Final Technical Report
CAF2016-RR03-CMY-Pereira

Integrating CCA, DRR and L+D to Address Emerging Challenges due to Slow Onset Processes

The following collaborators worked on this project:

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PROJECT OVERVIEW

PROJECT DURATION	**:**	3 Years
FUNDING AWARDED	**:**	US$ 50,000 (Year 1); US$ 45,000 (Year 2); US$ 45,000 (Year 3)
KEY ORGANISATIONS INVOLVED	**:**	1. Southeast Asia Disaster Prevention Research Initiative, Universiti Kebangsaan Malaysia (SEADPRI-UKM) - Joy Jacqueline Pereira (Malaysia); 2. Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN) - Nguyen Van Thang (Vietnam); 3. University of The Philippines Los Banos (UPLB) - Juan Pulhin (Philippines); 4. Royal University of Phnom Penh (RUPP), Cambodia - Chhinh Nyda (Cambodia); 5. Myanmar Climate Change Watch & SEEDS Asia - Tun Lwin (Myanmar) and Rajib Shaw (Japan); 6. Institute for Global Environmental Strategies (IGES) - SVRK Prabhakar (Japan).

PROJECT SUMMARY

The research project entitled "Integrating Climate Change Adaptation, Disaster Risk Reduction and Loss and Damage to Address Emerging Challenges due to Slow Onset Processes" brought together distinct groups of biophysical and socio-economic scientists from six countries i.e. Malaysia, Vietnam, Philippines, Myanmar and Cambodia, with transfer of expertise from Japan. The project deployed an area-based approach, where local level pilots were conducted to determine (i) characteristics, priorities and emerging issues related to slow onset processes; (ii) limits to adaptation and propose risk based approaches that integrate CCA and DRR; (iii) methodologies to evaluate prospective L+D; and (iv) policy and planning strategies to integrate CCA, DRR and L+D. The pilot areas were Kampong Speu Province (Cambodia), Selangor State (Malaysia), and Thatdama Kyun Village (Myanmar), Kanan Watershed (Philippines) and Quang Ngai Province (Vietnam).

The original amount requested from APN was reduced but the proposed objectives and work plan was maintained through in-kind contribution from APN Project Partners. Additional support was received in the organization of joint events, particularly from the Cambridge funded Asian Network on Climate Science and Technology (ANCST), Association of Southeast Asian Nations (ASEAN), Asian University Network on Environment and Disaster Management (AUEDM) and other partners. The project also maintained close ties with another complementary project on funded by APN, which was led by the Institute of Global Environmental Studies (IGES) led by Yohei Chiba with involvement of S.V.R.K Prabhakar. Partnership with SEEDS Asia served to support collaborators in Myanmar. The close collaboration and partnerships facilitated the creation synergies and optimization of resources, which further enriched the outputs and outcomes of the project.

The project has resulted in a legacy of enhanced capability and collaboration in multidisciplinary research, which links climate change adaptation, disaster risk reduction and loss and damage whilst fulfilling the goals of Asia-Pacific Network (APN). It has also served to improve "context specific"

understanding of slow onset processes, identify integrated approaches to link CCA, DRR and L+D, and facilitate development of robust methodologies on evaluating prospective economic and non-economic loss and damage. This is relevant to the Katowice Climate Package adopted in COP 24 in December 2018 (the Rule Book for the Paris Agreement), which gives prominence to loss and damage in the upcoming global stocktake. Through its outreach events, the project contributed to enhance coordination and partnership between Disaster Risk Reduction and Climate Change Adaptation institutions in ASEAN Member States.

KEYWORDS

Climate Change Adaptation, Disaster Risk Reduction, Loss and Damage, Slow Onset Processes, Southeast Asia

PROJECT OUTPUTS AND OUTCOMES

Project Outputs: The project focused on training young scientists and about 12 were involved (RUPP, Cambodia: Cheb Hoeurn, Sothun Nop & Rido Thath; SEADPRI-UKM, Malaysia: Nurul Syazwani Yahaya, Umi Amira Jamaluddin & Lim Choun Sian; SEEDS Asia, Myanmar: Mitsuko Otsuyama; UPLB, Philippines: Lorena L. Sabino, Arnan B. Arnanza & Josephine E. Garcia; IMHEN, Vietnam: Tran Dinh Trong & Mai Van Khiem) with some four obtaining graduate degrees. Project members also shared their findings at eight major events convened in conjunction with key regional partners, and interacted with stakeholders to advance their work. Further information including the program is available at the project website (www.ancst.org/apn) that is hosted by the Asian Network on Climate Science and Technology (ANCST) and linked to the APN. The events are as follows:-

- **Asia Pacific Adaptation Forum 2014, Kuala Lumpur, 1-3 October 2014.** Organisers: APAN, UNEP, SEI, AIT, IGES, APN etc. The Forum served as the platform to hold the Inception Meeting of the Project and conduct a preliminary stocktake of knowledge status and interfacing with the APN funded Project of IGES led by Yohei Chiba. There were presentations by Joy Jacqueline Pereira, SEADPRI-Universiti Kebangsaan Malaysia (at Panel 2.3 Knowledge foundations of loss and damage systems, moderated by Linda Anne Stevenson of APN); Sothun Nop, Royal University of Phnom Penh (RUPP); Tran Dinh Trong, Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN); and SVRK Prabhakar & Yohei Chiba, Institute of Global Environmental Studies (IGES), Japan (at Panel 6.1 Climate Extremes and Disaster Risk Reduction, focusing on Emerging Issues and Priorities: Adapting to Climate Extremes and Slow Onset Disasters).

- **Workshop on Enhancing Climate Change Adaptation in Southeast Asia, Bangi, 5-6 February 2015.** Organisers: ASEAN, APN, ANCST, etc. The Workshop served as the platform to harmonise approaches, terminology, methodology etc.; enabled APN Project Members to connect with their respective country representatives of UNFCCC National Focal Points; and share preliminary findings with participants from other ASEAN Member States. Presentations were made by Royal University of Phnom Penh (RUPP); Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN); University of The Philippines Los Banõs; SEADPRI-Universiti Kebangsaan Malaysia and Myanmar Climate Change Watch at the special session on Local Level Climate Extremes, Slow Onset Events and Loss & Damage.

- ❖ **Workshop on Climate Science for Loss and Damage Projection, Port Dickson, 11-13 June 2015.** Organisers: APN, ANCST, START etc. The Workshop enabled expert consultation on economic evaluation as well as peer review of local level pilots and other project findings from Year 1. Presentations were made by Institute of Global Environmental Studies (IGES)*;* SEADPRI-Universiti Kebangsaan Malaysia; etc.

- ❖ **Workshop of the ASEAN-India Project on Enhancing Climate Change Adaptation in Southeast Asia, Manila, Philippines, 14-15 October 2015**. Organisers: ASEAN, APN, ANCST, etc. The Workshop facilitated side meetings on progress and publication plans; interaction of APN Project Members with UNFCCC National Focal Points; and share findings on local-level needs and priorities with about 40 participants from ASEAN Member States. There were presentations by Sothun Nop (RUPP), Joy Jacqueline Pereira (SEADPRI-UKM), Khin Maung Cho (MCCW), Juan Pulhin (UPLB) and Tran Dinh Trong (IMHEN).

- ❖ **Workshop on Climate Change and Disaster Resilience – Post Sendai 2015, Manila, Philippines, 16-17 October 2015.** Organisers: ASEAN, APN, ANCST, etc. The Workshop enabled side meetings were held with project members from the APN funded IGES Project led by Yohei Chiba and interaction with National Focal Points on Disaster Risk Reduction. There were presentations on L+D and adaptation by three project members: S.V.R.K Prabhakar (IGES), Sothun Nop (RUPP) and Tran Dinh Trong (IMHEN).

- ❖ S**EADPRI Forum 2016 on Insurance for Disaster Risk Reduction and Climate Adaptation, Bangi, Malaysia, 6 October 2016**. Organisers: APN, ANCST, etc. The Forum facilitated an informal peer review of key findings on loss and damage. Project Member, S.V.R.K Prabhakar (IGES) made a presentation to end-users from the insurance, banking and investment sector.

- ❖ **Regional Science-Policy Dialogue, Putrajaya, Malaysia, 16 November 2017.** Organisers: ANCST, APN, UNISDR-ASTAAG, ISC-ROAP, etc. There were presentations on the APN project findings from Joy Jacqueline Pereira (SEADPRI-UKM), Chhinh Nyda (RUPP), Lorena Sabino (UPLB) and Tran Dinh Trong (IMHEN); and interaction with National Focal Points on Disaster Risk Reduction.

- ❖ **Workshop on Status of Climate Science and Technology in Asia, 15-16 November 2018.** Organisers: IPCC, ANCST, APN, ISC-ROAP, etc. Project Members made presentations and posters from the APN project, to share findings with IPCC-AR6 authors from Asia. Plans were made to publish the pilot studies in peer reviewed journals.

Project Outcomes: The project brought together, researchers, policy makers and practitioners from the fields of CCA, DRR and L+D to work on a specific area (i.e. the local level pilot). This served to improve "context specific" understanding and facilitate development of robust methodologies. The legacy of the project is enhanced capability and collaboration in multidisciplinary research. Project members have maintained their linkages and are now focused on preparing manuscripts for peer reviewed journal. Specific outcomes are follows:-

- ❖ **Improved capacity of researchers** on "context specific" understanding of slow onset processes, integrated approaches to CCA and DRR, and methodologies on evaluating economic and non-economic L+D;

- **Enhanced interaction between researchers** from multidisciplinary fields in CCA (i.e. climate, biophysical scientists, etc.), DRR (mainly engineers, physical scientists, emergency respondents, etc.) and L+D (mainly social scientists, economists, etc.);
- **Improved access of researchers** to policy makers and practitioners at local, national and regional levels;
- **Sustained linkages** of researchers beyond the APN funding under the aegis of the ANCST and ASEAN (ASEANadapt Network under the aegis of the ASEAN Working Group on Climate Change).

KEY FACTS

- 5 local level pilot areas were investigated in the project;
- 5 local stakeholder consultations were held, one each in Cambodia, Malaysia, Myanmar, Philippines and Vietnam;
- 12 young scientists from multidisciplinary backgrounds were trained on the project;
- 4 young scientists obtained graduate degrees;
- 8 major events were convened with key regional partners to disseminate project findings.

POTENTIAL FOR FURTHER WORK

A major challenge for the local community in several countries has been access to government information. For example, in Malaysia, much of the scientific data (i.e. hazard maps etc.) is restricted to technical governments, and the local community is not aware of their existence. Such information is critical for the local community to understand the hazards that they are exposed to. The use of big earth data comprising earth observation and satellite information and crowd sourced information are important tools to be considered in the future, to by-pass such restrictions and enhance awareness of the community regarding the hazard profile in their areas. This will be particularly useful for communities along low-lying coasts, drought prone areas as well as urban settlements.

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PULL QUOTE

The APN Project findings on loss and damage associated with slow onset hazards will be a useful reference for the upcoming IPCC Sixth Assessment Report and global stocktake of the Paris Agreement (Professor Joy Jacqueline Pereira, APN Project Leader and Vice Chair, IPCC Working Group 2 on Impacts, Adaptation)

ACKNOWLEDGMENT

- ❖ Asia Pacific Network for Global Change Research (APN)
- ❖ Asian Network on Climate Science and Technology (ANCST)
- ❖ Association of Southeast Asian Nations (ASEAN)
- ❖ Asian University Network on Environment and Disaster Management (AUEDM)
- ❖ Institute of Global Environmental Studies (IGES)
- ❖ SEEDS Asia
- ❖ UNISDR Asia Science, Technology and Academia Advisory Group (AASTAG)
- ❖ International Science Council Regional Office for Asia and the Pacific (ISC-ROAP)
- ❖ Intergovernmental Panel on Climate Change (IPCC)
- ❖ Asia Pacific Adaptation Network (APAN)

EXECUTIVE SUMMARY

INTEGRATING CCA, DRR AND L+D TO ADDRESS EMERGING CHALLENGES DUE TO SLOW ONSET PROCESSES

The Executive Summary has been developed from key findings of the pilot areas, which are documented in the subsequent sections (Chapters 1-5). The references and glossary of terms used is available in individual chapters. Project outputs and outcomes including funding sources and young scientists trained are mentioned in the preceding section on Project Overview.

INTRODUCTION

The world is already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice, among other changes (IPCC, 2018). A changing climate leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events (IPCC, 2014). Extreme events may also trigger associated or cascading hazards depending on its nature, intensity, extent and locality. All types of fast and slow onset hazards are expected to increase as the climate changes. Ten key risks associated with fast and slow onset hazards have been identified for Asia, where a majority of these have direct impact to society in terms of health, well-being and safety (IPCC, 2014). If global warming exceeds 1.5ºC, tropical Southeast Asia is projected to experience a range of fast and slow onset hazards that will impact economic growth (IPCC, 2018). Scientifically robust research is increasingly critical to document and report on loss and damage (L+D) due to climate impacts, particularly for Southeast Asia. It is also relevant to the Katowice Climate Package adopted in COP 24 in December 2018 (the Rule Book for the Paris Agreement), which gives prominence to loss and damage in the upcoming global stocktake.

The 3-year research project on "Integrating Climate Change Adaptation, Disaster Risk Reduction and Loss and Damage to Address Emerging Challenges due to Slow Onset Processes" brought together distinct groups of biophysical and socio-economic scientists with the following objectives:-

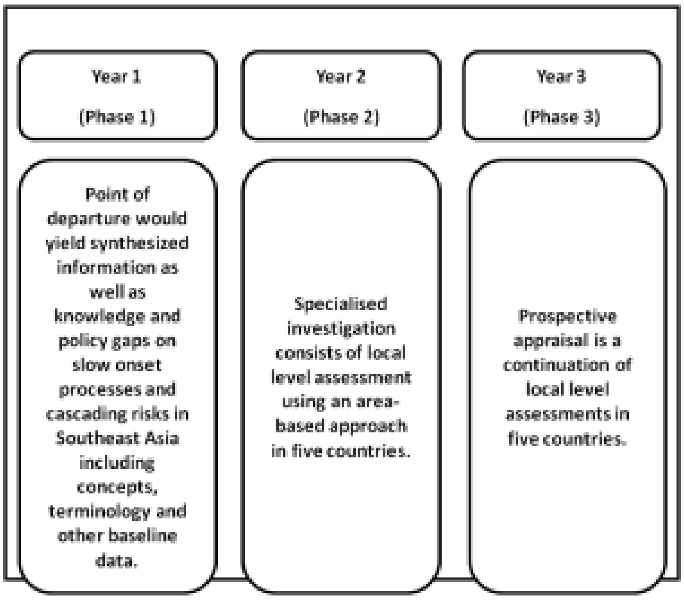
(i) Identify characteristics, priorities and emerging issues related to slow onset processes in low-lying coastal areas, floodplains and highlands of Southeast Asia that impacts the livelihood and well-being of the communities therein;
(ii) Assess limits to adaptation based on the "best available science" and propose risk based approaches that integrate CCA and DRR;
(iii) Develop methodologies to evaluate prospective L+D (both economic and non-economic) associated with adverse and cascading impacts of climate change drawing on lessons from disaster risk management, and discerning natural and anthropogenic causes of climate change; and
(iv) Recommend policy and planning strategies to integrate CCA, DRR and L+D in development plans in line with existing governance systems.

Six countries were involved in the project led by (1) Malaysia, with participation from (2) Cambodia, (3) Myanmar, (4) Philippines and (5) Vietnam, and transfer of expertise from (6) Japan. Local level pilots were implemented by five country teams comprising researchers from multidisciplinary backgrounds, working closely with their respective policy and decision-makers and local communities. Researchers from Japan facilitated transfer of knowledge, particularly on economic and non-economic valuation for L+D.

METHODOLOGY

A risk framing approach was used in the project. This enabled the evaluation of the need for climate change adaptation (CCA) and disaster risk reduction (DRR) in a common setting over a continuous timeframe. The approach takes into account the spatial context as well as existing and future susceptibility to hazards, exposure and vulnerability, drawing on the best available science, ranging from the atmospheric, geological, biological, chemical, and engineering to the social sciences and humanities. This is line with the key message of IPCC (2014) which states that "the first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability and associated extremes".

The project was deployed over three sequential phases, covering bio-physical, socio-economic and policy aspects. Phase 1 (Point of Departure) identified knowledge and policy gaps on slow onset processes and cascading risks in Southeast Asia including concepts, terminology and other baseline data. Phase 2 (Specialised Investigation) consisted of local level assessment using an area-based approach in five countries, which enabled identification of priorities and emerging issues related to slow onset processes. Phase 3 (Prospective Appraisal) saw the continuation of local level assessments to test L+D methodologies developed or modified in the project for slow onset processes and cascading risks.



Meta-analysis of peer reviewed research was conducted to identify the state of science on biophysical, social and economic and non-economic valuation as well as policy. Participatory appraisals were used to identify and rank local level hazards and processes. Questionnaire surveys and interviews were also carried out to supplement information for evaluating loss and damage. Comparative studies through local level pilots in selected countries helped to develop and test approaches. Dialogues between researchers and policymakers of multidisciplinary backgrounds were conducted on a periodic basis, to delineate effective options that address and integrate DRR, CCA and L+D in development plans.

RESULTS AND DISCUSSION

Projected impacts for Southeast Asia include increases in the number of hot days and heavy rains, higher risks of floods, flash floods and landslides, net reductions in yields and nutritional value of rice (IPCC, 2018). In addition, an increase is expected in populations that are both exposed and susceptible to poverty, particularly those dependent on agriculture and coastal livelihood. As the sea-level rises, much of the low-lying coasts in areas of Southeast is expected to be affected, bringing new migration and security issues for the region.

The project used an area-based approach in five countries. Local level pilots were identified in Cambodia, Malaysia, Myanmar, Philippines and Vietnam. The pilot areas were Kampong Speu Province (Cambodia), Selangor State (Malaysia), and Thatdama Kyun Village (Myanmar), Kanan Watershed (Philippines) and Quang Ngai Province (Vietnam). Findings of the local level pilots are presented in Chapters 1-5 of this report. The highlights are summarized below.

The Kampong Speu Province in Cambodia is located primarily within the catchment of the Prek Thnot River, with forests in the eastern highlands and agriculture in the western lowlands. Hazards common in the area are floods, drought and heatwaves. The slow onset characteristics of drought makes it difficult to detect as an emerging threat. Drought requires effective water management within the affected community, who would be the first to experience the hazard. The response of the authorities at the national and local levels to drought have been relatively slow compared to the actions taken to address floods. This indicates that it is important to build the capacity of the local community so that they can respond effectively while waiting for external support. Rainfall monitoring and forecasting as well as effective irrigation systems are major challenges for this agrarian community. This is compounded by disconnects between planning at the national and local levels, weak institutional arrangements and capacity as well as poor engagement of all stakeholders, particularly the local community.

The Selangor State in Malaysia comprises a western coastal region that gets progressively more rugged to the east, where the highlands straddles part of the Titiwangsa Range. Kuala Selangor, the area that was studied in detail, is located in the coastal lowlands and is exposed to hazards such as floods, saline intrusion and sea-level rise. Agriculture areas in Kuala Selangor are susceptible to impacts of coastal inundation and saline intrusion, giving rise to future implications on food security as this is an important rice-production area. Saline intrusion is expected to affect sub-surface aquifers. Groundwater is affected in terms of both quality and quantity of reducing reserves for industrial, agricultural and domestic use. An emerging hazard that has been detected in the Selangor State is the cascading effects of landfills and open dumps that are exposed to floods and landslides. The rapid expansion of urban areas has brought residential zones closer to landfills and abandoned open dumps. Future disaster events may expose such population and make them vulnerable to emerging hazards. Preliminary assessment conducted on landfills and open dumps in Selangor reveals that six out of 20 landfill sites in the state are highly exposed to the 100-year flood while two sites are exposed to slope failure (including mass waste movement). The exposed sites are currently without any protection measures making populated areas in the vicinity vulnerable to hazards and their cascading impacts. An integrated framework has been recommended in Kuala Selangor, Malaysia, building on existing policies such as the Integrated Coastal Zone Management (ICZM) and Environmental Impact Assessment (EIA). The integrated framework incorporates comprehensive and iterative adaptation, taking into account the natural state, projected conditions, potential impacts both at the surface and subsurface, deployment of science, technology and innovation as well as economic cost benefit analysis to identify suitable adaption options as well as continuous monitoring and evaluation, in conjunction with the local community, among others.

The Thatdama Kyun Village in Myanmar is a landmass with changing morphology, at the confluence of the Ayeyarwady and Pathein Rivers. The area is exposed to hazards such as flooding, river bank erosion, extreme temperature and irregular rainfall. The island-setting of the village makes it prone to flooding and river bank erosion, which has damaged agriculture land, depleted livestock, reduced household income, affected food security, displaced village population and caused other social impacts. Heatwaves and an increasing number of hot days have caused health problems to the villagers. Vector and water borne diseases as well as scarcity of drinking water are also health issues that of concern. While households receive weather related information such as the river level, wind speed and flood warnings from television and radio, the lack of electricity is a barrier to receive timely information on disasters. The lack of awareness has made it difficult for villagers to deal with the changes in climate and increased frequency of disasters. This is compounded by inherent vulnerability due to poor nutrition, health services and access to education. Enhanced capacity and technical information as well as strengthened institutional frameworks is critical to enable these villagers to manage the impacts of climate change.

The Kanan Watershed in the Philippines is a forestland drained by the Agos River with some 35 tributaries, stretching from the Sierra Madre Mountain to the Pacific Ocean. The area is exposed to flash floods, mudslides and landslides exacerbated by strong typhoons. Flood waters that contaminate the local supply of drinking water resulting in increased cases of waterborne-diseases. Intense rainfall contributes to river siltation while increased temperatures dries up irrigation channels and other sources of water. Households in this area are vulnerable to land and forest degradation associated with climate change. Proactive interventions to raise awareness on the importance of the watershed and improvement of farming systems are important. Land and forest degradation has created cascading effects on infrastructure, agriculture, forestry and coastal sectors, among others. This includes reduction in crop harvest by 30%, reduced fish catch from rivers, loss of soil fertility due to soil erosion leading to low crop yields, damaged river canals and planted crops, decrease in water flow due to a month-long intense heat and loss of livelihood sources. Such events have contributed to economic and non-economic loss and damage in the area. Government institutions are providing assistance and support to communities in adapting to climate change and managing disasters.

The Quang Ngai Province in Vietnam is a coastal province with diverse terrain with multiple fast and slow onset hazards. These include typhoons, tropical depressions, floods, flash floods, landslides, monsoons, thunderstorms, tornados, lightning, droughts, forest fires, saltwater intrusion and sea-level rise. The management of drought is challenging, and requires improvements in early warning and irrigation systems. Prolonged drought in combination with high temperatures create a high risk of forest fires that destroy the environment on a large scale and seriously affect the microclimate. Sea-level rise and saltwater intrusion, which are typical slow onset processes have been classified as low risk in the Province. The Ly Son Island is particularly sensitive to disasters is most vulnerable to climate change. A vulnerability index developed at the national level based on parameters such as exposures, sensitivity and adaptive capacity was used to rank each district in the in the Quang Ngai Province. This is to enable comparison between districts so that appropriate measures can be identified to build resilience to disasters and climate change. The priority for Quang Ngai Province is to increase resilience of the natural environment. Loss and damage due to natural disasters is high in the Province.

CONCLUSIONS

The project deployed an area-based approach, where local level pilots were conducted to determine (i) characteristics, priorities and emerging issues related to slow onset processes; (ii) limits to adaptation and propose risk based approaches that integrate CCA and DRR; (iii) methodologies to evaluate prospective L+D; and (iv) policy and planning strategies to integrate CCA, DRR and L+D. The pilot areas were Kampong Speu Province (Cambodia), Selangor State (Malaysia), and Thatdama Kyun Village (Myanmar), Kanan Watershed (Philippines) and Quang Ngai Province (Vietnam).

The characteristics, priorities and emerging issues related to slow onset processes are context and area dependent. The local level pilot areas are exposed to multiple climate driven fast and slow onset hazards such as flood, landsides, drought, saline intrusion and forest degradation. Pilot areas with low-lying coastal areas are exposed to floods, saline intrusion and sea-level rise while some are also affected by storms and typhoons. Pilot areas in the floodplains are exposed to hazards such as floods and river bank erosion while the highland areas are affected by flash floods, mudslides, landslides and forest degradation. Some hazards are found to be independent of setting. These include dry conditions and high temperatures that trigger forest fires as well as landfills and open dumps that could become the source of emerging hazards.

The limits to adaptation is dependent upon the natural setting of an area, social capacity, resources and availability of technology. The risk framing approach is useful to assess both fast and slow onset hazards in a specific area over a continuous time-frame. The short term requires DRR while the long term calls for CCA, when it is within natural limits. In Myanmar, the island-setting of the Thatdama Kyun Village at the confluence of two rivers made it prone to flooding and river bank erosion. The loss of agriculture land, livelihood opportunity, health and other social issues have caused great hardship to the people and some have migrated away from the area. In Kuala Selangor, Malaysia, areas in the agriculture rich lowlands will be exposed to slow onset coastal inundation and saline intrusion is expected to affect sub-surface aquifers, giving rise to future food security issues. While some areas will have to be let go in the future, it is important that the community is informed of this hazard and that resources are allocated for long term adaptation efforts. Increasing temperatures and heatwaves are already reported in the Kampong Speu Province (Cambodia), Thatdama Kyun Village (Myanmar) and Quang Ngai Province (Vietnam). This hazard contributes to forest fires and impacts human health and the situation is expected to worsen in Southeast Asia as global warming increases to 1.5ºC. The Governments of the region need to make comprehensive, coordinated effort via ASEAN at the UNFCCC and other bilateral platforms, to limit global warming below 1.5ºC. Resources should also be deployed in the region to adapt to a 1.5ºC world.

Methodologies to evaluate prospective L+D depend on the evolution of the concept of loss and damage in the policy domain. There are many approached to assess L+D, which can be further differentiated into economic and non-economic losses. However, when deployed at the local level, a great many of these approaches assume that all impacts are linked to climate, which is not necessarily correct. For example, in some coastal areas, the impact of intensive groundwater extraction may be greater than the impact of sea-level rise, causing sea water infiltration and ground subsidence. In the UNFCCC platform, climate change is defined as change attributed to anthropogenic causes; making loss and damage evaluation challenging for developing countries, where there is a paucity of data linking impacts to human induced climate change. However, science has clearly linked global warming and sea-level rise to anthropogenic causes. Thus, the impacts of sea-level rise such as coastal inundation and saline intrusion, where there is no groundwater extraction, could be attributed to human contribution at the local level, making L+D assessments legitimate in the UNFCCC platform. Similarly, L+D could be assessed for depleting freshwater sources related to glacial melt or desertification. Once the attribution to anthropogenic causes is established for a local area, it is possible to use historical information to conduct a prospective L+D evaluation. This can be using multiple scenarios, including the worst case situation for the local area.

Policy and planning strategies that integrate CCA, DRR and L+D are easier to deploy for specific local areas compared to a country-wide basis. The integration is also easier in small areas compared to large tracts of land, with a higher number of interacting hazards. The risk framing approach for DRR and CCA can be expanded for a specific local area to include L+D. Historical L+D information is useful to provide insights for developing prospective L+D scenarios, both for DRR (near term) and CCA (long term). On a conceptual level, the three elements of DRR, CCA and L+D can be incorporated into land use planning and development control policies. The integrated framework should take into account fast and slow onset hazards and be suited to existing governance systems. Important aspects include natural state of the local area, projected conditions, potential impacts both at the surface and subsurface, deployment of science, technology and innovation, suitability of adaption options as well as continuous monitoring and evaluation in conjunction with all stakeholders, especially the local community.

FUTURE DIRECTIONS

The findings of the project will be shared and sustained beyond the period of APN funding through SEADPRI-UKM, which coordinates ANCST and ASEANadapt Network as well as through other institutional arrangements with ASEAN. Future work for ASEAN can build on the findings of the project results and draw on the enhanced expertise of project members. This is particularly important for the attribution of climate change impacts to the rise of global warming from current levels to 1.5ºC. Such work should support the ASEAN in developing comprehensive and coordinated strategies to limit global warming below 1.5ºC, while optimizing resources to adapt to a 1.5ºC world.

CHAPTER 1

CASE STUDY OF KAMPONG SPEU PROVINCE, CAMBODIA

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1.1 INTRODUCTION

Cambodia has gone through a series of war, atrocities and instability from the early 1970s to the 1990s including the genocidal Khmer Rouge regime. After the end of the conflict, the country started to reap the peace dividend. Economic growth has been impressive and recently among the fastest growing economies in the world. The per capita GDP (at current USD) was a mere 300 USD in 1995 has been increased almost 4 folds to 1,140 USD in 2016 (WB, 2017). This impressive growth led the Asian Development Bank to dub Cambodia, Asia's new tiger economy[1]. Also, poverty has significantly reduced from 50.2 % in 2003 to 17.7% in 2012 (WB, 2017).

The growth of Cambodia economy is based on four main sectors, agriculture, tourism, construction and garment, which have significantly contributed to the employment, foreign exchange earnings through export and tourist spending. It is worth noting that besides agriculture, other sectors are susceptible to external shock as Cambodian economy is heavily dependent on foreign markets, especially the EU and US markets for exports of garment products and tourism. When those market are not functioning well, it negatives impact the Cambodian economy such as during the Lehman shock in 2008/09, which saw export earning shrink and the economic growth was a minimal 0.1% (ABD, 2017).

