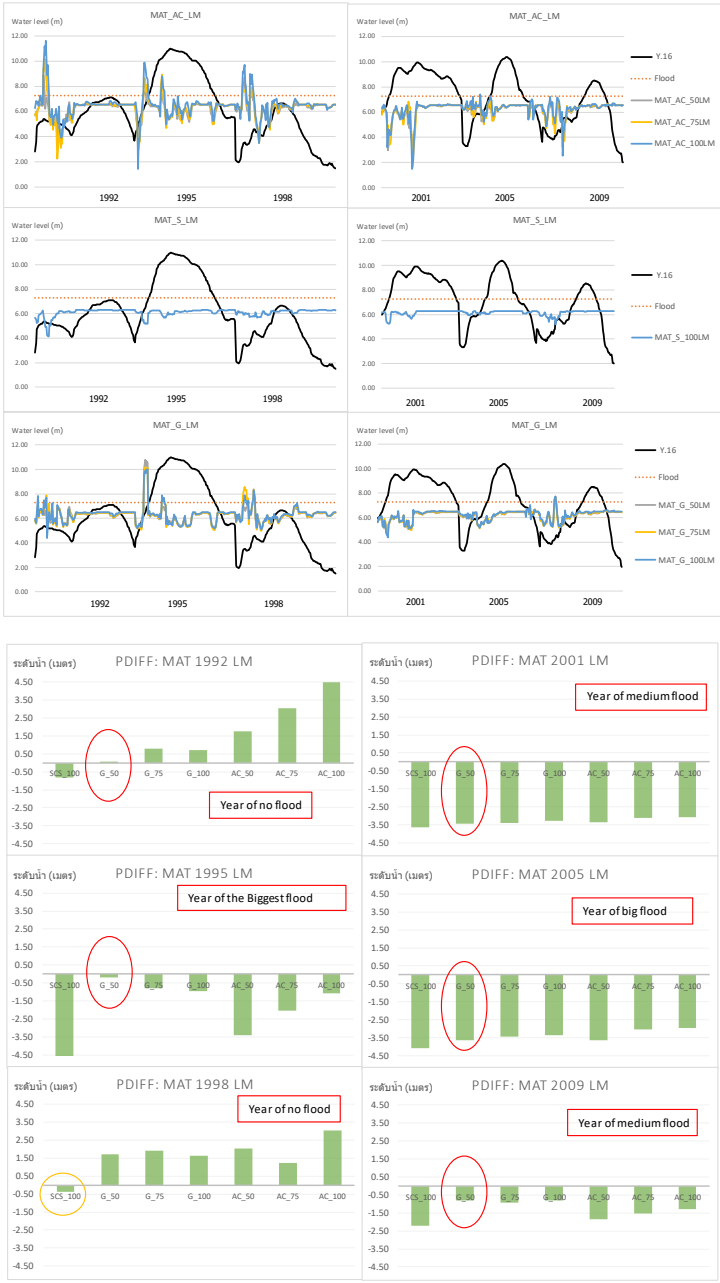


Figure 5. *Results of MAT technique.*

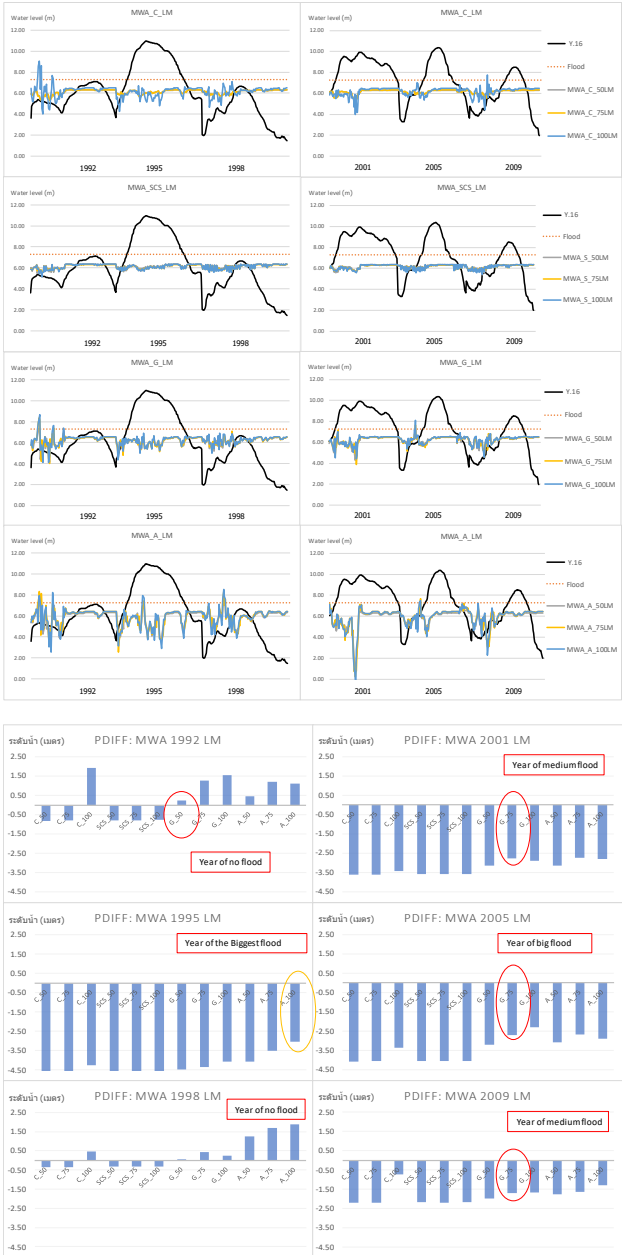


Figure 6. *Results of MWA technique*

In the meanwhile, MWT rainfall grid type (representing Time and Space), all models seem to be able to improve model performance as most hydrographs show more reasonable of water levels (Fig.7 top). Overall PDIFF values display more errors than MWT but better than MWA, particularly in the biggest flood event, the best PDIFF, which is close to 2.5 meters, is more than the other 2 rainfall grid types. However, it can be seen that model S with 75% hidden node (MWT_S_75LM or S_75) is the best model in medium, big and biggest floods (2001, 2005, 2009 and 1995 respectively) (Fig.7 bottom).

The second step is to select the best of the 2 models from all 3 rainfall grid types, then MAT_G_50LM and MWT_S75LM are chosen to compare the performance. As it can be seen in Fig.8 (up), all 6 flood events for testing model performance, model MAT_G_50 is the best prediction in 4 years; 1992, 1995, 1998 and 2009, while model MWT_S_75 has the best PDIFF values in the year 2001 and 2005.

Finally, using these two models to predict future flood (2035-2064), it is significant that the model MAT predicts only 1 small flood in the year 2061, while model MWT predicts 5 small and 5 medium flood events but no big flood event. From the results of testing of the past flood event, models tend to show under prediction such as model MAT with approximately 3 meters (the year 2001 and 2005) or model MWT about 2-3 meter (the year 1995 and 2005) (Fig.8, down).

Therefore, it can be corrected that the peak level by adding the error value, which is averaged from the PDIFF values of all 6 flood events, are 1.05 and 0.85 meters for MAT and MWT respectively. After correcting the peak value, there will be floods every year with the highest aspect of 8.37 meter in the year 2061 and 10.59 meter in the year 2041 by model MAT_G_50 and MWT_S_75 respectively. Although, the new peak floods are not the actual value as the range of error for each model could be up to 3 meters of under the actual peak level.

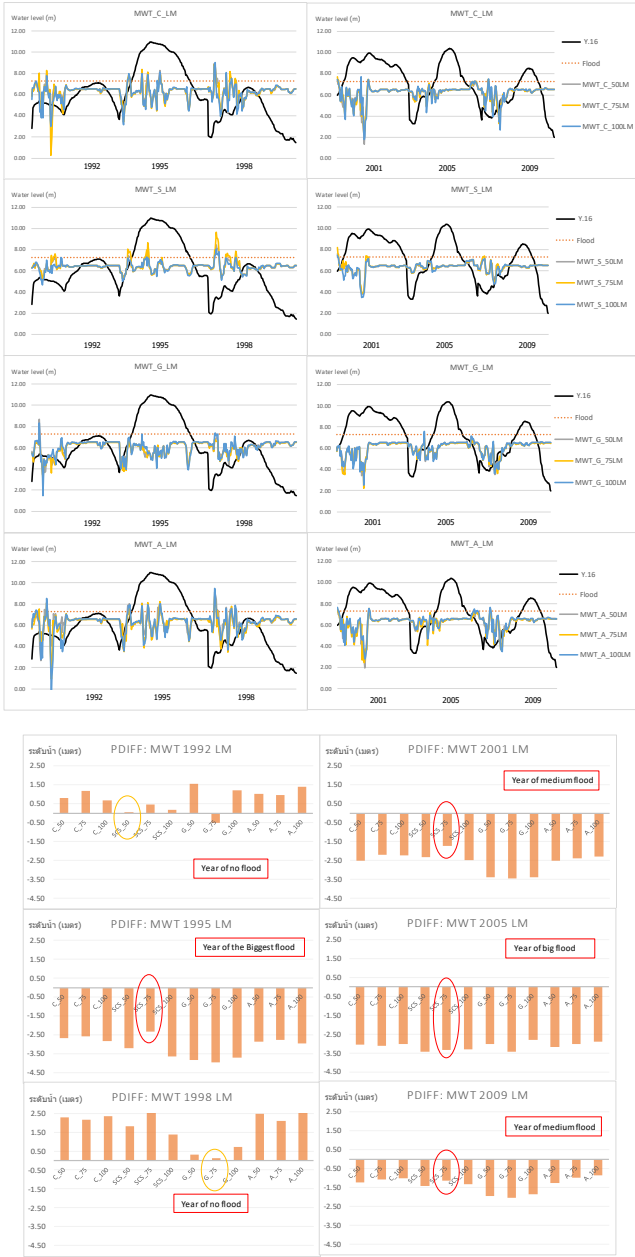


Figure 7. *Results of MWT technique*

Figure 8. *Comparison between MAT and MWT models*

5. Conclusion

The total model in this study is 34 models, which compared 3 types of rainfall grids (MAT, MWA, MWT), 3 different hidden nodes (50%, 75%, 100%) and 3 input determination techniques (Cross correlation, Stepwise regression, Genetic algorithm). The most suitable models, which show good performance are 2 models; MAT technique (moving average time step back: time approach), also selecting input variables with Genetic algorithm technique and number of hidden nodes should be 50% of input variable and MWT technique (moving window average time step back; time and space approach) with stepwise regression technique and hidden node should be 75% of input variables.

Acknowledgment

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Capacity Building for Research and Innovation in Disaster Resilience 2019

International collaboration for enhancing research and innovation in the context of disaster resilience

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Abstract

International Collaboration (IC) is very important for the improvement of resilience of countries to disasters. The rapid growth of science and technology is pivotal in this context to assist the resilience building process through innovation. Especially, when it comes to Asia, IC can assist Higher Education Institutions to carry out research activities that are robust and significant and strive towards research excellence to achieve global recognition. However, the knowledge on levels and issues for collaborative research work in Disaster Risk Reduction (DRR) in the Asian region is limited, which urges the necessity of conducting regional studies to identify possible areas of improvements. This paper aims to fill this gap.

Keywords:

Higher Education Institutions (HEIs); International Collaboration (IC); Disaster Risk Reduction (DRR), Disaster Resilience; Research and Innovation (R&I)

1. Introduction

More than half of the population of the world live in cities and this number is expected to increase up to 70% by 2050 (UNISDR, 2017). With the rapid uncontrolled growth of cities, societies are facing greater threats from disasters. According to UNDP reports, 75% of the population in the world live in areas at least once affected by natural disasters during 1980-2000 (Tarhan, Aydin, & Tecim, 2016). In developing countries like Sri Lanka, when a disaster/ hazard occurs, the impact caused to the communities is high and more time is taken for the recovery process. The resilience of these people is very low and government agencies also do not prioritize vulnerable communities, until something bad happens. Thus, improving the resilience of these communities is very important because it helps in reducing impact and

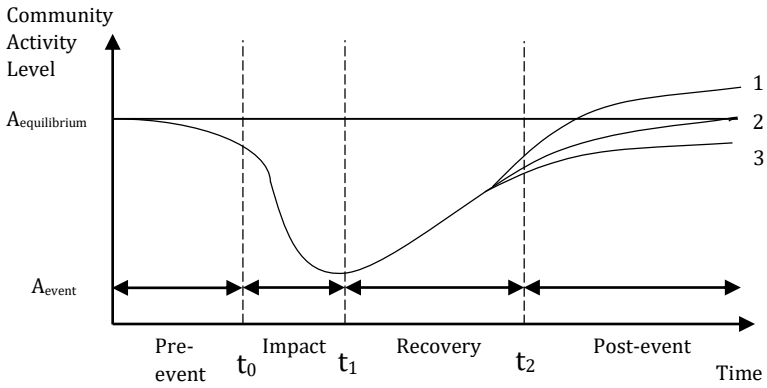

Figure 1. *Conceptual depiction of resilience capacity with event occurring at time* t_0

societies can rebuild to a better state thereafter.

More resilient societies can be represented as in the curve 1 of graph 1. After impact, even though the level of activities decreases, these societies come back to a better state. Some communities return to the same level after an impact and the community activity level of less resilient societies is represented by curve 3. Thus, the purpose of building resilience must be to achieve what is represented by curve 1.

To build resilience of communities and to achieve the level of curve 1, it is necessary to identify gaps, barriers and the requirement of the

respective regions. This study is based on an ERASMUS+ project titled ASCENT – Advancing Skills Creation for Enhancing Transformation. The findings of the paper are based on a comprehensive literature review and questionnaire survey data. Altogether 382 questionnaire survey responses were collected from academic and research staff from 08 Higher Education Institutions (HEIs) involved in the ASCENT project from Bangladesh, Sri Lanka and Thailand. The questionnaire included questions on level of IC, reasons to pursue IC, benefits of IC and barriers to IC.

2. The object of the study

The objective of this research is to identify gaps in international collaborative research in the context of disaster resilience in HEIs in Bangladesh, Sri Lanka and Thailand and thereby to propose strategies for the development of IC research activities. Further, it is expected to identify current levels of IC, to identify reasons of pursuing IC, to identify benefits from IC, to identify barriers to IC and to identify the government/ institutional support for IC.

3. Methodology

3.1 Research method

The research method used for the study was a survey, using questionnaires as the data collection tool. The questionnaire was developed by a few academics who are involved in the ASCENT project from the University of Central Lancashire, UK and University of Moratuwa Sri Lanka. Then, the questionnaire was sent to chief investigators of the ASCENT Project from the University of Huddersfield, UK. After their comments, the revised version of the questionnaire was used to conduct a pilot study in University of Moratuwa and the survey was refined based on the comments from the participants. This survey was then made available on an online platform of UClan (University of Central Lancashire) and was distributed among academics from 8 universities from Bangladesh, Sri Lankan and Thailand. The universities involved in the survey were 1.) University of Dhaka, Bangladesh, 2.) BRAC University, Bangladesh, 3.) Patuakhali Science and Technology University, Bangladesh, 4.)

University of Moratuwa, Sri Lanka, 5.) University of Colombo, Sri Lanka and 6.) University of Ruhuna Sri Lanka, 7.) Chiang Mai University Thailand and 8.) Naresuan University, Thailand.

The Snowball sampling technique, which is a non-probabilistic sampling method was used when selecting participants for the survey. The survey was available for 3 months and analysis of the results was conducted thereafter. The survey was designed to receive responses in a five-point Likert Scale.

3.2 Tests performed on the data set

3.2.1 Cronbach's alpha test – Reliability and Validity check

This test was performed to check the reliability and validity of the data set as it is important to identify internal consistency of the data set. The overall Cronbach Alpha value of the data set was 0.965 which is close to 1, which indicates that the data set is reliable.

3.2.2 KMO – Bartlett's test

KMO and Bartlett's test was done to check the sample adequacy. The value range for the index is from 0 to 1. As a thumb rule it is accepted that an index over 0.6 is sufficient for a given sample. For this data set, all the values for the KMO – Bartlett's test was above 0.9 which was more than sufficient.