Agriculture is more resilience and less dependent on external factors. It even functions as an employer of last resort absorbing workforces from other sectors in the face of economic crisis. However, agriculture is sensitive to climate variation (Chhinh, 2013). In the era of climate change and global warming, agricultural production become erratic so as the livelihood of the farmer, especially small-scale farmers. Therefore, it is vitally important to manage the climate so that agriculture can still play its role.

Economic development of Cambodia is also laden with frequents and high intensity natural hazards including flood, drought, and windstorm among others. Typhoon Ketsana, for instance, hit Cambodia in 2009 claimed 43 death tools, 67 injuries, about 50 thousand family loss home and livelihood. The Typhoon was accompanying with flash flood. The cost of disaster caused by Ketsana was about USD 132 million (damage: USD 58 million and loss: USD 74 million). It was estimated that flood cause Cambodia agriculture about USD 100-170 million annually. Current socio-economic development approaches are driven by agencies, priorities, and resources availability.

Similarly to other provinces of Cambodia, huge percentage of people in Kampong Spue province are farmers who rely mainly on agricultural productions including rice and other cash crops. Since farmers are predominantly applying conventional agricultural practices, their livelihood activities become less certain, especially in the face of climate change impacts. With the limited adaptive capacity, rural communities of KPS have increasingly experienced the climate change effects including head wave, droughts and floods (Chhinh, 2014). The emerging of those climate related risks, the government departments and local communities have come across different alternatives and strategies in preparing

[1] https://www.adb.org/news/features/here-comes-cambodia-asia-s-new-tiger-economy

for and responding to the potential risks including the slow onset processes. This article aims to scrutinise the existing responses which have been established and applied by rural farmers in Kampong Spue province in coping with slow onset processes. While numbers of responses and interventions have been established, the concerns on the impacts of slow onset process have increasingly raised among local farmers and state agencies and development partners. This study aims to understand how policy and/or action plan for disaster risk management playing role in provincial development plan as well as local development plan.

1.1.1 Overview of the impacts of slow onset process

The impacts of climate change can be classified into slow and rapid onsets. Climate change will bring both rapid disasters such typhoon or flash flooding and slow onset disasters such as sea-level rise or drought. Drought is regarded as slow onset due to the fact that the event is creeping making it hard to identify onset and cessation (D. A. Wilhite & Glantz, 1985). Moreover, the slow onset impacts are defined as emergencies or disasters that are not caused by only one event, but by several different events gradually (Adamo, 2011). There are eight slow onset disasters listed in the report of the UNFCCC (2012), namely sea-level rise, increasing temperature, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity, and desertification. In the same report, the UNFCCC also outlined key methods and tools to deal with the problem of each slow onset process, and proposed four methods to tackle the impact of the increasing temperature including developing programs to conserve water, determining how increasing temperature is related to vector diseases and finding ways to deal with the diseases problems, developing protected areas for coral reef and improving the resiliency of agriculture to increasing temperature.

1.1.2 Policy framework and interventions

In a bid to cope with the impact of climate change, the Cambodian government has ratified and become parties to international agreements on environment such as the ratification of the UNFCCC in 1995. And in 1999, Cambodia launched the first climate change project. In fact, an environmental law enacted in 1994 already contains clauses supporting the effort to cope with the impact of climate change (Watt et al., 2012).

In addition, Cambodia is a party to other international framework such as the Kyoto protocol and the Hyogo Framework for Action (HFA). HFA outlines five priorities for action including 1) insuring that disaster risk reduction is a policy priority to be implemented with strong institution, 2) identifying, assessing, monitoring disaster risk and improving early warning system 3) utilizing knowledge and technology innovation for improving disaster resilience 4). Reducing risk factors and 4) strengthening preparedness for effectiveness of disaster response.

At the regional level, Cambodia is a member an ASEAN Agreement on Disaster Management and Emergency Response (AADMER), which is a regional framework aimed at promoting cooperation among member countries to cope with the disaster loss. AADMER outlines key activities such as identification of disaster risks, prevention, early warning and rehabilitation.

At the national level, the Cambodian government formulated many policy documents to deal with climate change such as the National Adaption Program of Action to Climate Change in 2006, the Climate Change Strategic Plan 2014-2023 in 2013 and the Climate Change Action Plan 2016-2018 in 2016. These documents which comprehensively cover activities ranging from raising awareness of and mainstreaming the impact of climate change to effective response and international cooperation[2]. Also, in 2006, the government created the National Climate Change Committee, which is comprised of representatives from 20 government ministries and agencies, and in charge of all activities pertinent to climate change, from policy making to asessing the impact (Watt et al., 2012).

The Cambodian government has created the disaster management at the local level as depicted in the Figure 1.1. In each commune, there are three teams, namely security and rescue, health and hygiene, and information and response team. The commune administration may mobilize available local human resources such as the commune police, school principal and volunteers with the support of the Cambodian Red Cross. In addition, in each commune there is Village Disaster Management Group consisting of at least three members, who will help provide information and support to the CCDM.

1.1.3 Current strategic responses of communities

Cambodia faces different disasters such as drought, flood, sea water intrusion forest degradation and so on. In Kampong Speu, where the study is conducted, the main disaster is drought. Drought requires effective water management in the affected community. Since drought is slow on set the response from the government is relatively slow compared to other disaster such as flood (Nguen et. al., 2009). The establishment of the Farmer Water User Community (FWUC) is one of the national policies to respond to drought. Also, the government has expanded the construction of irrigation system so that farmers will have sufficient water for agriculture and household use.

Donors and other development partners are also involved in irrigation and water management. The French Development Agency (AFD), for instance, supported irrigation project in Kampong Thom province, central Cambodia. As a result, farmers are able to responds to climate change, diversify their crops and generate higher income (AFD, 2017).

NGOs such as SNV[3], for example, introduced small-scale farmers a new technology of water management that enable them to adapt to and become more resilient to drought. In addition, their income also have increased and status of food security improved as the technology allows them to prolong the production cycle, diversifying crops and increase yield.

At the community level, as agriculture is one of the villagers' main sources of income, drought was most frequently reported among other disasters. And in order to cope with drought, farmers either change the crop varieties or cropping calendar (Thomas et al., 2013). However, sometimes villagers know that they need to use the drought resistant varieties of crop to grow, yet the price of the seed is too expensive (Nguyen et al., 2009).

In responding to drought, although there various stakes holders such as the central and local government, and also NGOs are involved, the community was found to be the first to response when drought hit their locality (Nguyen et al., 2009). This indicates that it is important to build the capacity of the local community in order that they can effectively response to drought while waiting for the external support.

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[2] Cambodia Climate Change Strategic Plan 2014-2023. Available at http://www.cambodiaip.gov.kh/DocResources/ab9455cf-9eea-4adc-ae93-95d149c6d78c_007729c5-60a9-47f0-83ac-7f70420b9a34-en.pdf

[3]http://www.snv.org/public/cms/sites/default/files/explore/download/csa_technology_case_study_eng_final.pdf

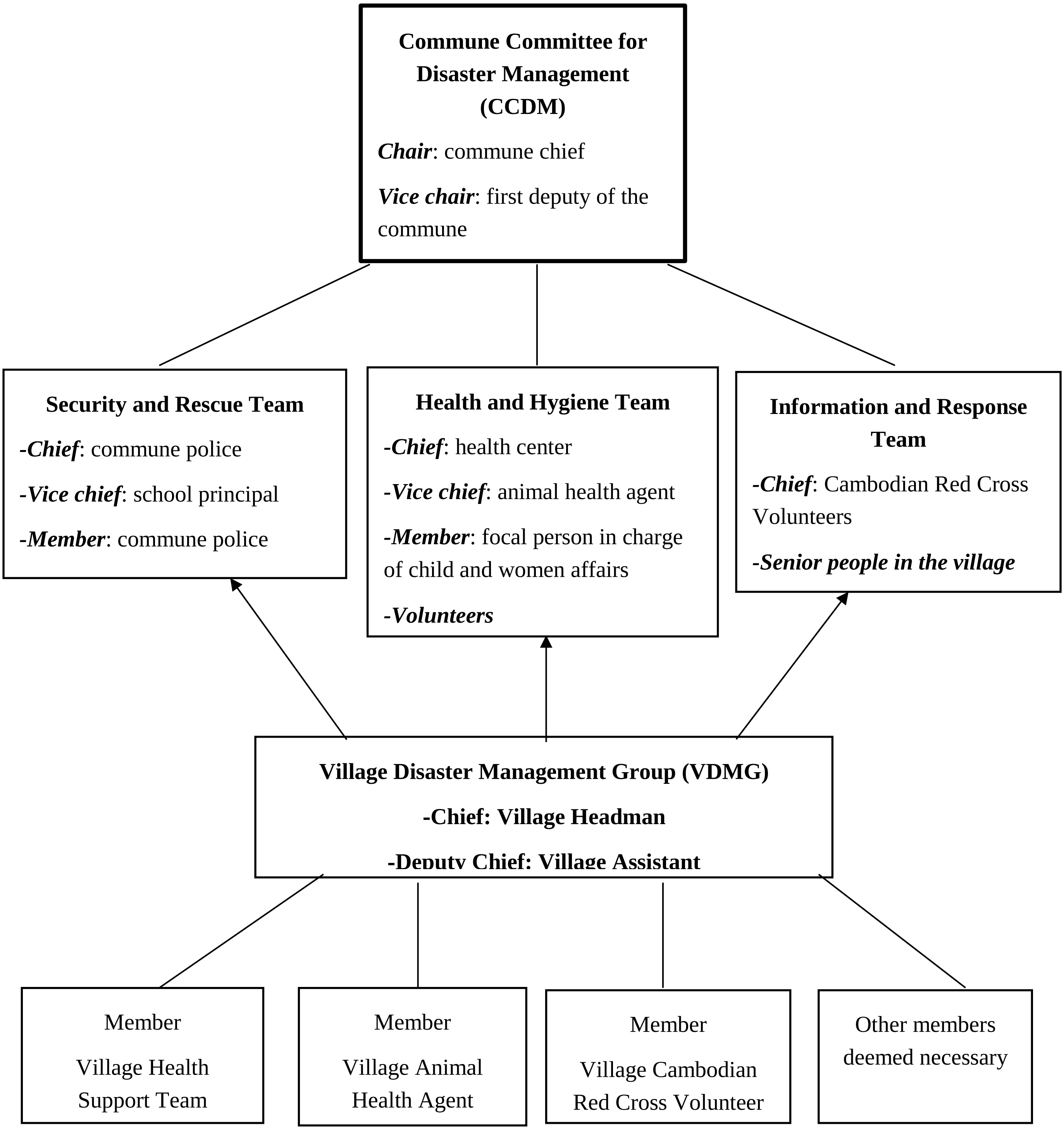

Figure 1.1: Structure of the local disaster management

Source: Adapted from Leng (2014) and Sam (2015)

1.2 APPROACH

This study concentrated on the rural context of Cambodia, particular Kampong Speu Province. The province has been selected for the study because it covers many vulnerable locations, where local people experienced major climate related hazards, such as drought and floods. Those locations are known as the major areas for agricultural production particularly rice, which is the main sources of communities' livelihoods. Consequently, slow onset process, especially the prolonged droughts have negatively affected crops productivity. This became a big concern for local farmers, development partners and related government agencies that are working for improving rural community livelihoods and their well-being.

This qualitative study relies on both secondary and primary information. The secondary data was collected through reviewing existing peer-reviewed articles and reports from government agencies and development partners such as NGOs. The primary data was gathered from two Focused Group Discussions (FGDs) with the involvement of 16 participants, including community representatives and village chiefs. In addition, Eight Key Information Interviews (KIIs) was conducted with the representatives from Department of Water Resource Management and Methodologies, Department of Agriculture, Department of Planning and Provincial Hall. The processes of KII were to gather information related to main hazards facing local farmers, strategic policy intervention and the process of establishing strategic plan and policy responses and the key challenges in translating strategic plan and policy into actual implementation. The process of primary data collection was conducted between November 2017 to May 2018. It took approximately around one and half hour for each FGD, and about 45 minutes for key informant interview (KII). The qualitative data from FGDs and KIIs have been recorded in the diaries with the verification and quality control among researchers. Thematic Analysis was applied for structuring, analyzing and synthesizing the obtained information.

1.3 RESULTS

The result section is divided into the discussion of slow onset context in the study site, the previous findings in this research project, mechanism of development of policy and action plan on disaster management at national and provincial level, and recommendation of L&D, DRR and CCA be integrated into development plan at sub-national and local level.

1.3.1. Slow onset hazard

Kampong Speu (KPS) is one of drought prone provinces in Cambodia. Drought manifested of its impact on local livelihood in different forms but the most direct one is associated with agricultural activities. It should be noted that about 92 percent of KPS population is depending on agriculture, mainly paddy rice. The practice of cultivating paddy rice, moreover, is changing overtime depending of many factors such as rainfall, accessing to irrigation, and some other socioeconomic factors and/or technology.

Some farmers are still cultivating their rice using long duration variety by starting the cultivation from late May and harvest early December (which mean that they use the entire raining season – May to November) as in Figure 1.2. This variety of rice is good taste (traditional varieties), good price, heavy grain, and drought resistant (for some varieties). If there is good rainfall during early season (late May or June), about 30 percent of farmers would transplant this variety. In the context of climate change and variabilities, these farmers are prone to early onset drought (due to less rainfall in July), mid-season dry spell (Cambodia normally has two weeks without rain in August), and early cessation of rainfall (November). These famers, moreover, would cultivate again if their crop fail due to early onset drought by cultivating medium varieties in August. This medium varieties would take about four months to harvest meaning that the cultivation period is from August to November or early December.

The practice of cultivating medium varieties is highly common in Cambodia now. It could be associated with rainfall variabilities, technological change, and rural labour shortage. As mentioned earlier that some farmers would cultivating their crop very early if good rainfall, and that if their crop fail, they will cultivate second crop during August. If combine the first group of farmers and those who cultivating paddy in August/September, the paddy production is in its full potential during this period. Most of the time, there should be enough rainfall for cultivation during August/September.

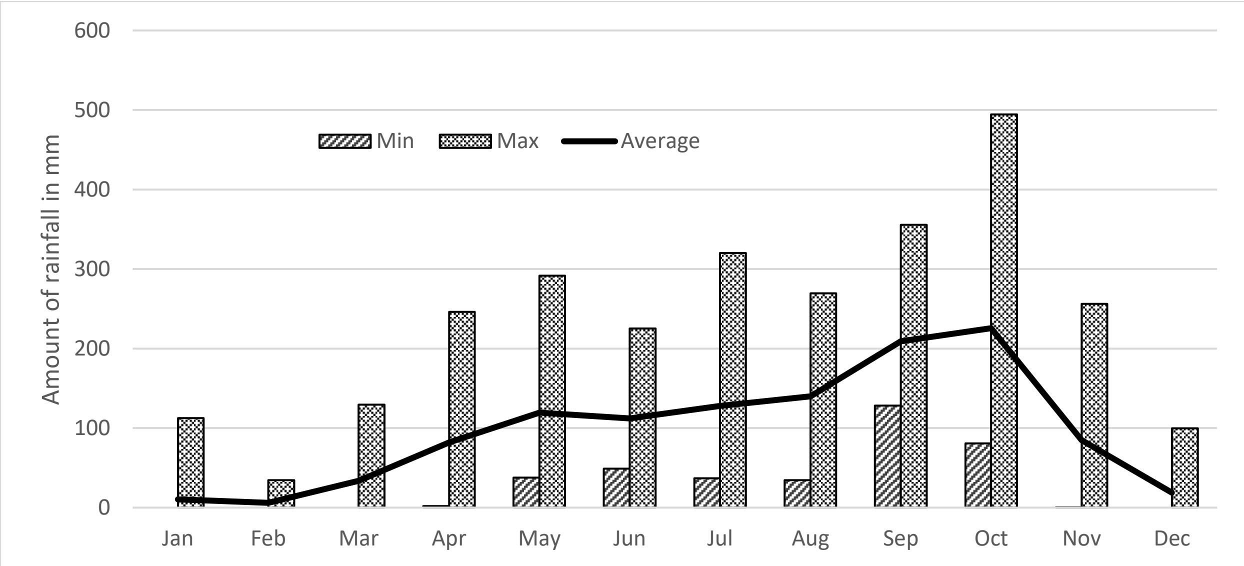

Figure 1.2: Rainfall pattern in Kampong Speu

From Key Informant Interview, more and more farmers prefer not to have lot of rainfall during August. This is related to the change of technology and cultivation practices. In the past, farmers would transplant rice but now they put seed directly into the ploughed soil. This practice would not be possible if the soil is inundated. Most of famers have access to agricultural machinery such as power tiller. With the combination of machineries and direct seedling, farmers could complete the cultivation with less than 3 hours on one hectare of land which is much less time spent compared to human labour.

In terms labour shortage, it is very common in rural Cambodia as almost all young adult is migrating to urban and/or other country for wage labour. This create a generation gap in the household which is normally living grandparents and grandchildren. The combination of lack of adult in the household, machinery for rent, and direct seedling are perfect combination of cultivating medium varieties rice. The remaining challenges are 1) rainfall during August must not be too much (or not inundated the paddy field) and 2) drought onset occurs due to early cessation of rainfall. Related to the first challenge, farmers may fail to cultivate one season if they are waiting for dry spell. Two major solution is that there must be a good drainage system so that farmer could dry their paddy field for direct seed practices or monitoring rainfall systems be available. With the monitoring systems, authorities could predict if there are more rainfall or dry spell. With this information, farmers may wait for cultivating by direct seed or transplanting practices.

The less practice of cultivating paddy is using short varieties which required less than 120 days from seedling to harvest. Normally, farmer cultivate this varieties only if their second wave of cultivate was failed. This varieties are not popular in Cambodia and they cultivate this varieties for sale only. It is generally safe for famers (if they transplanting) to cultivate in late September. Given that this varieties would experience drought if there is early rainfall cessation.

The implication of slow onset associated with paddy production here is that it is very critical to identify the arrival of the slow onset event. First, long maturing varieties rice planted in very early cropping season and it is very prone to drought throughout the season. Since most of paddy production is depending on rain fall, having information of slow onset event may help them to recuse or prepare the following cropping. Second, the medium maturing varieties (in the combination of direct seed, machinery, and lack of labour) is going to be the most common practices in rural Cambodia, then too much rainfall and/or inundated paddy field would hinder farmer from starting their cultivation. Then, it is very critical to give farmers information about the dry spell during August/September, for farmers would be looking for dry spell during this period. Last but not least, the short maturing varieties may not require any information about rainfall during plantation but it is very critical for them toward harvesting period. It appears that it is imperative to have drought monitoring systems in place so that authorities could recommend interventions to farmers.

1.3.2. Drought response

Based on the framework, the province has partly practiced reactive response to drought impact only. It is almost absent of drought responses except some measures to mitigate drought disasters such as distribute seed to farmers and/or sending pumping machine to help farmers who have access to surface water nearby their paddy field.

Moreover, while the provincial departments recognize the impacts of slow onset risk (drought) on rural farmers' livelihoods, their strategic interventions remain pragmatic. The result from FGDs and KIIs reveal that almost every department's strategic and action plan has been developed with limited involvements of relevant key actors from outsides. It means that those plans have been formulated by a team in the department and by matching with the strategic interventions of the national development plan. Although the departments' plans have been shared at the provincial level meeting coordinated by the department of planning (DoP), those combined plans remain passive due to the limitation of public disclosure and lack of financial resources to translate the plans into implementation. More often, every department has implemented their strategic activities at their own timeframe and ability. Besides, given their proposed activities could not be implemented as planned, those would generally move to the next fiscal year plans.

These kind of practices seem to be challenging in responding to drought impacts because given that huge amount of support and interventions have been established as mentioned in the literature such as Thomas et al., 2013 and Nguyen et al., 2009, those have not been strategically and systematically build the strengths of local government and communities. This is due to the plans are less likely responding to the real priorities of the local communities and the intervention itself tends to be choppy and less robust.

Apart from this, to promote drought response, as it is a slow onset hazards, the province must consider the following model (as in Figure 1.3) for disaster management mainly drought.

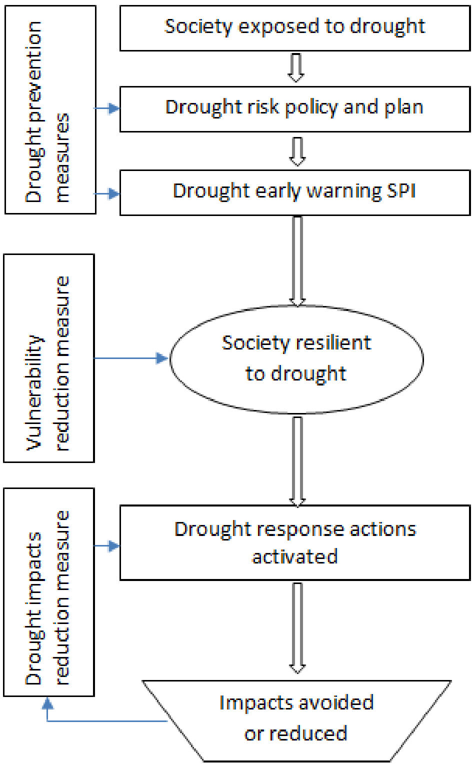

Figure 1.3: Drought risk management framework

Source: Modified from UNISDR (UNISDR, 2009) and (Donald A Wilhite, Sivakumar, & Wood, 2000).

A drought risk management framework, as proposed by United Nations Office for Disaster Risk Reduction (UNISDR) (UNISDR, 2009), is summarized as shown in Figure 1.2 and includes drought preparedness (drought prevention measures), drought vulnerability reduction (vulnerability reduction measures), and drought recovery actions (drought reduction measures). Wilhite et al. (Donald A Wilhite, Sivakumar, & Pulwarty, 2014, p. 9) has suggested a 10–step process required to make the framework operational:

1. appoint a drought task force or committee;
2. state the purpose and objectives of the drought mitigation plan;
3. seek stakeholder input and resolve conflicts;
4. make inventory of resources and identify groups at risk;
5. prepare and write the drought mitigation plan;
6. identify research needs and fill institutional gaps;
7. integrate science and policy;
8. publicize the drought mitigation plan to build awareness and consensus;
9. develop education programs; and
10. evaluate and revise drought mitigation plans

If the province could activate the model, early waring could be established as suggested in the following section.

1.3.3. Drought early warning

Part of drought resilience society, drought early warning is going to play a very significant role in drought protection. It is noteworthy that SPI is not used for drought prediction but it could be used to identify drought onset, drought severity, and drought cessation. Given that limitation, we can associate SPI with regional climate namely El Niño Southern Oscillation (ENSO) to predict drought occurrence based on regional climate influence. ENSO occurrence is always linked with drought occurrence in Cambodia. The good news is that there is about a 1 to 3-month time lag of ENSO occurrence to influence on Cambodia climate. Then, if ENSO happens in May 2017, it would impact the Cambodia climate on June and/or up to August 2017. ENSO onset is based on Bureau of Meteorology from Australia[4], and is updated every two weeks (Figure 1.4).

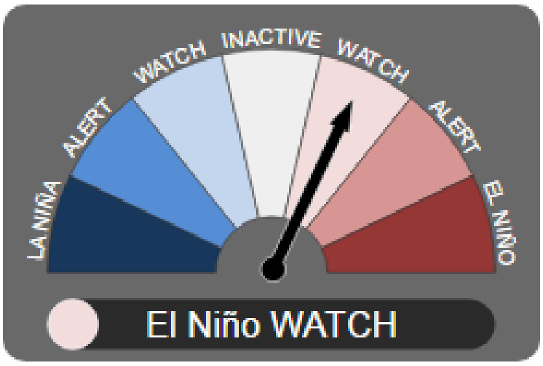

Figure 1.4: El Nino Watch produced by BOM, Australia

Source: http://www.bom.gov.au/climate/enso/outlook/

Assuming that SVR' SPI in May 2017 is negative number bigger than 1 (or -1.5), while ENSO is showing that there is an event happening (positive +3), we expect drought to become severe in the following month (as shown in Figure 1.5). The precise value of ENSO can be accessed through the NOAA webportal[5]. The El Niño WATCH (Figure 1.4) pointing to El Niño means that the value of ENSO is starting from positive 0.5. For WATCH and ALERT segment mean that be careful with ENSO onset, and this gives early warning to people about the arrival of ENSO.

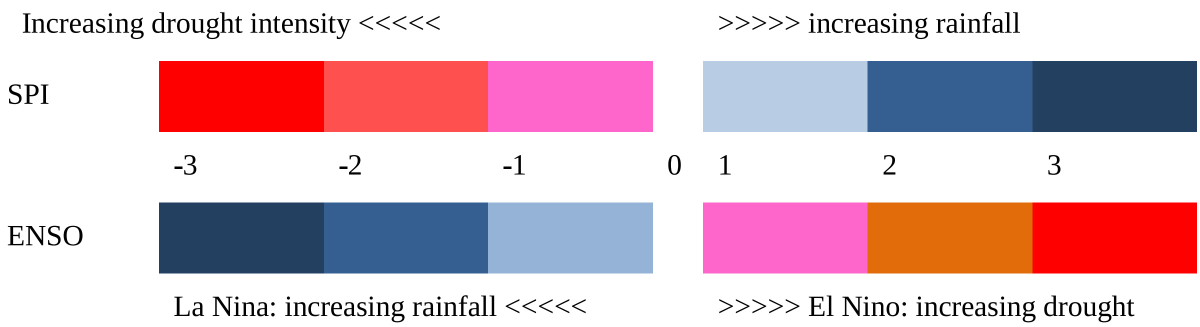

Figure 1.5: SPI and ENSO relationship

[4] http://www.bom.gov.au/climate/enso/outlook/
[5] https://www.esrl.noaa.gov/psd/gcos_wgsp/Timeseries/Data/nino34.long.anom.data

If SPI is negative and ENSO is positive (El Niño episode) >>> we are expecting more severe drought in the province (Figure 1.5). If SPI is negative and ENSO is also negative (La Niña episode) >>> we are not expecting any more severe drought to come. If SPI is positive and ENSO is also positive (El Niño episode) >>> we are expecting less rainfall for the province. If SPI is positive and ENSO is negative (La Niña episode) >>> we are expecting more rainfall for the province (or flooding).

1.4 DISCUSSION

Climate change may be a kind of panacea for agricultural production in Cambodia, especially paddy rice production. It has been said that climate change will bring more rain in wet season (late-April to early October) with longer dry spell in July-August. If the finding of climate change holds true, then farmer could adapt to this change very well.

Farmer cultivating short varieties of rice (90 days from seedling to harvesting)

Firstly, holding that there will be more rainfall in early wet season, farmer could start their short maturing rice in mid-April and catching the breath of rainfall in late April and harvest during dry spell in late July and early August.

Secondly, given a longer break during late July and early August, farmer could start their second crop. Expected that climate change will prolong this dry spell longer than normal (more than two weeks), then it is very good period for ploughing (ploughing need dry paddy field to do) and direct seedlings. This crop will be being harvested in late November. Climate change scenario predicted that there will be shorter wet season meaning that during November there will be not much rain like before which is very good for harvesting time.

Finally, farmers, having access to irrigation, could start their third cropping. In the long run, rural and/or remote area must have water storage harvesting during wet season. Reiteratively, more rainfall will be during wet season and if farmers without storages, they will face water shortage during dry season. It should be emphasized that harvesting water during wet season is very critical to avoid severe drought in dry season since it is going to be longer if climate change prediction is valid and reliable.

There are some critical issues with short maturing varieties rice (mainly the seeds from Vietnam). First, it is very sensitive to diseases, too much fertilizers and required labor intensive (caring). Also, the cost of production is very high compared to local varieties. Moreover, this rice is produced mainly for selling for Vietnam customers.

Given all the positives about climate change, one should note that climate variability causing by climate change will lead to more challenges to farmers especially those without supplementation irrigation. If there is too much rainfall for couple of days (as suggested by climate change scenario and observed during the last few years) in the month and left the remaining days without rainfall, farmers will not be able to adapt to the changes. Then, supplementary irrigation is the most recommended options to adapt to climate change. This is not couple with inter-seasonal variability causing by ENSO events.

Farmer cultivating medium maturing varieties (120 days from seedling to harvest)

In the context of drought for this cropping calendar, they are not likely to face with drought during early cropping as they will start production in late July and/or early August. The longer the dry spell, the better for land preparation is. Since Cambodia normally has less rainfall during this period, it is much favorable condition for farmers who practice direct cropping. Then, only early cessation of rainfall will impact on this period cultivation which is very similar to the third cropping using early maturing varieties. Farmers also reported that they faced some challenges with too much water and/or rainfall during harvesting (late November).

It should be noted that these varieties are produced for domestic consumption. Based on key informant interview, those who cultivate early maturing varieties would sell the crop and buy these medium maturing varieties for household consumption. The most popular seeds are Krasang Teap (ក្រសាំងទាប) accounted about 90 percent of total usage followed by Smeur (ស្មើ) and Tong Chhouk (ទងឈូក). The following reccomendations are proposed:

- Drying machine should be available within the commune so that farmer could dry their crop after harvesting when there is too much rainfall during late November or early December
- Greenhouse or high ground may be the options for cash crop farmers to avoid any over-supply of moisture if they cultivate during wet season
- While direct seedling is very good (cost saving, less labor intensive, high yield) and suitable for climate condition, but still under the condition of climate change which will vary rainfall patterns, transplanting technique should not be abandoned. Some years, there will be no dry spell during late July and August. Perhaps, there should be a technology that can help transplanting during this period.
- While the government is promoting climate change adaptation including building physical infrastructure such as irrigation, it should be playing dual roles: supplying water and drainage systems. It will be the source of supplementation irrigation during drought condition and drainage systems during too wet condition mainly during early season and harvesting. In this regard, all relevant provincial department should work more closely in developing holistic plan for responding to slow onset impacts. The departments' strategic plans should be formed through active involvement of all relevant stakeholders from the grassroots to provincial levels. Also, the plans should be well disseminated amongst stakeholders in order to promote effective collaboration in responding to the risks.
- Drought monitoring and early warning of drought should be available for the province. There is high feasibility to establish information systems of drought early waring with the following steps to be taken for drought preparedness:

    1. Check SPI for the current local condition of drought monthly (preferability every fortnight);

    2. Check ENSO for regional climate condition if it is in El Niño or La Niña condition;

    3. Check drought vulnerable communities and their current livelihood;

    4. Seek drought mitigation measures and activate the interventions when SPI value is -1 and El Niño is active.

1.5 CONCLUSIONS

Based on the climate change prediction model, given not at provincial level, Cambodia is going to face changes of rainfall pattern (which include shifting from dry season to wet season), early cessation, number of rain days, amount per rainfall. These will lead to challenges in rice cultivation as well as cash crop in Kampong Speu province, and/or Cambodia.

The current trend of rainfall is slightly increasing with very high variability: minimum of rainfall at 765 millimetres (in 1987) and maximum at 1,560 millimetres (in 2013). The combination of high variability and monthly and seasonally distribution of rainfall will spell drought disasters from rural communities, mainly rice and cash crop production.

It has been identified that there were all forms of drought (late onset, dry spell during wet season, and early cessation of rainfall) occurred in the province. Those drought types will spell different impacts on communities' livelihood. Once drought set its toes, farmers response to it by delay crop calendar, changing crop varieties, pumping water from surface and/or underground. For the post-ant responses are including migration and diversify livelihoods. Given that drought impacts in the past was reduced at minimum degree.

It seems that drought issues are not isolated from other hazards (manmade and natural ones). The Provincial Committee for Disaster Management (PCDM) has a Disaster Risk Reduction Plan published in 2013 and drought was part of the Plan. Given that, only drought impacts were reported but how drought will be tackle was almost absent. When there were drought impacts, the government agencies (mainly Provincial Department of Agriculture, Water Resources Meteorology, and PCDM), they should work very closely to form a concrete and holistic plans in building farmers' capacities and assist them with some drought relief fund, especially to fix pumps, make new ones if possible, and/or supplying new seeds.

The United Nations Office for Disaster Risk Reduction proposed a framework to ensure community resilience to drought. However, the framework is not well adopted by our government. It has been suggested that drought monitoring and drought early warning should be a breakthrough for the province for improving drought understanding as well as the entry point for drought intervention.

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CHAPTER 2

CASE STUDY OF SELANGOR, MALAYSIA

Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM)

2.1 INTRODUCTION

The changing climate accelerates the rate of sea-level rise and this has been observed since the mid-19th century (IPCC, 2013). Sea-level rise could result in higher occurrence of inundation and saltwater intrusion (Klein et al., 2001; Nicholls & Cazenave, 2010; Wong et al., 2014) that lead to negative impacts on coastal zones and its natural resources. Coastal ecosystems are particularly vulnerable to climate change as the rise in sea level will lead to damage of infrastructure, degradations of agricultural areas, contamination of surface and groundwater and loss of biodiversity; which covers a wide range of negative impacts to various socio-economic sectors. Although sea-level rise will only directly impact coastal zones, the impacts are huge and cover an extensive range of sectors. Considering that 10% of the world's population lives in coastal areas, sea-level rise is seen as a major threat (McGranahan et al., 2007). Coastal ecosystems comprise valuable resources including fertile land, groundwater and high-level biodiversity. Such conditions attract human activities which lead to rapid development and hence many major cities are located on coastal plains.

In a warmer future climate, an increase in extreme precipitation events is expected to increase the risk of large floods events in a number of major river basins due to high river discharge, including during north east monsoon in the Southeast Asian countries (Meehl et al., 2007; Seneviratne et al., 2012; Christensen et al., 2013). An escalation of extreme sea level has also been observed, which may exacerbate the intensity and frequency of flooding in coastal floodplains (Meehl et al., 2007; Nicholls, 2002). These conditions will increase the frequency and exposure to flood hazards for sites located on low-lying areas of floodplains and coastal plains. Floods have affected the highest number of people and caused the highest economic damage compared to other types of disasters in Malaysia within the period of 1980 to 2015 (EM-DAT, 2014).

Incidentally an increase of extreme precipitation events under the effect of climate change is expected to intensify slope processes (Crozier, 2010). Infrastructure such as waste disposal sites located on steep terrain or on hill slopes are subject to an increasing risk of landslides associated with climate extremes. Structural or slope failures of disposal sites following heavy or prolonged precipitation events had occurred in a number of cases (Blight, 2008). Waste slope failures can occur when the shear strength of the wastes becomes lower than the shear stress, due mostly to lack of technical control at the sites. This includes unrestrained piling up of wastes on an already steep face and lack of compaction of the wastes, among other contributing factors. Although in many cases the process are often exacerbated by extreme weather events.

2.2 APPROACH

This report features two case studies on slow-onset hazards in Selangor, Malaysia. The first case study focused on implications of sea-level rise to coastal groundwater. The second case study was on exposure of municipal solid waste disposal sites to climatic hazards. The findings from both the case studies have been published in peer reviewed journals, where the APN Project (CAF2016-RR03-CMY-Pereira) has been duly acknowledged. Highlights of the case studies are reported in the following sections.

The study commenced with a review of literature including the global sea-level rise projection reported by the Intergovernmental Panel on Climate Change (IPCC). The primary source of information for the analysis were reports from Government agencies such as the National Hydraulic Research Institute of Malaysia (NAHRIM), Mineral and Geoscience Department (JMG), the Town and Country Planning Department (JPBD) and the Department of Survey and Mapping Malaysia (JUPEM), National Solid Waste Management Department website (JPSPN) among others. The information collated included local sea-level rise projection, coastal inundation susceptibility map and areas prone to risk of flooding, land use and landfill locations. Satellite imageries and field investigation was conducted to evaluate exposure of coastal areas to sea-level rise as well as landfill to floods and landslide hazards.

The case study on on implications of sea-level rise to coastal groundwater was conducted in Kuala Selangor, which hosts extensive groundwater aquifers and serves as an important granary area for Malaysia. Part of the Northwest Selangor Integrated Agriculture Development Area (IADA) is situated in this area. It is about 40 km long and 50 km wide with some 19,000 hectares allocated for paddy cultivation. The area extends along the coast of the district of Kuala Selangor and Sabak Bernam in the northwest-southeast and represents one of the most significant national "rice bowls" due to the high productivity of paddy yield. Part of the district is classified as flood-prone as depicted in the environmentally-sensitive area map of the Town and Country Planning Department of Peninsular Malaysia (JPBD, 2005). The agricultural sector dominates land use in the area and plays a major role in economic development. The area comprises Quaternary alluvium overlying meta-sedimentary strata of Devonian-Silurian age (Hamzah et al., 2007). The aquifer is made up of layers of clay, sand, and gravels with meta-sedimentary strata as bedrock (JMG, 2000). Water tables of the exploration wells are recorded between 0.33 m to 4.02 m. In 2000, a hydrogeological investigation was carried out by JMG, covering an area of 400 km^2 that includes the vicinity of Kuala Selangor to Bestari Jaya and parts of Tanjung Karang (JMG, 2000).

The case study on exposure of municipal solid waste (MSW) disposal sites focused on the entire State of Selangor, which is the most developed area in Malaysia and produces the highest MSW per capita owing to the high standard of living (Leete, 2005; Agamuthu, 2001). With ever growing economic activities and increasing population, the challenge to manage solid wastes in the urban regions of Selangor becomes greater. In Malaysia, proper disposal of solid waste at sanitary landfills constitute only a small portion and were built recently compared to open dumps which constitute around 90% of all the waste disposal sites (Agamuthu & Fauziah, 2011; Sharifah & Latifah, 2013).

2.3 RESULTS

2.3.1 Implications of sea-level rise in Kuala Selangor

Stability of water resources is fundamental to cater for the needs of an increasing population, industry and agricultural activities. Surface water is the main supply of water resource in Malaysia despite its small amount relative to groundwater. Surface water is generally polluted due to improper urbanisation practices and this deteriorates the quality and quantity of usable surface water. Groundwater is a major freshwater resource and could serve as a cost effective alternative source of water. However, groundwater is facing several natural and anthropogenic threats. Particularly, coastal groundwater aquifers are threatened by the effects of rising sea levels and changes in the hydrologic regime associated with a changing climate.

Coastal groundwater aquifers, which form the most productive groundwater in the country are facing the threat of saltwater intrusion. Groundwater salinization occurs as seawater displaces or mixes with fresh groundwater. It often results from overexploitation of fresh water aquifers, which reduces or reverses groundwater flow towards the sea. Climate change is projected to exacerbate these impacts in terms of sea-level rise due to increase in temperature resulting from a warmer atmosphere. Higher sea levels pose negative impacts to coastal areas including coastal aquifers. Climate change will alter the hydrological cycle with associated influences on aquifer recharge. The implications of climate change, sea-level rise and alteration of the hydrologic cycle will have serious implications to various socio-economic sectors.

Saline intrusion occurs when saltwater replaces the freshwater in coastal aquifers (Ranjan et al., 2006). It can threaten aquifers especially when fresh groundwater is actively extracted. With the rise of sea level, the saltwater-freshwater interface moves landward and upward, accelerating saltwater intrusion into the freshwater aquifer and resulting in groundwater salinisation. Saltwater intrusion is controlled by a variety of factors which includes coastal topography, recharge, and groundwater extraction (Oude Essink et al., 2010; Ferguson & Gleeson, 2012). It has been observed that saltwater intrusion related to groundwater extraction of coastal aquifers was more significant than the impact of sea-level rise (Ferguson & Gleeson, 2012).

In 2009, approximately 0.2 million m^3/day of groundwater was acquired in Peninsular Malaysia (Yunus Abd. Razak & Mohammed Hatta, 2009). Groundwater distribution in Malaysia are allocated to three major sectors: (i) domestic (65%); (ii) industry (35%); and (iii) agriculture (5%). Groundwater usage in Malaysia has been rising since the last century due to several factors: (i) surface water is severely depleted during the dry season in some areas such as Kedah, Perlis, Melaka and within the Klang Valley; (ii) water demand has been increasing rapidly due to rapid growth of population, agriculture and industrialisation; and (iii) frequent lack of viable source of surface water from either reservoirs or lakes in newly developed areas (Chu, 2004; Suratman, 2004). This study evaluates the potential of saltwater intrusion into the coastal groundwater aquifer in Kuala Selangor, Malaysia. Adaptation measures in response to the rising sea level specifically in preserving groundwater resources in coastal zone is also discussed.

It is observed that the rate of sea-level rise in Peninsular Malaysia based on satellite altimetry data from 1993 to 2010 is 4.28 mm/year, which is higher than the global rate of 3.2 mm/year as reported by the IPCC (2013). NAHRIM has projected sea-level rise over 20 years in Malaysia from 2021 to 2100. The mean sea-level rise in Peninsular Malaysia is projected to be 2.19 mm/year from 2001 to 2020, 3.02 mm/year for 2021 to 2040, 4.06 mm/year from 2041 to 2060, 4.77 mm/year from 2061 to 2080, and 5.10 mm/year from 2081 to 2100. For the overall hundred years, the estimated sea-level rise is 3.87 mm/year. By 2100, sea level is expected to rise about 0.517 m (NAHRIM, 2010). On the other hand, global sea level is projected to increase around 0.52 m up to 0.98 m by the year 2100 (IPCC, 2013).

Based on the projection of sea-level rise, area susceptible to coastal inundation was mapped and were overlaid by geological map and distribution of boreholes in the study area. Based on boreholes data, the potential of saltwater intrusion into the groundwater aquifer is analysed for two scenarios: (i) saltwater intrusion from the surface (vertical) due to coastal inundation and (ii) saltwater intrusion due to landward movement of saltwater-freshwater interface (lateral).

2.3.1.1 Saltwater intrusion from the surface

Based on boreholes data, the groundwater in the area has been classified as fresh, brackish and saline, where the saline zone is located near and parallel to the coast and extends about 2 km to 4 km inland (Hamzah et al., 2007) (Figure 2.1). Three sets of cross-section of the aquifers that extend from the ocean to the land (southwest-northeast) indicate that the study area consists of confined and unconfined aquifers (Figure 2.2(a), 2.2(b) and 2.2(c)). The aquifer is made up of sand and gravels and is found to be thicker towards the coast with thickness ranging from 15-45 m. 13 out of 16 boreholes are located in the confined aquifer which were overlain by layers clay and peat with thickness varies between 7-29 m. Saltwater intrusion from the surface is least likely to happen due to the presence of the impermeable clay layer. Three boreholes (BH10, BH11 and BH12) in the unconfined aquifer are located in Bestari Jaya and Hulu Tinggi. The area is not expected to experience coastal inundation due to higher topography of the area.

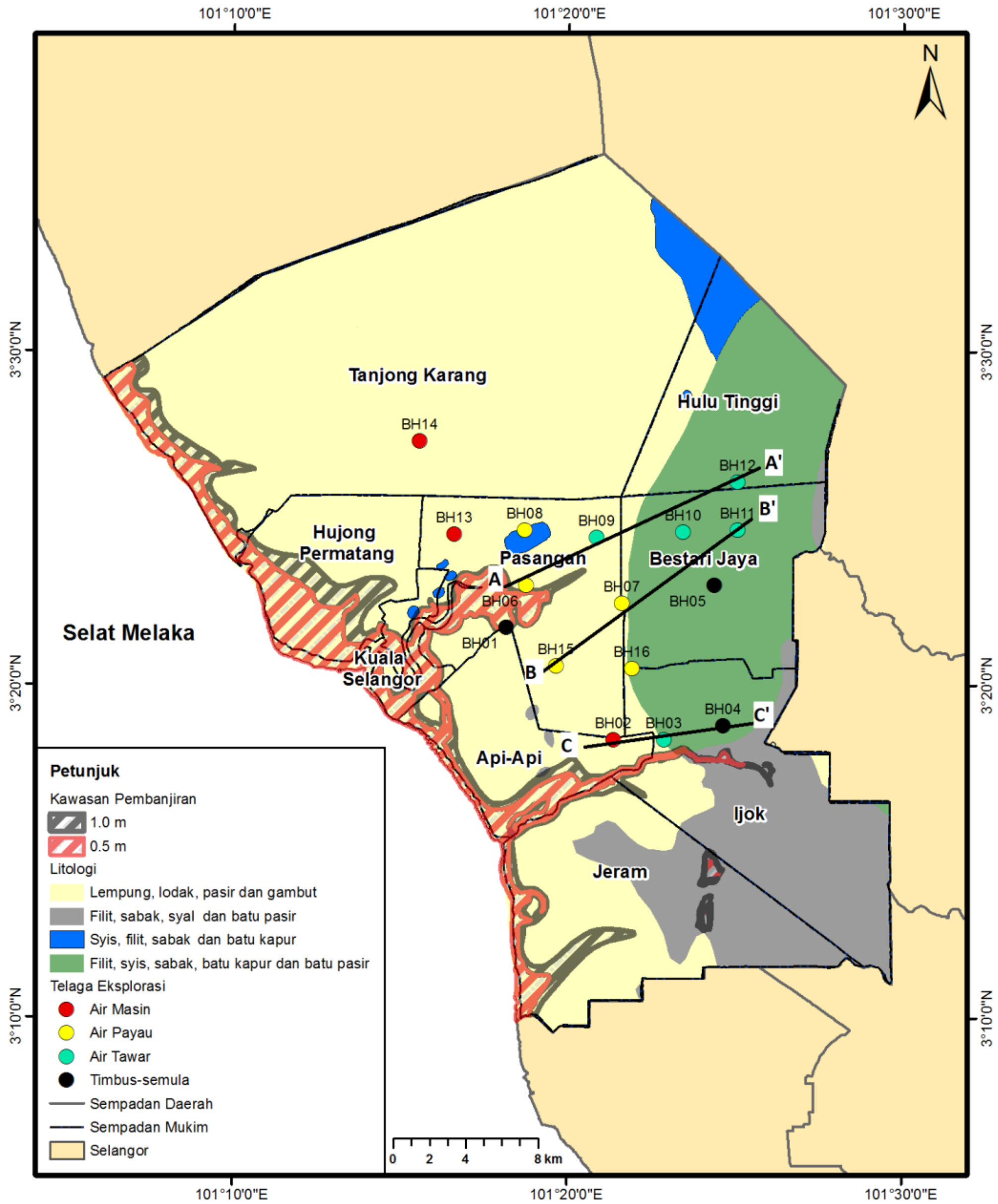


Figure 2.1: Distribution of boreholes and groundwater quality for each boreholes on inundation susceptibility map due to sea-level rise of 0.5 m and 1.0 m. Location of drilling holes and groundwater quality in map of flooding vulnerability due to sea-level rise of 0.5 m and 1.0 m.

Boreholes data source: JMG, 2000

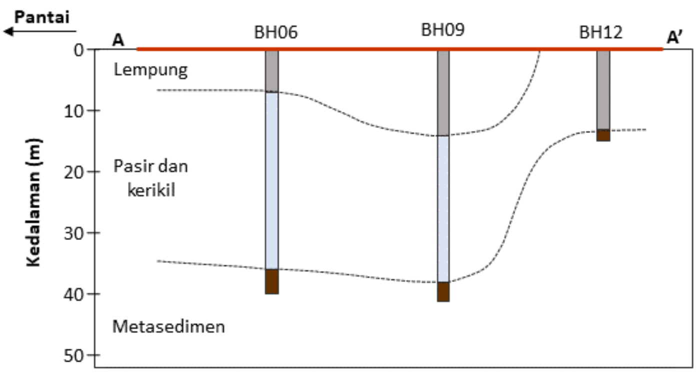


Figure 2.2 (a): Cross-section of aquifer (A-A ') based on information from BH06, BH09 and BH12

Data source: JMG 2000

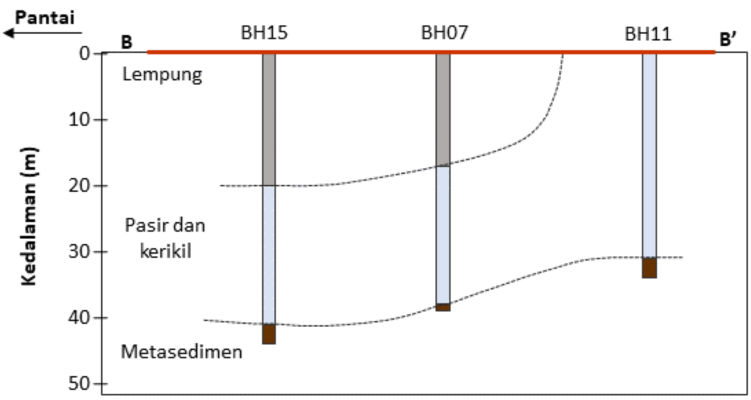


Figure 2.2 (b): Cross-section of aquifer (B-B') based on information from BH15, BH07 and BH11

Data source: JMG 2000

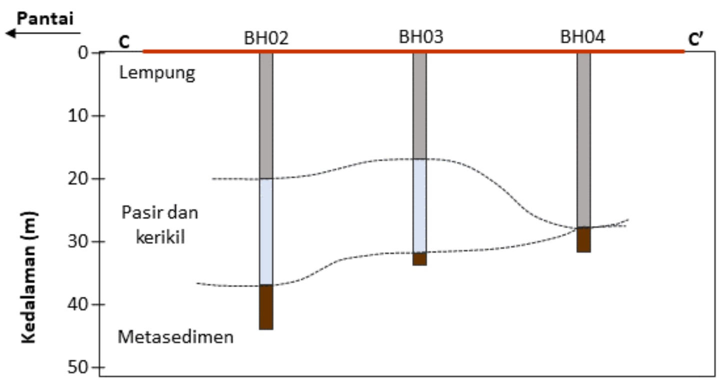


Figure 2.2 (c): Cross-section of aquifer (C-C') based on information from BH02, BH03 and BH04

Data source: JMG 2000

2.3.1.2 Saltwater intrusion from the subsurface

Based on boreholes data, the confined aquifer is overlain by clay layer with very low permeability value of about 15 m thick (Figure 2.3(a), 2.3(b), and 2.3(c)). Saltwater infiltration is assumed to take place very slowly and the amount is insignificant to pollute the groundwater. With the rise of sea level, the saltwater-freshwater interface moves landward and upward, accelerating saltwater intrusion into the freshwater aquifer and resulting in groundwater salinisation. In Kuala Selangor, saltwater intrusion has already occurred based on saline groundwater represented from the boreholes near the coast. The situation will be exacerbated during dry season with less amount of rain and surface water which will also impact the clean water supply.

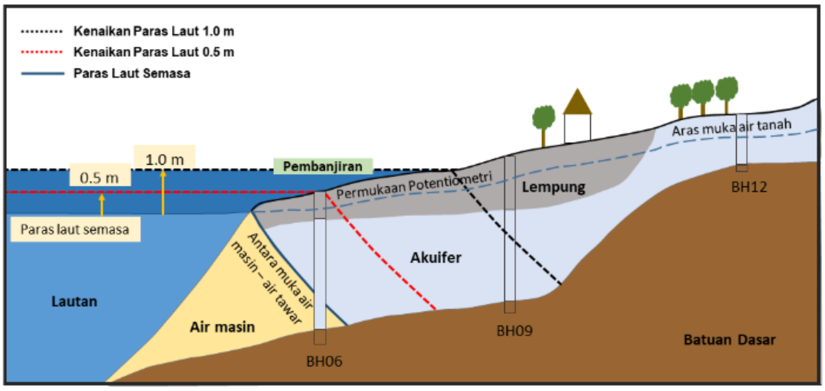


Figure 2.3 (a): Interpretation of the aquifer system based on information from BH06, BH09 and BH12
Data source: JMG 2000

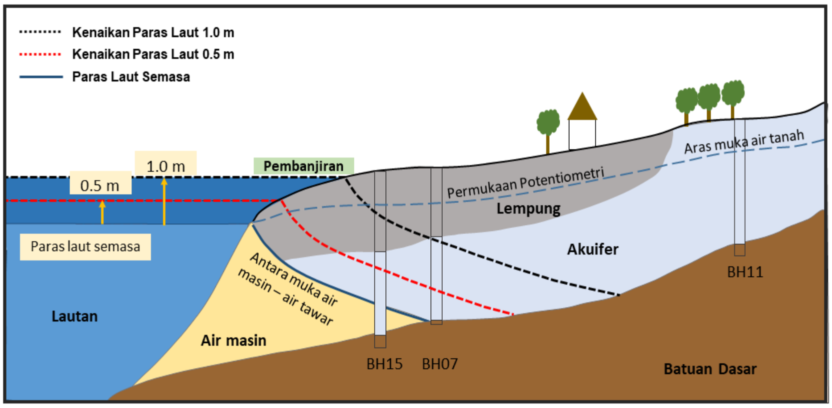


Figure 2.3 (b): Interpretation of the aquifer system based on information from BH15, BH07 and BH11
Data source: JMG 2000

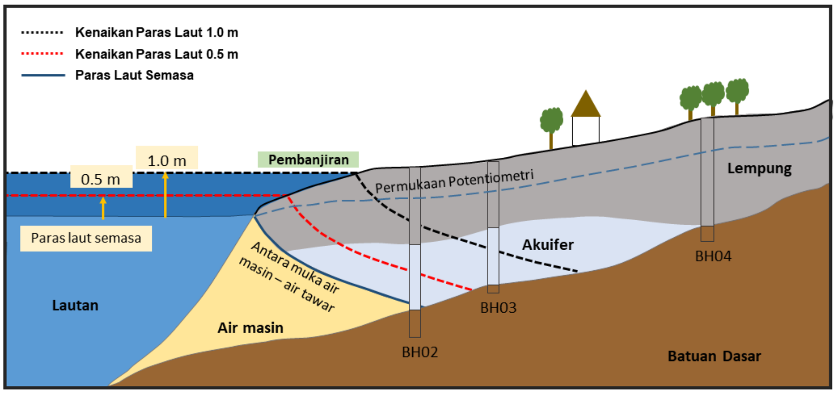


Figure 2.3 (c): Interpretation of the aquifer system based on information from BH02, BH03 and BH04.

Data source: JMG 2000

2.3.2 Exposure of municipal solid waste disposal sites to climate related hazards

Municipal solid waste disposal sites are a source of environmental hazard that could bring adverse effects on humans and surrounding ecosystems. Significant pollutants emission in the form of leachate and gases to air, water resources and soil can persevere for centuries after sites closure until they are compatible with the environment (Belevi & Baccini, 1989). Hazardous organic and inorganic substances and disease vectors from waste disposal sites endanger the health of people exposed by direct contact including through inhalation or ingestion (El-Fadel, 1997; Agamuthu, 2001; Yong et al., 2007; Giusti, 2009). Review of literatures on waste disposal facilities disrupted by geohazards has revealed pervasive cascading effects on physical environment, public health, waste management as well as the economy. The cascading effects include direct, indirect, and long term interconnected failures that propagate in a cascade of cause and effect chain sequence (May, 2007; Pescaroli & Alexander, 2014). Vulnerability of the exposed subjects is the main attribute of the propagation of the cascade as repeatedly observed in disaster events. Landfills endangered by climate-related hazards can have adverse effects on the public and on natural resources. Exposure of local landfills to such hazards is still not well studied in Malaysia. Selangor generates the largest amount of municipal solid waste per capita in the country, and has numerous landfills. Climate-related hazards at landfills often result in remobilization of wastes that lead to insidious impacts on communities and natural resources (Flynn et al., 1984; Hwang, 2001; Young et al., 2004; Blight, 2008). Early identification of possible implications of waste mobilization on exposed communities and natural resources is crucial to prioritize adaptation measures for affected areas.

In Malaysia, municipal solid waste is disposed in both the newer sanitary landfills and older open dumps. Generally, the older waste disposal sites are improperly sited and the status of their exposure to climate-related geohazards is unknown. This study evaluates the exposure and susceptibility of municipal solid waste disposal sites in Selangor to hazards such as slope failure and floods, which would occur slowly over time. Landfills of both sanitary and open dumps in Selangor are classified into several different levels as follows (Department of Local Government, 2006). These are Level 0: Open dumping; Level I: Controlled tipping; Level II: Sanitary landfill with a bund and daily soil cover; Level III: Sanitary landfill with leachate recirculation system; and Level IV: Sanitary landfill with leachate treatment facilities. Many of the landfills and open dumps in Selangor are located within and outside of flood prone areas (Figure 2.4), while some may be exposed to sea-level rise.

Currently, there are a total 20 landfill sites in Selangor, six of which are operating and the rest already closed. Only four sites are classified as sanitary landfills (three with Level IV and one Level II) and the rest are classified as dump sites (Level 0 and Level 1). In addition to the landfills, Selangor also has one Refuse Derived Fuel (RDF) plant located in Semenyih that is being used to dispose MSW from the Municipality of Kajang. Information on open dumpsites is scarce as these sites were built prior to the Environmental Impact Assessment (EIA) implementation in 1987. However various studies reveal very high contaminants levels in the groundwater underneath the non-engineered waste disposal sites in Selangor (Bahaa-eldin et al., 2010; Taha et al., 2011; Suratman & Sefie, 2010). The subsurface soils were considerably polluted by heavy metals where wastes were dumped directly on top of unlined natural formation (Mohd et al., 2013). These poorly equipped waste disposal sites are more susceptible when subjected to geohazards due to total absence or the lack of protection measures. Unengineered active sites are particularly most vulnerable.