3.3.3 Missing data

A total of 382 academics participated in this survey. The percentages of missing data for each question of the questionnaire were within the acceptable limit which is below 10%.

3.3 Composition of the questionnaire

Out of the participants of the research, 65.4% were males and 30.6% were females. The other respondents did not want to identify with respect to gender in filling the questionnaire. When considering the job titles of academics who were involved in the research, 38% percent were senior lecturers (including 25.4% professors), 48.7% were lecturers and 13.3% were junior researchers.

4. Research Findings

4.1 Current Level of International Collaboration

There are very few initiatives to create international research collaborations in Sri Lanka and the "International Collaboration Research Programme (ICRP)" initiated by the National Science Foundation (NSF), Sri Lanka in 2017 is an example for this. To take part in this programme, a local researcher affiliated to a Sri Lankan University or Research Institute should submit a proposal to the NSF with the involvement of a researcher from a foreign university or a research institution ("International Collaborative Research Programme (ICRP)," 2017). In terms of disaster resilience research, apart from the EU funded ASCENT project and CABARET project, there had not been many projects aiming to develop research in the context of disaster resilience. This is also similar in the Bangladesh and Thailand context. Apart from the involvement with a few EU funded projects, they don't show much research collaboration in the context of disaster resilience. However joint research collaborations are very important because natural hazards like Tsunamis, Earthquakes and Cyclones can affect multiple regions at the same time.

The first section of the survey attempted to identify the level of IC of the three partner countries and Table 1 reveals the findings.

Table 1. Overall findings related to forms of international collaborations

Form of IC	Bangladesh	Sri Lanka	Thailand	Overall
Participation in international conferences and seminars	3.8	3.5	3.2	3.55
Jointly authoring papers	3.4	3.1	2.8	3.15
Membership of international scientific bodies	3.4	3.1	2.6	3.12
Participation in International Collaborative R & D Projects	3.1	3.1	2.7	3.0
Visiting/Using International research facilities	3.3	2.9	2.6	2.95
Research mobility and capacity development	2.9	2.7	2.6	2.75
Purchasing of research and technological services	2.7	2.4	2.2	2.45

When comparing the overall figures, only the first three criteria show above average values and other aspects are on the lower side. When

comparing scores country wise, it is clearly evident that Bangladesh and Sri Lanka show more international research collaborations than Thailand in every aspect. However, all these three countries need to improve their involvement in aspects 4 to 7. Apart from these findings, the research further highlighted that most academics in these countries are mostly engaged in consultation-based collaborations which are mostly on a short-term basis. Thus, the exposure of researchers to these kinds of collaborations is limited. This is even true in the context of Bangladesh and Thailand. These kind of consultative basis collaborations are mostly linked to leading international scientific bodies, including the World Bank, Asian Development Bank, UN, UNESCO etc. Further, when the involvement of academics in international collaborative research work is considered, majority of their research collaborations are linked with universities and higher education institutes. They show limited involvement in collaboration with public sector establishments, governments & policy makers, research funders, small and medium size businesses and large businesses (Table2).

Table 2. Involvement of the academics in international collaborative research works

Forms of IC	Bangladesh	Sri Lanka	Thailand	Overall
Universities & Other HEIs	3.6	3.6	3.0	3.43
Public sector research establishments	3.0	3.0	2.5	2.84
Government & Policy makers	2.9	2.7	2.2	2.68
Research funders	2.8	2.7	2.4	2.63
Small and Medium Size businesses	2.1	2.2	2.1	2.13
Large businesses	1.9	2.0	1.8	1.89

University-Industry collaborations are very important to encourage knowledge and technological exchange, but unfortunately the findings clearly show that collaborations with industrial organizations are very low in these three countries. In terms of region-wise collaboration levels, most are with South Asian countries and East Asian countries. A moderate level of involvement was identified with European countries, but collaboration is very limited with the American region, Middle East, Russia and Africa.

4.2 Reasons to Pursue International Collaboration

The intentions of different researchers for collaborative research works can vary and the second part of the questionnaire was designed to identify this factor. The outcomes show that most academics engage in collaborative research to pursue excellence in research & innovation and to gain access to the world's major research and innovation facilities. Apart from that, they also show interests in gaining access to global funding, access to global leaders in research and innovation, for personal satisfaction, to strengthen impact and competitiveness and to access strategic partnerships. However, the views of academics further highlighted that they do not seek IC with the motive of promotions, reduced allocated teaching time and financial rewards. In-fact, it is very prudent that intentions of academics are to improve research and innovation and is not centred or based on personal reasons.

4.3 Benefits of International Collaboration

Identifying the aspects beneficial for researchers was done through the third part of the questionnaire survey. From the responses, it was evident that improved access to knowledge and expertise, improving the strength of research collaboration, increased technological capabilities, increasing the robustness of research outputs, improved visibility and reputation, increased rate of innovation, contribution to global societal challenges and improving national competitiveness as the main beneficial aspects. Although the three partner countries do not acquire a great deal of benefits from international collaborative research, the researchers are aware about benefits they can gain from international collaborative research activities.

4.4 Barriers to International Collaborative Research

The researchers were asked to rank the barriers to international collaborative research works and the ranking of all the three countries showed a similarity. The overall ranking is as follows:

1.) Financial Issues
2.) Lack of resources to support IC
3.) Lack of institutional support IC
4.) Bureaucratic issues

5.) Lack of networking opportunities
6.) Finding partners with same research interests
7.) Enforcement of intellectual property rights
8.) Language Differences
9.) Cultural differences

The top three barriers were ranked by most academics of the selected universities. The financial barrier was identified as the most significant as indicated by more than 70% of the researchers. This is clearly evident from the proportion of allocation of the GDP for Research and Innovation in Sri Lanka. This value has been declining and the present allocation level is 0.1%. This is very low compared to other developed countries in the region including Singapore 2.2% (2014), India 0.63% (2015) and Malaysia 1.3% (2015) ("Research and development expenditure (% of GDP)," 2019). The allocation for Research and Innovation in Bangladesh is less than 0.1% ("Research and development expenditure (% of GDP)," n.d.)

4.5 Government/ Institutional Support for International Collaboration

The academics of the three partner countries were of the view that their governments provide reasonable support for training and mobility schemes. However, the support in freeing up time, gaining leave and assistance in networking activities from government institutions is found to be less. On the other hand, the burden on academics related to administrative and paper work in freeing up time for foreign research visits can be seen as a main factor that reduces efficiency. For example, in the case of Sri Lanka, permanent academic members need to gain approval from the ministry to leave the country for foreign collaboration and these processes are time consuming.

5. Discussion and Conclusions

The overall results of the survey show that selected universities from Bangladesh, Sri Lanka and Thailand lack international collaborative research programmes in the DRR sector. This reflects the status of DRR related collaborative research in the respective countries as well. The major issues which impede progress are financial barriers and poor institutional mechanisms. However, these universities hope to get

involved in more international collaborative programs to improve their knowledge capabilities and to stride forward in research and innovation. Collaborative international projects like ASCENT can substantially assist universities to develop their capacities through training programs, workshops, joint publications and mobility schemes.

6. Recommendations

1) Government initiatives should be introduced to fund international collaborative research programmes and thereby assistance should be provided for the development of the capacities of academics in respective fields.
2) A unit should be established at the ministry of higher education and a dedicated staff should be allocated to assist international research programmes. This initiative should aim to improve the efficiency of the processes by reducing paperwork.
3) Incentives should be introduced for academics who are involved in international research programmes and they should be motivated by recognizing their contribution.
4) Institutional mechanisms should be enhanced to strengthen international collaborative platforms.
5) University mechanisms should be developed to ease University-Industry Collaborations.

Acknowledgement

This study was done under the Work Package 7 of the Advancing Skill Creation to Enhance Transformation (ASCENT) Project, which is funded by the Erasmus+ Programme of the European Union. References

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Investigating the resilience of critical systems of tertiary hospitals in Sri Lanka

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Abstract

This paper describes a study done to investigate the resilience of critical systems of Sri Lankan tertiary level hospitals using two case studies done using an evaluation criterion developed by the World Health Organization and the Pan American health Organization. The results of the investigation were used to identify the resilience level of each critical system evaluated in the study. The resilience level was lowest for fire protection systems and highest for telecommunication systems on average.

Keywords:

Critical Systems; Disaster Risk Reduction, Resilience, Safe Hospitals

1. Introduction

In modern societies, Critical Infrastructure Systems (CI's), play a major role in the daily life of people and therefore their ability to function at optimum level with minimal amount of disruption is imperative. In hospitals, this need is even more crucial, as the continuous and uninterrupted functioning of a hospital is needed for the betterment of the patients within the hospital (Hasalanka, Siriwardana, Wijesekara, & Kodituwakku, 2018; Kularatne, Siriwardana, & Hasalanka, 2018).

There are two major reasons for the need of safe and resilient CI's in hospitals. One reason is generic for all places in that in the modern developed society, CI's are not independent systems conversely, they CI's of a community can be clustered and referenced to as a system of systems where damage or failure in one CI can cascade onto other related CI's and can increase the damage to society by multiple folds. For example, disruption in the service of the electrical system in a community can disrupt the functioning of other systems like a wastewater treatment plant (waste management system) and a water purification plant (water supply system).

The second reason is specific to hospitals. For a hospital to be named as a "Safe Hospital", it has to be functional at all times, at maximum capacity. In order to fulfil this goal, keeping the CI's of the hospital is very important. For example, the Hurricane Katriana in Louisiana, USA caused 24 hospitals to evacuate their patients due to the loss of power, water and sewage services (Janius, Abdan, & Zulkaflli, 2017). Therefore, it is apparent why CI's need to be safe and resilient at all times.

There are eight CI considered in this study; electrical, telecommunication, water supply, fire protection, waste management, fuel storage, medical gases and heating, ventilation and air-conditioning (HVAC) systems. The guideline used to evaluate these eight systems in Sri Lankan hospitals is included in the Hospital Safety Index Guide for Evaluators published by the World Health Organization (WHO) and the Pan American Health Organization (PAHO) (WHO & PAHO, 2015).

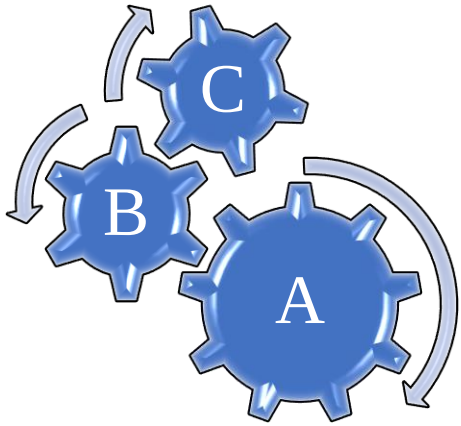

Figure 7: *Depiction of linkage between CI's in a community*

2. The object of the study

This study seeks to identify safety levels of individual CI's in hospitals in Sri Lanka and therefore their resilience levels by mean of two case studies in hospitals representing general tertiary hospital types in Sri Lanka. The resilience of CI's can be defined using the definition for technical resilience (Labaka, Hernantes, & Sarriegi, 2015). This definition states that this is the ability of a physical system to perform correctly in the face of a crisis.

The resilience level of a CI can be given as the function of three kinds of capacities of a CI: absorptive capacity, adaptive capacity and restorative capacity (Labaka et al., 2015). In the evaluation criteria used, it was observed that the evaluation of each of these capacities have been considered. The guidelines given by the Hospital Safety Index Guide for Evaluators considers factors such as availability of alternate sources, safety of the CI system's major and minor components, safety of the locations of the systems and availability of emergency maintenance for the systems.

Along with the evaluation of the CI's of the hospitals, assessments were done into the hospitals which included the basic details of each hospital structure such as the age, being engineered or non-engineered and presence of a master plan as well as the administration structure of each hospital.

At the end of the evaluation, the development of safety levels of individual CI's and the overall safety levels of the CI's of the hospitals are compared along with their characteristics to identify the resilience level of CI's in hospitals in Sri Lanka and specific CI's that should be improved by the Ministry of Health to increase the resilience.

3. Methodology

The District General Hospital (DGH) Gampaha and the Teaching Hospital (TH) Kegalle were selected to be evaluated regarding the hospitals' critical systems. Both hospitals are governmental tertiary hospitals and receive a large number of patients daily. To evaluate the critical systems of the hospitals, a section of the assessment checklist given in the Hospital Safety Index Guide for Evaluators was used. The section used falls under module 3 of the guideline named Non-structural Safety and is categorised as Critical Systems. It contains a total of 53 assessment criteria under 8 categories; electrical systems, telecommunication systems, water supply systems, fire protection systems, waste management systems, fuel storage systems, medical gas systems and HVAC systems.

The checklist rating scale included three options for the safety level: low, average and high. The rating was given as low=0, average=1 and high=2. The final rating for each CI and the overall level of safety of the critical systems of the hospitals were given as a percentage.

The evaluation was done with the help of the Administrative Units of the DGH Gampaha and the TH Kegalle. The evaluation consisted of two methods. The first was interviews with the maintenance and supervisory crew in charge of each critical system in both hospitals. The second method was visual inspection of the critical systems and their locations.

4. Results

After a thorough evaluation, safety levels of the critical systems of DGH Gampaha and TH Kegalle were quantified. A sample calculation is shown for the first system: Electrical systems in DGH Gampaha.

Table 6: Electrical systems in DGH Gampaha

Check	Safety Level	Relative Score
Capacity of alternate sources of electricity (e.g. generators)	Average	1
Regular tests of alternate sources of electricity in critical areas	High	2
Condition and safety of alternate source(s) of electricity	Average	1
Condition and safety of electrical equipment, cables and cable ducts	Average	1
Redundant system for the local electric power supply	Low	0
Condition and safety of control panels, overload breaker switches and cables	High	2
Lighting system for critical areas of the hospital	Low	0
Condition and safety of internal and external lighting systems	Average	1
External electrical systems installed for hospital usage	Average	1
Emergency maintenance and restoration of electric power supply and alternate sources	High	2
Total Score		11

The safety level of each submodule was calculated using the equation (1).

$$\text{Safety level} = \frac{\text{Total score}}{2 \times \text{Number of applicable checks}} \times 100\% \qquad \text{Eq.1}$$

The Safety Level of electrical systems in DGH Gampaha was calculated as shown below.

$$\text{Level} = \frac{11}{2 \times 10} \times 100\% = 55\%$$

The safety level of the other seven systems were calculated and then tabulated similarly. Afterwards, the overall safety levels of critical systems of DGH Gampaha and TH Kegalle were calculated using the individual scores of each system and the weightage of each system as shown in equation (2).

$$\text{Overall Safety Level} = \sum \frac{SL \times n}{N} \qquad \text{Eq.2}$$

SL = Safety level of individual critical system
n = Number of applicable checks for the relevant critical system
N = Total number of applicable checks in the assessment

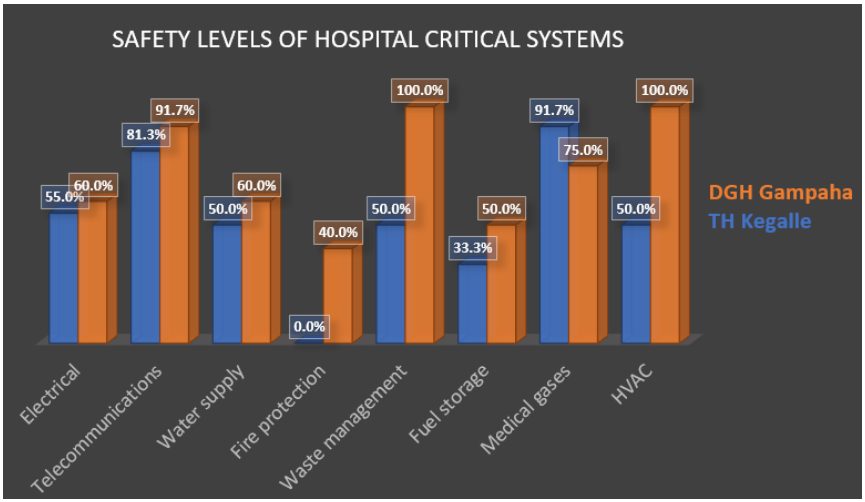

Figure 8. *Safety levels of hospital critical systems*

Table 7. Overall safety levels of the critical systems in hospitals

Hospital	DGH Gampaha	TH Kegalle
Overall Safety Level	54.9%	92.3%

5. Discussion

Critical systems are important for a hospital since those play a major role in the continued functioning and service providing in the hospital. Electrical systems play a major role as they account for the functioning of the lighting, the elevators, HVAC systems, medical equipment, etc. Telecommunication systems and their functioning are always crucial in the sense that hospitals require rapid and accurate communication and information exchange with other healthcare institutions and other relevant organizations such as the fire brigade and disaster

management agencies. Internal communication within the hospital system is also very important. Similarly, it can be understood that the continuous functioning water supply systems, fire protection systems, waste management systems, fuel storage systems, medical gas systems and HVAC systems is vastly important to hospitals and therefore, assuring their safety levels is of paramount value.