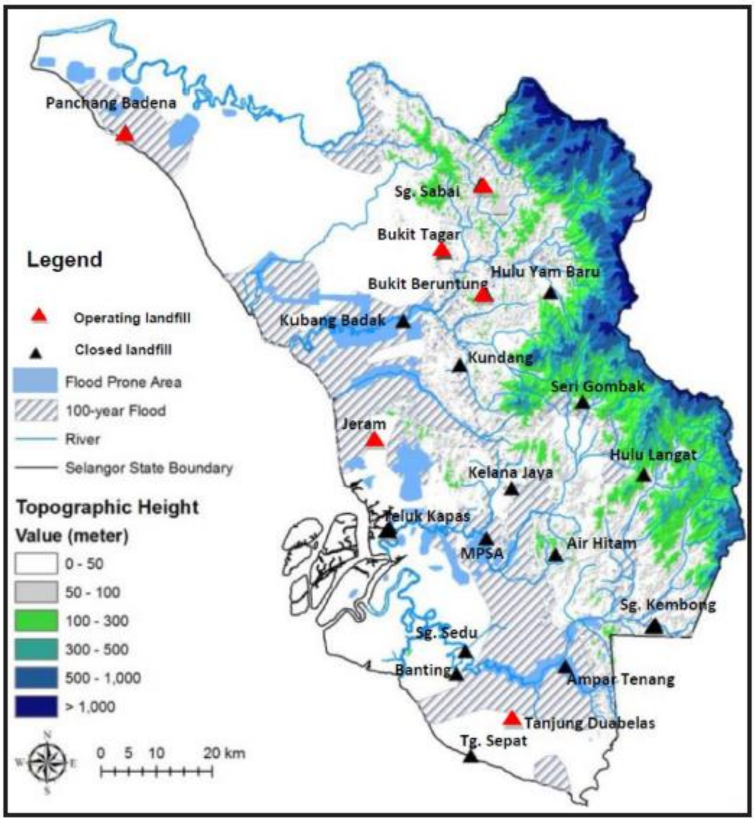


Figure 2.4: Distribution of selected landfills and open dumps on topographic, flood prone and 100-year flood zones in the state of Selangor, Malaysia.

Sources: Flood maps: JPBD, 2009; Landfill sites: JPSPN 2013; Suratman & Sefie, 2010; JPBD, 2012

Limited literature were found for cases involving geohazards at the landfills in Selangor. One of the cases includes a flooding event at Kundang landfill situated about 10 meters from Kundang River. The river overspill following a heavy rainfall had inundated the landfill area and disabled waste disposal activity. The waste dumping crisis had resulted in a dispute among the waste management parties (Suryani, 2001). Another case of flooding was revealed indirectly based on a groundwater quality study at Ampar Tenang landfill. Slow onset groundwater contamination had been observed upstream of the landfill, which can be reasonably explained by flooding events in the past that would be able to mobilize the contaminants from the landfill located downstream (Bahaa-eldin et al., 2010). A dump landslide located at 200 m topographical height had been reported at an illegal dumping site at Seri Gombak site close to a village on September 2013 after prolonged rainfall event. The slides from the top of a hill slope occurred in a very close proximity to the neighborhood area, endangering the lives of 300 villagers living near the hillslope. The wastes also flowed into a small river nearby the area and blocked the stream (Norafiza, 2013). These types of failure cases at landfill sites that are exposed to geohazards can have severe environmental pollution consequences if the sites remain unmitigated. Although only three cases were discovered from available literatures, there may be others that possibly went unreported especially when involving closed landfills and dumpsites in rural parts of Selangor. A systematic analysis was conducted to facilitate ranking of the level of exposure in order to take proper actions.

2.3.2.1 Exposure to 100-year Flood

The statistical recurrence interval of 100-year flood map represents a large flood event. Using GIS, the flood prone and 100-year flood maps are overlaid on the Digital Elevation Model of Selangor with superimposed landfills distribution. Flood risk exposures are assigned based on distance from flood prone areas. Land elevation difference of the landfills to flood boundary were measured to estimate the potential depth of 100-year flood relative to the landfills, assuming the floodwater is flat boundary to boundary. Observation for potential cascading hazards at the exposed sites was made based on the land-use surrounding the landfills during the field investigation using land-use maps and satellite imageries (Google Earth).

Landfill exposure to slope failure was screened based on terrain topography and natural slope relief. Identification of the potentially exposed landfills was made using topographic map to find sites that are located above or close to topographic elevation of 100 meter. This was then followed by field investigation of the potential sites. In Selangor, wastes deposited on the slopes are not compacted or covered and is expected to have low shear strength (leading to mass movement of wastes). Based on the assumption of low shear strength, sites located on natural slope with slope angle of more than 30^{o} are categorized as endangered to the risk of slope failure. Observation for potential cascading hazards at the exposed sites was made based on the land-use surrounding the landfills during field investigation using land-use maps as well as satellite imageries (Google Earth).

The spatial-proximity analysis enabled an assignment of flood risk exposures based on distance of the landfill from flood prone areas (Table 2.1). The findings reveal that six of the 20 landfill sites in Selangor are currently endangered to the risk of flooding (Table 2.2). The result for inundation analysis (Figure 2.5) shows that all the endangered sites are also sitting at low elevation hence will be inundated by the modeled flood. The Ampar Tenang landfill which had been closed since 2010 is expected to have the highest risk of damage from a 100-year flooding based on the estimated depth of inundation of 45 m. Ampar Tenang landfill is also exposed to regular floods as it is located inside flood prone area and the same goes to MPSA. Teluk Kapas and Kubang Badak landfills are located very close to the flood prone area and may also be exposed to the risks of regular floods. Many of the landfills in Selangor (both operating and closed) are located near stream and may be exposed to flood and erosion during high stream flow. Three sites are identified to be located in close proximity to the coastlines and may be endangered by risks from coastal impacts and sea-level rise, namely Teluk Kapas, Panchang Bedena and Tanjung Sepat.

The potential impacts and cascading hazards based upon the details of location found that all of the sites that are endangered by 100-year flood are also located in close proximity to either populated or cultivated areas. The populations living in the residential areas near the endangered landfills become vulnerable to the cascading hazards from landfill flooding. The cultivated or plantation areas that are located near the endangered landfills such as Panchang Bedena and Kundang will also be exposed to pollution hazards by these landfills by large flood events.

Exposure category	Criteria
Endangered	Landfill is situated inside the 100-year flood area OR flood prone area
Probably Endangered	Landfill is situated within 500m from 100-year flood area OR flood prone area
Probably Not Endangered	Landfill is located between 500 – 2000m parameter from the 100-year flood area
Not Endangered	Landfill is located more than 2000m from the 100-year flood area

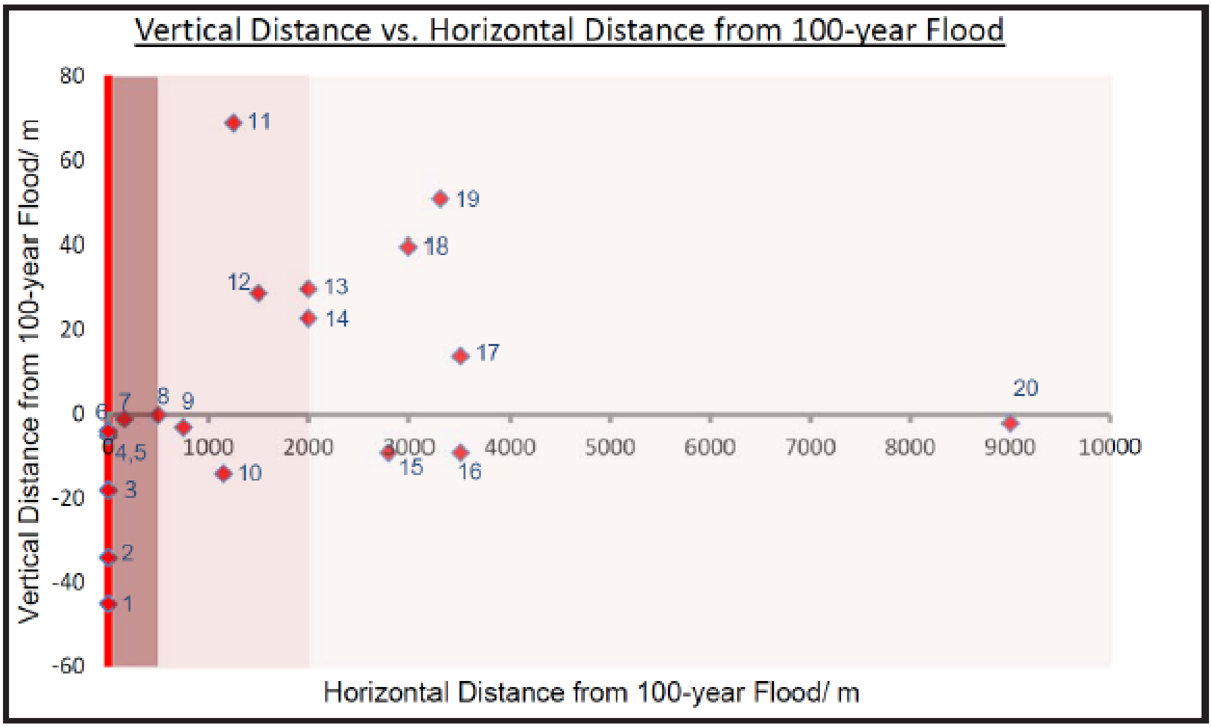
Table 2.1: Evaluation categories for exposure to flood of MSW landfills in Selangor.

2.3.2.2 Exposure to Slope Failure

From the findings of exposure to slope failure analysis, there are two sites that are endangered to the risk of slope, namely Seri Gombak and Hulu Langat. Both sites are located on hilly terrains with 83 m and 132 m topographic height respectively. Even though the height of the Seri Gombak illegal dump is less than 100 m, it is located on such a steep slope and a case of slope failure at the site had also been reported in recent years. The two sites are listed as closed sites by official records but are still actively receiving inert wastes during the time of visit to the sites. Both Hulu Langat and Seri Gombak landfill sites are located close to residential areas down from both sites, endangering the nearby communities. However, more detailed study is required in all waste disposal sites as landslides may even occur in low areas where the height and gradient of slopes make it susceptible to mass movements. Severe cascading hazards can especially be expected from non-engineered landfills with level 0 and I that are exposed to the risk of flooding and are located within close proximity to developed and populated areas.

Table 2.2. List of MSW landfill sites in Selangor with the category of exposure to 100-year flood and location details based on spatial analysis and evaluation.

Site Name (Local Authorities)	*Status	*Level	Location Details	Proximity to surface water
Endangered				
1 Ampar Tenang (MP Sepang)	Closed	I	Near residential areas	30 m to a river
2 Kubang Badak (MD Kuala Selangor)	Closed	II	Near residential areas,	20 m to a river
3 MPSA (MD Shah Alam)	Closed	0	Near industrial area	10 m to a river
4 Panchang Bedena (MD Sabak Bernam)	Operating	I	Near residential and cultivation areas, 2.5 km from coastline	10 m to a creek, 3 km to coastline
5 Kundang (MP Selayang)	Closed	0	Near a residential area	30 m to a river
6 Kelana Jaya (MB Petaling Jaya)	Closed	0	Near developed and populated area	20m to a river
Probably Endangered				
1 Jeram (MD Kuala Selangor)	Operating	IV	Within plantation area, no residential	No river nearby
2 Teluk Kapas (MP Klang)	Closed	I	300m to flood prone area Densely populated areas on downstream and upstream	100 m to a river 3.6 km to coast line
Probably Not Endangered				
1 Banting (MD Kuala Langat)	Closed	I	Near residential and developed areas with plantation	20 m to a river
2 Tanjung Dua Belas (MD Kuala Langat)	Operating	IV	Surrounded by plantation No residential area nearby	Drainage ditch No river nearby.
3 Seri Gombak	Closed	0	On hillslope, near residential areas	500 m to a river
4 Air Hitam Sanitary Landfill (MP Subang Jaya)	Closed	IV	Nearby residential areas and a creek	30 m to a river
5 Bukit Beruntung (MD Hulu Selangor)	Operating	0	Located right next to a freeway, near plantation area	5 m to a drainage, No river nearby
6 Sg. Sabai (MD Hulu Selangor)	Operating	0	Remote, cultivation area	300 m to an old mine pond, 2 km to a river
Not Endangered				
1 Sg. Sedu (MD Kuala Langat)	Closed	I	Near to plantation area	20 m to a river
2 Sg. Kembong (MP Kajang)	Closed	0	Residential area <300m from site	220 m to a river
3 Hulu Yam Bharu (MD Hulu Selangor)	Closed	0	Near cultivated and residential areas	No river nearby
4 Bukit Tagar (MD Hulu Selangor)	Operating	I	Remote area surrounded by plantation	100 m to drainage 3 km to a river
5 Hulu Langat (MP Ampang Jaya)	Closed	0	On a steep slope and adjacent to main road, a small resort down the slope	No river nearby
6 Tanjung Sepat (MD Kuala Langat)	Closed	0	Near residential area	No river nearby 200 m from coastline



Landfill Site:

1. Ampar Tenang
2. Kubang Badak
3. MPSA
4. Panchang Bedena
5. Kundang
6. Kelana Jaya
7. Jeram
8. Teluk Kapas
9. Banting
10. Tanjung Duabelas
11. Seri Gombak
12. Air Hitam
13. Bukit Beruntung
14. Sg. Sabai
15. Sg. Sedu
16. Sg. Kembong
17. Hulu Yam Baharu
18. Bukit Tagar
19. Hulu Langat
20. Tanjung Sepat

Figure 2.5. Potential depth of inundation at landfills with the distance from 100-year flood area.

2.4 DISCUSSION

Groundwater as a valuable and renewable fresh water resource should be managed properly and sustainably to ensure a long-term supply of fresh water to meet the needs of the growing population. Adaptation measures proposed cover groundwater governance, capacity building and groundwater zone mapping. The most prominent step in ensuring sustainable groundwater development is by integrating and mainstreaming adaptation strategies into coastal management plans while coordinating institutional arrangements in adaptation implementation. The implications of climate change in Kuala Selangor can be addressed by undertaking adaptive measures that take into account both surface and sub-surface aspects, which are then integrated into the coastal zone planning policy. Effective adaptation involves the collection of scientific information, risk assessment, determination of adaptation objectives, assessment of adaptation options, selection of appropriate adaptation measures, planning, implementation and monitoring.

Detailed study on potential impacts and cascading hazards at each of the endangered sites can be made by considering details of the landfill settings such as volume and age, geomorphology and subsurface geology profile, flow capacity of nearby river and its erosion potentials. For coastal landfills, a detailed future study on the potential coastal hazards to these landfills can be made by including factors such as local sea level profile and field data of the coastal erosion. Meaningful information in looking into the cascading effects includes potential landfill emissions and the extent of waste pollutants migration on the surface and in the subsurface during floods. A list with the degree of vulnerability of municipal solid waste disposal sites to climate hazards which include flood hazards, slope failure and coastal hazards should be produced for the Selangor state area.

The implications of climate change can be minimized through a comprehensive coastal zone planning policy that involves continuous adaptation management. Adaptive capacity for coastal zones can be enhanced by adaptation measures during the development process and land use planning such as infrastructure design that can mitigate the risk of climate change impacts. Adaptation to climate change impacts should be aligned with the coastal zone planning policy and should take into account the natural state of the coastal zone as well as potential impacts on natural resources and human resources (Boateng, 2008). The integrated approach should be developed using existing coastal zone planning policies such as Integrated Coastal Zone Management (ICZM) and Environmental Impact Assessment (EIA) combined with several adaptation measures to ensure the adaptation process is carried out holistically and continuously.

An adaptation framework to the implications of climate change taking into account both surface and sub surface surfaces and integrated into the coastal zone planning policy is recommended for Kuala Selangor (Umi et al. 2018). The integrated framework consists of six main steps. The first step involves the collection of information, especially scientific information that can raise awareness about the impact of climate change in the coastal zone of Kuala Selangor. The basic information about a coastal zone involving physical characteristics, human activities and the natural processes involved is important in formulating data repositories while providing understanding and awareness to all stakeholders (Klein et al., 2001). The second step involves assessing the risk of climate change impacts on the coastal zone based on the information collected. The risk assessment should take into account three major components, namely (i) hazards that have a negative impact on the coastal zone and contribute to susceptibility of an area; (ii) exposure to coastal zone components to the impacts of current and future climate change; and (iii) vulnerability of the components of the coastal zone to the impacts of current and future climate change. After identifying the risks of climate change in coastal zone, cost-benefit analysis can help in the decision-making process with a comparison of the situation that takes steps to adapt to situations without step adaptation.

The third step is the determination of the objectives of the adaptation step to be achieved based on the analysis results obtained from the previous step. The purpose of the adaptation could encompass either (i) avoiding losses; (ii) accepting losses; (iii) sharing loss; (iv) changing of affected activities; or (v) changing location of an activity. The fourth step involves an assessment of the adaptation options, which essentially involves the deployment of science, technology and innovation. For example, adaptation to address coastal flooding in Kuala Selangor includes construction of structures, ecosystem approaches, use of land use planning systems, among others. The main factor to be taken into account in assessing the suitability of adaptation options is its natural state, current development, temperature projection, rainfall and rising sea levels and the involvement of stakeholders and locals.

The fifth step deals with selection of appropriate adaptation measures. The characteristics of the identified coastal zones will influence the type of action taken i.e. whether it is for protection, adaptation or abandonment (let go). In general, protection is the most suitable adaptation option for a well-developed coastal zone. However, if the cost of protection structure is above the value of economic activity in the coastal zone, other options should be considered. Abandonment is an option for non-developed coastal zones or areas where adaptation measures require higher costs than development value and economic activity.

The next step involves planning, implementation and monitoring. Depending on the impacts of climate change to be addressed in the coastal zone, adaptation measures for surface and subsurface areas typically require different planning and design processes. After identifying and implementing adaptive measures that are capable of addressing the impacts of climate change in coastal zones, the results monitoring and evaluation process will be undertaken to determine if the adaptation step has achieved its stated objectives. If adaptation objectives are not achieved, the selected adaptation steps may not be appropriate and this adaptation process should be repeated starting with the new identification and selection process of adaptation. However, adaptation selection is not appropriate (maladaptation) can also be due to incomplete information. If this is the case, the adaptation process needs to be modified.

2.5 CONCLUSIONS

Climate change and sea-level rise pose several negative consequences to coastal environments and aquifers. Groundwater is affected in terms of both quality and quantity of reducing reserves for industrial, agricultural and domestic use. To fulfil the needs of development and urbanisation, groundwater as an alternative freshwater resource should be protected so that the high reliance on surface water that is facing deterioration in quality and quantity due to improper practices of development and natural stresses such as climate change can be augmented. Coastal areas, such as the agriculturally-active Kuala Selangor, are susceptible to impacts from sea-level rise. This has future implications on the demand for irrigation water and food productivity. Detailed comprehensive research is required to assess the impacts of climate change to groundwater resources and coastal ecosystems so that appropriate adaptation measures can be identified as early as possible.

Malaysia and other developing nations in general are still struggling towards achieving a sustainable waste management due to increasing waste generation and land scarcity. Along with the rapid development in urbanizing areas, the expansion of settlements closer to landfills will further increase the exposure of the population to the hazards during disaster events, making them vulnerable. Preliminary assessment conducted on landfills and open dumps in Selangor reveals that six out of 20 landfill sites in the state are highly exposed to the100-year flood while two sites are exposed to slope failure (including mass waste movement). The exposed sites are currently without any protection measures making populated areas in the vicinity vulnerable to hazards and their cascading impacts. More detailed investigation is required at the exposed sites to plan appropriate mitigation measures. This is crucial to reduce the risk of disasters and ensure the sustainability of the surrounding population and environment in a changing climate.

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CHAPTER 3

CASE STUDY OF THATDAMA KYUN VILLAGE, MYANMAR

SEEDS Asia

3.1 INTRODUCTION

Myanmar is predicted to experience more intensified and frequent hydro-metrological hazards. People in Ayeyarwady delta region in Myanmar are facing flood induced erosions in the past few years. Average annual rainfall in Hinthada District was 77.18 inches in 107 rainy days from 1972 to 1981; however it intensified to 80.92 inches in 100.71 days from 2011 to 2017. In the target village, 90 percent of households are affected by extreme and irregular weather patterns. Income decreased in 80 percent of households due to loss of land/livestock or degradation of farmland. Seven out of the twelve communities eventually vanished by the floods and erosions in the target village. In 2017, 58 percent of households in the village have relocated three times due to the erosion in 2017. Due to population decrease, interception of local knowledge and traditions are being concerned

While understanding the impact of climate change through experiences and possessing a strong will to confront the phenomenon, village members lacked knowledge on the mechanism and technical resources on what/how to do for adaptive/mitigation measures. To cope with the emerging risk, 1) Developing village disaster management plan and development plan at village level, 2) Data sharing inter-departments/township to village for planning for taking actions, 3) Establishment of Ayeyarwady River CCA-DRR integration platform to share the good practices and lessons leant, are recommended.

The research was conducted under the aegis of Mr. Aung Zeyar Soe, Joint Secretary of Young Engineer Committee of Myanmar Engineering Society, and U Than Soe, Hinthada District Office, Department of Disaster Management, Ministry of Social Welfare Relief and Resettlement. They gave invaluable guidance to reach and conduct the joint survey in the target village. The community members and children from *Thatdama Kyun* Village provided background information and shared their experiences. The support of Myanmar Climate Change Watch (Tun Lwin) is also acknowledged.

3.1.1 Background

Individuals and communities around the world today confront the need for climate change adaptation and disaster risk reduction, with varying levels of severity and urgency. Myanmar is one of the most disaster-prone nations in the globe and ranks 2nd out of 180 countries, which assessed the extent of impact of weather-related events in the period from 1996 to 2015 (Kreft et al., 2017). The research indicates that the country has been affected by climate change, as average temperatures increased by 0.25°C (Horton et al., 2017). The Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016–2030 (Government of Myanmar, 2017) points out that the country's geographical characteristics, such as large river systems ending in the vast Ayeyarwady delta, and coastline exposure to the Bay of Bengal and the Andaman Sea, make it vulnerable to severe and frequent natural weather events. Additionally, Myanmar's socioeconomic development has dependended on primary industries, particularly agriculture, which contributes to 30 percent of the GDP and occupies 61 percent of the labour force in the country (Government of Myanmar, 2017). Ayeyarwady Region holds high-risk of extreme weather events due to its topographical condition, which was revealed out by Cyclone Nargis in 2008 and massive flood in 2015. Rising sea levels, unstable weather, and increased coastal flooding due to climate change further exacerbate the socio-economic conditions of such areas (Zöckler, et al., 2013). Furthermore, McNeil & Engelke (2014, p.70) assert that glacial melt of the Himalaya Mountains have increased due to higher temperatures; this changes the amount and timing of the river flow, which affects the ecosystem and livelihoods for communities along the river. The Ayeyarwady River is also one of the rivers which originates from the Himalayan ranges, and the effect of glacial melt is unavoidable. The slow onset of such phenomenon has trickled down to visible impact in the form of frequent floods and erosions in the area already. A technical report on slow onset by UNFCCC (2012) also alerts that "initially, melting produces erosion, mudslides and flooding, including very dangerous glacial lake outburst floods (GLOFs), but, as glaciers recede, water shortages will become a long-term problem for hundreds of millions of people, reducing runoff and river flows that support ecosystems and human livelihoods, and water availability for irrigation, hydropower and drinking water".

SEEDS Asia, in partnership with Myanmar Engineering Society, Yangon Technological University and Department of Relief and Resettlement[6] conducted Coastal Community Resilience Index[7] (CCRI) surveys in all 26 townships of Ayeyarwady Region in 2015-2017. CCRI index is a tool to measure the complexity of resilience with 125 variables in five dimensions that are environment & natural, socio-economic, physical, coastal zone management and institutional. The CCRI applied study (SEEDS Asia, et al. 2017) in the Region shows that *Ingapu* Township in Hinthada District with population of 214,384, is categorised as one of the " low" groups in the overall resilience as Figure 3.1. Moreover, the township is categorised as "very low" for physical and social economic dimensions in the index. CCRI evaluated and mainly attributed their vulnerabilities to geographical conditions of the population, namely the back marshland along the Ayeyarwady River. Therefore, houses are built on natural levees at risk of being wiped away in the event of a large flood. 11- 20 percent of the riverbank streamlines in the township are damaged, which disturbs social and economic activities of the people. These geographical conditions have led to lower income and fewer job opportunities for the residents, compared to other townships in the region.

The extensive surveys in the all townships in the Region captured the overview and general condition of each Township as shown in Figure 3.1. However, the loss and damage, as well as survival strategies of individuals at the community level, was not researched or highlighted. Moreover, academic papers and reports based on field research on disaster management or climate change in *Ingapu* Township do not exist in English, possibly due to difficulties in wetland access and administrative processes. Therefore, this report takes a case study approach to identify socio-economic and environmental impacts, as well as illuminate adaptive strategies to climate change at the community level in a village.

3.1.2 Site Selection

The research aimed to highlight three main aspects: Identify climate related risk concerning sudden or slow onset disaster events; understand socio-economic and environmental impacts on communities due to climate change; and delineate adaptive/mitigation measures by communities for climate change end actions to integrate climate change adaptation and disaster risk reduction for a community.

As a protocol in the country, foreign agencies cannot independently conduct field research in the country. Thus, consultations were taken with a local counterparts, Myanmar Engineering Society and its sub-committee, Young Engineering (YE) Committee, to seek assistance to conduct research. SEEDS Asia and YE have a working relationship from previous joint relief item distribution operations for the flood affected village in 2015 in Hinthada District. Secondly, another consultation was held with the

[6] The department has renamed as Department of Disaster Management after 2018 January

[7] The survey was conducted under the Myanmar Consortium for Capacity Development on Disaster Management (MCCDDM), with the financial support from USAID. The surveys consists of socioeconomic, physical, /infrastructural, institutional, coastal management, environmental dimensions.

Department of Disaster Management, which is the national focal agency to handle disaster management. Recognizing the high vulnerability to climate change by reviewing flood reports in 2015 by government bodies, *Thatdama Kyun* Village, *Ingapu* Township, Ayeyarwady Region (location: 17°51'12.2"N 95°26'46.1"E)) was selected as target area of the study in consideration of the objectives. The village is one of five villages in the *Sit Kone* Village Tract, *Ingapu* Township with 1,025 population in 335 households (Table 3.1). The village is an island in the braided river area of Ayeyarwady, located at the junction where the Pathein River (also known as the Nga Wun River) branches out (Figure 3.2, 3.3, 3.4). Due to this topographical situation, *Thatdama Kyun* village kept changing its land shape as historical satellite maps shows since 1984 (Figure 3.5). The defenceless environment to flooding causes erosions and the village is also easily affected by the other water related weather events such as torrential downpour.

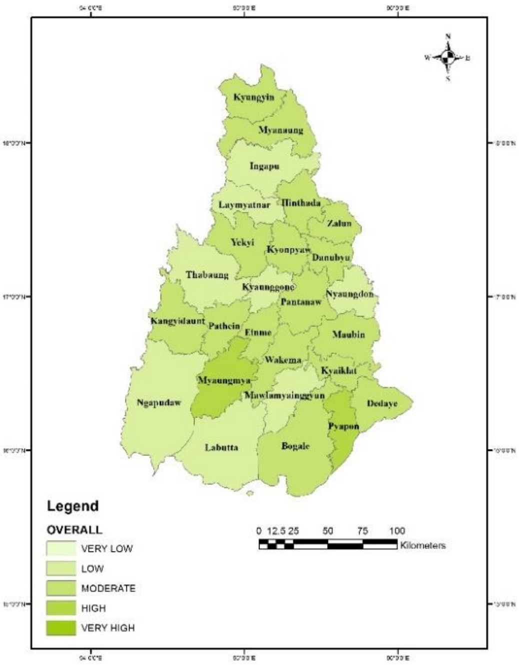

Figure 3.1. Overall Resilience of 26 Townships

Source: SEEDS Asia et al., 2017

Table 3.1. Basic profiles of the Region, District, Village Tract and Thatdama Kyun Village

	Population	Number of Households
Ayeyarwady	6,184,829	1,488,983
Hinthada District	1,138,710	298,452
Ingapu Township	214,384	57,229
Sit Kone Village Tract	2,884	759
Thatdama Kyun Village	1,055	335

Source: Government of Myanmar Census, 2014

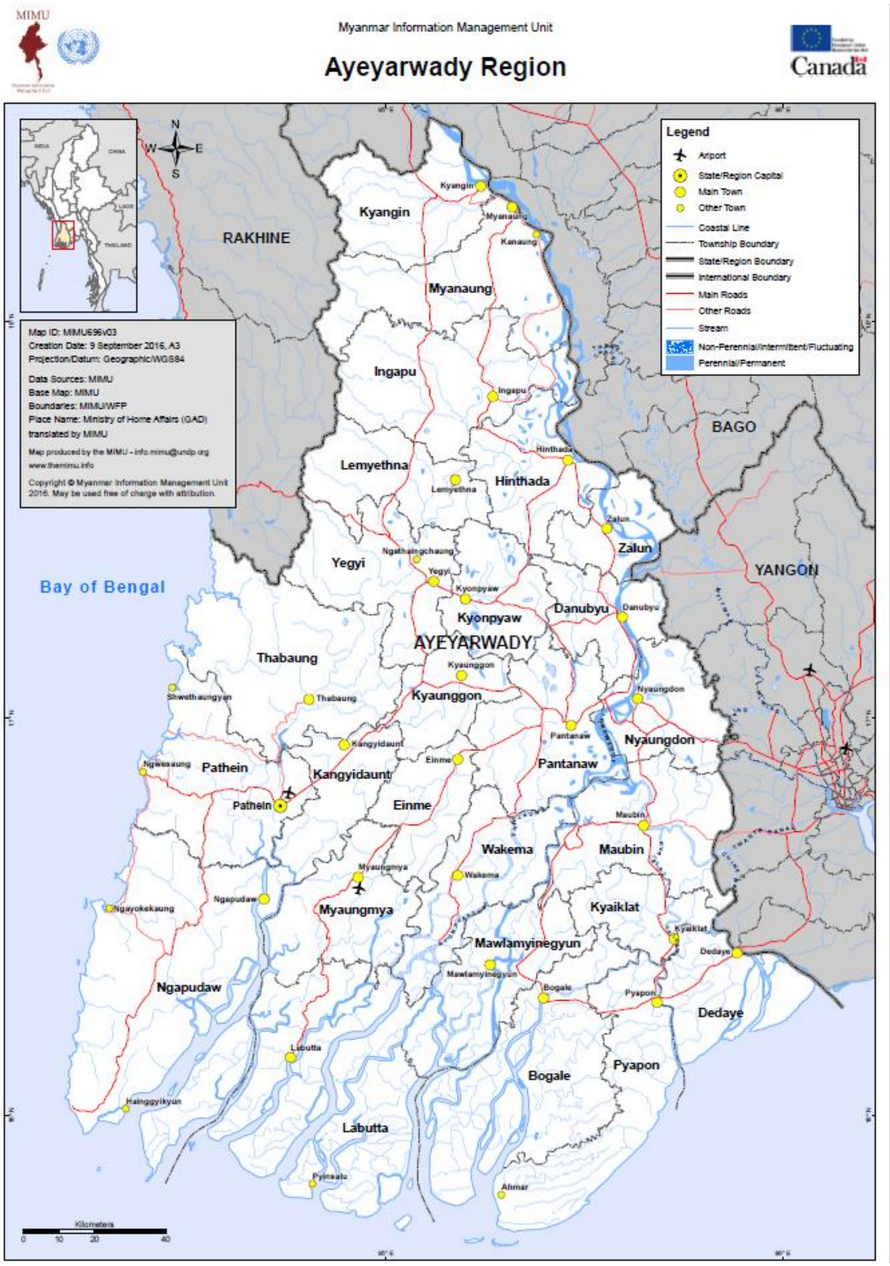

Figure 3.2. Ayeyarwady Region Map and Location of the Study Site

Source: Myanmar Information Management Unit

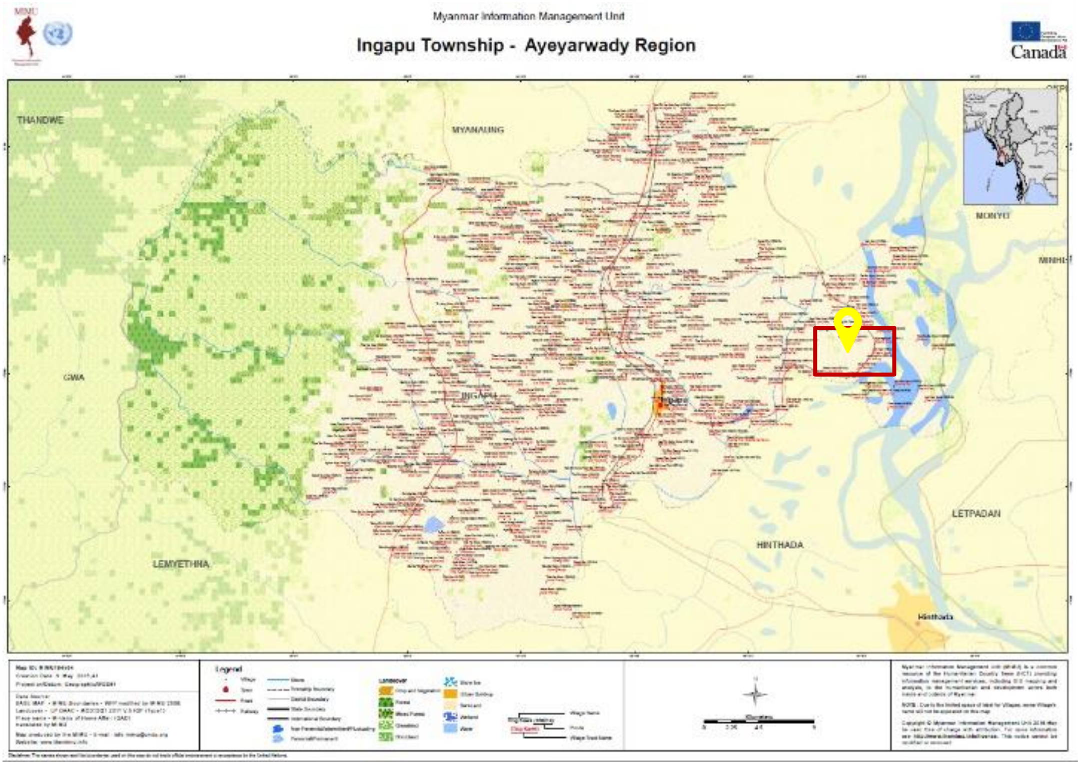

Figure 3.3. Ingapu Township Map and Study Site
Source: Myanmar Information Management Unit

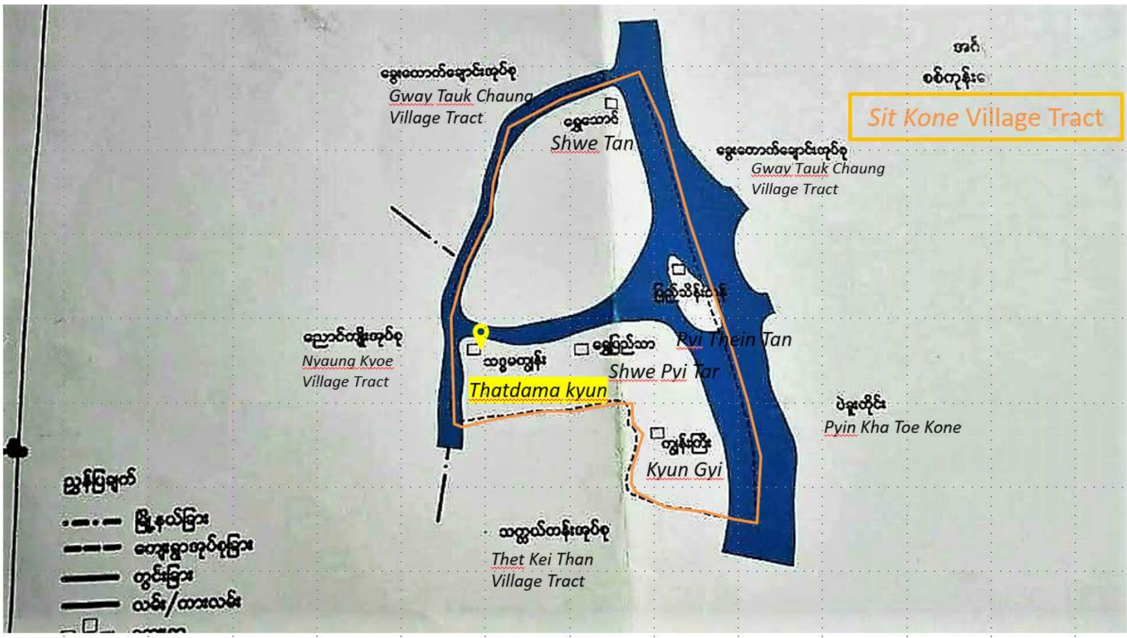

Figure 3.4. Sit Kone Village Tract Map and Study Site
Source: General Administrative Department

31/12/1984 15/1/2017

Figure 3.5. Comparison of land shape at the same coordinates between 1984 and 2017

Source: Google Earth, 17°51'12.2"N 95°26'46.1"E

3.2 APPROACH

Table 3.2 shows the schedule of the research, methodology, and target. The research methodology for the case analysis of *Thatdama Kyun* Village consisted of five main components, which together, depicts a comprehensive picture of the current situation of climate change and disasters in Myanmar.

Literature review and data collection from the District Department of Disaster Management, District Department of Agriculture and Irrigation, and *Ingapu* Township General Administrative Department, Department of Disaster Management

Structured interview:

Village authority questionnaire survey (Annex 1) on the status quo and effects of climate change and disasters (n=10, members of the Village Development Committee).

Structured interview:
Household questionnaire survey (Annex 2) on the status quo and effects of climate change and disasters (n=20, randomly selected households).

Focus group discussion (FGD):
Group discussion on status quo and effects of climate change and disasters (n=20, randomly selected village residents).

Assessment to school children:
Development of IEC materials on climate change and coastal resilience; presentation and assessment to school children
(n=18, Grade-8 students from Basic Education Middle School *Thatdama Kyun*).

Table 3.2. Research Schedule

Schedule in 2018	Methodology	Target
Jan-April	Literature review and data collection	-Literature review on Climate change and erosion -Demographic data of the target area -Flood records, rainfall/days data -Agricultural product data
Feb-April	Development of structure of the questionnaire	Identification of target group of interviews
March-May	Development of Information, Education and Communication (IEC) materials on climate change	Completion of Paper slide show "*Phu Phu* and Mangroves" on Climate Change
2nd May	Presentation/workshop of and IEC materials at Nargis Memorial Day at national event	Government authorities, students and teachers, communities (Annex 10)
20th June	Questionnaire survey	20 affected households (Annex 2)
20th June	Questionnaire survey	10 village authority members village's development (Annex 1)
21st June	Focus group discussion	20 residents (different sectors) (Annex 8)
21st June	Presentation/workshop of IEC materials and knowledge assessment on Climate Change	Students of Basic Education Middle School Thatdama Kyun (Annex 9)
21st June	Data collection and interviews	Government authorities
21st June	Data collecting and interviews	Department of Disaster Management Ministry of Social Welfare Relief and Resettlement, Hinthada District
21st- 30th June	Data collections and analysis	Completion of the report

3.3 RESULTS

The results highlighted below are a synthesis of the surveys, data collection, and the focus group described above (Annex 1-10).

3.3.1 Awareness and knowledge level

The questionnaires revealed that most of the surveyed residents of *Thatdama Kyun* Village identified they knew and understood climate change. About 90 percent of village authority members and 100 percent of households answered they knew of the phenomenon, although most were not familiar with the exact terminology, "climate change." The methods of learning about climate change was through television, radio, government departments, village authority, civil society organizations, social media, and neighbours and friends. Moreover, 100 percent of households receive weather related information such as river level, wind speed, and flood warnings from television and radio. However, lack of electricity is a barrier to receive timely information for disasters from such media outlets, and 76 % of households responded that they receive early warnings from the village authority department, disseminated by loud speakers. The village authority members closely monitor the changes in water level and speed of the river, as well as the habitation of plants and animals to check for irregularities.

3.3.2 Identification of climate related risk and impact

The most frequent and damaging climate related risk for the village were identified as flooding and river erosion (Table 3.3). *Thatdama Kyun* village experienced catastrophic flooding in 2015 and 2016, as well as large river erosion in 2016 and 2017. 90 percent of village authority members and 100 percent of households claimed the two disasters as significant climate related risks in their community. Assessments of Grade 8 middle school students also highlighted the frequency and wide-spread phenomenon of flooding and river erosion, as all students responded they had experienced or seen both events. Moreover, 100 percent and 27 percent of students identified that their school had been affected by flooding and river erosion respectively. According to the Hinthada District Office, Department of Disaster Management, Ministry of Social Welfare Relief and Resettlement, 193 households (58 percent of total) were relocated a total of three times from the banks of the Ayeyarwady River due to risk of flooding and flooding induced erosion in 2017 (Hinthada District Disaster Management, 2017).

Table 3.3. Disaster and Operation Records of relief support[8]

Year	Flood	Wind	Erosion	Affected Household	Affected Population
1963*			1	420	1,400
1974*	1				
1975*		1			
1976*	1				
1978*		1			
1982*		1			
1988*			1	420	1,500
Data not available in this period (1989-2014).					
2015	1			335	1,055
2016	1		1	39	142
2017	1		16	193	639
2018 up to May			26		Not yet finalised

Source: Hinthada District Department of Disaster Management for 2015-2017 and extracted data for 1963-1988 from interview records in FGD

Extreme temperature and irregular rainfall were also mentioned as climate related risks, especially in the years of 2016 and 2017 (Table 3.4). Heatwaves[9] and an increasing number of hot, humid summer days in March and April have caused health problems for members in the village who mostly work outside. According to the Village General Administrative Officer Mr. Than Oo, 85 percent of the population are suffering from extreme temperatures since 2011, and 90 percent have been impacted from irregular rainfall patterns. Indirectly, vector/water borne diseases and scarcity of drinking water are also the concern in the village in the link of extreme weather and health.

[8] The Relief supported by Disaster Management Office in *Thatdama Kyun* Village 2015-2017, and list of village disaster records through FGD

[9] Department of Meteorology and Hydrology(DMH) defines heatwave as the temperature exceed more than 7 ℃ than normal temperature

Table 3.4. Average temperature in Ingapu Township (March-May) from 2011-2018

Year	March (Average Temperature ·°C)		April (Average Temperature °C)		May (Average Temperature °C)	
	Min	Max	Min	Max	Min	Max
2011	23.74	32.40	26.16	37.06	27.64	33.93
2012	24.87	36.03	28.16	37.60	28.19	35.72
2013	24.58	35.94	26.07	38.13	29.94	34.65
2014	23.38	34.06	27.66	37.80	28.51	35.06
2015	22.56	33.46	23.90	36.86	23.77	32.41
2016	21.51	31.29	24.43	36.00	26.42	35.29
2017	20.22	37.13	23.70	35.33	26.00	36.10
2018	21.35	36.74	22.76	38.56	24.06	35.87

Source: Department of Agriculture, Hinthada District

The significant impact of climate change on the agriculture sector of *Thatdama Kyun* was reiterated by all village members who responded to questionnaire and participated to FGD. The majority of the population on the village are farmers, and 87 percent (700 out of 800 acres) of the land is used for agriculture purposes according to the Village Administrative Officer, Mr. Than Oo. The main agriculture crops are rice, peas, grains, chili, betel, and vegetables in the village. According to the village authority, 30-40 percent of *Thatdama Kyun* has been highly affected due to loss of agriculture production and decline in crop quality. The impact of climate change on agriculture has spiralled into livelihood transformation of the village.

3.3.3 Socio-economic impact of climate change

Climate change has acutely affected the economic levels and capacities of the residents of *Thatdama Kyun* Village. Intensified rain, increased flooding and erosion, especially after 2015, has damaged agricultural lands leading to production loss and quality degradation of crops. Loss of livestock during evacuation for extreme weather is another impact to their livelihood. Such devastation has resulted in a decline of both household income and food security. 80 percent of village authority members claimed that 50-79 percent of the community income decreased due to changes in climate. This was reinforced by the household surveys in which 60 percent of respondents also identified that 50-79 percent of their household income decreased due to climate change. Additionally, a notable 20 percent of households answered that 80-100 percent of their income decreased as well.

Moreover, 97 percent of survey respondents reported that their properties had either been lost or damaged. In such cases, most residents could not rebuild or rehabilitate in their damaged land, due to the severe devastation. Therefore, they utilized government subsidies of 100,000 kyat, provided by the Department of Disaster Management, to purchase new land.

Surveys and FGD illuminated multiple social consequences correlated to economic impact, including disturbances to children's education and social cohesion. For example, the decrease in income due to agricultural land loss or crop reduction, has led families to pull children out of school to contribute to household finances or help in recovery and rehabilitation post-disasters. Residents also explained how numerous children have had to give up pursuing higher education such as university or vocational training schools to support household income.

Furthermore, 96 percent of all surveyed respondents identified a change in population density due to climate change. As safe and secure land decreases due to erosion, households are forced to gather in the limited space available. Additionally, migration and resettlement due to the reduction of habitable and agricultural land, and consequently income, is a critical problem for the village. For example, the number of households in the past twenty years decreased from around 420 to 335 because of the climate change as per the interview record with Village Administrative Officer. Residents emphasized the spiralling consequences of increased flooding and erosion, as the younger generation often leave the village for job opportunities in urban areas. This not only affects the sustainability of agriculture-based economy, but the capacity of *Thatdama Kyun* to prepare and respond to disasters. Finally, the time and resources to recover from frequent disasters prevents village residents from planning and participating in traditional religious events, which are an important part of their livelihood. Respondents mentioned feelings of depression and unhappiness of not being able to take part or conduct such traditional ceremonies, which have played a critical role in enhancing social cohesion in the village for centuries.

3.3.4 Environmental impact of climate change

The environmental impact of climate change in *Thatdama Kyun* has especially been severe in the past few years. According to the record from Township Irrigation Department (1982), the average number of days of rainfall was 107 days between 1972 and 1981, and 100.71 days between 2011 and 2017. Average annual rainfall was 77.18 inches between 1972 and 1981, and 80.92 inches between 2011 and 2017. The increase in average rainfall despite the decrease in average number of days of rainfall may be explained by an increased prevalence of severe rain. Moreover, all respondents of the questionnaire reported they experienced global warming with extreme temperatures. The temperatures have especially risen in the past ten years, affecting agriculture and fishery with 97 percent reporting degradation in land and soil.

Furthermore, deforestation is a significant problem which has exacerbated the livelihood of the village. Excessive logging for firewood and housing reconstruction has led to a decrease in trees and forests. Village members seemed not to be familiar with the effect of deforestation on soil and river erosion. Additionally, village members lacked knowledge on how to balance forest and mangrove conservation with immediate livelihood needs. For example, firewood is essential for cooking due to the lack of electricity, and trees are used for reconstruction of housing after devastation from the increasing disasters.

In the assessment for Grade 8 middle school children, a paper-slides on climate change, mangroves, and erosion was developed and presented (Annex 6). When asked if the cutting of mangroves effected the environment, 78 percent answered positively before the presentation and workshop. This number increased to 88 percent after the presentation, suggesting that even minimal interventions using educational materials has the potential for village members.

3.3.5 Adaptation measures by the community

Village members articulated strong needs for community-wide adaptation measures, as such activities are currently limited. The most wide-scale adaptation measure is afforestation and plantation, with 76 percent of respondents experiencing the planting of trees with seeds supported by the Department of Forestry, to alleviate the impact of river erosion. Moreover, 56 percent reported they were in the process of planning appropriate land use to mitigate land degradation, and 77 percent answered they were planning the implementation of climate change adaptation and disaster risk reduction awareness programs in schools and communities. A notable 50 percent answered to be in the process of promoting sustainable agriculture schemes. However, interviews highlighted a gap in technical expertise and knowledge of actual conducting sustainable practices, as even data collection/sharing of water levels and weather is limited.

After the 2015 catastrophic flooding and flood induced erosion, coordination between government departments such as the Department of Disaster Management was enhanced. With government support, the elevation level of rebuilt houses increased to around 5-7 feet. Moreover, water tanks to collect rain water were placed in highland areas to secure safe drinking water.

Strong interest was expressed on contributing to adaptation measures and actions by village members. 75 percent responded they strongly agree to conduct adaptive activities to reduce the impact of climate change, and all participants answered positively to participating in climate change and disaster risk reduction training. However, when village authority members were asked if they thought it was important to integrate climate change adaptation and disaster risk reduction into the community's development plan 40 percent strongly agreed, 45 percent agreed, and 15 percent neither agreed nor disagreed. The idea of climate change and disaster risk reduction as a separate activity, rather than actions which need to be integrated into the whole development, may exist due to lack of education and knowledge on such concepts, including causes and impact. Moreover, FGD's participants mentioned "we do not understand how to integrate such measures into development". Therefore, the participants expressed the strong need of some institutional mechanisms, such as a Disaster Management Committee and Disaster Management Plan of the village, with technical support from the Department of Disaster Management or aid agencies.

3.4 DISCUSSION

The analysis of the questionnaires, interviews, and FGD have demonstrated the current situation of *Thatdama Kyun* Village regarding climate change and disaster risk, and identified both socio-economic and environmental impact. Moreover, the research suggests three main underlying problems and challenges for the community as they work to adapt to climate change and onset disasters.

1. No specific group in the community has been identified to promote mitigation/adaptive action despite of increase in risk.
2. Lack of understanding about the mechanisms and data of disasters makes integration of climate change adaptation in the village development difficult.
3. Although village members recognize the need and are interested, sustainable development practices which also promote the village's immediate socio-economic needs do not widely exist, due to lack of knowledge and awareness.

Based on the above identified challenges, three main recommendations have been formulated to improve the adaptation of climate change and disaster risk reduction in communities in Myanmar. Because this is a case-based study for *Thatdama Kyun* Village, the recommendations may not be fully applicable across the country. Although such recommendations are merely first steps, they are nonetheless important insights into how communities can start to improve their environment.

3.4.1 Development and disaster management plans

The urgency of developing countries, including Myanmar, to reduce their vulnerabilities and enhance capacity through systemic institutions and plans have been reiterated, as adaptation is a necessary resilience process to mitigate the impact of climate change (UNFCCC, 2007). People in *Thatdama Kyun* Village have begun to notice the gradual increase of the impact climate change and its' effect on their livelihood, especially in the last five years. Especially due to challenges in the village of understanding data and mechanisms of climate change, climate change should be integrated into an institutional framework or plan, such as a village development plan, with a specific sub-committee group to lead the initiative to mitigate the risk for sustainable development. Moreover, such plans should be reviewed on an annual basis to understand the strengths and vulnerabilities of the village, with specific considerations to climate change and disaster risk. Therefore, indicators to measure climate change and disaster risk should be determined with cooperation from the township government to facilitate understanding of climate change. Moreover, data collection to monitor the situation of the village in cooperation between authorities at the village level and the township government is crucial. An institutionalized plan with specific consideration to climate change adaptation will also guide decision making and discussion on further economic activities which may be harmful to the environment. The Government of Myanmar has implemented disaster risk reduction and management systems at the national, state, regional, district, and Township levels. Chapter IV in the Formation of Natural Disaster Management Bodies and its Duties and Powers Formation of Disaster Management Law (Government of Myanmar, 2013, pp.4) also orders that the government "shall, in order to provide close supervision for effective implementation of natural disaster management in Self-administered Division or Self-administered Zone, District, Township, Ward and Village Tract within the Region or State, form Natural Disaster Management Bodies comprising suitable persons and assign duties and powers thereof[10]." However, execution of such systems at the village tract level is still very limited, and *Thatdama Kyun* village and its village tract also does not have such bodies. Cooperation between communities at the village/village tract level and the township government to create such development plans are critical to lay a foundation of awareness and action for sustainable livelihoods.

3.4.2 Raising awareness on climate change

Although village residents understood the phenomenon of climate change, they did not have any data collection methods to measure mid-term impact, such as rainfall patterns, temperature fluctuation, water levels, and erosion rates over extended periods of time. As technical training capacities of local governments to educate a wider public on climate change is currently limited, it is recommended that governments first start with data consolidation and dissemination to village, so they can begin to comprehend changes in their environment. Without data and evidence, it is difficult to fully understand the environment and create a basis for specific action steps to confront and adapt. Since cause and effect of climate change is varied, inter-department approach is required. Moreover, such data sharing is also a critical channel to disseminate early warnings in the case of severe disasters. Early warning systems are essential to villages as disasters have a long-term effect on the livelihood of communities which are struggling in poverty and continuous recovery from weather related events.

3.4.3 Establishment of Ayeyarwady basin platform

A large population who live along the river are facing similar risks of riverine flooding and erosion similar to *Thatdama kyun* village. To cope with the emerging challenges in various sectors, good practises and lessons learnt on adaptive/mitigation measures should be shared. Pilot villages should be selected to conduct comprehensive activities as recommended in 1 and 2. The adopted actions and measures, experience of good practices as well as lessons learnt, should be integrated into future interventions. Thus, proper monitoring and evaluation system needs to be consulted within and between relevant stakeholders, using evidence-based scientific methods.

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[10] Chapter VI, section 14 notes "establishing sound preparations to resolve the natural disaster at every level from the National Level to the ward or village tract level"

3.5 CONCLUSIONS

This report highlighted the impact of climate change on *Thatdama Kyun* village, *Ingapu* Township, Myanmar, to articulate the risks faced by many vulnerable communities in the country. In accordance with this research on climate change and disasters in Myanmar, the case study of Thatdama Kyun revealed an increase in extreme weather events, especially flooding and erosions. This is especially relevant as village members explained the disappearance of seven communities out of the initial 12, due to flooding and erosion. The residents have lived with the Ayeyarwady River throughout their lives but are not equipped to deal with the sudden and severe changes in climate patterns and disaster frequency, especially as they do not understand the causes. The effect of climate change to their agriculture-centric economy is acute, and such impacts make the village more vulnerable in areas such as nutrition, health, and education access. It is important to note the community members' willingness to participate in adaptation measures to mitigate risks. However, technical expertise and data is necessary to guide members on sustainable development methods as well as institutional frameworks to facilitate the process and a platform to share. The authors hope this report will contribute to understanding the severity and urgency of climate change and disaster risk reduction in communities in Myanmar, and the learnings will be translated into further research and policies.

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ANNEXES (1-10)

Interviews

U Than Oo, Village Administrative Officer, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018.

U Than Soe, Assistant Director of Hinthada District Department of Disaster Management, Ayeyarwaddy Region. Personal interview on June 19, 2018.

U Thein Lin Kyaw, Senior Assistant Engineer, Hinthada District Irrigation Department, Ayeyarwaddy Region. Personal interview on June 22, 2018.

Questionnaire Surveys

U Aung Tin Myint, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018.

U Aye Chan, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018.

Daw Aye Thaung, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018.

U Hla Min, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018.

Daw Htay Win, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Khin Tint, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Kyi Hla, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 22, 2018

Daw Kyu Kyu Wai, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Mi Nge, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Mya Maung, Village Second Administrative Officer, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Myint Hlaing, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Nwe Nwe Oo, Women's Affairs Federation, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Nyo, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Ohnn Mya, Maternal and Child Care Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Sann Win,Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Saw Mahn Oo, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Shwe Hla, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Than Linn Htike, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Than oo, Village Administrative Officer, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Than Than Hlaing, Maternal and Child Care Association member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Than Than Myint, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Than Zaw, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Thinn Shwe Sin, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Thu Zar Aye, Women's Affairs Federation, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Tin Lay New, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Tin Ohnn, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Tin Zar Aung, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

U Tun Maung Oo, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Tun Tun Htet, Village Development Committee Member, Thatdama Kyun village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Daw Yi Yi Cho, Village Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 20, 2018

Focus Group Discussion

U Aung Kyaing, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Aung Lwin, Construction worker, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Aung Than, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Hlaing Win, Construction worker, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Hlaing Win, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Hla Win Kyi, Agribusiness, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Kan Chain, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Khin San Win, Fishery Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Personal interview on June 21, 2018

U Kyaw Naing Oo, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Moe Yu Twe, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Myint Myint Gyi, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Myaint Kyaw, Merchant, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Mya Maune, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Than Than Nyunt, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Thay Thay, vendor, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Tin Ohnn, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Tun Maung Oo, Village Development Committee Member, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Yu Naing, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Daw Yu Yu Maw, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

U Zaw Htet, Farmer Association, Thatdama Kyun Village, Ingapu Township, Ayeyarwaddy Region. Focus group discussion on June 21, 2018

Annex 1: Survey Question Form for Climate Change and the Effect on the Community (Village Authority)

This survey aims to identify the process and impact of Climate Change Adaptation and Disaster Risk Reduction and the socio-economic impact of disasters. The data will be used to develop and recommend planning strategies for communities to adapt to and build resilience towards climate change and related disasters caused by it. The data at the community level will be useful to identify adaptive strategies which have integrated local knowledge to cope with the changing climate and environment. We highly appreciate your time and sincere cooperation.

(A) Basic Information

Respondent Name	
Age	(1)Under 20 □ (2) 21 to 30 □ (3) 31 to 40 □ (4)41 to 50 □ (5)51 to 60 □ (6) Over 60 □
Education back ground (last completed academic)	(1) Monastic school □ (2) Primary School □ (3) Middle School □ (4) High School □ (5) University □ (6) Other □
Family Size (# of people)	
Job	(1) Farmer-Landless □ (2) Farmer-Landlord □ (3) Fisherman □ (4) Fishing Business/Pond □ (5) Vendor □ (6) Daily worker □ (7) People depend forest resources □ (8) Cottage industry □ (9) Boat taxi service □ (10) Other □
Position in village	(1)Village GAD member □ (2) Village Development Member □ (3) Women Association □ (4) Maternal & Child Care Association□ (5)Fishery group □ (6)Agriculture Group □ (7)Forestry Group□ (8)Community □ (9)Other□
Monthly household income	(1)100,000 - 150,000 kyat □ (2) 150,000 - 200,000 kyat □ (3)200,000 - 250,000 kyat □ (4) More than 250,000 kyat □
Disaster History (please check disasters you have experienced and explain when)	(1)Cyclone □ : (2)Flood □ : (3)Earthquake □: (4)Erosion □ : (5)extreme temperature □ :

	(6)Irregular rain □ : (7)Strong wind □ :
Land use Properties	Ownership □ Renting □
How many times do you evacuate in a year from flood induced erosion?	One □ Two □ Three □ Four □ Five □ Six □ More than six □
How many days do you usually need to evacuate?	

(B) Knowledge

(2) Have you heard about climate change in your community and if yes, how do you know?

□ Yes □ No

Information sources	**When**	**What kind of information did you get**
Television		
Radio		
Newspaper		
Magazine		
Internet		
Publication/Journals		
Government Departments/Township Authority		
Village Authority		
INGO		
Local NGO		
CSO		
Red Cross		
Social Media		
Your neighbors or friends		

(C) Identifying Climate related risk

(3) What kind of hazards are in your community? You can choose more than one.