The two hospitals DGH Gampaha and TH Kegalle represent the two types of tertiary hospitals most commonly found in Sri Lanka. The DGH Gampaha is an old hospital consisting of a mix of small non-engineered buildings and one engineered eight-story building. The hospital was not designed according to an initial master plan. On the other hand, the TH Kegalle is a more recent hospital which was designed and built according to a master plan. All structures consist of engineered buildings. The administrations of the two hospitals also differ vastly. It was observed that the administration in TH Kegalle was more structured and organised than in DGH Gampaha.

The results of the assessment of the two hospitals can be summarized as follows. The safety level of critical systems for DGH Gampaha had a value of 54.9% while that of TH Kegalle had a higher value of 92.3%. Both hospitals had high safety levels for telecommunication systems with values above 80% and for medical gas systems with values above 75%, which is to be expected as they are directly related to patient care and hospital administration activities. The lowest safety level values were for fire protection systems with a value of 0% for DGH Gampaha and 40% for TH Kegalle. It was observed that there is a lack of training for hospital staff in fire hazard management. There is also a lack in updating and replacing of fire hazard management equipment such as fire extinguishers and fire hose reels.

Additionally, the TH Kegalle had 100% safety values for waste management systems and HVAC systems, unlike the DGH Gampaha which had values of only 50% for both of those systems. In TH Kegalle, waste management systems were in good condition with an excellent functioning process of solid waste and hazardous waste collection. The waste water management system was also in good condition with the hospital having its own waste management plant within the hospital land. However, in DGH Gampaha, the systems were at a lower level with

major issues in the waste water disposal system. TH Kegalle has a good safety level of HVAC systems, with regular maintenance being done by the organisations contracted for the work by the hospital. On the other hand, in DGH Gampaha, some of the HVAC systems do not undergo regular maintenance since the job of maintenance has not been contracted to someone by the hospital.

6. Conclusion

The CI's of a hospital need to be at full resilience level, both to keep the hospital at a functional level as well as to prevent any cascade of critical system disruptions. For example, if the electrical system in a hospital fails, this will disrupt the functioning of most of the HVAC systems as well as lighting systems in the hospital. This would prevent important activities in the hospital such as operations, which would put the lives of critical patients directly in danger. It would also stop the functioning of power dependent equipment such as mechanical ventilators which would again put patients' lives at risk. The study shows that the characteristics of the hospital structures and the administration structure have an impact on the resilience level of some of the CI's. It is especially important to have a good master plan for a hospital in order to ensure good resilience levels for CI's.

The study was able to identify the variation in resilience levels of different CI's in tertiary Sri Lankan hospitals. Overall, on average, the resilience level is low for fire protection systems and high for telecommunication and medical gas systems. The medical gas systems were also at a good resilience level, although it was noted that the location of gas storage areas should be more selectively chosen considering possible risks. Overall, it can be concluded that there should be more focus by governmental bodies in charge to improve the safety and resilience levels of CI's, especially fire protection systems.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

Politics of post-disaster management: A case study of Menik farm welfare camp, Vavuniya Sri Lanka

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Abstract

Among the man-made disasters, civil war or terrorism causes serious consequences in terms of generating refugees and re-settlement problems all over the world. Menik Farm was a welfare camp which functioned in Chettikulam, Vavuniya during and after the civil war of the North and East. It was one of largest welfare camps in the world and there were around 300,000 (86364 families) locally displaced people (IDPs). The welfare camp was maintained under a special institutional and administrative set up with the coordination of civil administrative mechanism, intervention of military leadership and monitoring of international agencies. Since the military leadership played a leading role in the post-disaster management process, it was of much concern all over the world and the camp was closed in September 2012. The main objective of this paper is to critically analyse the role of politics in post-disaster management of the Menik Farm welfare camp in Sri Lanka.

Since this welfare camp was under the direct control of the government military, there were many limitations in carrying out the study and field data collection was influenced by security measures and ethical issues. Qualitative and explorative methodology were adopted for primary data collection. Accordingly, qualitative data collection tools such as

observation, in-depth interviews and informal group discussions were conducted. Although there were 9 Zones (from Zone 0 to Zone 8) and three villages, the IDP sample was selected for the interviews and discussions were conducted in Zone 6 and the village of Weerapuram. The key informants (project, state, military, medical officers, sanitary workers and host community) were selected from the entire camp.

The most important finding of this study is the power relationship that existed among three leading sectors as a joint mechanism of post-disaster management. They are the military authority, government representation by District Secretary and Disaster Management Center (DMC) and International Agencies (UNCHR, UNDP, SLRC). Although there was more commanding power with military involvement, international agencies and civil administrations of the government played a key role in developing critical and social infrastructure (security, health and sanitation) within the camp (761 hectares of land). Even if the military authority was always criticized for dominating the joint mechanism by external sources, IDPs were satisfied with the involvement of the military in terms of providing security and immediate infrastructural facilities. It is also important to mention that the security and well-being of IDPs is always socially constructed based on the power discourse related to war and peace. The media and the international diaspora community together with local politicians mainly engage in the process of making power discourses considering military connections. Among the IDPs, there were social-cultural conflicts owing to the notion of caste and cultural pollution and some livelihood programs reinforced inequitable relations of power among them. These value-oriented power conflicts negatively influenced post-disaster management of the camp. The poor facilities and political attention towards the local host community compared to IDPs, created a tensed situation between them. The host community did not enjoy any benefits through the political economy of the welfare camp. In conclusion, it can be emphasized that the unseen institutional power structure and socially and culturally mandated power relationships played a vital role in the management of welfare camp.

***Key Words**: Disaster Politics, Joint Power Mechanism, Discourse and Cultural Pollution*

1. Introduction

Disasters have become part of human life today and people seem to be adapting to disaster vulnerabilities. These disasters may be natural or man-made and are well-absorbed into the political economy and cultural ecology of those countries. The impacts of these disasters have created huge changes in local and global politics and development. The recent large disasters such as the Indian Ocean Tsunami, the South Asian Earthquake, Hurricane Katrina, Hurricane Nargis, Sichuan earthquake and man-made disasters such as the September 11th terrorists attacks, Bokoharam in Nigeria and war disasters in the Middle East have highlighted the significance of the political context and post disaster impact and response in national, sub-regional and international politics. Disasters and politics may be two integral parts of the same process and the combination of the two can have two processes namely, "disasters producing politics" and "politics producing disasters". From this point of view, it is politics itself, as a mode of ordering the world that produces disasters for its own purposes and according to its own rules.

According to Oliver-Smith (2002) & Tierney (2007), the new relationship between politics and disasters can be understood by combining two important movements within the social sciences. The first relates to an interest in breaks and ruptures, rather than continuity and structure. This is closely linked to an attendant idea of politics as problematization of the composition of the world. Disasters as ruptures produce new compositions of the world and they force explications of these compositions. The second movement relates to an interest in the reconceptualizing nature or the 'non-human' as actors. Disasters, like accidents, are sociologically speaking the result of the combination of these two: they radically question the composition of the world, in all its technical, natural and social forms.

According to Surendra Kumar (2009), innocent people who flee in search of a secure and stable environment due to war, protracted conflicts, mass violation of human rights, repression of minorities, natural and technological disasters are generally known as 'internally displaced people' (IDPs). The global crisis of IDPs finally caught the attention of the international community and aid agencies after this

definition, mainly due to three vital developments in three areas. Firstly, a sharp increase in the number of IDPs over the decades. Second, the issue of internal displacement emerging as one of the most pressing humanitarian, human rights, political and security issues faced by the global community, third, national authorities been unable to provide necessary assistance due to resource constraints. According to the International Displacement Monitoring Centre (IDCM), by the end of 2009, there were approximately 27.1 million people displaced due to conflict, generalised violence or human rights violations across the world. This figure was high compared to 2007 and 2008 figures (25 and 26 million respectively). Most of the displacement was due to internal armed conflict, rather than international armed conflict. The most affected region was Africa (11.6 million), followed by South and South-East Asia, which saw an increase of 23 % from 3.5 million to 4.3 million.

Sri Lanka suffered from conflict between the Government and the Liberation Tigers of Tamil Eelam for approximately 30 years resulting in economic, social and political devastations. Since the inception of the conflict, several waves of displacement took place in the North and East causing at least 1,000,000 displaced throughout the conflict (Badurdeen, 2009). With the liberation and recapturing of LTTE controlled areas in the Northern Province, nearly 300,000 people from the LTTE held areas were shifted towards safe areas in the south of the Northern province in May 2009. Due to the large numbers of IDP arrivals within a short period of time, the government of Sri Lanka was compelled to provide them with basic needs at any cost without considering the environmental impact or planned development concerns of the areas that are proposed for IDP housing.

These people were temporarily settled in 13 IDP centers in the Vavuniya and Anuradhapura districts due to security and logistical reasons. IDPs were provided with day to day needs in these make shift camps till the resettlement process began after clearing landmines and other security related issues. These zones have been named as zone 1 ,2,3,4,5,6 A,6B,7,8, Dharmapura, Veerapura and Sumathipura. This place is popularly known as Menik Farm (locally known or used term for the place) Chettikulam (15 to 20 km from Medawachchiya in Mannar road). The provision of logistic facilities and development of the camps were undertaken by a special task force working under the

presidential secretariat and the Ministry of Nation Building (UNCHR, 2009).

Even though there are disaster risk reduction concerns that have to be taken into account in planning stages of such zone establishments, due to the rapid building of these zones to meet the demands of the large influx of IDP's, there was neither time nor resources to establish standard good practices in the construction of these sites. According to UNCHR (2009) and CEPA (2014), the GoSL was forced to select IDP camp sites and prepare camp sites to suit the living conditions of IDPs with least priority for disaster concerns. The Disaster Management Centre (DMC) which operates under the Ministry of Disaster Management and Human Rights has been entrusted with the responsibility of managing natural and manmade disasters through the Disaster Management Act of Sri Lanka (No.13 of 2005). Apart from other responsibilities, the main priority of the DMC was to coordinate and monitor DRM activities with other stakeholders in order to ensure that available resources are effectively used by DRM partners in the discharge of their functions towards DRM. For this purpose, many International and local NGOs and government institutes or departments joined in preparing the physical infrastructure of the IDP camp. The Government Agent of Vavuniya, DMC, SLRC, UNCHR, UNDP, UNOPS, CARE International, Oxfam, UNICEF, Sarvodaya, SL Army, Road Development Authority, Assistance Commissioner for Local Governance, Forest Department, Water Resource Board, Central Environment Authority, Sri Lanka Land Reclamation & Development Corporation and National Building Research Organization functioned as key partners in this regard. The major activities carried out by these partnerships at the initial stage to facilitate infrastructure are safety fencing, establishing a one- way road traffic system, construction of pedestrian crossings, reforestation programme, construction of community centers, distribution of relief items, flood mitigation in field hospitals, drainage maintenance, public preparedness for Monsoon rains and solid and liquid Waste Management

2. Objective

The main objective of this paper is to critically explore the politics of post-disaster management of IDPs in 2008 and 2009 at Menik Farm Chettikulam, Vavuniya Sri Lanka. In both post-disaster management related to natural disasters and war related disasters existing power dynamics or power relationship is very crucial in determining the total function of emergency management. This paper attempts to make a sociological and qualitative analysis of the power relationship that existed among government armed forces, different state institutes, NGOs, civil society and IDPs and how all of them finally influenced the overall management of the welfare camp. Here, power related to cultural values and informal social mechanisms were also taken into consideration in the study of politics related to post disaster management.

3. Methodology

This study mainly utilized an explorative and qualitative methodology used in sociology and anthropology. Qualitative information was collected through qualitative means of data collection. Due to security reasons, data collection was restricted to a few zones and villages by the competent authority of the camp management. Ethical considerations related to IDPs and their experiences of the war also limited the access of data. Thus, although there were 9 Zones (from Zone 0 to Zone 8) and three villages, the IDP sample was selected for the interviews and discussions were carried out in Zone 6 and in the village of Weerapuram. The main data collection tools were (1) observations, (2) thirty in-depth interviews and (3) six informal discussions.

Direct observation was carried out in order to collect information regarding the physical infrastructure of camps and safely measures for people and the lifestyle of IDPs. In-depth interviews were done with GA Vavuniya, ACLG, DS, International Agencies & NGOs, (UNCHR, UNICEF, UNOCHA, UNOPS, CARE, Oxfam) Engineer (RDD), Coordinator of DMC, Zonal commander, Zonal manager, Grama Niladhari, Army officers, Medical officers, Public Health Inspector, Health volunteer, Supervisor and the waste collector. Critical information about power relationships

and contradictory views of power dynamics of camps were collected through in-depth interviews. Informal discussions were conducted with IDPs and members of the host community to get subjective experiences of people and information regarding other social aspects of conflicts such as caste, identity and gender issues.

Secondary data and information from government institutions, international agencies (UNCHR & UNDP) and NGOs were also utilized for further justification of qualitative aspects of the study. Qualitative data were analysed based on themes and discourses through the concepts related to power and politics that are found in sociology and social theories.

4. Results and Discussions

Policies or actions related to power is politics and can be exercised by any party, institution, military, soft, local or cultural politics- anything connected to power and society is power dynamics. In this paper, it is important to understand disasters as politics, and politics as disasters. When critically analysing the process of post-disaster management in Sri Lanka through a political sociological lens, one could find many different types of power dynamics within and outside natural and man-made disasters. However, all disaster politics have not been properly studied in Sri Lanka. According to Jones et al (2013), the governance of risk and resilience vis-à-vis community organization rarely is analysed in terms of practical feasibility. Community-based disaster risk reduction (CBDRR) is reasonably well-established in some parts of South Asia, such as Bangladesh, India, and Sri Lanka, but governance and function of as well as opportunities for community-based resilience-building remains largely undocumented.

As Tudor Silva (2009) and Amarasiri De Silva (2008) have mentioned in studies related to Sri Lankan disaster politics in the case of the Tsunami, there have been power relationships or politics in the general disaster management process. In Sri Lanka, power exists in the form of local politics, patron client politics, ethnic politics or institutional politics and it is closely related to the disaster management process during floods, landslides, droughts or waste dumping site disasters.

The joint mechanism found and used to coordinate the activities of Menik Farm is the most important factor considered here. This mechanism consists of government, non-governmental or international, military and various other volunteer sectors or agencies. This collective body was vested with all political, military, financial and civil power that managed the entire system of relief, rehabilitation and resettlement of IDPs (around 300000 at the beginning) in a sustainable manner. This mechanism can be illustrated as follows in Figure 1.

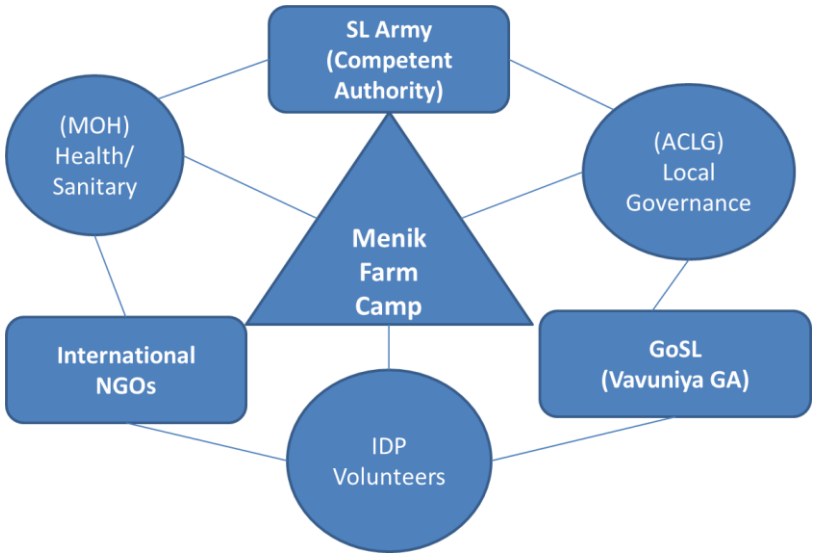

Figure 1. *The Joint Mechanism of overall management of IDP camp*

According to data derived from in-depth interviews, it was interesting to identify a partnership agreement among international agencies (UNCHR, UNDP, SLRC) and local organizations (DMC) in order to carry out emergency humanitarian activities in Menik Farm. Although international agencies maintained mutual and non-influential partnerships among them, the DMC under the patronage of the SL government was very influential in the partnership network.

Diaspora communities, the international media and politics severely projected criticism against the military leadership given to the management of camp. Ethical issues and human rights concerns were also crucial with regard to the leading role of the military in the camp

administrative process. However, most of the people (IDPs) were happy about the way in which the military leadership organized the relief and addressed the needs of the people immediately without any corruption or delay. According to the interviews and informal discussions, the joint mechanism established for camp management was successful because of the strong military leadership.

The complexity of the humanitarian crises is problematic due to politicization and its persistent nature is caused by inducing natural or man-made disasters internationally to enable the transfer of assets from the weak to the strong. The supply and access to food, health services and humanitarian assistances becomes an instrument of local power politics rather than an entitlement and therefore crises as associated with resettlements or humanitarian emergencies after a disaster become highly politicized and protracted and developed their own structure of power (Nafziger et al, 2004).

In many disaster management processes, NGOs are outraged when local government units divert emergency discretionary funds (5 % of the budget) to the military, justifying their actions by pronouncing insurgency a human-induced disaster. As a direct result, many communities are deprived of funds needed to protect themselves from recurrent disasters. Moreover, NGOs are unwilling to accept military protection of their disaster relief supplies through insurgent-active territory due to the fear of being closely associated with right-wing ideologies and armed forces' practices in such areas. This is evident by the disaster management practices carried out in the Philippines (Bankoff & Hilhorst,2009).

According to Kim et al (2016), there are many politicized issues and financial problems that arise due to the involvement of NGOs in disaster management in developing countries. This is no exception in the case of NGOs operating in Sri Lanka. The role of NGOs is crucial in terms of political practices and ideology promulgated in the case of Sri Lankan humanitarian aid processes in post-disaster management. Several types of NGOs such as High NGOs, National NGOs, Provincial NGOs, Local NGOs & CBOs are in operation. From the beginning to the end of the Menik farm, NGOs played a key role in all its activities. Some high NGOs such as SLRC, UNCHR, UNDP are very powerful and there were

instances where even the military leadership happened to depend on them. However, all NGOs were programmed into a common management plan through the DMC Medical, sanitary, safety measures and environmental management.

The role of NGOs in post Tsunami disaster management created new discourses of disaster politics in Sri Lanka. As many as 500 international NGOs arrived in Sri Lanka in response to the disaster. In addition, INGOs (international non-government organizations) already active in Sri Lanka such as CARE International, PLAN International and World Vision Lanka, swiftly modified aid portfolios to assist the survivors. A significant part of the aid was used to finance salaries of expatriate staff, maintain luxury vehicles and exceedingly high living costs. The INGOs and NGOs divided themselves among different districts and sectors (e.g. housing, water and sanitation, health, psycho-social support, and livelihood development), but there was limited coordination among different players and frequent competition for territory (Silva, 2005).

Despite sharing a common language and advocating a similar programme of emergency response, the government and NGOs constitute two parallel domains that accord radically different meanings to disasters. The state views disasters as a temporary and unfortunate deviation from development and gears all its activities to effect a return to that prior condition as soon as possible. NGOs, on the other hand, view disasters as a symptom of mal-development, for which they hold the former responsible. They view disasters primarily as the outcome of bad governance. While helping people to strengthen their resilience to disaster, NGOs also consider disasters as an opportunity to raise people's awareness and mobilize them for social change.

In the case of shelter & sanitary programs, state partners such as ACLG and the Water Board played a crucial role. The state was found imposing over inter-governmental organizations in maintaining partnerships and cluster welfare schemes for IDPs in the Menik welfare sites. It was learned that this competent authority was more powerful and significant among stakeholders in the joint mechanism. All the relief, welfare, health, administrative, awareness, and construction programs have been subjected to security scrutiny. This nature of tight

security measures within a controlled socio-physical environment had a greater impact on IDPs and their future existence.

The humanitarian governance with regard to refugee management has been changing according to changing discourse of power and the role of international power agencies such as UNHCR. According to Garnier et al (2018), different arguments of power such as 'Money is power', 'Knowledge is power', 'Discursive power', 'Relational power' and 'Governmentality' all these have changed the source of power and execution of power in terms of humanitarian management in the contemporary context. The power of UNCHR, World Bank, Human Rights Organizations and other international agencies, humanitarian and other financial organizations have become very powerful in providing humanitarian aid and financial debt specially for Disaster Risk Reduction projects in developing countries. Even in the case of Menik Farm activities, UNCHR was very crucial and attempted to bring its maximum power of humanitarian governance challenging certain proposals and activities of the Sri Lankan government.

Even if there were best practices of emergency governance regarding post disaster management in the Menik Farm, no proper study has been conducted due to security reasons and poor interest of sociological research in this regard. Thus, many lessons learned from post-disaster management are yet to be converted into new knowledge. It is important to promote more political and cultural responses of disasters for future disaster resilience planning. Any conflicts associated with social values and cultural pollution also leads to 'soft politics' in any post-disaster management process. Ethnicity, regional differences and minority groups have different impacts on post disaster management as socially or culturally constructed politics.

According to studies on Post Tsunami disaster management in Sri Lanka by Amarasiri de Silva (2009), in ethnically mixed communities, the distribution of economic and political power have the implications for coping with disaster-based vulnerabilities. Disaster vulnerability among racial and ethnic minority communities has reportedly increased in the recent past. Significant differences in risk perception among different ethnic groups vis-à-vis disaster events have been

reported and different consequences of hazards for ethnic minorities have been highlighted.

Silva (2009) further argues that in the process of recovery, cultural boundaries have been reinvented and culture-based discrimination has resumed. During this process, some people and community groups sought advantages while others were deprived of benefits and opportunities for recovery. Despite the indiscriminate effects of disasters, it is generally recognized that disaster risk and vulnerability are not equally distributed, particularly in the recovery stage. Thus, the recovery process is seen as sensitive to ethnicity and social stratification, especially those that emerge post disaster.

There were many micro level and subjective conflicts of interest among IDPs in the Menik Farm. These underlining power relationships were based on many different social identities based on religion, caste, regional differences and family background. It was possible to observe forms of cultural politics based on the notion of 'dirt' or 'pollution' and caste among IDPs as revealed by interview data. This can be understood by the cultural theory of dirt introduced by Marry Douglas. According to this theory, what makes things dirt or clean is based on the moral order of a society which periodically renews and reaffirms its basic relations and collective sentiments (Mahees, 2018). The politics or social divisions based on cultural pollution is found in many disaster management sites of Sri Lanka. For example, even in the post disaster management process of floods, landslides and Tsunami there were hidden and subjective social value-based conflicts based on the debate of what is pure and what is dirt within welfare camps. The culture based soft politics of Menik Farm was based on the following three factors.

1. Cultural notion of dirt within the camp
2. Caste consciousness
3. Gender difference or poor gender sensitivity

There were different social stratums or layers among Menik Farm IDPs. Caste, different economic backgrounds (class), education level and religion were very significant among them. As revealed by the interviews with IDPs, there were serious contradictions among IDPs based on the 'class' factor. For an example, IDPs who were economically

rich consumed more goods from shops established within the zones in addition to the free food given to them. This was an unbearable situation for the poor IDPs. Since there were communication (uses of mobile phones) and banking facilities, economically viable IDPs enjoyed privileges while in camps. Sometimes different caste groups had to inhabit in one temporary shelter and even non-lower caste individuals happened to engage in cleaning work. These situations created a kind of cultural pollution which was difficult to be objectively measured by any study. The success of sanitary and environmental services provided by different agencies was also dependent on the social integration of IDPs.

The gendered dimensions of disasters have been attracting significant scholarly attention since the 1990s. Interest in gender stemmed from the vulnerability paradigm, as it had become obvious that disasters affect women disproportionally, along with other marginalised social groups such as children, the elderly, and people with disabilities (Gaillard et al 2017). Although there is some significant gender-based policies adopted in Sri Lankan national level disaster reduction programs, they are not practiced appropriately in all regions and cultures equally. For an example, the property ownership traditionally held by men and micro finance (credit facilities) for women has negatively influenced women at grassroot level in post-disaster development programs.

In the case of Menik Farm, without over generalization or over specification of gender issues, women in the welfare camp faced a double impact of war and happened to be continuous victims in the post war scenario because of poor gender sensitivity. Many women were widows and had faced severe crises and experiences even among the IDPs. Many of the issues faced by women in Menik Farm did not come out due to cultural barriers and tight security measures but rather by the poor identification of gender needs in terms of planning and implementation of camp management. The decision-making process of the camp was mostly based on patriarchal social and political frameworks. Although there were basic sanitary facilities provided to IDPs, the necessary gender needs were poorly identified in the designing, planning and implementation process. However, women in the camp were highly satisfied with the health and medical facilities

available. Majority of the health workers (medical doctors and nurses) were Sinhalese from the South and there was a good rapport and interaction among IDP patients and health workers. For instance, most of the IDP women frequently wanted to visit medical officers more than their medical requirement and share their grievances and issues. However, since there was no proper system of counselling, health workers happened to use informal mentoring tactics or an advocacy role even with language barriers.

As pointed out by Pelling and Dill (2010), some political impacts of disaster management unfold during reconstructions, others may be felt only at a distance indirectly and some of them are yet to influence. Some political impacts are at times coded, hidden or destroyed by the media or rapidly suppressed by other powerful means of politics. Even in Sri Lankan post disaster management activities or development, the media has become very powerful and these local electronic media which function with a super mass culture attempt to capitalize the political context of disaster management. Moreover, the disaster management process or disaster relief work have resulted in the emergence of disaster 'heroes' or disaster related 'political superstars' through the media. In contemporary Sri Lanka disasters have created a new political space or a new political ecological soil for new political leaders to emerge.

Compared to other IDP camps in the country, Menik farm had many infrastructural facilities (water, electricity, roads & sanitation) and many other social, education and medical facilities. Thus, whatever issues related to freedom, human rights and grievances of war, majority of IDPs were happy about the basic infrastructure facilities and the management process carried out by the military leadership. On the other hand, the local community around the camp had significant financial and infrastructural problems. They did not have any access or opportunities to interact with the camp or any advantages like others in camps that function in other areas of the country. The host community of Menik farm were unhappy about the way in which the camp was run by the management and they were totally excluded from the process due to other political factors of tight military control over the camp. Under such circumstances, no IDP was allowed to go out of the camp site except for valid reasons. Even outsiders were totally

restricted from visiting the camp and all relationships within camp were controlled by military rules.

Usually the host communities around any resettlement area or welfare camp reap many financial benefits and other social relationships. Sometimes, there are competitions and conflicts between IDPs and host community in terms of enjoying economic, political and natural resources. Wherever IDPs are temporarily settled, the host community receives both positive and negative benefits. According to opinions of the host community, unlike in other IDP welfare sites, Menik Farm does not bring any significant benefits to them. The host community does not have any direct or face to face interaction with those in the camp due to security measures. They also did not receive any new economic benefits by getting a better price for their land or other products (food) or demand for their labour and professions. It is reported that almost every material and manpower supply were done by the host community. In other words, it was not people in Chettikulam but outsiders who were politically powerful and had links with the camp management who enjoyed economic and other advantages from the Menik Farm IDP welfare sites. The only benefit was that Chettikulam became recognized all over the world and people were made aware of certain novel factors related to administration and politics. Instead, the host community experienced many environmental problems, such as dusty atmosphere, deforestation and waste disposal and tightened security. Since many of the state institutions and government departments (LAs, RDA, and MOH) have given priority to IDPs, the host community did not receive due services from such institutions. The regular development activities in the areas were also disturbed by welfare programs. Thus, the host community was dissatisfied with the performance of such institutions.

Finally, the welfare camp was decommissioned in a gradual process from May 2009. Since there were many infrastructural facilities for IDPs, the government of Sri Lanka wanted to provide permanent settlements for some IDPs but a clear majority of people (IDPs) preferred to leave the place and settle down in their own land. However, the government and some political parties were more concerned about assisting IDPs to settle in their usual villages considering their votes for the presidential election in 2010. Again, it

was obvious that national level politics resulted in swift changes in the post disaster management.

4. Conclusion

The lessons learned and experiences gained from this historical and unique process of Sri Lankan emergency management of around three hundred thousand IDPs need to be critically shared with the international community and used for future local academic and practical requirements in any disaster management. The joint mechanisms of the GoSL, military leadership and NGOs were the focal point, functioning as the central mechanism of disaster mechanisms peculiar to Sri Lanka. However, there is a huge gap between what really happened in the field and what has been taped as new empirical knowledge for the future. Many emergency functions for the betterment of the IDPs were carried out under strict military discipline. Although military leadership was severely criticized regarding human rights violations during the war, IDPs were mostly satisfied with basic infrastructural facilities and for the commitment of soldiers in contributing to better welfarism. Thus, the military leadership functioned as a benevolent dictator. Menik Farm was the thriving place for NGO politics in Sri Lankan disaster management after the Tsunami NGO politics in 2004. The role of UNCHR and UNDP were unique and the DMC which functioned as the responsible body of handing disasters were exposed to new experiences. It was evident that a new form of diversified disaster politics was recognized in the Menik Farm emergency management process. The informal soft power dynamics as well as cultural politics were another scenario that highlighted psychological disaster politics. Finally, it was apparent that Sri Lankan disaster politics is getting diluted and diversified as a new mode of power dynamics depending on the contextual political economy, experiences of state welfarism and military culture.

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Scenario analysis to identify a sustainable pond rehabilitation approach for flood mitigation: A case study in Jaffna, Sri Lanka

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Abstract

Jaffna peninsula which spans over a land mass of 1026 km^2 with 9.3% of inland water bodies suffers from severe flooding during the second inter-monsoon (October ~ December) where it receives about 68% of its total annual rainfall. Its ancient pond system was used to drain the accumulated runoff to the lagoon without much inundation. However, due to the dilapidating condition of the pond system, now the flood spreads out into the highly populated areas causing inconvenience to the public. This study seeks to identify the most sustainable pond rehabilitation approach for flood mitigation considering the HEC-ResSim model results of the Paalkulam pond cascade in Jaffna Municipal Council. The analysis results show that in upstream ponds, bund level raising and pond bed dredging reduce the total inundation area by 27.5% and 19.7%, respectively. However, in downstream ponds, the results do not tally with the upstream ponds, where bund level raising reduces the total inundation area by only 21.4% while the pond bed dredging reduces the total inundation area by 34.3%. Therefore, results conclude that when the pond system is rehabilitated, the actual intervention at an individual pond should be based on its relative location in the cascade system in order to achieve sustainable results with a positive impact on flood risk mitigation.

Keywords:

Flood Mitigation; Inundation; Pond Cascades; Pond Rehabilitation; Water Sustainability

1. Introduction

Many urban areas are facing flood issues during high rainfall events due to the poor design and working condition of its drainage system (Kuller, Dolman, Vreeburg, & Spiller, 2017). The peak rainfall values in the dry zone are relatively higher compared to that in the wet zone (Alam, bin Toriman, Siwar, & Talib, 2011). The social and environmental damages from this disaster indicate the need for an immediate sustainable practice to overcome this crisis.