Climate relative hazards	**Year**	**Frequency**	**Intensity** **(1) Low (2) Medium (3) High**	**Affected Duration**
Cyclone				
Flood				
River erosion				
Drought				
Extremely temperature				
Climatic health hazards				
Irregular Rainfall patterns				
Desertification				
Deforestation				
Other				

(D) Climate Change Impact

(4) Please answer all that applies to the community.

Climate Change effect	**When**	**Impact**	**Percentage of village affected**
Loss of Agriculture Production			
Declining crops quality			
Crops pattern change			
Salinity intrusion			
Acidity in soil			
Loss of tree, garden and soil			
Loss of domestic animals			

Loss/scarcity of aquatic species			
Scarcity of drinking water			
Migration			
Seasons change			
Habitat change (Animals and Plants)			
Air pollution			
Water Pollution			

(5) Has the income of your community been affected due to a change in climate? Please choose one.

(1) Strongly affected. 80-100percent of community income decreased.	**(2) Affected.** 50-79percent of community income decreased.	**(3) Moderately affected.** 10-49percent of community income decreased.	**(4) Barely affected.** 1-9percent of community income decreased.	**(5) Not affected.** 0percent of community income decreased.

(6) Please choose all that you think have been affected by change in climate?

Density of village demography □

Climatic health problem (Heatstroke, diseases etc) □

Disturb to student's education continuity □

Disturb social cohesion □

Cultural □

Household income □

Employment opportunity □

Properties loss/damage □

Human dignity □

Investment □

(7) Can you elaborate on the effect you have chosen above? (Answer written by interviewer).Note to interviewer: Please ask specific circumstances and duration of the impact (specific number of days, months or years).

(8) Please choose all that you think has been affected by change in climate for the environment, and the duration period (one season, one year, more than one year, etc.)?

Global warning with extreme temperature□ :

Pollution □:

Sea level rising□:

Reducing fresh water flowing □:

Degradation land and soil □:

Ecosystem change (Interaction of plants and animals)□ :

Limitation of Water resources (surface water/ground water)□:

Threatened to species □ :

Deforestation □:

(9) Can you elaborate on the effect you have chosen above? (answer written by interviewer). Note to interviewer: Please ask specific circumstances and observations.

(E)Adaptation to Action

(10) Do you have the following adaptive measure for climate change? Please choose one only for each.

No	**Adaptive Action**	**Impleme nted**	**Not implement ed, but plan**	**Not yet plan But necessary**	**Neither plan nor necessary**
1	River and creek water resource management for flood protection (raise crest level of dyke, enlarge reservoirs, upgrading drainage system) in community's involvement				
2	Afforestation and plantation.				
3	Appropriate land use planning without degradation and any impacts of Climate change.				
4	Taking action for Environment and Ecology conservation (Biotic & Abiotic).				
5	Implementing plans or projects for conservation of biodiversity, aquatic animals and species.				
6	Promoting sustainable agriculture development schemes (measurement salinity, acidity, conserving moisture, improved irrigation, soil erosion prevention measures, integrated pest management, controlling excess fertilizers selection of appropriate varieties for cultivation, avoid burning)				

7	Controlling over using Fire wood for cooking and other purpose.				
8	Controlling about emission of CO,CO2 to atmosphere, directly discharging waste water disposal into river, canal and creek by Industry, factory etc.				
9.	Participatory in DRR-CCA activities.				
10.	Encourage enhancing awareness in DRR-CCA activities of school and community.				

(F)Management

(11) Do you have an early warning mechanism for your village? If yes, please explain.

(Flood, water level, intensity of rainfall, etc)

□ Yes □ Not Sure □ No

(12) Does your village have a Disaster Management Committee?

(1) Yes	**(2) No**

(13) Do you think the integration of disaster risk reduction and climate change adaptation is important for the village development? Please explain why or why not?

(1)Strongly Agreed	**(2)Agreed**	**(3)Moderate Agreed**	**(4)Less Agreed**	**(5)Never**	

(14) Please choose one answer for each. If you have your perception, please reason for each.

Action	**Agree Strongly Do**	**Agree Do**	**Neither agree nor Disagree to do**	**Disagree to do**	**Disagree Strongly to do**
I will motivate to do some adaptation activities to reduce the risk of Climate Change in my community.					
I will manage to do more plantations in my compound and more participate for community forest schemes.					
I wish to participate for volunteer service in the sandbag protection to prevent river erosion induced flooding together with my community in my village.					

I wish to coordinate Disaster Risk Reduction and Climate Change training in our community.					
I think it is important to integrate CCA and DRR into our community's development plan.					
I will be good management in waste water disposal and household's rubbish discharging into river by enhancing awareness in my community.					
I will be consultation to conserve or control excess exploration of the surface water and ground water in our community.					
I will be promoting controlling over fishing or using unofficial way like using chemical or battery shock to protect our marine aquatic species.					
I will more pay attention on weather forecasting on disaster and climatic events from Television, radio and concerning department and warning to my community timely.					
I will try more collaboration with external stakeholders to monitor or making action about the salinity rate or acidity rate in agriculture land, heavy metal contamination, erosion prevention, making assessment Environmental and social impact before new project start.					

Annex 2: Survey Question Form for Climate Change and the Effect on the Community (Community)

This survey aims to identify the process and impact of Climate Change Adaptation and Disaster Risk Reduction and the socio-economic impact of disasters. The data will be used to develop and recommend planning strategies for communities to adapt to and build resilience towards climate change and related disasters caused by it. The data at the community level will be useful to identify adaptive strategies which have integrated local knowledge to cope with the changing climate and environment. We highly appreciate your time and sincere cooperation.

(A) Basic Information

Respondent Name	(1)Under 20 □ (2) 21 to 30 □ (3) 31 to 40 □ (4)41 to 50 □ (5)51 to 60 □ (6) Over 60 □
Age	
Education back ground (last completed academic)	(1) Monastic school □ (2) Primary School □ (3) Middle School □ (4) High School □ (5) University □ (6) Other □
Family Size (# of people)	
Job	(1) Farmer-Landless □ (2) Farmer-Landlord □ (3) Fisherman □ (4) Fishing Business/Pond□ (5) Vendor □ (6) Daily worker □ (7) People depend forest resources □ (8) Cottage industry □ (9) Boat taxi service □ (10) Other □
Position in village	(1)Village GAD member □ (2) Village Development Member □ (3) Women Association □ (4) Maternal & Child Care Association□ (5)Fishery group □ (6)Agriculture Group □ (7)Forestry Group□ (8)Community □ (9)Other□
Monthly household income	(1)100,000 - 150,000 kyat □ (2) 150,000 - 200,000 kyat □ (3)200,000 - 250,000 kyat □ (4) More than 250,000 kyat □
Disaster History	(1)Cyclone □ : (2)Flood □ :

(please check disasters you have experienced and explain when)	(3)Earthquake □: (4)Erosion □ : (5)extreme temperature □ : (6)Irregular rain □ : (7)Strong wind □ :
Land use Properties	Ownership □ Renting □
How many times do you evacuate in a year from flood induced erosion?	One □ Two □ Three □ Four □ Five □ Six □ More than six □
How many days do you usually need to evacuate?	

(B) Knowledge

(2) Have you heard about climate change in your community and if yes, how do you know?

□ Yes □ No

Information sources	**When**	**What kind of information did you get**
Television		
Radio		
Newspaper		
Magazine		
Internet		
Publication/Journals		
Government Departments/ Township Authority		
Village Authority		
INGO		
Local NGO		
CSO		

Red Cross		
Social Media		
Your neighbors or friends		

(C) Identifying Climate related risk

(3) What kind of hazards are in your community? You can choose more than one.

Climate relative hazards	**Year**	**Frequency**	**Intensity** (1) Low (2) Medium (3) High	**Affected Duration**
Cyclone				
Flood				
River erosion				
Drought				
Extremely temperature				
Climatic health hazards				
Irregular Rainfall patterns				
Desertification				
Deforestation				
Other				

(D) Climate Change Impact

(4) Please answer all that you applies to you, in regard to change in climate (filled in by interviewer).

Climate Change effect	**When**	**Impact**
Loss of Agriculture Production		
Declining crops quality		
Crops pattern change		
Salinity intrusion		
Acidity in soil		

Loss of tree, garden and soil		
Loss of domestic animals		
Loss/scarcity of aquatic species		
Scarcity of drinking water		
Migration		
Seasons change		
Habitat change (Animals and Plants)		
Air pollution		
Water Pollution		

(5) Has your income been affected due to a change in climate? Please choose one.

(1) Strongly affected. 80-100percent of household income decreased.	**(2) Affected.** 50-79percent of household income decreased.	**(3) Moderately affected.** 10-49percent of household income decreased.	**(4) Barely affected.** 1-9percent of household income decreased.	**(5) Not affected.** 0percent of household income decreased.

Density of village demography □

Climatic health problem (Heatstroke, diseases etc) □

Disturb to student's education continuity □

Disturb social cohesion □

Cultural □

Household income □

Employment opportunity □

Properties loss/damage □

Human dignity □

Investment □

(6) Please choose all that you think have been affected by change in climate?

(7) Can you elaborate on the effect you have chosen above? (answer written by interviewer).Note to interviewer: Please ask specific circumstances and duration of the impact (specific number of days, months or years).

Global warning with extreme temperature□ :

Pollution □:

Sea level rising□:

Reducing fresh water flowing □:

Degradation land and soil □:

Ecosystem change (Interaction of plants and animals)□ :

Limitation of Water resources (surface water/ground water)□:

(8) Please choose all that you think has been affected by change in climate for the environment, and the duration period (one season, one year, more than one year, etc.)?

Threatened to species □ :

Deforestation □:

(9) Can you elaborate on the effect you have chosen above? (answer written by interviewer). Note to interviewer: Please ask specific circumstances and observations.

(E)Adaptation to Action

(10) Do you have the following adaptive measure for climate change? Please choose one only for each.

No	Adaptive Action	Implemented	Not implemented, but plan	Not yet plan But necessary	Neither plan nor necessary
1	River and creek water resource management for flood protection (raise crest level of dyke, enlarge reservoirs, upgrading drainage system) in community's involvement				
2	Afforestation and plantation.				
3	Appropriate land use planning without degradation and any impacts of Climate change.				
4	Taking action for Environment and Ecology conservation (Biotic & Abiotic).				

5	Implementing plans or projects for conservation of biodiversity, aquatic animals and species.				
6	Promoting sustainable agriculture development schemes (measurement salinity, acidity, conserving moisture, improved irrigation, soil erosion prevention measures, integrated pest management, controlling excess fertilizers selection of appropriate varieties for cultivation, avoid burning)				
7	Controlling over using Fire wood for cooking and other purpose.				
8	Controlling about Emission of CO,CO2 to atmosphere, directly discharging waste water disposal into river, canal and creek by Industry, factory etc.				
9.	Participatory in DRR-CCA activities.				
10.	Encourage enhancing awareness in DRR-CCA activities of school and community.				

(F)Cooperation

(11) Please choose one answer for each. If you have your perception, please reason for each.

Action	**Agree Strongly to do**	**Agree To do**	**Neither agree nor Disagree to do**	**Disagree to do**	**Disagree Strongly to do**
I am highly willing to do some adaptation activities to reduce the risk of Climate Change in my community.					
I will participate more plantations in my compound and more participate for community forest schemes.					
I wish to participate for volunteer service in the sandbag protection to prevent river erosion induced flooding together with my community in my village.					
I wish to join Disaster Risk Reduction and Climate Change training in our community.					
I think it is important to integrate CCA and DRR into our community's development plan.					

I will pay attention in waste water disposal and household's rubbish discharging into river.					
I will motivate by myself and share to others to conserve or control excess exploration of the surface water and ground water in our community.					
I will be promoting controlling over fishing or using unofficial way like using chemical or battery shock to protect our marine aquatic species.					
I will more pay attention on weather forecasting on disaster and climatic events from Television, radio and concerning department and warning to us.					
I believe that it is important to get data for salinity rate or acidity rate in agriculture land, heavy metal contamination, rainfall, temperature, humidity, and cyclone and flood warning colors, water level for our country to reduce/mitigate the socio-economic and environmental impact due to climate change effect.					

Annex 3: Results of Climate Change Impact

(n=30)

Climate Change Impact	**When**	**Impact**	**Village population affected** **(as identified by Village Authority)**
Loss of Agriculture Production	2015, 2016, 2017	- Agricultural land was damaged due to flood and erosion as well as high intensity of temperature and rainfall. Production rate is sharply declining, impacting on the household's income. - Less profit/income due to labor cost, one season crop, extreme weather events (flood, erosion, and storm) and other miscellaneous costs like fertilizer, transportation. - Agriculture lands were affected and damaged by flood induced erosion. Some landowners became landless. -The impact on social problems due to decreasing economic such as depression, effect on human health, children's education and anxieties.	30 to 40 percent of village community highly affected.
Declining crops quality	Since 2015	- Constraints in market penetration especially in Hinthada market, high impact on socio-economic of households. - Disturb student's education especially higher education and university because of their family's income decreasing. - Leads to increase in student's dropout rate and increasing more child labor rate. - The impact of disasters on agriculture and declining crops quality resulting food unsafely, food insecurity, food scarcity. - Less participatory in communities' traditional events due to effect on economy/	30 to 40 percent of village community highly affected.
Crops pattern change	Since 2014.	- Some new vegetation changes according to the market demand.	NA.
Salinity intrusion	After erosion in 2016, 2017	- No salinity intrusion, but some fresh water reducing. River color changes due to debris and some poor rubbish management in urban.	NA.
Acidity in soil	NA.	- Crop rate quality reducing, soil degradation and production rate decrease directly effect on household's income. - Insufficient budget and technical intervention in reclamation for soil quality resulting more increasing poverty rate especially for poor communities.	20 percent of village community highly affected.
Loss of tree, garden and soil	Since 2016.	-Tree loss due to erosion, logging, excess firewood and more weather changes like temperature and rainfall.	NA.

Loss of domestic animals	Since 2015.	- Huge losses in cattle, pig, chickens, ducks, and pets due to climatic hazards like flooding, erosion, extremely temperature. -Difficult evacuated places for domestic animals.	10-30 percent of village community highly affected.
Loss/scarcity of aquatic species	2015, 2016, 2017.	-Extremely temperature, climate change targeted to impact on loss/scarcity of aquatic species and less availability of fish. -Over fishing, using chemical, battery shock fishing, excess pesticide and fertilizer in agriculture discharging into river and creek impact on loss of aquatic species and affected on human eater. -Fishing market decreasing in price.	20-30 percent of village community highly affected.
Scarcity of drinking water	During March, April, May.	- People are using rainwater for their drinking, constraints the availability of rainwater during extremely temperature and shorter rainfall duration.	100percent of village community highly affected.
Migration	Since 2014.	- Younger generation migrates to urban areas such as Yangon or other countries like Malaysia in search of job opportunity. - High vulnerability to disasters due to the decrease of youth in participation of village development activities, disaster preparation, mitigation and volunteering during disaster like flooding ,erosion and insufficient human resources in emergency response and recovery process.	10-15percent of village community highly affected.
Seasons change	NA.	- Increased occurrences of extreme temperature, intensity of rainfall pattern, soil degradation due to change in climate. - Longer summer seasons and less rainfall duration. -Impact on the livelihood of human, animals and plants.	NA.
Water Pollution	NA.	-Waste water and solid waste disposal from some rice mill or factories from urban directly discharging without filtration system into river which is highly impact on water pollution for domestic as well as drinking for community. - Sediment issues due to water pollution.	-Harmful for children due to low resistance.

Annex 4: Results of socio-economic impact

(n=30)

Social Impact	**Details**	**Affected percentage of respondents** **(n=30)**	**Economic Impact**	**Details**	**Affected percentage of respondents** **(n = 30)**
Density of village population	-More population density in village because of limitation land use due to erosion, constraints in job opportunity.	96percent	Household income	- Increasing decline of household income, leading to effect on mental well-being. - Income decreasing since 2015 due to disasters onset by climate change and its effects on agricultural land, impacting the community's livelihood. -Lack of financial arrangement or allocated budget for disaster risk reduction or emergency funds after disasters.	96percent
Climatic health problem (heatstroke, diseases etc)	-Insufficient health care facilities, equipment, and human resources in general.	13percent	Employment opportunity	-During flooding season, all agricultural lands are flooded and damaged; there is no secondary income. -Due to limitation in availability of job opportunities, most of the youth migrate to urban centers such as Yangon.	96percent
Disturb students' education continuity	-Two months of education disturbances; - 5 - 10 days for inland evacuation during erosion. - Dropout due to family income reduction and more child labor.	96percent	Properties loss/damage	- Recovering loss and damage of household properties is often pushed aside as their previous land is vulnerable or unusable. First	93percent

				priority is to get new land for their housing by purchasing or negotiating price with land owners because they receive 100,000 kyat for each household from Department of Disaster Management.	
Disturb social cohesion	-Climatic hazards can disturb social cohesion because there will limited availability in the involvement of community in village development activities due to high disaster impact lasting nearly 3 months, especially in 2015 to 2017 catastrophic flooding and erosion. -In the process of rehabilitation, some development programs lack transparency, accountability, inclusiveness and equality, leading to issues on fairness for targeted areas.	67percent	Investment	-All investment for agriculture, livestock and fishery sectors receive huge damage. -Lack of institutional arrangements (loan, microfinance, banking) for new investments to implement rehabilitation process after disasters lead to increase in poverty rate.	93percent
Cultural	-Less activities for religious and traditional culture festivals due to the impact on economy. - Some culture change in village due to low income in family like higher female employee rate (seasonal worker, street vendor), normally wife is taking care her family's house chore.	6percent			
Human dignity	-Some villagers prefer better rehabilitation process like agriculture reclamation, soil filtering depending on themselves for their future's development, rather than relief aid. - People work twice more than before due to income loss; feelings of anxiety and unhappiness when they cannot participate in traditional/religious festivals.	16percent			

Annex 5: Results of Environmental Impact

(n=30)

Environmental impact	**Details**	**Affected percentage of respondents** **(n = 30)**
Global warning with extreme temperature	- Extreme temperatures have increased in the last ten years, and affected agriculture and marine resources including aquatic species and biodiversity.	100percent
Pollution	-The main impact caused by water pollution is on species that depend on water quality such as fish, crabs, other aquatic creatures. Such fish have been killed by pollutants in their habitat. Pollution disrupts the natural food chain. - Pollution also leads to scarcity of safe drinking water in summer especially during the extremely temperature season and catastrophic flooding induced erosion times. -Impact of clean water scarcity and resources leads to outbreak of diseases and sanitation problems such as diarrhea, malnutrition, dengue fever in children under 5 years old.	16percent
Sea-level rise	-Sea-level rise causes a wider area of inundation during storm surges and coastal floods. -Impact on physical environment like salinity intrusion and acid soil in agriculture lands; river acidification and water temperature changes for rivers; seasonal crops damage, loss of domestic animals.	67percent
Reduction of fresh water flow	-Freshwater ecosystems have become unbalanced by human activities and industrial waste from urban areas, such as excess use of pesticides and fertilizers in agriculture lands. This causes reduction in flow of fresh water, acid soil, water pollutants, and water-related health impacts.	3percent
Degradation land and soil	-Decrease in production rate in agriculture sector due to degradation of land and soil, leading to loss in income. - Large effect on food security, nutrition, and livelihoods, as crops and livestock are sensitive to numerous climate variables and vulnerable to extreme weather events.	97percent
Ecosystem change (Interaction of plants and animals)	- The ecosystem change has a huge impact on community's development schemes, sea-level rise, salt water intrusion into river water, increasing rainfall intensity with flooding and erosion, and migration of aquatic species for the fishery sector.	50percent
Limitation of Water resources (surface water/ground water)	- Poor integrated water resources management and water shortages can lead to disease, malnutrition, reduced economic growth, social instability, conflict, and environmental disasters. - River water is main resource for drinking water. Normally, it is enough/ well sufficient for community but during disaster like flooding and erosion, the debris, dead animals and contamination are very harmful without any filtration. - Due to the lack of technical supporting for checking/ inspection for safer drinking water, weather related diseases especially effect children.	13percent

Threatened to species	- High threat to species like range-restricted species, slow-moving species, low-dispersal species, and species most vulnerable to climate change. - The threat to fish and aquatic creatures will affect fishery sector.	76percent
Deforestation	- Deforestation is one of the main factors of climate change harmful to community. - Village members are conducting excessive tree tree cutting for firewood and housing. This leads to soil erosion, river erosion, changing habitats for animals and livelihood for humans.	90percent

Annex 6: Results of Adaptive Measures by the Community

(n=20)

Adaptive Action	**Implemented**	**Not implemented, but in process of planning**	**Not yet planned but necessary**	**Neither planned nor necessary**
River and creek water resource management for flood protection (raise crest level of dyke, enlarge reservoirs, upgrading drainage system) in community's involvement.	17percent	73percent	10percent	
Afforestation and plantation.	76percent	24percent		
Appropriate land use planning without degradation and any impacts of climate change.	24percent	56percent	13percent	7percent
Taking action for environment and ecology conservation (Biotic & Abiotic).	3percent	47percent	43percent	7percent
Implementing plans or projects for conservation of biodiversity, aquatic animals and species.	13percent	60percent	23percent	4percent
Promoting sustainable agriculture development schemes (measurement salinity, acidity, conserving moisture, improved irrigation, soil erosion prevention measures, integrated pest management, controlling excess fertilizers selection of appropriate varieties for cultivation, avoid burning)	20percent	50percent	23percent	7percent
Controlling over using firewood for cooking and other purpose.	7percent	17percent	53percent	23percent
Controlling about emission of CO,CO2 to atmosphere, directly discharging waste water disposal into river, canal and creek by Industry, factory etc.	3percent	10percent	63percent	24percent
Participatory in DRR-CCA activities	17percent	70percent	13percent	
Encourage enhancing awareness in DRR-CCA activities of school and community.	17percent	77percent	6percent	

Annex 7a: Results of Cooperation Willingness for Climate Change Adaptation by the Community

(n=20)

Action	**Agree Strongly to do**	**Agree To do**	**Neither agree nor Disagree to do**	**Disagree to do**	**Disagree Strongly to do**
I am highly willing to do some adaptation activities to reduce the risk of Climate Change in my community.	75percent	25percent			
I will participate more plantations in my compound and more participate for community forest schemes.	25percent	75percent			
I wish to participate for volunteer service in the sandbag protection to prevent river erosion induced flooding together with my community in my village.	65percent	35percent			
I wish to join Disaster Risk Reduction and Climate Change training in our community.	35percent	65percent			
I think it is important to integrate CCA and DRR into our community's development plan.	40percent	45percent	15percent		
I will pay attention in waste water disposal and household's rubbish discharging into river.	25percent	40percent	35percent		
I will motivate by myself and share to others to conserve or control excess exploration of the surface water and ground water in our community.		25percent	70percent		5percent
I will be promoting controlling over fishing or using unofficial way like using chemical or battery shock to protect our marine aquatic species.	25percent	45percent	25percent	5percent	
I will more pay attention on weather forecasting on disaster and climatic events from Television, radio and concerning department and warning to us.	85percent	15percent			
I believe that it is important to get data for salinity rate or acidity rate in agriculture land, heavy metal contamination, rainfall, temperature, humidity, and cyclone and flood warning colors, water level for our country to reduce/mitigate the socio-economic and environmental impact due to climate change effect.	30percent	35percent	35percent		

Annex 7b: Results of Management Willingness for Climate Change Adaptation by Village Authority

Action	**Agree Strongly to do**	**Agree To do**	**Neither agree nor Disagree to do**	**Disagree to do**	**Disagree Strongly to do**
I will motivate to do some adaptation activities to reduce the risk of Climate Change in my community.	40percent	50percent	10percent		
I will manage to do more plantations in my compound and more participate for community forest schemes.	40percent	60percent			
I wish to participate for volunteer service in the sandbag protection to prevent river erosion induced flooding together with my community in my village.	30percent	70percent			
I wish to coordinate Disaster Risk Reduction and Climate Change training in our community.	10percent	90percent			
I think it is important to integrate CCA and DRR into our community's development plan.	30percent	70percent			
I will be good management in waste water disposal and household's rubbish discharging into river by enhancing awareness in my community.	30percent	50percent	20percent		
I will give consultation to conserve or control excess exploration of the surface water and ground water in our community.		70percent	30percent		
I will be promoting controlling over fishing or using unofficial way like using chemical or battery shock to protect our marine aquatic species.	30percent	60percent	10percent		
I will more pay attention on weather forecasting on disaster and climatic events from television, radio and concerning department and warning to my community timely.	50percent	40percent	10percent		
I will try more collaboration with external stakeholders to monitor or making action about the salinity rate or acidity rate in agriculture land, heavy metal contamination, erosion prevention, making assessment Environmental and social impact before new project start.	30percent	60percent	10percent		

Annex 8: Main Points from Focus Group Discussion with 20 village members

Question for Focal Group Discussion	Discussion Points
What hazards does your community experience?	The most frequent hazards in village are normal floods every rain season, catastrophic flooding from 2015 and 2016, big river erosion in 2016 and 2017, strong wind in pre monsoon and post monsoon season. Moreover, they suffer extremely temperature effect and rainfall intensity which effects their livelihood, agriculture land and soil degradation. Other extreme weather events are major challenges and severity affected to the human's health sector. Heat waves and increasing frequency of very hot days especially in summer of March and April coupled with high humidity, can cause severe health complications and are a significant cause of weather-related deaths. The elderly and young people are most at risk, while outdoor workers can also be severely affected by heat.
What kinds of issues did you experience in the 2015 catastrophic flooding?	2015 flooding significantly affected food security, nutrition, and livelihoods, as crops and livestock are highly damaged due to flooding of agriculture lands, flooding, and erosion. They were facing difficulties due to the availability of safer drinking water as debris had entered the river water, making it unsafe and threatening water quality, sanitation and disease outbreaks. The early warning for flooding as well as water level from government departments were delayed.
Did you change any habits or start any countermeasures after the 2015 flooding, for job, household, school, etc.?	After 2015, village members changed some habits like more supporting primary health care facilities in village health care center with medicine and one nurse; more cooperation with government department like DDM, Agriculture Department and GAD, to develop in agribusiness sectors. A new school construction project in high elevation area was donated by ASEAN Institute of Technology, Myanmar Engineer Alumni with school facilities (building, teaching facilities). Development of new housings for erosion affected communities supported by DDM budget (one housing for one lack). The new houses have an elevation level of 5 to 7 ft. according to lessons learned from previous disasters. More construction of water tanks collecting rain water for drinking in highland area. Most people are using solar panel and battery for electricity to receive weather forecasting and warning.
Have you heard of climate change? What do you think it is?	Among 20 participants from focal group discussion, 90 percent had never heard about climate change terminology, but they know the phenomenon, such as extreme temperature, rainfall intensity.
Do you think there is any change in your environment due to change in climate?	The production rate in agriculture declining, the scarcity of aquatic animals and biodiversity issues, sour-acidity in agriculture land, deforestation due to human effect as well as climate change.
Are there any problems or disasters due to the change in climate?	The main problems due to disasters are impact on socio-economic status such as income reduction due to decline in quality of crops and production rate, resulting the market price decreasing. Fewer agriculture workers due to migration to urban areas for new living.

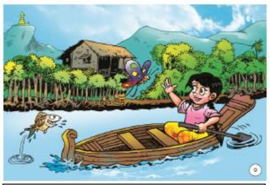
	Disasters are frequent, like 2016 and 2017 (big river erosion and evacuation inland area during 2017).
What kind of early warning system exists in your community? (Flood, water level, rainfall etc.)	Normally, local people have indigenous knowledge for checking river water changes, water level and current speed, and observation of some animal's behaviour, but they don't understand data and scientific knowledge. They only receive the danger level of river water for floods, but they do not receive detail data for maximum and minimum temperature, rainfall data, humidity etc.
Do you think it is important to integrate disaster risk reduction and climate change adaptation into village development's activities? If yes, please mention your idea?	All 100 percent of participants strongly agreed that it is very important to integrate disaster risk reduction and climate change adaptation into village development's activities. They don't know exactly what the starting point to start this plan is and how they can get technical supporting. They think that it is more integrated with township development plan.
What do you think is the best way to mitigate the impact of climate change in community?	Enhancing capacity building for local community, training or seminar about climate change and its impact, integrating in school curriculum about climate change as well as mechanism and safety tips of disaster. All development plans should be targeted into practical implementation goal.