During October ~ November period, higher rainfall is received in the Jaffna peninsula where it accounts for about three fourth of the total annual rainfall (Fig. 1) (Sivakumar, 2015; Sutharsiny, Manthrithilake, Pathmarajah, Thushyanthy, & Vithanage, 2014). The most recent flood in the Jaffna peninsula occurred in the year 2017 where a considerably large extent of the peninsula was inundated. During the course of finding remedies for this long lasting flood crisis, authorities have suggested several alternative solutions. However, none of the solutions were proven successful including the rehabilitation/restoring of individual ponds (Shanmugarajah, n.d.). Among the fifteen divisional secretariat divisions in the Jaffna district, the Jaffna Municipal Council (JMC) holds the highest population density of 2986 per km^2 (Rajeswaran, 2005). Considering its significance for the living community, JMC area was selected for this study (Fig. 2). The municipal council area had more than 100 ponds acting as the central water retaining mechanisms of the city stormwater management (Thushyanthy & De Silva, 2012). However, with the lack of proper maintenance, only 47 ponds are remaining at present. The primary reason for the physical damages to the pond system is the unawareness of the importance of the pond system for flood mitigation and pond encroachments (Thushyanthy & De Silva, 2012).

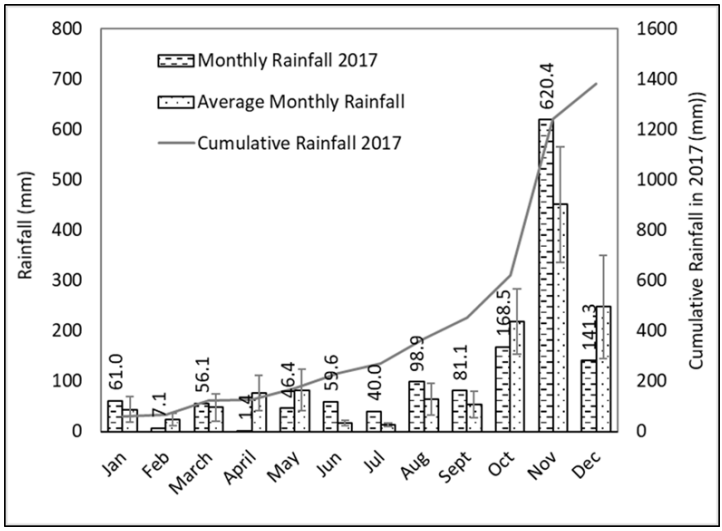

Fig. 2. *The monthly rainfall pattern in Jaffna peninsula*

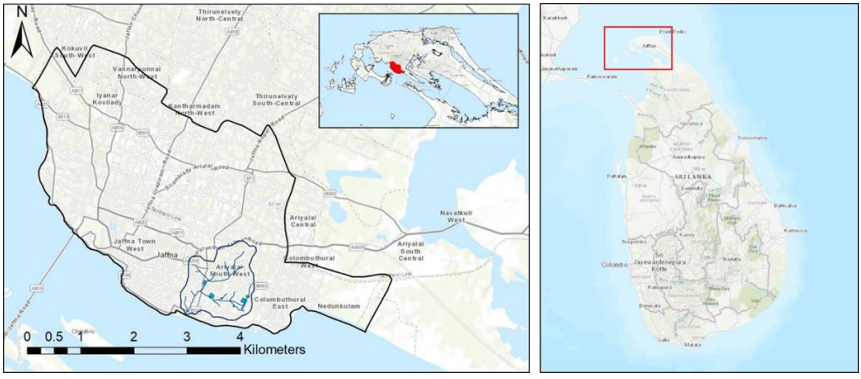

Fig. 1. *a) Study area: Jaffna Municipal Council, b) Jaffna Peninsula in Sri Lanka map*

Strategic development of the pond system rehabilitation approaches increases the water retention capacity (Vincenzo & Molino, 2013) as well as the sustainability of the system. The existing pond system acts as an interconnected water sharing network where it speedily distributes nearby floods downstream. This holistic behavior of water retention bodies is highly beneficial in flood mitigation until the connectivity is broken by the failure of one or more ponds (Panabokke,

Tennakoon, & Ariyabandu, n.d.; Tennakoon, 1999). When the 47 ponds in the Jaffna Municipal Council area are considered, many of them are not in proper working conditions, seeking immediate restoration (Itakura, 1995). If the pond cascade system is restored by identifying a proper methodology, the flood issue is expected to be minimized. Further, it increases the total water retention and the net groundwater recharge. Since the peninsula suffers from a severe water scarcity during the dry season, this approach can be identified as a viable solution. The holistic view of pond rehabilitation enables maximum water sustainability in the cascade system. Several early studies have tried to identify the best methodology leading to the identification of the best rehabilitation approach for water retention bodies (*Detailed Design of Rehabilitation of Ex-Mining Pond and Existing Wetland for Integrated Storm Water Facilities*, 2015; Perera, Wijayaratna, Manatunge, & Priyadarshana, n.d.; Vincenzo & Molino, 2013) focusing on different individual objectives. The present study engulfs an approach based on holistic perspectives to achieve pond rehabilitation goals while recognizing sustainable aspects.

2. Materials and study objectives

The study focuses on finding the most reliable rehabilitation approach for flood mitigation and methodology was developed accordingly. This methodology compares two pond capacity increment tactics for higher storm water retention. Forty-seven ponds in the Jaffna Municipal Council area were selected for this study and they fall into eight pond cascade systems according to the basin separation of the catchment. Out of these eight cascades, Paalkulam cascade which mothers seven ponds was selected for this study (Table 1). This study uses a computer simulation application termed HEC-ResSim (Hydraulic Engineering Center, U.S. Army Corps of Engineers, USA) which is based on the water balance. A geographical information system was used to generate flood contour maps to identify the inundation areas for different scenarios.

Table 8. Paalkulam cascade ponds

Pond	Total capacity (m^3)	Max. depth (m)	Pond	Total capacity (m^3)	Max. depth (m)
Vannankulam	5,525	2.5	Paalkulam	11,800	2.0
Maravakulam	7,175	1.5	Pasaiyoorkulam	4,975	2.0
Makkiyakulam	10,300	1.5	Vilaththikulam	4,200	2.0
Mudalikulam	1,575	2.0			

2.1 Study area

The Paalkulam cascade has a basin area of 156.7 ha and the land use pattern of the area is identical to the typical characteristics in the majority of catchments in Jaffna where they are mostly residential and is a paddy cultivated area (Sutharsiny, Pathmarajah, Thushyanthy, & Meththika, 2012). The topography of the area is relatively flat, and land elevation holds a maximum of 14 m AMSL (above mean sea level) and drops when reaching the shoreline. The climate of the region is tropical monsoonal with a seasonal rainfall pattern and the highest monthly rainfall is received during the month of November (Rajeswaran, 2005). The temperature ranges from 26 ˚C to 33 ˚C and annual precipitation ranges from 847.7 mm to 1909.3 mm (Rajeswaran, 2005). The second inter-monsoon period (October to December) brings about 68% of the total annual rainfall. The study area falls within two Divisional Secretariat (D.S.) administrative divisions, namely Jaffna Municipal Council and Nallur Pradeshiya Sabha.

One of the significant contributions of these pond systems is their groundwater recharge capabilities. The peninsula is receiving relatively much lower rainfall during the first nine months of the year and many of the water needs are satisfied by the freshwater available as groundwater. Therefore, the aquifer system in the area is vital to meet the domestic and industrial water demand. The aquifer system in the region is a highly karstic Miocene limestone and freshwater is present as mounds or lenses by floating over the saline water.

2.2 Research objectives

The primary objective of this study is to propose a sustainable rehabilitation approach for Jaffna pond system. The specific objectives of the study are to identify the cascade systems in the JMC area and to find the best rehabilitation approaches for upstream/downstream ponds.

If all the specific objectives are achieved, then the overall objective will inevitably be achieved. Then, the Jaffna communities will have a reliable water source and flood hazards will be mitigated. Furthermore, the study results can be tested in different geographical locations and evaluate its adaptability to similar pond cascades elsewhere with identical management issues.

2.3 Data processing

HEC-ResSim computer application is used for the modelling of Paalkulam cascade and this application uses a simple water balance approach to model the temporal behaviour of the pond storage. The water balance equation for the storage change is given in Eq. (1)

$$\Delta S\ (Storage\ change) = Q_i(Inflow) - Q_o(Outflow) - E(Evaporation) - S_e(Seepage) \quad \text{Eq.1}$$

The study uses monthly average evaporation values (Table 2) of Thondamanar gauge station for the HEC-ResSim modeling. The pond survey maps were referred to identify the elevation-area-storage relationship of each pond in the cascade. Also, the physical characteristics of the spillway were fed into the model using the data collected based on pond survey maps. The daily rainfall data from the Department of Meteorology were used for runoff generation, and the pond seepage rate was taken as 0.5% of the storage (Ponrajah, 1984).

Table 9. Monthly average evaporation values of Thondamanar gauge station

Month	Evap. (mm)
Jan	115.5
Feb	113.1
Mar	133.5
Apr	139.3
May	171
Jun	164.6
Jul	151.8
Aug	153
Sep	156
Oct	135
Nov	107.6
Dec	111.6

2.4 HEC-ResSim modelling

Individual pond basins in the Paalkulam cascade were identified prior to the HEC-ResSim modelling. Runoff generation in each sub-catchment was taken as a lump and fed to the model. Computer application simulates the pond storage behaviour considering the physical characteristics of the canal network which connects two ponds. Moreover, when the water spills through the spillway, a part of it flows to the downstream pond and the balance causes flooding.

There are three modules in the computer program which is being used for pond cascade modelling and each contains different sets of functions and data directories. First, modelling begins with the Watershed Setup module and it seeks the stream network and all the ponds in the system. Next, the Reservoir Network module is prepared using physical characteristics of the pond and hydrological characteristics of the catchment. Finally, the simulation module carries out model simulations and it shows the individual pond and canal behaviour (Klipsch & Hurst, 2013). The simulations were carried out using daily rainfall data of the year 2017 to check the probable inundation area. The spill discharge rates during the second inter-monsoon were observed to be much higher and it results in a hazardous flood situation in the sub-catchment levels. The 2017 flood caused

severe damages to the peninsula and it has been identified as one of the most hazardous events that has occurred in the last fifty years.

2.5 GIS flood analysis

Jaffna Municipal Council area was modelled using a geographical information system. From spot height values and contour data of Paalkulam cascade, Triangular Irregular Network (TIN) and Digital Elevation Model (DEM) were generated. The results were validated by checking elevation data extraction using the Google Earth software and ground truthing. The spatial analyst supplemental tool was used to generate the storage capacity relationship of each sub-catchment and in the entire Paalkulam catchment, accordingly.

Cascade catchment area is divided into the miniature scale (sub-catchment), and for the quantified spill amount, the inundation area was identified. The exact procedure was followed, when the whole cascade was considered too. Those results can be directly used to test and prove the initial hypothesis. ArcGIS results play a significant role, to achieve the specific objective of this study and the cascade connectivity was totally ignored when the ponds were modelled individually.

3. Methodology

Prior to the methodology development, upstream (Vannankulam, Makkiyakulam and Pasaiyoorkulam) and downstream (Paalkulam and Maravakulam) ponds of the Paalkulam cascade were identified. The flood situations when the upstream bund level is raised, and the pond bed was dredged, were modelled using the HEC-ResSim application and ArcGIS toolkit.

The Paalkulam cascade is divided into seven sub-catchments considering the runoff contribution of individual ponds. During the rainy seasons, the generated runoff in each sub-catchment drains to the corresponding individual pond and pond spills when the Full Supply Level is reached. The HEC-ResSim computer simulation application

identifies the net spill water quantity in the rainy period which causes floods in the downstream.

3.1 Increasing the bund height levels

The first approach of the pond rehabilitation was bund height raising and this was followed for upstream and downstream ponds, separately. Each upstream/downstream pond bund height was raised by 0.5 m, and HEC-ResSim simulations were used to find the storage behaviour. Pond elevation-area-capacity input values were changed accordingly while all other parameters were kept constant. The modelling procedure was the same for both upstream and downstream ponds. HEC-ResSim model simulation dates on 1st of January, 2017 to 31st of December, 2017 for the simulations. Evaporation values and runoff generations from rainfall were fed to the model as described in the HEC-ResSim modelling.

Later, the total inundation area was established using the DEM generated for the cascade catchment area. The GIS flood analysis shows an inundation area of 21 ha was there before any rehabilitation approaches had taken place.

3.2 Pond bed dredging

The next approach was the pond bed dredging and dredging quantity was calculated as it would be the same as capacity increment by bund height raising. Dredging quantity is calculated using Eq. 2.

$$Dredging\ Quntity = \sum^{Reservoir\ capcity\ increment}_{by\ bund\ height\ raising} \quad \text{Eq.2}$$

The dredging quantity was distributed among them considering its individual capacity values. Eq. 3 illustrates the dredging quantity calculation for upstream ponds of the Paalkulam cascade.

$$\left\{\begin{matrix}\text{Dredging} \\ \text{quantity of} \\ \text{pond}_\text{i}\end{matrix}\right\} = \left\{\begin{matrix}Total \\ dredging \\ quantity\end{matrix}\right\} \times \frac{Capacity\ of\ pond_{\ i}}{\sum_{j=1}^{n} Capacity\ of\ pond_j} \quad \text{Eq.3}$$

The pond Elevation-Area-Storage relationship was accordingly changed, keeping the pond bund heights constant and depth value was changed in the range of 0.5 – 2.0 m. The dredging depth was identified following an iteration method (Fig. 3). When the storage ratio (Eq. 4) is higher than 4, dredging starts from a higher contour.

$$Storage\ Ratio\ (SR) = \frac{Dredging\ Quantity}{Maximum\ dredging\ upto\ 0\ m\ contour} \quad \text{Eq.4}$$

If the pond bed dredging was carried out assuming a conical variation of area-elevation, then the bottom area is calculated using Eq. 5.

$$Bottom\ contour\ area = \frac{2 \times Volume}{\Delta(contour\ height)} - Top\ contour\ area \quad \text{Eq.5}$$

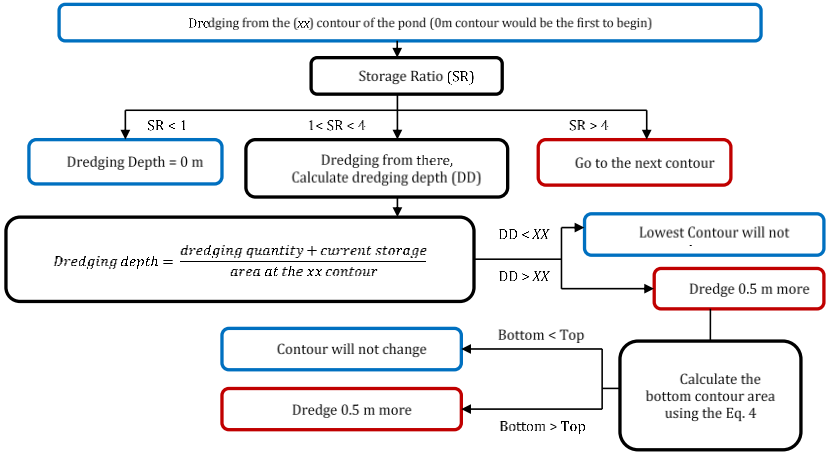

Fig. 3. *Dredging Depth Calculation Method*

3.3 Methodology development

Considering the cascade behaviour, two different rehabilitation approaches for flood mitigation were considered here and their model analysis results are to be used to identify the most suited approach considering the location of the pond in the cascade system.

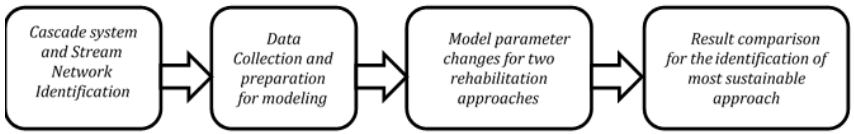

Fig. 4. *Methodology Flow Chart*

4. Results and Discussion

The scenario analysis results show that upstream pond rehabilitation should be carried out by increasing bund heights and downstream pond rehabilitation would be optimised by dredging the pond bed. In this analysis, dredging quantity is determined by using capacity increment by bund level raising and then it is distributed among corresponding ponds. The dredging depth and contour lines are determined from an iteration method. The storage ration (SR) limit is taken as 4 by carrying out numerous sample calculations and checking for the best-suited dredging option.

Subsequently, the total inundation area was established using the generated DEM of the cascade catchment area. The total catchment area of the Paalkulam cascade is 156.7 ha and before carrying out any rehabilitation approach, the inundation area was 21 ha. First, the upstream pond rehabilitation was carried out by considering the bund height level increasing and pond bed dredging. Later, downstream pond rehabilitation was carried out for the same two rehabilitation approaches. The summary of the model simulation results is shown in Table 4. Further, the inundation areas of Paalkulam cascade for four scenarios (which were visualized using a GIS toolkit) are shown in Fig. 5.

When selecting the numerical value of 0.5 m for the step increment of bund raising, previous rehabilitation approaches were considered (Itakura, 1995; Nagarajan, 2013; Perera et al., n.d.; Vincenzo & Molino, 2013). Furthermore, the bund height increment of 0.5 m indicates a 0.5 m spill height increment. These two approaches (bund height raising/bed dredging) were not modelled simultaneously and only one

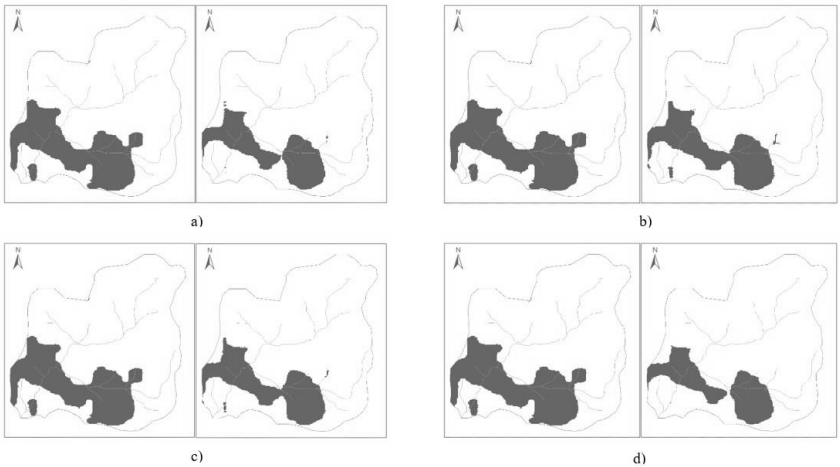

Fig. 5. *a) Inundation Area Reduction after the Upstream Bund Raising, b) Inundation Area Reduction after the Upstream Bed Dredging, c) Inundation Area Reduction after the Downstream Bund Raising, d) Inundation Area Reduction after the Downstream Pond Bed Dredging*

parameter was changed in one simulation. The elevation-area-storage relationship of each pond was accordingly updated. The increased spill height and bund height upturn the storm water retention in the pond and it results in a reduction in the inundation area. However, further consideration should be given for the water balance in the system during the dry season where the downstream ponds highly depend on upstream water sources.

Table 10. Summary of different rehabilitation approaches

	Upstream pond rehabilitation		**Downstream pond rehabilitation**	
	Increasing the bund levels	Pond bed dredging	Increasing the bund levels	Pond bed dredging
Inundation area (ha)	15.23	17.12	16.51	13.8
Reduction percentage (%)	27.5	18.5	21.4	34.3

When the upstream pond bed dredging was considered, the dredging quantity was decided by calculating the total capacity increment by spill height increment. Makkiyakulam has twice the capacity than

Vannankulam and Pasaiyoorkulam, and its dredging quantity (3664.42 m^3) was approximately twice than that of the other two (1965.63 m^3 and 1769.95 m^3). Though the dredging quantity if found, then there are two questions to follow. The dredging level is decided considering the ratio of dredging quantity and the maximum of dredging up to 0 m contour, (with/without changing the existing pond bed level). The pond capacity is increased and it changes the area elevation profile of the pond accordingly. This methodology may give fabricated outcomes if applied to larger water retention bodies. However, considering the extent of the pond capacities in the Paalkulam cascade, this dredging will not affect its boundary stability.

The scenario analysis was carried out to recognize the most sustainable rehabilitation approaches for each pond. In this analysis, only pond bund height raising and pond bed dredging were considered and for better results, various other rehabilitation approaches are recommended to follow.

5. Conclusion

As conclusions, it can be postulated that the upstream ponds/water retaining bodies in a cascade system should be rehabilitated by raising the bund and the downstream ponds/water retaining bodies should be rehabilitated by bed dredging. Further, when the pond connectivity for effective storm water management is considered, the canal connectivity is vital as it helps in directly distributing accumulated floods to the downstream ponds in the cascade system.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

Sustainable dengue prevention through enhanced premise inspection

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Abstract

Social, economic and health system costs due to Dengue epidemics are significant. Sri Lanka experienced intermittent Dengue outbreaks with varying severity since 1989 with the highest recorded in 2017. A team of 1350 Field Assistants in Mosquito Control dedicated for field work were recruited during 2017 and 2018 to address this issue. This has led to increased coverage of premise inspection resulting in an increase of potential and positive breeding places from 2017 to 2018 (premises inspected: 2017 –2.7 million, 2018 – 1.4 million; potential: 2017 – 20.48%, 2018 – 21.46%; positive: 2017 – 1.98%, 2018 – 2.27%). Reflectively, there has been an overall reduction of reported Dengue cases from 2016 (55150) to 2018 (51591) by 6.5% amidst an outbreak in 2017 due to the introduction of a new virus type (186,101). Therefore, capacity development at grass root level will produce successful outcomes in dengue control.

Key words:

Dengue Control in Sri Lanka; Premise Inspection for Dengue; Source Reduction for Dengue; Dengue Control; Field Workers for Dengue Control

1. Introduction

Dengue viruses (DENV) are mosquito-borne flavi viruses that have affected humans for centuries. Globally, Dengue was identified as the second most important tropical infectious disease following malaria in 1998. The estimated case load during the year was close to 100 million, including nearly 500,000 cases of dengue hemorrhagic fever and 25,000 deaths annually (Gubler,1998). Rapid changes due to urbanization and human population growth have led to the current global dengue pandemic, characterized by a dramatic increase in DENV infections and an expanding geographic distribution of DENV and mosquito vectors, *Aedes aegypti* and *Aedes albopictus*, which transmit DENV among humans. The extent of dengue transmission and therefore the risk of outbreak are determined by a combination of various modifiable and non - modifiable factors; distribution and virulence of the virus, population density, movement of humans and level of herd immunity, vector competence of *Aedes* mosquitoes and weather and climate variables amongst other environmental factors accentuated by human behaviour (Sirisena & Noordeen, 2014).

Dengue is now endemic in more than 100 countries mainly in regions of the Americas, the Eastern Mediterranean, South-East Asia and the Western Pacific. There are 3.9 billion people at risk and 50 - 100 million dengue infections occurring each year which includes nearly 5 million Dengue Haemorrhagic Fever cases and 22,000 deaths. America, South-East Asia and Western Pacific are the most seriously affected regions, exceeding 1.2 million cases in 2008 and over 3.2 million in 2015 (WHO, 2014).

In the South East Asian region, Dengue Fever/Dengue Haemorrhagic Fever is endemic in 10 countries and detection of all four serotypes has now rendered these countries hyperendemic. Sri Lanka is grouped under this hyperendemic category (other categories being 'endemicity uncertain' and 'non endemic') by the World Health Organization (WHO, 2019).

Dengue is a major vector borne disease in Sri Lanka, being endemic within the country since the mid-1960s. Urbanization and human population growth in the tropical regions of the world including Sri Lanka have produced favourable conditions for the transmission of

dengue virus (Sirisena & Noordeen, 2014). The established vectors within the country are *Aedes aegypti* and *Aedes albopictus* which belong to the subgenus *Stegomyia*, carrying all four subtypes of the dengue virus (DV) (Sirisena & Noordeen, 2014). With these favourable determinants, amiability to sudden outbreaks of dengue has made the country highly vulnerable over the decades. Up until 2009, the reported number of dengue patients from the country remained around 10,000 per annum. However, a rapid rise of over 30,000 cases was reported during 2009. Since then, the baseline remained the same with higher numbers around 50,000 reported during 2012, 2014, 2016, 2017 and 2018. The year 2017 reported the largest outbreak in the history, recording over 180,000 patients (833.9 per 100,000 population) and 414 deaths (Case Fertility Rate: 0.24) throughout the country (Epidemiology Unit, 2019).

Integrated Vector Management (IVM) which is defined as "a rational decision-making process for the optimal use of resources for vector control" is the mainstay of prevention and mitigation of Dengue outbreaks. This process takes into consideration the efficacy, cost effectiveness, ecological plausibility and the sustainability of combined approaches compared to single measures for disease control and prevention by facilitating a multi sectoral approach (WHO, 2019). The main components of IVM constitutes environmental management, use of chemical methods, use of biological and bio chemical methods, inter sectoral collaboration, health education and law enforcement in extreme situations (National Dengue Control Unit, 2016).

However, the efficacy of the IVM measures is dependent on comprehensive and persistent enforcement of them on the community. These measures are generally implemented by local health authorities and the residents of the area to varying degrees in different geographical locations worldwide. Among some of the affected countries, certain categories of health workforce have been developed and trained to address unique control measures such as fogging. However, environmental manipulation, which is a key component for effective disease control outcomes, lacks a defined work force in most of the affected countries.

Certain countries such as China, Singapore, Philippines and Australia call upon temporary workforces for field mosquito control during

needy times (Lin et al, 2016; Renganathan et al, 2003). However, the effectiveness and sustainability of such a force has become a major obstacle to continue their services on a regular basis. It is paramount to train and familiarize them with many modes of operandi including the basics of dengue disease dynamics, intricacies of environmental manipulation and disease transmission, technical knowhow of commonly adopted control measures, community engagement, personal safety and work ethics. Sustaining continuous 'on the job' training to update knowledge on current trends and latest innovations in disease control prove to be a challenge, since a dedicated syllabus and a skilled, professional teaching staff is needed to undertake such an enormous task. To sustain continuous budgetary allocations from already stretched public health funding channels and convincing political and bureaucratic hierarchy to commit to such a programme found to be challenging. Since the job description includes a strong community engagement aspect, grooming an unskilled worker into a more community friendly, interactive and socially acceptable community worker was the biggest obstacle encountered by many countries in the region.

2. The objective of the study

Environment management that incorporates premise inspection and elimination of breeding places has been identified as a major component of IVM. However, lack of a work force to facilitate such grass root level activities was regarded as a drawback of the Dengue control programme in Sri Lanka.

Considering Dengue as a priority public health problem and the need of a trained workforce to augment field activities, a timely policy initiative was taken to develop the capacity of field teams at divisional level by recruiting a dedicated field team "Field Assistants Mosquito Control" (FAMCs) to implement prevention and control activities at community level.

3. Methods

A total of 1350 FAMCs were recruited in a phased manner during 2017 and 2018. The potential candidates were between 18 – 45 years old both males and females with an educational qualification of a grade 8

pass or above, from all parts of the country. The previous experience of community-based health work was a prioritized qualification. The candidates were interviewed by a panel of Community Health Professionals on their qualifications, attitudes and physical capacity to engage in the community for long hours. Those who fulfilled the above criteria were recruited as FAMCs to the Ministry of Health and allocated to the National Dengue Control Unit (NDCU). An initial brief training of two weeks followed by an extensive training of 12 weeks was conducted. This constituted a theoretical component targeting development of knowledge on mosquito and breeding sites, environmental management including modification and manipulation of potential breeding sites, handling chemicals and insecticides including fogging, cultivation and distribution of larvivorous fish, handling and maintenance of vector surveillance and control equipment, legal background on vector control, provision of health education, Personal Protective Equipment, feedback returns and formats and administrative procedures within the Ministry of Health. This was followed by practical sessions in the field to practice acquired knowledge.

The FAMCs were dispatched to 26 districts prioritized according to the risk level for dengue. The number of FAMCs that was assigned to high risk districts was greater than for low risk districts, thus nearly half of the work force was being disposed to the Western Province. Within the district, they were stationed in all high-risk Medical Officer of Health (MOH) units which is the smallest health authority that is responsible for the enhancement of community health in their catering area.

Their main duties included inspection of premises around each reported dengue case for mosquito breeding places and assisting the community to eliminate them, regular house to house inspection and removal of breeding places in high risk areas, educating the public on mosquito breeding and prevention activities including distribution of health education materials and public announcement, educating the public on waste segregation and disposal, assisting technical officers for vector control during outbreaks, assisting in entomological surveys, fogging under guidance and supervision of technical officers and relevant documentation including returns.

4. Results and Discussion

Currently, FAMCs are working in all high-risk districts with a majority (47%) in the Western province. They engage in routine premise inspection and elimination of mosquito breeding sites based on epidemiological and entomological surveillance evidences, in special premise inspection as teams during Special Mosquito Control Campaigns (SMCCs) and under outbreak situations as a rapid response team. Premise inspection targets all high-risk localities and high-risk premises namely, houses, schools and higher education institutions, government and private institutions, construction sites, factories, religious places and public places. They also assist in entomological surveys which enable proactive public health actions. They occupy targeted vector control measures by means of barriers, chemical and biological methods for breeding places which cannot be eliminated completely. They empower and engage communities for sustainable preventive actions working together at micro level by forming street committees, organizing clean-up campaigns and raising awareness through health education.

Together with the Tri-Forces, FAMCs engaged in SMCCs covering inspection of 2.7 million premises in 2017 and 1.4 million premises in 2018. Of them, 20.48% and 21.46% were potential and 1.98% and 2.29% were positive in the respective years. Majority of potential and positive breeding places were acted upon immediately. Notices were issued for premises which couldn't be addressed immediately urging appropriate instructions for correction. Corrections were ensured by strict follow-up methods by the public health team. Legal actions were taken for repeated offenders.

Inspection of vulnerable premises such as schools and construction sites demonstrated a remarkable increase in proportions from 2017 to 2018 (schools from 0.3% to 0.6%; construction sites 0.4% to 0.9%). Detailed inspection of these premises has resulted in an increase in detection of potential (from 35.5% to 58.7% in schools; from 41.1% to 54.5% in construction sites) and positive (from 5.3% to 11.8% in schools; from 5.8% to 9.6% in construction sites) breeding places in 2018 compared to 2017 (Figure 1). These findings warrant innovative policy decisions to overcome challenging situations in the educational

sector and the construction industry (National Dengue Control Unit, 2019).

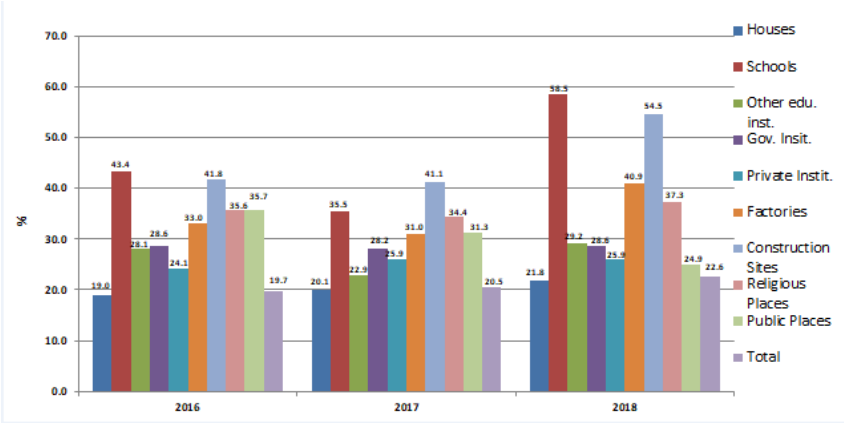

Figure 1. *Comparison of potential premises Island wide 2016 – 2018 (National Dengue Control Unit,2019)*

Operationalization of this novel strategy has resulted in an overall reduction of reported Dengue cases in 2018 by 75% and 6.5% compared to 2017 and 2016 respectively.