Annex 9: Student Assessment Data on IEC Materials for Climate Change, Erosion, and Mangrove Conservation Change, Erosion, and Mangrove Conservation

School Name	Grade	Gender		Question	Before		After	
		Male	Female		Yes	No	Yes	No
Basic Education Middle School That Da Ma Kyun	8	11	7	Have you experienced flooding?	100%	0%	100%	0%
				Was your school affected during flooding time?	100%	0%	100%	0%
				Was your home affected during flooding time?	100%	0%	100%	0%
				Have you experienced or seen erosion in your community?	100%	0%	100%	0%
				Was your school affected in erosion?	27%	73%	27%	73%
				Was your home affected in erosion?	16%	84%	27%	73%
				Are mangroves important to protect your community?	100%	0%	100%	0%
				Does the cutting of mangroves effect the environment?	78%	22%	88%	12%
				Do you wish to maintain and conserve trees and mangrove in your village and along the river bank?	100%	0%	100%	0%
				Do actions of human beings effect the environment?	100%	0%	100%	0%

Annex 10: Developed IEC Material for Climate Change, Erosion, and Mangrove Conservation

School Name	Grade	Gender		Question	Before		After	
		Male	Female		Yes	No	Yes	No
Basic Education Middle School That Da Ma Kyun	8	11	7	Have you experienced flooding?	100%	0%	100%	0%
				Was your school affected during flooding time?	100%	0%	100%	0%
				Was your home affected during flooding time?	100%	0%	100%	0%
				Have you experienced or seen erosion in your community?	100%	0%	100%	0%
				Was your school affected in erosion?	27%	73%	27%	73%
				Was your home affected in erosion?	16%	84%	27%	73%
				Are mangroves important to protect your community?	100%	0%	100%	0%
				Does the cutting of mangroves effect the environment?	78%	22%	88%	12%
				Do you wish to maintain and conserve trees and mangrove in your village and along the river bank?	100%	0%	100%	0%
				Do actions of human beings effect the environment?	100%	0%	100%	0%



ဟိုးရှေးရှေးတုန်းကပေါ့ကွယ် . . .

မြန်မာနိုင်ငံမှာရှိတဲ့ ဧရာဝတီတိုင်းဒေသကြီးအတွင်းက ဘိုကလေးဆိုတဲ့မြို့လေးမှာ ဖူးဖူး ဆိုတဲ့ ကောင်မလေးတစ်ယောက် နေထိုင်သတဲ့ကွယ်။ ဖူးဖူးဟာ အမြဲတမ်းပဲ စူးစမ်းလိုစိတ်ပြင်းပြပြီးတော့ သူမရဲ့ ပတ်ဝန်းကျင်အပေါ် စူးစမ်းလေ့လာရတာကို နှစ်သက်သတဲ့ကွယ်။

သူမရဲ့အိမ်ကတော့ လှပတဲ့မြစ်ကြီးတစ်စင်းနဲ့ အပြိုင်ရှိပြီးတော့ မြက်ခင်းစိမ်းလေးတွေနဲ့ ပန်းပွင့်လေးတွေလည်းရှိသတဲ့ကွယ်။

ရှစ်၊ ရှစ် ... သူမဟာ အိမ်ကနေပြီး ဒီအသံကိုနားထောင်ရတာ နှစ်သက်တယ်ကွယ့်။

သူမအနှစ်သက်ဆုံးက မြစ်ကိုသွားပြီး ရေကူးရတာနဲ့ တစ်ခါတစ်လေ ငါးဖမ်းရတာကိုတောင်မှပေါ့။

ဖူးဖူးဟာ ရာသီအပြောင်းအလဲမှာ ရေတွေဘယ်လိုပြောင်းလဲသွားတယ်ဆိုတာနဲ့

ဘယ်လိုငါးအမျိုးအစားတွေက ဘယ်လိုအချိန်တွေမှာ ရောက်လာတယ်ဆိုတာကိုပါ ခံစားပြီးသိနိုင်တယ်။

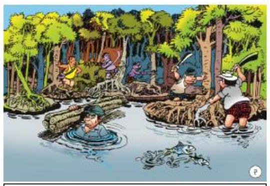
နေ့တိုင်း၊ လတိုင်း၊ နှစ်တိုင်း မြစ်ရေတွေတရိပ်ရိပ်တိုးလာပြီး ပိုပိုမြင့်တက်လာသလို ဖူးဖူးတို့မိသားစုလဲ စိုးရိမ်လာခဲ့ကြတယ်။ အမှိုက်၊ အညစ်အကြေးတွေဟာ သူတို့နေရာကိုပိုပိုပြီး ရောက်လာကြတယ်။ မိသားစုလယ်ယာမြေတွေဟာလည်း အမှိုက်၊ အညစ်အကြေးနဲ့ ရေတွေပါဝင်လာလို့ ဆန်စပါးနဲ့သီးနှံတွေလည်း လျော့နည်းလာကြတယ်။ သူတို့အိမ်ကလေးရှိရာကို ရေတွေက ပိုလို့ ပိုလို့ တိုးတိုးပြီး တက်လာနေကြတယ်။ ဒီရေတွေဟာ အရမ်းငန်လွန်းတာမို့ စပါးတွေအတွက်တော့ မကောင်းဘူးပေါ့။

"ငါတို့ ဘာလုပ်သင့်လဲ။ ငါတို့လယ်တွေ အရင်ကရှိခဲ့တာရဲ့ တစ်ဝက်ပဲရှိတော့တယ် ..." သူမရဲ့အဖေက ပြောလိုက်တယ်။

ဒီလိုနဲ့ တညမှာတော့ ... ဖူးဖူးဟာ သူမအမေရဲ့ စူးစူးဝါးဝါးအော်သံကြောင့် အိပ်ရာမှ နိုးခဲ့ရပါတယ်။

"ဖူးဖူးရေ ရေတွေတက်လာပြီ။ အမေတို့ သွားရတော့မယ်"

ဖူးဖူးလည်း အမြေအလှူးနဲ့ အိပ်ရာမှထလိုက်ပြီးတဲ့အခါမှာတော့ မြစ်မှနေပြီး သူမတို့အိမ်လေးအတွင်းသို့ ရေများ အလုံးအရင်းနှင့် ဝင်ရောက်လာနေသည်ကိုကြည့်ကာ အံ့သြသွားပါတော့တယ်။ ရေတွေဟာ အပြာရင့်ရောင်ရှိပြီး အလွန်ပဲလျှင်မြန်လှပါတယ်။ ဒါဟာ သူမအမြဲတမ်းဆော့ကစားလေ့ရှိတဲ့ မြစ်နဲ့တော့ တကယ့်ကို ကွဲပြားခြားနားနေပါတယ်။ ငြိမ်းချမ်းလှပသောရေများ ဘယ်သို့ရောက်သွားပါသနည်း။



ဖူးဖူးဟာ မနက်တိုင်း သူမရဲ့မိသားစုကို မွေ့ဖက်နှုတ်ဆက်ပြီးမှ ကျောင်းသွားတယ်။ ကျောင်းသွားပြီဆိုရင်လဲ သူမရဲ့သူငယ်ချင်းတွေနဲ့အတူ မြစ်ကမ်းဘေးတစ်လျှောက်မှာ ရှိနေတဲ့လမ်းအတိုင်း ကျောင်းမှအတန်းချိန်များအကြောင်း၊ ပျော်ရွှင်စရာအကြောင်းများ ပြောရင်းနဲ့သွားတတ်သလို တစ်ခါတစ်ခါ စိန်ပြေတမ်းကစားကြရင်းနဲ့လည်း သွားကြတယ်။

ဒါပေမယ့် ... မြစ်ကမ်းတစ်လျှောက်မှာရှိနေတဲ့ ဒီရေတောတွေကို လူတွေအများကြီးက ခုတ်လှဲနေကြတဲ့အတွက် သူတို့လည်း

ဂရုတစိုက်သွားခဲ့ကြရတယ်။

တစ်နေ့မှာ . . . ဖူးဖူးအိမ်ပြန်ရောက်လာတဲ့အခါ သူမရဲ့မိဘတွေဟာ သူတို့ရဲ့အိမ်ကနေ မြစ်ဘက် စိုးရိမ်တကြီး လှမ်းကြည့်နေတာကို သူမတွေ့လိုက်ရတယ်။ မြစ်ရေရဲ့အမြင့်ဟာ တစ်ဖြည်းဖြည်းခြင်း မြင့်တက်လိုလာနေတယ်။

"ဒါဟာ နေတိုင်းမိုးရွာနေလို့ပဲ ဖြစ်ရမယ်"လို့ ဖူးဖူးကတော့တွေးလိုက်တယ်။

သူမတို့မိသားစုဟာ လမ်းမပေါ်ကိုပြေးပေမယ့် လမ်းကမရှိတော့ပါဘူး။ လမ်းမကြီးက မြစ်ပြင်ကြီးတစ်ခု ဖြစ်နေပါပြီ။

မြေပြင်ရဲ့အရောင်ကတော့ အညိုရောင်ဖြစ်နေပြီး အမှိုက်၊ အညစ်အကြေးများနဲ့သာ ပြည့်နှက်နေပါတော့တယ်။

"ငါတို့ ဘာလုပ်နိုင်မလဲ"လို့ ဖူးဖူးက တွေးလိုက်ပါတယ်။ အဲဒီနောက်မှာတော့ သူမ အကြံကောင်းတစ်ခု ရသွားပါတော့တယ်။

ဖူးဖူးဟာ မိုးကြီးလာတော့မယ်ဆိုလျှင် မြစ်နဲ့ဝေးပြီး ခိုင်ခံ့ကာ ဘေးကင်းလုံခြုံသည့်ကျောင်းသို့ သွားရောက်ခိုလှုံရမည်ဆိုသော ကျောင်း၏ဆရာမသင်ထားသည်ကို သတိရသွားပါတယ်။

ဒီလိုနဲ့ ဖူးဖူးလည်း သူမရဲ့မိသားစုကို အိမ်နီးချင်းတစ်ဦးရဲ့အိမ်ကို ခေါ်ဆောင်သွားခဲ့ပြီး မိသားစုမှာလည်း ဘေးကင်းစွာ နေထိုင်နိုင်ခဲ့ကြပါတယ်။

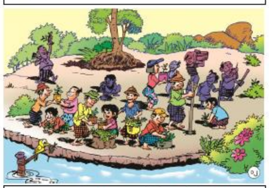
ဒီအခါမှာတော့ "ဖေဖေတို့ရဲ့ ပတ်ဝန်းကျင်အကြောင်းကိုသိပြီး ကူညီပေးတာ ကျေးဇူးတင်ပါတယ် သမီးလေး ဖူးဖူးရယ်"ဟု သူမ၏အဖေမှ ပြောလိုက်ပါတော့တယ်။

မိုးတိတ်သွားပြီး နောက်တစ်နေ့မှာတော့ ဖူးဖူးနဲ့ သူမရဲ့မိသားစုဟာ သူတို့ရဲ့အိမ်လေးကို ပြန်နဲ့ကြပါတယ်။ အဲဒီအခါမှာတော့ သူတို့အိမ်လေးရဲ့ တစ်ဝက်ဟာ မြစ်ထဲမြုပ်နေတာကိုတွေ့ပြီး စိတ်ဆျောက်များစွာရပါတော့တယ်။ သူတို့ရဲ့အိမ်နီးချင်းဖြစ်တဲ့ မလတ်လတ်ကတော့ "ငါ့အိမ်လေးတော့ အမှိုက်၊ အညစ်အကြေးတွေ၊ ရေတွေ၊ သဲတွေနဲ့ ပြည့်နေပါပြီတော်" ဟုပြောရင်း ငိုနေပါတော့တယ်။ ဖူးဖူးလည်း ငိုချင်ခဲ့ပေမယ့် စိုးရိမ်မှုတွေကလည်း ဖြစ်နေခဲ့ပြန်တယ်။

"ဒါ ဘာကြောင့်ဖြစ်ခဲ့တာလည်း။ နောက်တစ်ကြိမ်ကော ထပ်ဖြစ်ဦးမှာလား။"

ဖူးဖူးဟာ သူမရဲ့သူငယ်ချင်းတွေ အထင်မြေ မမြောကိုလည်း သိချင်နေတာနဲ့ ကျောင်းကိုသွားခဲ့ပါတယ်။ သူမရဲ့သူငယ်ချင်း ကောင်းဖြစ်တဲ့ ချစ်ရကတော့ "ငါ့အိမ်လေးကတော့ ဒီရေတောတွေက ရေတွေဝင်မလာနိုင်အောင် ကာကွယ်ပေးထားတဲ့အတွက် ဘာမှမဖြစ်ခဲ့ဘူး"လို့ သူမကိုပြောပြခဲ့တယ်။ "ဒါဆိုရင် ဒီလိုပဲဖြစ်ရမှာပေါ့"လို့ ဖူးဖူးကလည်းပြောလိုက်ပါတယ်။ ဖူးဖူးရဲ့အိမ်လေးအနီးအနားမှာရှိခဲ့တဲ့ ဒီရေတောတွေအားလုံး ခုတ်လှဲခံရတယ်။ တစ်ပင်တစ်လေတောင် မကျန်တော့အောင် ပါပဲ။ သစ်ပင်တွေဟာ ဒီလိုကွဲပြားခြားနားမှုကြီးဖြစ်အောင် ဘယ်လိုများလုပ်နိုင်ခဲ့တာလဲဆိုတာကို သူမ အံ့သြနေမိပါတော့တယ်။

ဖူးဖူးဟာ အိမ်ကိုစိတ်လှုပ်ရှားစွာနဲ့ပြန်လာပြီး သူမရဲ့မိဘတွေကို "တကယ်လို့ သမီးတို့သာ ဒီရေတောတွေကိုပြန်စိုက်နိုင်မယ်ဆိုရင် သမီးတို့ ဘေးကင်းလိမ့်မယ်"လို့ ပြောပြလိုက်ပါတယ်။ ဒါပေမယ့်လည်း သူမရဲ့အဖေကတော့ "ဒီရေတောတွေကိုစိုက်နေရင် (၁၀)နှစ်လောက်ကြာမှ အမေတို့ တစ်ခြားဘေးကင်းတဲ့ နေရာတစ်ခုကိုပဲ ပြောင်းရမယ်"လို့ ပြန်ပြောလိုက်တယ်။ "ဟိုး" ဒီအချိန်မှာ ဖူးဖူးတွေးလိုက်တာက "ဒီရေတောတွေ ရှင်သန်ကြီးထွားဖို့ ဒီလောက်တောင် အချိန်အကြာကြီးလိုပေမယ့် လူသားတွေကတော့ အချိန်တစ်ရက်လေးအတွင်းမှာတင် သူတို့ကို ခုတ်ပစ်နိုင်ကြပါလား ..."တဲ့။



ဖူးဖူးနဲ့အတူ သူမရဲ့မိဘများ၊ သူငယ်ချင်းများ၊ အိမ်နီးချင်းများနဲ့ ရွာသူရွာသားအပေါင်းတို့ဟာ ဒီရေတောပင်တွေရဲ့

မျိုးစေ့လေးတွေ ရှင်သန်ကြီးထွားလာပြီး နောက်တစ်ကြိမ် နေထိုင်ဖို့အတွက် ဘေးကင်းတဲ့နေရာလေးတစ်ခု

ဖြစ်လာလိမ့်မယ်ဆိုတဲ့ မျှော်လင့်ချက်နဲ့ စိုက်ပျိုးခဲ့ကြပါတယ်။

(၁၀)နှစ်ကြာပြီးနောက် ...

ဖူးဖူးတစ်ယောက် အထက်တန်းကျောင်းသူကြီး ဖြစ်လာတဲ့အခါ ဒီရေတောပင်တွေဟာ သူမရဲ့အိမ်ဟောင်းလေးများအတစ်လျှောက် ရှင်သန်ကြီးထွားနေကြပါပြီ။ သူတို့ဟာ မြစ်ရေတွေတက်မလာနိုင်အောင်လည်း ကာကွယ်ပေးထားကြပါသေးတယ်။

သူမရဲ့မိသားစုဟာ သူတို့ရဲ့အိမ်ဟောင်းလေးကို ပြန်လည်ပြောင်းရွှေ့လာနိုင်ခဲ့ပြီး ဖူးဖူးလည်း သူမချစ်တဲ့ သာယာလှပသော ရေစီးသံလေးကိုနားထောင်ရင်း အိပ်ပျော်နိုင်ခဲ့ပါပြီ။

CHAPTER 4

CASE STUDY IN KANAN WATERSHED, PHILIPPINES

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4.1 INTRODUCTION

Land and forest degradation is one of the slow-onset events associated with climate change (UNFCC, 2012). It has been a major global issue during the 20th century and will remain high on the 21st century in the international agenda (Utuk and Daniel, 2015). Also, it is an issue for world food security and on the quality of the environment (World Meteorological Organization, 2005). In 2009, over 250 million people are directly affected by land degradation (United Nation Convention to Combat Desertification, 2009). Deforestation, mainly through conversion of forests to agricultural land, and other types of forest degradation remains the main driver of forest biodiversity loss. Other phenomena like climate change, natural disasters, forest fires, airborne pollution, forest fragmentation, invasive alien species also play a role in the loss of forest biodiversity (McAlphine, 2009).

Likewise, in the 21st century, climate change is one of the most pressing environmental concerns (IPCC, 2001). Climate change is seriously affecting forests through changes in temperature and rainfall resulting to changes in forest physiology, structure, species composition and health. Also, it places additional stress on people who are dependent on the forests for livelihoods and other ecosystems services (McAlpine, 2009). The impacts of climate change if not mitigated and appropriately adapted or coped with, are referred to as 'loss and damage' (Mathew and Akter, 2015). These include loss of nutrients and organic matter, salinization, acidification, pollution, compaction, and subsidence (Asio et al., 2009). Loss and damage is a result of insufficient ability to adapt to climate and that loss and damage is a real phenomenon with tangible consequences (Geest and Warner, 2015). Moreover, climatic change and variations are recognized as major factors contributing to land degradation affecting sustained development (World Meteorological Organization, 2005; Kumar and Das, 2014). Nevertheless, deforestation is said to have been the cause of the 20% annual greenhouse gas emissions in the 1990s (FAO, 2005; Millenium Ecosystem Assessment, 2005; IPCC Fourth Assessment Report, 2007).

In the Philippines, soil erosion, however, appears to be the most common cause of land degradation (Briones, 2010) which is aggravated by deforestation and cultivation of steep sloping lands. It is affecting the physico-chemical and biological properties of the soil, rendering the land unproductive for crop production (Aggangan, undated). In addition, unsustainable land management practices and human development over a period of time further cause land degradation (World Meteorological Organization, 2005). Agricultural practices and economic pressures have also severely degraded the agricultural resource base, associated with accelerated soil erosion, siltation of irrigation systems, flooding, and water pollution (Briones, 2009). Lasco et al. (2007) pointed out that shifting cultivation or "kaingin" is the most common land use of the watersheds in the Philippines followed by grazing and subsistence upland agriculture in areas that are generally located in slopes ranging from 0-50%. Due to extensive anthropogenic activities such as timber and non-timber product harvesting, wildlife poaching, increasing number of shifting cultivators and land conversion, significant number of hectares of forest have been lost.

The Philippine uplands are even more vulnerable to accelerated soil erosion primarily due to inappropriate land uses. Both land and forest degradation is a serious national environmental concern with long-term implications on the sustainability of agricultural production (Briones, 2010) and on efforts toward self-sufficiency (FAO, 2013). Forest degradation has contributed to economic and social problems (FAO (2011). It hampers food production and security at the field level as well as causes problems such as flooding and sedimentation at the national level. More so, at the global level, land degradation also contributes to the changing climate and to losses in biodiversity (Pagiola, 1999) thereby threatening the ecosystems' goods and services. As such, the welfare of many people who depend on agriculture and natural resources for their livelihoods are undermined (Pagiola, 1999).

Forests are increasingly threatened as a result of deforestation, fragmentation, climate change and other stressors that can be linked to human activities. Deforestation adversely affects agricultural productivity, human health as well as that of livestock, and economic activities such as ecotourism (http://unfccc.int/resource/docs /publications/forest_eng.pdf). More so, it is expected to have an impact on forest biodiversity as well as on the ability of forests to provide soil and water protection, habitat for species and other ecosystem services, including food, fodder, water, shelter, nutrient cycling, cultural and recreational value (http://unfccc.int/resource /docs/publications/forest_eng.pdf).

Thus, reducing vulnerabilities, impacts, disaster risks and enhancing resilience associated with the adverse effects of climate change including the impacts related to extreme weather events and slow onset events like land and forest degradation is the key to minimizing losses and damages.

On the third Year 3 of the research project, this study specifically attempted to:

1. Identify the causes and effects of land and forest degradation in the study area;
2. Examine the household vulnerability to land and forest degradation;
3. Examine the cascading effects/risk of land and forest degradation associated with climate change;
4. Determine the losses and damages of land and forest degradation associated with climate change in multiple sectors;
5. Model flood regulation service quantification;
6. Assess the adaptation strategies to land and forest degradation associated with climate change; and
7. Identify program and policy as well as entry points for mainstreaming CCA and DRR in local development plans.

4.2 APPROACH

4.2.1 Study area

This case study was conducted in Kanan Watershed, Municipality of General Nakar, Province of Quezon, Philippines (Figure 4.1).

General Nakar is one of the Philippine municipalities at the northernmost part of Quezon province, belonging to Region 1V-A, in the eastern part of Luzon Island. The town is bounded on the south by Dingalan (Aurora), southeast by Doña Remedios Trinidad, Bulacan, north by Real and Infanta, Quezon, and on the east by Rodriguez, Antipolo City, Tanay (Rizal), and Norzagaray (Bulacan). It faces the Pacific Ocean, Polillo Straight and Lamon Bay on the eastern side, and its western boundary embraces the Sierra Madre Mountains. It lies between $121^{0}15'$ and $121^{0}38'$ east longitudes and $14^{0}34'$ and $15^{0}13'$ north latitudes. The municipality has a total land area of 161,769 ha of which 151,342 ha are classified as forest lands, and only 10,437 ha or six percent (6%) are agricultural lands or lands classified as alienable and disposable (A&D).

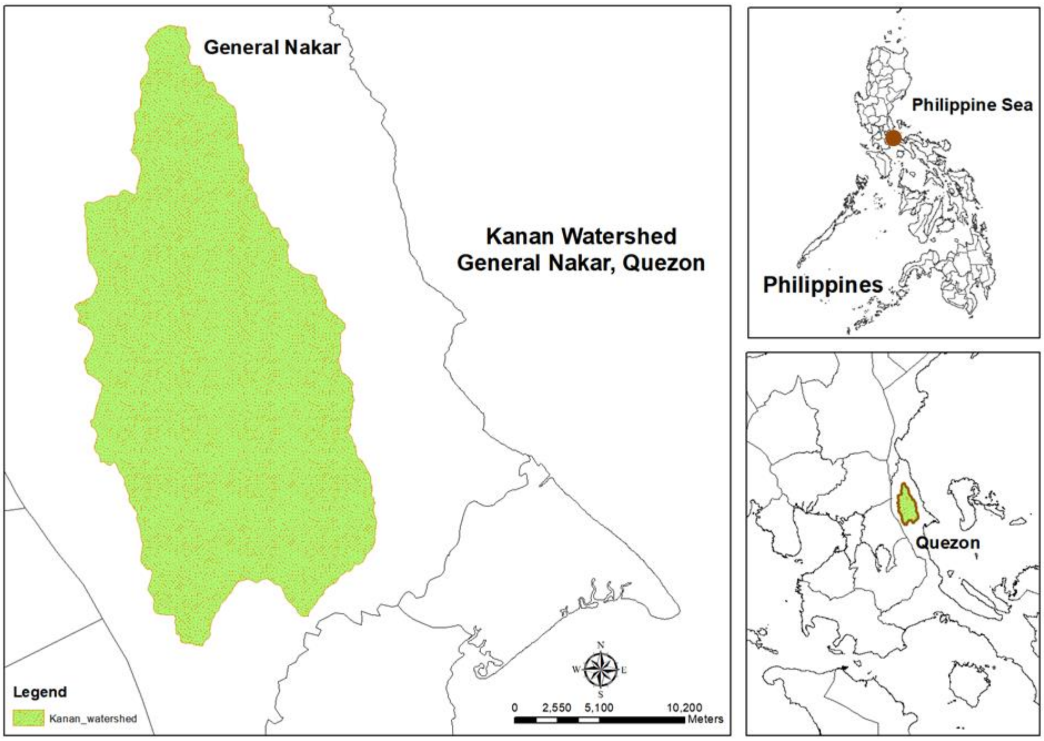


Figure 4.1. Location map of the study site

The municipality of General Nakar is a first class and the biggest municipality in the Province of Quezon. It has the largest tract of forest accounting for almost ninety four percent (94%) of its total land area. Its climate is marked by the absence of a dry season with a very pronounced maximum rainfall during the months of November to January. Typhoons and tropical depressions batter the region between May and December of each year (Wernstedt and Spencer, 1967; Philippine Atmospheric, Geophysical and Astronomical Service Administration, 2005 as cited in Gaillard et al., 2007).

General Nakar has one of the most biodiversity-rich mountain ranges in the country, but is under threat of illegal forest products extraction (Forest Land Use Plan, 2010). The Conservation International-Philippines, Department of Environment and Natural Resources (DENR), and Haribon Foundation, (2006) highlighted that a large part of the Mt. Irid-Angelo, of the southern Sierra Madre Mountains, is considered a key biodiversity area (KBA: #18 or Mt Irid-Angelo Binuang, and Candidate KBAs: C12, C13, C14) for conservation under the international Convention on Biological Diversity. Also, Mt Irid-Angelo Binuang is one of the 117 Important Bird Areas (IBAs) for conservation in the Philippines.

Topography of General Nakar is characterized by rugged and mountainous terrains with few plain areas as well as narrow coastal terraces along river banks. Its slope is characterized as steep (30-50%) to very steep slope (50% and above) as shown in Figure 4.2.

Based on the 2015 population census, General Nakar has 19 barangays and is the home of 29,705 people (Philippine Statistics Office, 2016).

Land and forest degradation is visible in the study area (Figure 4.3) which represents the typical watershed in the Philippines having threats of illegal forest products extraction and pressure from increasing human activities. Its flora and fauna are threatened by disruption and fragmentation of their habitat, forest lands converted to upland agriculture, increasing slash and burn cultivation brought about by migration, small-scale illegal extraction of timber, charcoal production, and small-scale mining which is becoming rampant (FLUP, 2010)

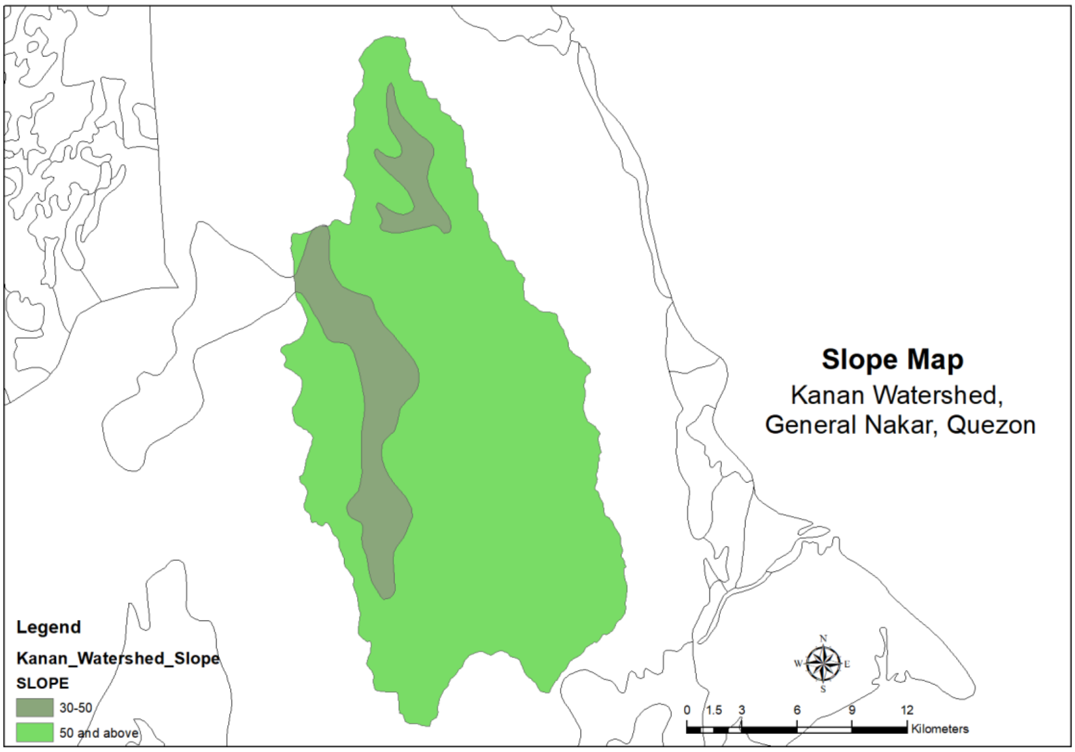


Figure 4.2. The slope map of the study area

Figure 4.3. Landscape of the Kanan Watershed in the Municipality of General Nakar, Quezon Province, Philippines

There are 16 watersheds within the provincial territory of Quezon, of which four, namely: Agos, Kaliwa, Kanan, and Umiray, supply water for domestic and irrigation purposes of neighboring municipalities and even Metro Manila (FLUP, 2010). The focus of the case study is in the Kanan watershed which is less explored and with limited project interventions but considered as the highest priority for development interventions followed by Umiray Watershed, Kaliwa Watershed, then the Agos- Nakar Watershed (Figure 4.4).

Figure 4.4. Watersheds in General Nakar, Quezon Province

Kanan watershed covers a total land area of 40,535 ha comprising of only two barangays, namely Pagsangahan and Mahabang Lalim and 35 rivers/tributaries (Figure 4.5). It has a forestland area of 38,882 ha or about 96% while the A&D land is only 1,652 ha or 4%. Likewise, the study area is a disaster-prone area. It is situated along the Agos River, lying at the foot of the Sierra Madre Mountain and stretches along the Pacific Ocean. The municipality and the surrounding communities are always exposed to threats like flash floods, mudslides and landslides exacerbated by strong typhoons. For example, the flash flood that occurred in November 2004 resulted to unimaginable loss of lives, properties and damages to agriculture, livestock and infrastructure (Garcia, Undated; Social Action Center, 2014). Various vulnerabilities aggravate exposure to acute hazards due to its geographic location. There is also the need to contend with conditions in the ecologically, economically and politically fragile environment (Garcia, undated).