Table 2. Distribution of Dengue patients within Western Province and contribution to national value 2016 - 2018

District	2016 (Island total = 55 150)		2017 (Island total = 186 101)		2018 (Island total = 51 591)	
	Cases	**%**	**Cases**	**%**	**Cases**	**%**
Colombo	16767	30.40	34274	18.42	10258	19.88
Gampaha	7173	13.00	31647	17.00	5857	11.35
Kalutara	3502	6.34	10961	5.88	3155	6.11
	27442	49.76	76882	41.31	19270	37.35

(Epidemiology Unit, 2019)

The year 2017 saw the introduction of a new serotype of the Dengue virus, leading to a massive outbreak due to lack of immunity among the community. The most vulnerable province for the disease is the Western Province, comprising the Colombo, Gampaha and Kalutara districts due to favourable conditions for the vector mosquito *Aedes*, including breeding habitats and the weather pattern. However, despite the outbreak, in 2017, the contribution from the province to national

figures reduced from 49.76% in 2016 to 41.31% in 2017 and 37.35% in 2018. This correlates with the dispatching of initial FAMCs to the Western Province during 2016 (Table 2) (Epidemiology Unit,2019).

5. Conclusion

The recruitment of FAMCs has led to an increase in detection of total potential and positive premises in 2018 compared to 2016 and 2017. This has further contributed to an increase in detection of potential and positive premises in all types of vulnerable premises except public places in 2018 compared to 2016 and 2017. Detection and elimination/correction of potential and positive breeding places early have probably caused reduction in reported cases island-wide in 2018 compared to 2016 and 2017. Likewise, early distribution of FAMCs during 2017 in the Western Province which is the most vulnerable area for Dengue within the country, has led to marked reduction in contribution of Dengue patients in national values in 2017 and 2018 compared to 2016.

Capacity development at grass root level produces successful outcomes on Dengue control with substantial reduction in reported cases nationally, in the Western Province and the Colombo District, which are areas with the most significant risk for Dengue in Sri Lanka.

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Capacity Building for Research and Innovation in Disaster Resilience 2019

Why did they move in? A case of new Tsunami settlers in Galle, Sri Lanka

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Abstract

Numerous studies carried out in Tsunami resettlements in Sri Lanka disclose that many resettlers are moving out of their settlements due to various issues. As a result, a significant number of new settlers are currently living in Tsunami resettlements. This paper makes an attempt to obtain a comprehensive understanding of the factors that prompted new settlers to move in by studying three Tsunami settlements in the Akmeemana DS Division, Galle.

Forty-five household heads who were new settlers were selected as the sample and questionnaires, semi-structured in-depth interviews and observation were employed to collect data. The findings of the study revealed that low prices and rentals of houses, ease of access to education and health care institutions, and close proximity to relatives are the main reasons for new settlers to move in while lack of legal deeds, small floor area, lack of a drainage system, lack of an efficient waste disposal mechanism, drug abuse and illegal activities by Tsunami settlers were identified as disadvantages. Findings revealed that nearly 75% of respondents hope to leave the settlement in the future and only 25% were planning to occupy the houses permanently.

***Key Words**:*

Tsunami Relocation; New Settlers; Planned Settlements; Host Community

1. Introduction

This study attempts to identify reasons for leasing, renting or purchasing houses from Tsunami relocated settlements by outsiders (new settlers) in the Akmeemana Divisional Secretariat in Galle, Sri Lanka. After the 2004 Indian Ocean Tsunami, over 128,000 residents in the Galle district were displaced (Census, 2004). The Sri Lankan government, local and International Non-Government Organisations initiated construction activities of new houses for the displaced in areas identified to be safe from future Tsunamis and other coastal hazards. Many studies were carried out to identify the issues and problems experienced by relocated communities (Birkman & Fernando, 2008; Mulligan & Shaw,2007, Hettige, 2007; Ruwanpura, 2009). Nevertheless, researchers did not come across a single study which explored factors that led new settlers to purchase, rent or lease houses from Tsunami relocated settlers. This study makes an attempt to fill this gap by looking at various resettlements that record this phenomenon. This paper is divided into four sections namely an introduction, research methodology, findings, discussion and conclusion.

2. Research Methodology

The research was conducted in three post Tsunami resettlements in the Akmeemana DS Division, Galle, Sri Lanka. These resettlements are, Salzburg settlement, China-Friendship Village and Lakshman Kadirgamar Village, which are donor-built Tsunami settlements. A questionnaire consisting of close-ended and open-ended questions, semi-structured in-depth interviews and observation were employed to collect data from a purposively selected sample of 45 household heads who have either purchased, rented or leased housing units. Equal number of interviewees (15 respondents from each settlements) were selected from the above-mentioned settlements to achieve greater accuracy and rigor. Six hypotheses were formulated and tested using Chi-square tests to determine the nature of occupants moving into the said settlements.

In order to apply triangulation of analysis, both qualitative and quantitative analysis methods were utilized in the study to gain a comprehensive understanding of the phenomenon. Data collected from

sample households using questionnaires were entered using the Statistical Package for Social Sciences (SPSS) after editing and coding. Both Univariate and Bi-Variate statistical analysis tests were used in the study.

Data collected using key informant interviews and in-depth interviews with selected household heads were written down on field notebooks. All written interviews were then scrutinized, familiarized and coded, after which qualitative data were arranged in order of developed codes and thereafter was used to compare and contrast data.

For the purpose of this study, individuals who have rented, leased or purchased a house in the above-mentioned Tsunami settlements will be identified as "new settlers".

3. Reasons for moving out and settling in

Involuntary relocation creates risks and various stressors to relocated communities as well as host communities (Fernando, 2012; Sridarran, Keraminiyage & Fernando, 2018). Among them, disruption of livelihoods, disturbances to children's education (Amirthalingam, & Lakshman, 2015; De Silva. 2018), adverse impacts on mental health (Xi, Hwang, & Drentea. 2013), conflicts between host communities and relocated communities can be identified. Relocation programmes that lack proper planning and fail to identify the multi-faceted nature of issues arising from relocation often end up as relocation failures (Das, 2008). These prompts relocated communities to search for mitigation activities and coping strategies to reduce the said impact. These measures include, modifying existing houses, moving out of relocation settlements, moving back to previous residences or moving to different locations (Fernando, 2012; Hettige, Haigh & Amaratunga,2018). However, in the case of disaster-induced relocation, economic wellbeing of relocated communities is disrupted due to the losses of mobile and immobile assets (Hallegatte & Przyluski, 2010). In such situations relocated communities find it difficult to gain the financial capital required to engage in mitigation activities. Thus, relocated communities attempt to move out of relocated settlements by either renting, leasing or selling houses resulting in an opportunity for new settlers to migrate into such housing units.

In this context, it is essential to identify factors that were taken into consideration by the new settlers when purchasing, renting or leasing a house from Tsunami relocated settlers. It is evident that there are multiple factors that influence a family's decision of selecting a house. According to the Housing Education and Research Association [HERA, 2006] some of these factors are, age range (young, middle-aged, elderly) of the buyer, (as it determines lifestyle) type of household i.e. married-couples, female-headed families, single parent families, etc. in addition to the size of the family which refers to the number of members (HERA, 2006). Other factors that influence such decisions are location, built-up areas, surroundings, design and layout, developer's reputation, security and convenience (Hamid et al., 2006; Tan, 2007). Furthermore, the environment, family influence, available private living areas and aesthetics are also important (Ge & Hokao, 2005; Levy & Lee, 2002). According to Gajjar (2013), factors that are controlled by external environmental variables can influence behaviour. This includes culture and sub-culture, social class and social groups, family, and inter-personal influences as well as others such as geographical, political, economic, religious and environmental factors (Gajjar, 2013). Other studies reveal that more than any other factor, price is the most significant (Abdullah, Nor, Jumadi & Arshad 2012). Similarly, Reed and Mills (2006) identified affordability as the most influential factor. Kupke (2000) also affirms this finding yet elaborates more on economic factors such as affordability of the house irrespective of age, income, or family make up.

Although there is an abundance of research on disaster-induced forced relocation and resettled communities, a significant gap exists in existing literature about individuals who move into relocated settlements as new settlers by either renting, leasing or purchasing houses. Therefore, it is important to explore reasons why new settlers purchase houses from relocated settlers. This helps to understand the extent to which issues identified by beneficiaries affect new settlers. Further, it assists to identify mitigation methods employed by new settlers to minimise issues, negative impacts of settling in the relocation settlements, emergence of new concerns and future expectations of new settlers concerning housing.

Before identifying specific characteristics of new settlers, it is important to understand how they got an opportunity to move into such settlements. After the Indian Ocean Tsunami, the government of Sri Lanka declared a buffer zone within which residential buildings cannot be situated or constructed (Kennedy et al.,2008). The government later reduced the buffer zone due to requests of the communities (Boano, C., 2009). As a result, relocated communities found ways to move back to previous areas of residence. One of the strategies employed by the community was selling or renting the house. Their objective was to purchase a house in an area close to their previous residence, to renovate their previous house or even rent a house close to the place of employment. In this context, it is possible to identify three groups of individuals with different characteristics who would sell, lease or rent houses to outsiders.

The first group of individuals had their houses damaged but not completely destroyed by the Tsunami. However, with some renovation, one could resettle in them. Unfortunately, these houses were vacated, though in a liveable condition with small improvements but the house was situated in the coastal buffer zone. As a result, individuals were asked to move into newly built Tsunami settlements. With time, locals pressured the government to reduce the buffer zone citing problems at the settlements. As a result, the government decided to reduce the buffer zone up to 50 meters in some areas, and 25 meters in certain others. The relocated communities used this opportunity to move back to their previous residence, renovate it and continued to live there.

The second group of individuals also had their house partially destroyed by the Tsunami, however these houses were not located within the buffer zone. Considering their plight, they were offered houses in Tsunami settlements. However, with time similar to the previous group they too experienced issues and decided to move back to their partially damaged houses after renovating them. In order to find money to renovate houses, they also decided to sell, rent or lease houses in these settlements.

The final group of individuals received more than one house due to the fact that more than one family had been living in their previous house. After relocation, some of these individuals opted to sell one of the

houses and move into the remaining house to live together with the other family. In such situations they would sell, lease or rent the other house in order to add new sections to the remaining house to accommodate two families.

4. Findings

Findings related to new settlers will be discussed as follows,

- Demographic characteristics
- Reasons for moving into the community
- Disadvantages of living in the settlement
- Future plans

4.1 Demographic Information

When examining the demographic data of new settlers, some interesting patterns emerge. In terms of the composition of families, 71% is composed of less than five members. Among them, nearly 7% have two family members while 27% of families have three members. Further 36% are composed of four family members. Only 29% of respondents had five or more family members.

The age groups of the households ranges from 27 years to 71 years. In order to identify the age range of majority of the occupants, data was categorised as shown in Table 1 and two hypotheses were developed for testing.

Table 1. Age category

Category	Range
Category 1	25-37
Category 2	38-47
Category 3	48-58
Category 4	Above 59

Source: Own Survey

The first hypothesis was formulated to test if all the age categories occupy the houses with equal probabilities.

Hypothesis 1

H_0: All the age categories occupy houses with equal probabilities
H_1: All the age categories do not occupy houses with equal probabilities

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Age_category occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that all age categories do not occupy houses in equal proportion. Subsequently, a frequency test was conducted to identify the most popular age range as shown in Table 2.

Table 2: Age frequency

Age Category	Frequency	Percent	Valid Percent	Cumulative Percent
25-37	22	50.0	50.0	50.0
38-47	12	27.3	27.3	77.3
48-58	8	18.2	18.2	95.5
Above 59	2	4.5	4.5	100.0
Total	44	100.0	100.0	

Source: Own Survey

Based on the frequency table, the second hypothesis was formulated.

Hypothesis 2

H_0: 50% of occupants belong to age category 1 and 30% of the occupants belong to age category 2
H_1: 50% of occupants do not belong to age category 1 and 30% of occupants do not belong to age category 2

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Age_category occur with the specified probabilities.	One-Sample Chi-Square Test	.790	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that 50% of occupants belong to age category one that is, 25-37 years and 30% of occupants belong to the age category two that is, 38-47 years. These statistics suggests that majority of new settlers are young. It is evident from the data that new settlers consider Tsunami houses to be adequate to accommodate their families and suit their lifestyle (HERA, 2006; Hamid et al., 2006; Tan, 2007). On the other hand, outside settler's original place of residence, other than in few instances, seems to be from areas close to the settlements. In order to test this, data was categorised as shown in Table 3 and two hypotheses were developed for testing.

Table 3. Distance category

Category	Description
1	Within the district
2	Neighbouring district
3	Other districts

Source: Own Survey

The third hypothesis was formulated to test if all distance categories occupy houses with equal probabilities.

Hypothesis 3

H_0: All district categories occupy houses with equal probabilities
H_1: All district categories do not occupy houses with equal probabilities

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Distance occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that all distance categories do not occupy houses with equal probabilities. Subsequently, a frequency test was conducted to identify the most popular districts as shown in Table 4.

Table 4. Distance frequency

District	Frequency	Percent	Valid Percent	Cumulative Percent
Ampara	1	2.3	2.3	2.3
Anuradhapura	1	2.3	2.3	4.5
Badulla	1	2.3	2.3	6.8
Colombo	2	4.5	4.5	11.4
Galle	29	65.9	65.9	77.3
Gampaha	3	6.8	6.8	84.1
Hambantota	1	2.3	2.3	86.4
Kalutara	1	2.3	2.3	88.6
Matara	5	11.4	11.4	100.0
Total	44	100.0	100.0	

Source: Own Survey

Based on the frequency table, the fourth hypothesis was formulated.

Hypothesis 4

H_0: 66% of occupants belong to the Galle district and 11% of occupants belong to the Matara district
H_1: 66% of the occupants do not belong to Galle district and 11% of occupants do not belong to the Matara district

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Distance occur with the specified probabilities.	One-Sample Chi-Square Test	.957	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that 66% of occupants belong to the Galle district itself and 11% of the occupants belong to Matara which is the neighbouring district. These statistics confirm Gajjar's (2013) findings on the importance of environment and surroundings, as most new settlers come from nearby areas. A common characteristic identifiable in these previous residences is the fact that they have been situated considerably far away from the city of Galle in comparison to the Akmeemana DS division. This particular factor identifies another reason for the shift of these individuals from their previous residences.

In terms of income, nearly 61% receive a daily wage less than 600 Sri Lankan Rupees. Few of them (12%) had a daily income that exceeds 1,500 Sri Lankan Rupees, revealing the existence of a blue-collar workforce being a considerable portion of the community. When analysing employment data of new settlers, nearly 70% were engaged in daily labour activities, including fishing or construction-related employment. In addition, some individuals engaged in retail businesses, are enrolled as army cadets, navy cadets or salesmen and the rest are retirees. The existence of multiple income categories and types of employment suggests that new settlers consist of both low-income and lower middle classes. The study also reiterates that new settlers reveal similar socio-economic characteristics as previous settlers of the community. Thus, it allows them to easily adjust to the new surrounding and socio-cultural aspects of the new settlement making their transition very swift. This factor might have encouraged other outside individuals to move into the settlement and contribute to the increasing influx of newcomers to settlements. Moreover, the findings suggest that newcomers may be susceptible to the same issues experienced by the relocated communities.

In order to identify the occupancy status, data was categorised as shown in Table 5 and two hypotheses were developed for testing.

Table 5. Occupancy status

Category	Description
1	Bought
2	Rent
3	Lease

Source: Own Survey

The fifth hypothesis was formulated to test if all occupancy categories occupy houses with equal probabilities.

Hypothesis 5

H_0: All occupancy categories occupy houses with equal probabilities
H_1: All occupancy categories do not occupy houses with equal probabilities

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Occupant_status occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that all occupancy categories do not occupy houses with equal probabilities. Subsequently, a frequency test was conducted to identify the most popular occupancy status as shown in Table 6.

Table 6. Occupancy status frequency

Type of Occupancy	Frequency	Percent	Valid Percent	Cumulative Percent
Bought	31	70.5	70.5	70.5
Rent	10	22.7	22.7	93.2
Lease	3	6.8	6.8	100.0
Total	44	100.0	100.0	

Source: Own Survey

Based on the frequency table the sixth hypothesis was formulated.

Hypothesis 6

H_0: 70% of the occupants bought houses and 20% of occupants rented houses
H_1: 70% of the occupants did not buy houses and 20% of occupants did not rent the houses

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Occupant_status occur with the specified probabilities.	One-Sample Chi-Square Test	.738	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Chi-square test results show that there is significant evidence to prove that 70% of occupants bought houses and 20% of occupants rented houses. Majority of respondents who have bought a house in the

settlement should be regarded as a significant indication of them intending to live in the settlement permanently. Nevertheless, according to the findings, this intent of permanently living in the settlements have changed over time due to multiple issues experienced by new settlers (See disadvantages of moving section for more information). Interestingly, only one outside settler possessed a valid deed while all the remaining household heads admitted that they do not have a valid deed. This is a noteworthy situation mainly due to the fact that usually, one would rethink before purchasing a house under similar circumstances. In fact, one would even be reluctant to lease or rent a house without a deed fearing legal complications and fraud.

4.2 Reasons for moving in to the settlements

This section explores reasons given by new settlers to justify attempts of moving into Tsunami resettlement project areas. The respondents mentioned more than one reason to justify such decisions. A total of 65% of new settlers mentioned low prices of housing units as the main reason for buying the house. The research team collected data on both the market price of houses situated in the settlements and also the payments made by new settlers when purchasing new houses. The net value of a house similar in structure and facilities in the area with two bedrooms, a kitchen, a reception area and an indoor bathroom constructed on a 10 perch land with electricity and running water is sold for a price of 2-2.5 million Sri Lankan Rupees. Yet, none of the houses purchased by new settlers has been acquired by spending similar prices, rather purchasing amounts were extremely low as presented in table 7.

Table 7. Price ranges of the houses purchased

Price range (LKR)	Number of purchases	Percentage (%)
100,000 -150,000	07	27%
500,000 -690,000	08	31%
700,000 – 1,000,000	10	38%
More than 1,000**,000**	01	4%
Total	**26**	**100%**

Source: Own Survey

More than 58% of houses have been purchased for prices between LKR 100,000 to 690,000 while another 38% have been purchased between

LKR 700,000 to 1,000,000. This situation seems to affirm the findings of Kupke (2000) and Reed and Mills (2006) that the price of the house is often the most influential factor in the decision-making process of buying a house.

When explored further, interviews revealed that the lack of a legal deed is the main reason for low prices. A mutual agreement between the beneficiary and new settlers exists when selling land. Accordingly, usually half of the agreed amount is given to the beneficiary at the beginning. The rest is paid when transferring the deed of the land to the name of the newcomer. Unfortunately, there are difficulties for beneficiary families to obtain a deed from government authorities due to a condition of the resettlement policy which prohibits transferring of the land to another person other than the beneficiary for a period of 20 years.

Data suggests that this situation has also influenced renting of houses. Nearly 67% of new settlers who had rented a house mentioned low rent/lease as the major reason for moving in.

Table 8. Price ranges of the rented/leased houses

Price range (LKR)	Number of purchases	Percentage (%)
1000 -2000	01	5%
2100 - 3000	08	42%
3100 - 4000	07	37%
4100 - 5000	03	16%
Total	**19**	**100%**

Source: Own Survey

It is significant to note that a house with similar floor area and facilities would cost approximately LKR 10,000 to LKR 15,000 outside the settlement. The newcomers have snatched on to this opportunity to obtain a complete house in the suburbs of the Galle city. Under normal circumstances, a newcomer would usually have to pay a higher price for similar housing facilities.

Another reason identified is ease of access to education facilities for children including schools and tuition classes. According to the results, 34% of respondents are located close to a few reputed schools namely, Siridamma College, Mahinda College, Southland Ladies College,

Sangamitta Vidyalaya, and St. Aloysius College. Secondary data support this claim and shows that all the schools mentioned above are situated within a radius of 12 Km from the new settlements (Google Maps, 2018). In addition, the settlers mentioned that large-scale private tuition classes are also easily accessible from the settlements. Due to the highly competitive education system and unequally allocated resources, proximity to such popular schools results in parents having to make a minimum effort in having to enrol their children in well recognized schools. Often parents choose "Popular Schools" in their area, equipped with the best facilities, qualified teachers and most importantly the most impressive examination results gained by students in national examinations. Due to the high demand, these schools have strict selection criteria which are almost impossible to fulfil.

Always the distance from the school to the house is used as a key criterion in the selection process of children. Therefore, when parents mention the location of residence, it allows the authors to comprehend that they are referring to the possibility of enrolling their children to one of the above mentioned "Ivy League" schools by residing in these settlements. The proximity to schools also becomes a factor when receiving assistance from private tuition classes to successfully face highly competitive examinations conducted in Sri Lanka. Sri Lankan children have to endure three key examinations stipulated by the Education Ministry, namely the Scholarship Examination, Ordinary Level Examination and the Advance Level Examination. The Scholarship Examination and the Ordinary Level Examination allow children to move into a school with better educational facilities based on performance. Therefore, if the house is situated in close proximity to the school, parents can easily send their children to maximum number of classes spending little travel time to and from school. These factors disclose that the concern and commitment of parents to children's education have driven them to move into Tsunami settlements.

Ease of access to the national hospital in the district (Karapitiya hospital) was also identified as a major reason by respondents. A total of 16% held the opinion that proximity to the hospital motivated them to move into the settlement. The Karapitiya general hospital is the largest government hospital in the Southern province. The hospital is

equipped with all key facilities as well as all major surgery services including heart transplant facilities. It was revealed that 21% of respondents moved to the settlement to be closer to the hospital and majority of these individuals were employed at the Karapitiya hospital, mainly as labourers. It is important to keep in mind that the monthly income of these workers is in the ranges of LKR 20,000 to LKR 25,000. As a result, the amount that can be spent on housing is comparatively low in comparison to otherwise employed individuals. Often the strategy employed by these labourers is to obtain a room in a boarding house for a price of LKR 5,000. These rooms are extremely small, shared by two or more individuals, and have minimal facilities. When houses of the Tsunami settlements became vacant, these blue-collar workers ceased the opportunity of inhabiting a house, with two rooms, a complete kitchen and a private bathroom for a price that is affordable. These individuals had moved in from areas such as Akuressa, Ankokkawala, Halpitigala and Rambewa which are considerably far away from the Galle city. This is an interesting situation as this particular finding further strengthens the argument put forward earlier that low rent/price of houses have made houses more appealing to blue-collar workers or lower-middle income class.

In addition, 18% of new settlers have moved into settlements to live close to their relatives. When examined at their previous residence, they were located somewhat away from their relatives' location. It is possible to use two scenarios to explain this situation. First, houses of these individuals were damaged by the 2004 Indian Ocean Tsunami but were not located in the declared 100 meter "Buffer Zone". Yet, the house of a close relative located within the "Buffer Zone" was also damaged by the Tsunami to remain liveable. Due to this situation, the relative who lived within the buffer zone was relocated to the settlements in Akmeemana and the remaining relatives were given compensation to rebuild their houses. As a result of the close links between these families, relocation of one family disrupted their socio-economic relations and safety networks. This could be seen as a direct impact on the social capital of these individuals. As a result, when an opportunity arises to move close to the relatives, they used the opportunity and either purchased or rented a house within the settlement in hope of restoring disrupted relationships. The second scenario is related to the host community. Previous studies on host communities of the same

settlements revealed that host community members were somewhat disheartened by relocation of communities affected by the Tsunami to their area (Fernando, 2010, Sridarran, Keraminiyage, & Fernando, 2018). Clear physical confrontations and ideological clashes exist between relocated and host communities which have led to discrimination against relocated communities and labelling. In this situation, when a house in the settlement is being sold or rented, both the host community and the relocated community would perceive it as an opportunity of bringing one of their kin to the area both as a retaliation against the other party and also to improve their strength in numbers.

4.3 Disadvantages of living in the settlements

As for the disadvantages, diverse reasons were identified by respondents. A total of 18% held the opinion that drainage was a serious concern. These issues experienced by relocated communities have already been identified in previous studies conducted on the issue (Fernando, 2005). Lack of planning of drainage and disposal of liquid waste in the construction stages of settlements is the reason behind this particular issue. In addition, the nonexistence of an effective mechanism to dispose waste was also identified by 9% of the new settlers to be a serious issue. The respondents stated that this had given rise to many issues including the spread of Dengue, diarrhoea and other similar diseases. A newcomer from the Lakshman Kadhiragamar village complained that “Due the stench of wastewater and piles of garbage on the sides of the roads, we cannot invite our friends and relatives to the houses. Even if they come how can we offer them food with flies everywhere?” (In-depth interview, 2018). Another respondent pointed out the impact this situation has on the health of children “Children keep getting sick due to the unclean environment. My son is schooling at Siri Dhamma College in grade 5 and he often gets a cough with fever accompanied by stomach aches. The school attendance of my son has been impacted because of this” (In-depth interview, 2018). This particular finding suggest that the ill-planned waste disposal systems of settlements impact the health of newcomers, especially the health of children. Even though the newcomers mentioned close proximity to "IVY League" schools as a major reason for moving to settlements, the

health impact caused by ill-designed waste disposal seem to impede this advantage by disturbing the school attendance of children.

As stated before, only one individual had a deed for his house (the legal validity of the deed is questionable). When Tsunami resettlement houses were given to displaced communities, in order to expedite the relocation process houses were given without deeds with the promise of providing them within a short period of time. However, issuing of deeds is a slow process and more than 50% of the relocated families are yet to receive their deeds. This lack of legal ownership of houses could be seen as a major reason for selling houses for a low price as the purchasing party is at risk of legal action. This is another disadvantage recognised by the newcomers especially by those who have purchased houses without a deed.

Interestingly, nearly 30% of the respondents mentioned houses being too small as a disadvantage. As mentioned by a female respondent from the China – Friendship Village about the lack of space, "The bedrooms are barely big enough to accommodate a family. When the bed and the cupboards are put in, one has no space to move around. The rooms open up to the visiting area, so when a guest is at home, he or she can see inside the rooms. The kitchen is also quite small and dark. Even during the day, you have to keep the lights on to work in the kitchen" (In-depth interviews, 2018). Another female respondent from Salzburg village explained the difficulties she experienced, "When my daughter attained age I had difficulties in following the customs of keeping her away from eyes of men, including family members as the house is small" (In- depth interviews, 2018). It seems that the small floor space has impacted the lives of the respondents by obstructing cultural events and the privacy of family members. In the designing stages of these houses, members of the relocated communities were not consulted. This issue was identified in previous studies on the situation of the relocated communities in Galle (Fernando, 2005). The relocated communities had complaints about the quality of the building, privacy and lack of space. This issue seems to be impacting newcomers currently and affecting their daily life. This goes on to further emphasize the importance of Community Based Disaster Relocation which considers the attitudes, needs and opinions of displaced communities. Nevertheless, it should also be noted that 70% of the settlers have

ignored the size of houses as an issue. In other words, this is an indication that a large percentage of new settlers have given importance to other factors other than the size of houses including, proximity to education facilities and infrastructure.

In addition, 15% of respondents have mentioned the environment of the settlement to be challenging or ill-suited to bring up children. Often complaints are related to maintaining associations with relocated communities. They had concerns related to drug abuse, engaging in illegal activities and different behavioural patterns of settlers. These reasons had led to the discrimination of Tsunami settlers by new settlers. As revealed by a respondent of the Salzburg village "We do not mingle with settlers much, especially I don't send my son to play with the children from the settlements. They do not suit our standards" (In-depth interviews, 2018). This is a serious concern as already these Tsunami settlers are discriminated and labelled by the host community. Thus, this situation could be seen as an external pressure on relocated communities which leads to further discrimination. Therefore, this situation needs to be further explored to identify the phenomena clearly. Another explanation that could be brought to attention is that some of the new settlers are suffering from withdrawal from their previous residences or that they are still in the process of adapting to the new setting. This is evident from some of the comments made by the new settlers such as "The house is too close to each other therefore we are stuck inside the house" (In-depth interview, 2018).

4.4 Future plans

The study paid specific attention to future plans of new settlers. Nearly 55% of all respondents (including purchased, rented and leased) revealed that they are planning to move away from the settlement in the future. After inquiring about reasons for moving away, multiple reasons were identified. A total of 25% of respondents held the opinion that they would like to move out of the settlement to build their own house, as the current housing would not have enough space when children grow up. A further 16% of respondents stated that they have to move away as they have to hand over the houses to their owners. Nearly 14% of the respondents stated that the neighbourhood is not a suitable environment for children to live in due to the illegal activities

that take place. They mentioned that they were afraid about the security of their children and families. Another 11% held the opinion that they prefer to move back to their villages. Yet when analysed further, it was revealed that these individuals had moved into the area in order to support their children's education. They further reiterated that on completion of their children's education, they would move back to their previous residence. In relation to the individuals who are planning to stay permanently in the settlements, it was revealed that 18% of respondents are not in a financial position to move out from the settlement, even though they wish to do so. As a result, they have no option but to stay in the settlement. Also, another respondent cannot leave the settlement as he does not have a deed to his house, which has restricted him from selling the house and moving out. This was one of the risks that is associated with the low price of the housing unit. Only 25% of respondents have stated that they are content with the current facilities and the location of the settlements and therefore they are not planning to move out in the future.

5. Discussion

The findings of the study suggest that the influx of outside settlers have taken place due to multiple reasons. However, the key factor that prompted majority of new settlers to purchase a house rather than renting or leasing a house unit was the incomparable low price of housing units. This in turn also suggests that the findings of Reed and Mills (2006) and Kupke (2000) regarding the key role played by the affordability of the house are also valid in this situation. However, as the low price is a result of the lack of a deed, new settlers are taking a significant risk of losing the house, facing legal repercussions or both later on.

Another important finding of the study is that new settlers have similar socio-economic characteristics to relocated communities. However, it is possible to interpret that new settlers are more disadvantaged in comparison to the relocated communities as they opt to live in the settlement due to the lack of another option. In other words, they reside in the settlement because they are financially unable to purchase a house under normal circumstances.

Most significantly, new settlers also have to endure issues experienced by relocated communities which were created by the inefficient conduct of authorities. As a result, these settlements have become short-term "transitory points" to individuals attempting to exploit advantages such as low price, proximity to health and educational services. In this scenario, these resettlement programmes are prime examples of relocation failures, as they have failed to fulfil the needs of residents irrespective of whether the inhabitants are relocatees or outsiders.

Another important aspect is that majority of newcomers are more economically vulnerable in comparison to relocated communities. This is due to the lack of financial options available to newcomers in comparison to relocated communities that have moved back to their previous residences. As a result, these individuals reap more advantages due to permanent income sources from rented and leased houses. In addition, another factor that increases the vulnerability of newcomers is the fact that almost all of them have invested their savings in a house for which they do not have a legal document proving ownership. Legally, these houses are still under the ownership of the government and as a result, both the selling party and the buying party commit a legal offence by selling and purchasing a house owned by the government. However, newcomers are mostly at risk as relocated communities will obtain deeds of houses only after the arduous and protracted process of issuing deeds.

6. Conclusion

The new settlers who live Tsunami relocation settlements in Akmeemana, Galle, Sri Lanka, reside here mainly due to the affordability of housing and the ability of exploiting advantages such as the proximity to the city, education and health services and employment opportunities. Most of them do not expect to live permanently in these settlements and would move away once intended objectives are fulfilled. New settlers are also burdened with issues and complications similar to relocated communities although the difference is that they were forced to either purchase or rent housing units due to limited economic opportunities. This study could be extended in the future to develop a more comprehensive understanding of these

settlers and to construct better relocation policies which address actual needs of resettled communities.

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INDEX