Watersheds are very important to human beings. Aside from serving as source of water, they provide different ecosystem services including recreational opportunities and aesthetic beauty. Watersheds can deliver numerous benefits to people if they are well protected and managed. Thus, there is a need to look at the status of the Kanan Watershed and its inherent vulnerabilities, the intervention efforts/activities and adaptive measures that were and are currently being undertaken by the local communities, national agencies, local government units (LGUs) and non-government organizations to combat disasters and the different land and forest degradation interventions.

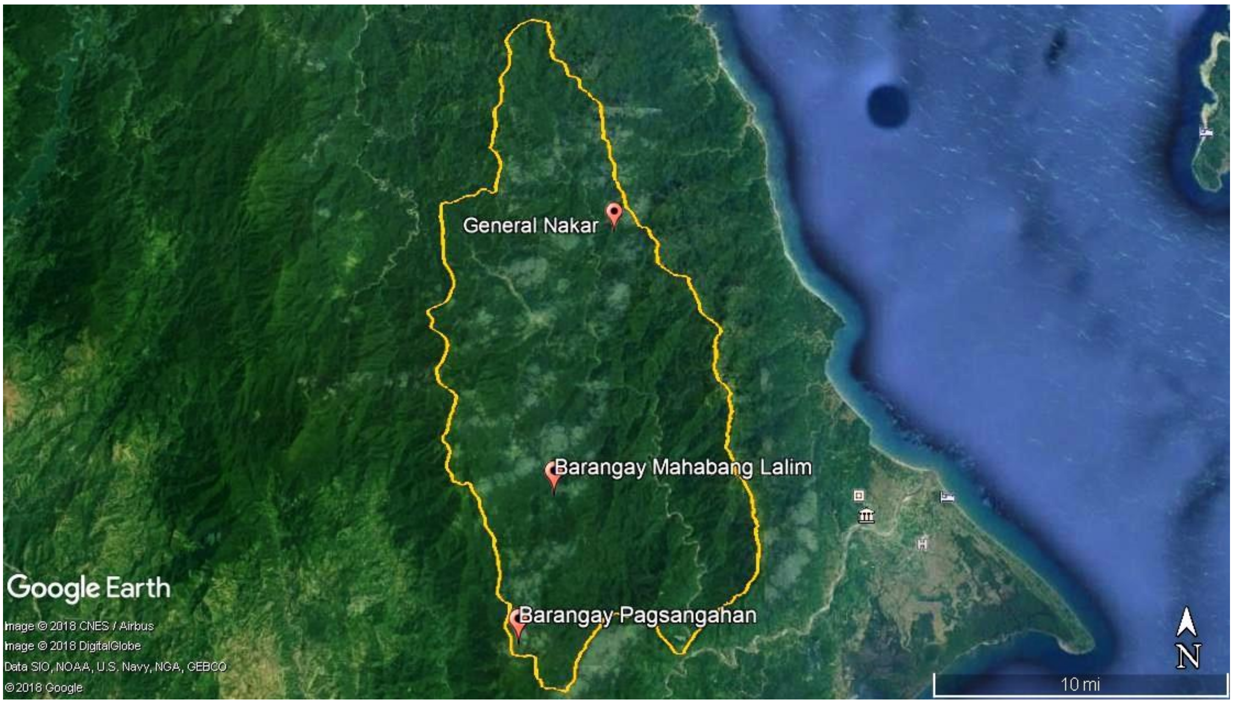


Figure 4.5. Kanan watershed with its covered barangays

4.2.2 Socio-economic profile of respondents

The socio-economic profiles of the residents in the two barangays in the Municipality of General Nakar, Quezon Province, namely Barangay Mahabang Lalim, and Barangay Pagsangahan are shown in Table 4.1. The results were based from 189 survey respondents with 56 (29.6%) of the respondents coming from Barangay Mahabang Lalim while 133 (70.4%) are from Barangay Pagsangahan.

Majority of the interviewed respondents for both barangays are female with 69.6% in Mahabang Lalim and 63.9% in Pagsangahan. In terms of civil status, most are married with 68.5% in Mahabang Lalim and 87.2% in Pagsangahan.

For educational attainment, in Mahabang Lalim about 1.8% of the respondents are college graduates, 7.1% are graduates of technical /vocational education while 5.4% are undergraduates in college. Many are undergraduates in elementary (23.2%) and only 17.9% have completed elementary education. There are also respondents who completed secondary level education (23.2%) or are high school undergraduates (16.1%). Around 1.8% of the respondents did not have formal education. Meanwhile, majority of the respondents in Pagsangahan are undergraduates in elementary (27.1%), followed by those who completed elementary education (23.3%). There are also a number of respondents who went to secondary level education (18% graduates and 15% undergraduates). Only a few reached the college level with 5.3% being undergraduates while 1.5 % are college graduates. Some took technical/vocational education vocational courses (3%). Similarly, there are respondents who have not undergone any formal education (6%).

In Barangay Mahabang Lalim, there are 23.2% of the respondents who are currently availing the Bridging Program for the Filipino family termed as "conditional cash transfer program" of the Philippine government under the Department of Social Welfare and Development also known as "Pantawid Pamilyang Pilipino Program" (4Ps). In Barangay Pagsangahan, only 21.9% availed of the 4Ps. For both barangays, majority (60.32%) have a monthly household income of PhP 5,000 and below. Only a few respondents (5 or 2.65%) have an income of above PhP 20,001. This means that in terms of income, many of the interviewed respondents are below the Philippine poverty threshold. Still, only a few who are in need of financial help gained benefits from the 4Ps.

Table 4.1. Profile of the respondents

Characteristics	Barangay Mahabang Lalim		Barangay Pagsangahan		Total	
	n	%	n	%	N	%
Gender						
Male	17	30.4	48	36.1	65	34.4
Female	39	69.6	85	63.9	124	65.6
Total	56	100	133	100	189	100
Civil Status						
Single	10	18.5	6	4.5	16	8.5
Married	38	68.5	116	87.2	154	81.5
Widow/Widower	7	11.1	6	4.5	13	6.9
Separated	0	0	3	2.3	3	1.6
No answer	1	1.9	2	1.5	3	1.6
Total	56	100	133	100	189	100
Educational Attainment						
None	1	1.8	8	6	9	4.8
Undergraduate Elementary	13	23.2	36	27.1	49	25.9
Elementary Graduate	10	17.9	31	23.3	41	21.7
Undergraduate High School	9	16.1	20	15	29	15.3
High School Graduate	13	23.2	24	18	37	19.6
Tech-Voc Graduate	4	7.1	4	3	8	4.2
Undergraduate College	3	5.4	2	1.5	5	2.6
College Graduate	1	1.8	7	5.3	8	4.2
Post College Graduate	0	0	0	0	0	0
No answer	2	3.6	1	0.8	3	1.6
Total	56	100	133	100	189	100
Lived in the place since birth						
Yes	40	71.4	62	46.6	102	54
No	16	28.6	71	53.4	87	46
Total	56	100	133	100	189	100
4Ps						
Availed	13	23.2	29	21.80	42	22.22
Not availed	43	76.8	104	78.20	147	77.78
Total	56	100	133	100	189	100
Monthly income (PhP)						
5,000 and below	24	42.86	90	67.67	114	60.32
5001-10,000	15	26.79	34	25.56	49	25.93
10,001-15,000	6	10.71	1	0.75	7	3.70
15,001-20,000	6	10.71	0	-	6	3.17
20,001 and above	1	1.79	4	3.01	5	2.65
No answer	4	7.14	4	3.01	8	4.23
Total	56	100	133	100	189	100

Majority of respondents (94.17 %) in both barangays have farming as are their main source of living. The rest are government employees (i.e. teachers), painters, welders, and waged laborers, construction workers, with local business enterprise, The Citizen Armed Force Geographical Unit (CAFGUs) or barangay tanod/officials and considered farming as their secondary livelihood source. There are senior citizens (34.9%) interviewed and are receiving monthly pension.

4.2.3 Land use and changes

The dominant land use that increased over time was closed forest land and inland water (Table 4.2 and Figure 4.6). For example, closed forest increased by 10% from 1988 to 2003 and almost 70% from 2010 to 2015. On the other hand, open forest decreased by 26% from 1988 to 2003 and 77% from 2010 and 2015. Inland water also increased its coverage by 12,336% from 2003 to 2010. This may be the effect of strong typhoons (e.g., Yoyong in 2004) that hit the Quezon Province which inundated low lying areas or scoured river banks.

Table 4.2. Land use/land cover changes of the landscape of Kanan Watershed: 1988-2015

LULC Class	Area coverage (ha)				Cover change between periods (%)			
	1988	2003	2010	2015	1988-2003	2003-2010	2010-2015	1988-2015
Open forest	9,822.61	7,279.15	17,938.15	4,079.94	-25.89	146.43	-77.26	-58.46
Closed forest	28,185.62	31,028.43	20,341.78	34,545.79	10.09	-34.44	69.83	22.57
Annual crop with	1,152.60				-	-	-	-
brushland/grassland								
Shrubs		376.81			-	-	-	-
Wooden grassland		290.02			-	-	-	-
Annual crop		177.64		120.61	-	-	-	-
Inland water		7.08	880.89	408.16	-	12,335.72	-53.67	-
Grassland				4.63	-	-	-	

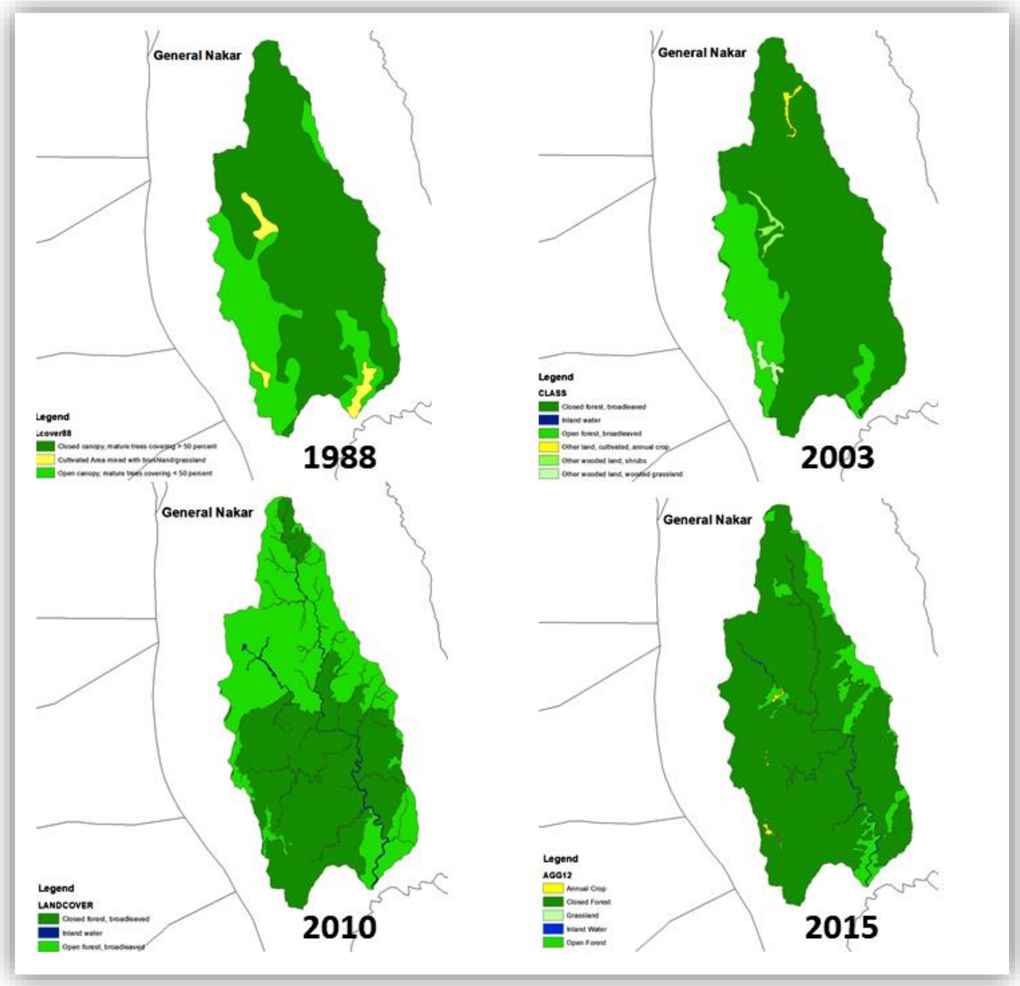


Figure 4.6. Land use/land cover data (1988, 2003, 2010 and 2015) of Kanan Watershed, General Nakar, Quezon

Source: NAMRIA

Table 4.3 shows the land use/land cover structure and its change in Kanan Watershed over a four-year series. Closed forest land is the primary land use/land cover type in the LULC structure and accounted for 50% to 88% of the total watershed over time. The positive trend observed implies that this land class has played an important role in environmental and socio-economic development of the watershed. The relative change rate of closed forest during 1988-2015 was 23% while open forest decreased by 58%, indicating significant change in forest land area. Such changes are characterized by its pattern and distribution.

Table 4.3. Structure and changes in land use/land cover of Kanan Watershed: 1988, 2003, 2010 and 2015

LULC Class	**1988**		**2003**		**2010**		**2015**		**Relative Change (%)**
	Area (Ha)	**%**	**Area (Ha)**	**%**	**Area (Ha)**	**%**	**Area (Ha)**	**%**	
Open forest	9,822.61	25.08	7,279.15	18.59	17,938.15	45.81	4,079.94	10.42	-58.46
Closed forest	28,185.62	71.97	31,028.43	79.24	20,341.78	51.94	34,545.79	88.22	22.57
Annual crop with	1,152.60	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00

brushland/grassland									
Shrubs	0.00	0.00	376.81	0.96	0.00	0.00	0.00	0.00	0.00
Wooden grassland	0.00	0.00	290.02	0.74	0.00	0.00	0.00	0.00	0.00
Annual crop	0.00	0.00	177.64	0.45	0.00	0.00	120.61	0.31	0.00
Inland water	0.00	0.00	7.08	0.02	880.89	2.25	408.16	1.04	0.00
Grassland	0.00	0.00	0.00	0.00	0.00	0.00	4.63	0.01	0.00

Source: NAMRIA

4.2.4 Research design

Courtesy Visit. Prior to conducting the Year 3 research study, a courtesy visit to the municipal local government units of General Nakar was done. A letter requesting permission for the conduct of household survey was also given.

Household survey was conducted involving 56 heads of the household as respondents from Barangay Mahabang Lalim and 136 respondents from Barangay Pagsangahan (total of 189 respondents). The number of respondents was computed following the formula given in Equation 1. It employed stratified random sampling with proportional allocation. It was complemented with secondary data and field observations.

Equation 1

$$n = \frac{N*P}{P*CV^2\,(N-1)+Q} = \frac{585*0.05}{0.50*0.06^2(585-1)+0.50}$$

Where:

n = sample size

N = household population (*585*)

CV = coefficient of variation (set to 0.06)

P = proportion of households who are vulnerable (set to 0.5)

Q = 1-P

n = 189 households (sample size)

Modelling was also undertaken using three (3) scenarios such as (1) water influx per scenario; (2) flood modelling using cellular-automata technique; and (3) GIS-based flood risk and damage cost quantification.

Household vulnerability to land and forest degradation associated with climate change was assessed based on two parameters such as biophysical and socio-economic factors. Each parameter has indicators. Eight indicators were used in assessing the level of vulnerability of household to land and forest degradation (Table 4.4). These indicators under biophysical index include slope of the farm, vegetation cover, type of farming system, adoption of contour farming, and climate extreme event experienced (e.g. landslide and or soil erosion). Meanwhile, socio-economic indices are household size, literacy/ education, and anthropogenic activities such as mining, deforestation, charcoal making, shifting cultivation, etc.

The overall household vulnerability rating to land and forest degradation was assessed using two approaches for purposes of comparison. First, average of the six indicators was obtained using equal weights for each variable (Table 4.5). Second, weights per indicator were assigned based on the researchers' judgement and according to its influence and understanding on the situation in the study area. Indicators and sub-indicators were normalized for aggregation purposes (Equation 2). The normalized values fall within the range of 0.00 to 1.00. The values close to 1 imply high vulnerability to land and forest degradation while 0 imply not vulnerable.

Equation No.2 …………………………….. $y = \frac{Max\ (X_1) - X_1}{Max\ (X_1) - Min\ (X_1)}$

Where: y - normalized value

$\boldsymbol{X_i}$ - value of the observation

Min{ X_i ***}*** - minimum value for all observations

Max{ X_i ***}*** - maximum value for all observations

The level of household vulnerability was computed by simply getting the average of normalized values of indicators and categorized into: not vulnerable, slightly vulnerable, moderately vulnerable, and very vulnerable to land and forest degradation associated with climate change.

Table 4.4. Vulnerability indicators to land and forest degradation and its corresponding weights

Parameters	Indicators	Remarks
Biophysical pressures	Slopes on the farmland	1 – Flat (low land rice) 2 – Gentle slopes 3 – Moderate 4 – Steep (30-50) 5 – Very Steep (50 and beyond)
	Vegetation/Land cover	derived from satellite images
	Type of Farming system	1 –Mix cropping/integrated/agroforestry 2 – Monocropping
	Adopted contour farming	1 – Yes 2 – No
	Climate related extreme events (e.g. heavy rainfall, intense heat, landslide, flashflood, typhoon)	Frequency of occurrence in terms of: 1 - Never Experienced 2 - Rarely (Beyond Five Years) 3 - Sometimes (Every 4- 5 Years) 4 - Often (Every 2-3 Years) - Always (Every Year) b. Degree of effect Low: 2 - medium and 3 - high
Socio-economic pressures	Household size	(1 to 2 household members) (3-4 household members) (4-6 household members) (7 and beyond household members)
	Literacy/education	1 – Post graduate level 2 – College graduate 3 – Undergraduate college 4 – Technical vocational graduate 5 – High school graduate

		6 – Undergraduate high school 7 – Elementary graduate 8 – Undergraduate elementary 9 – None
	Anthropogenic activities that caused to land and forest degradation (mining, cutting of trees, charcoal making, shifting cultivation, cultivating on a very steep slopes) and observed/experienced soil erosions/siltation, declining crop productivity, unproductive soil/infertile	If these activities were observed/experience and degree of experienced in terms of low, medium and high

Table 4.5. Weight distribution to each parameter/indicator

Index/parameter	**Indicators**	**Weight distribution**	
		Equal weights	Relative weights (Expert judgment)
Biophysical factors	Slope of the farm	12.5	15
	Vegetable/Land cover	12.5	15
	Type of farming system	12.5	10
	Adopted contour farming	12.5	10
	Climate related extreme events experienced	12.5	15
Socio-economic factors	Household size	12.5	10
	Literacy/education	12.5	10
	Anthropogenic activities	12.5	15
Total (%)		100	100

4.3. RESULTS

4.3.1 Causes and effects of degradation

During the focus group discussion conducted on August 17, 2016, the participants were asked if land and forest degradation is an issue in their communities. All of the participants relayed that this type of slow onset event was observed in the community. Land and forest degradation results from a number of interacting processes which include the climatic and human factors. With this, the participants came up with the problem tree analysis of land and forest degradation (Figure 4.7). Poverty or having low income is the main cause of land and forest degradation. This leads to illegal logging and kaingin system due to weak governance and lack of livelihood opportunities. Likewise, poverty leads people to migrate to neighboring municipalities to seek employment or look for alternative sources of income such as poaching or catching of wildlife and harvesting of non-wood products such as rattan. Poverty also prevents the farmers from sending their children to school.

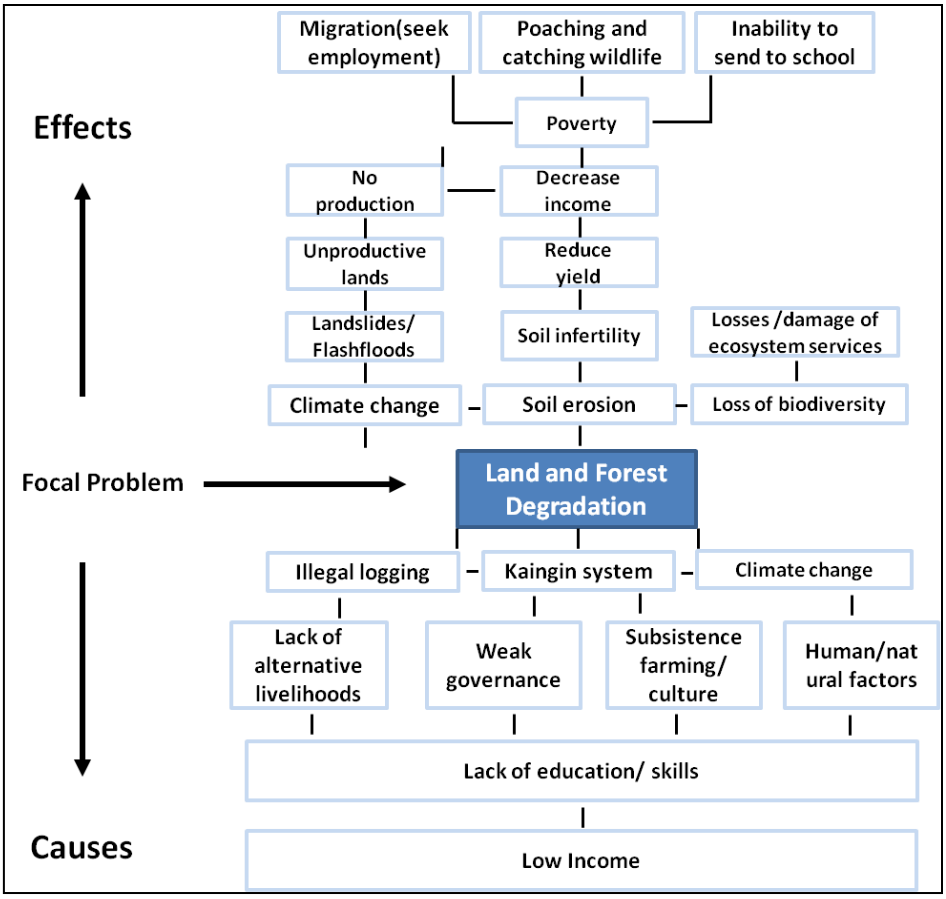


Figure 4.7. The cause and effect diagram of land and forest degradation identified by the participants during the focus group discussion conducted last August 17, 2016 in Kanan Watershed, General Nakar, Philippines.

The Forest Land Use Plan (FLUP) for 2010-2016 also highlighted the primary causes of forest degradation which include free access to forest lands, limited assets for sustained livelihood, population pressure, increased migration to forest lands, and weak implementing institution. On the other hand, secondary causes include inappropriate land uses, conversion of forest lands to other uses, ineffective on-site management of tenured and allocated areas, excessive logging without accountability to restore opened areas, illegal and inappropriate extraction of forest products, and weak law enforcement. Thus, the persistence of these issues continues to threaten the remaining forest and its sustainability thereby feeding the cycle of poverty and environmental deterioration. The growing population within and in adjacent communities and the increasing migrants from neighboring towns and regions, further intensify the pressure on forest lands. Present estimates of population within forest lands range from 35%-44% of the total population of the municipality General Nakar.

4.3.2 Household vulnerabilities

Overall vulnerability of households' livelihoods was assessed using equal and unequal weighting methods. The mean indices based on equal weighting ranged from 0.24 to 0.43 which implied that the households' livelihoods fall between low to moderate degrees of vulnerability. No household was categorized as having high vulnerability. On the other hand, with unequal weighting, the mean indices ranged from 0.25 to 0.68 which indicated low to high vulnerability (Table 4.5). The equal weighting has an overall mean of 0.41 and 0.35 for unequal weighting.

Table 4.6. Mean vulnerability indices based on equal and unequal weighting

LEVEL	NUMERICAL RATING	MEAN VULNERABILITY INDICES	
		Equal weights	Unequal weights
Low	0.00 - 0.33	0.24	0.25
Medium	0.34 - 0.66	0.43	0.39
High	0.67 - 1.00		0.68
Over-all mean		**0.41**	**0.35**

*Legend: (0.00-0.33 – Low); (0.34-0.66 – Moderate); (0.67-1.00 – High)

Based on equal weighting, in general, majority (73.02%) of the household respondents in Kanan Watershed were moderately vulnerable. Of these, 87.97% came from Barangay Pagsangahan and only 37.5 % were from Barangay Mahabang Lalim. There are 26.46% respondents categorized as having low vulnerability to land and forest degradation associated with climate variability and change and majority of them came from Barangay Mahabang Lalim. Only one (1) respondent was categorized as having high vulnerability and came from Barangay Pagsangahan (Table 4.7).

Table 4.7. Level and percentage of households' livelihood vulnerability using equal weighting

Barangay/no. of samples	Level* and Percentage		
	Low	**Medium**	**High**
Mahabang Lalim (n= 56)	62.5	37.5	0
Pagsangahan (n=133)	11.28	87.97	0.75
Total (N = 189)	**26.46**	**73.02**	**0.53**

*Legend: (0.00-0.33 – Low); (0.34-0.66 – Moderate); (0.67-1.00 – High)

The vulnerability of households' livelihood using unequal weighing through expert judgement method also showed that majority (59.79%) of the respondents were moderately vulnerable, in which most (81.20%) of them came from Barangay Pagsangahan, while 40.21% were categorized as low vulnerable with the majority (91.07%) coming from Mahabang Lalim. No respondent was categorized as having high vulnerability to land and forest degradation associated with climate variability and change (Table 4.8).

Table 4.8. Level and percentage of households' livelihood vulnerability using unequal weighting

Barangay/no. of samples	Level* and Percentage		
	Low	**Medium**	**High**
Mahabang Lalim (n= 56)	91.07	8.93	0
Pinagsangahan (n = 133)	18.80	81.20	0
Total (N = 189)	**40.21**	**59.79**	**0**

*Legend: (0.00-0.33 – Low); (0.34-0.66 – Moderate); (0.67-1.00 – High)

Results for both methods used (equal and unequal) showed that households vulnerability to land and forest degradation associated with climate change fall into low to moderate vulnerabilities with the majority, however, are moderately vulnerable. The findings suggest that proactive interventions such as awareness campaign on the importance of the Kanan watershed, policies related to kaingin, shift in farming system from monocropping to integrated farming should be strengthened to avoid another worse case scenario like the November 2004 tragedy. Climate extreme events threaten the forest, land and the surrounding communities. For instance, intense rainfall leads to erosion in the rice fields/farms, siltation of the river and bank erosion. Also, one month of intense heat experienced by the community dried up their water source was also mentioned as one of their sources of vulnerabilities to land and forest degradation.

According to Social Action Center (2014), barangays along the Agos river are highly vulnerable to flashflood/flooding. Also, General Nakar is dominated by moderately to very steeply-sloped ridges, thus, this condition and setting made the barangays in the municipality highly susceptible to landslide (DENR-MGB, 2011).

As disasters hit degraded ecosystems including deforested areas, more pressure is exerted on jobs and the economy, thereby, increasing the social vulnerability of poor communities (World Bank, 2013). Also, disasters related to climate- risks such as landslides, floods, mudslides, storm surges during typhoons, will result to losses and damages to property, territory, lives and livelihoods. Increasing population further increases the vulnerability of communities in the upland, lowland, coastal and swamp areas. Also, El Niño occurrences cause drought which poses a serious problem in all sectors (agriculture, forest, water, etc).

4.3.3 Cascading effects and risks

Some impacts of land degradation have both on-site and off-site effects and risks. On-site effects are the lowering of the productive capacity of the land, causing either reduced outputs (crop yields, livestock productivity) or the need for increased inputs. Off-site effects occur through changes in the water regime, including decline in river water quality, and sedimentation of river beds and reservoirs. Another main off-site effect is over blowing, or sand deposition (FAO, 1994). Also, deforestation disrupts watershed processes, including the infiltration of precipitation into soils. During periods of limited rainfall, soils dry out such that subsequent heavier rainfall results in greater and more rapid runoff, thereby increasing flooding and erosion. These processes reduce the productivity of the land, resulting in declining food production. Sediments and pollutants carried by heavy runoff are deposited to downstream water bodies, impairing water quality and leading to overbank flooding. In coastal areas, the increased siltation of river deltas from upstream erosion, together with the destruction of mangroves, reefs and other natural breakwaters, has increased exposure to storm surges and seawater intrusion into coastal aquifers (UNFCC, 2012).

Likewise, land and forest degradation has direct and indirect impacts/cascading risks to the people and to the communities in general. Direct cascading risks as identified by the participants include soil erosion, loss of biodiversity and changing climate. Soil erosion causes soil infertility resulting to reduced crop yields and less income which ultimately leads to increased poverty. Additionally, loss of biodiversity affects the ecosystem services including regulating, provisioning, cultural and supporting. Moreover, changing climate also increases poverty rate in the communities especially during landslides and flash floods events resulting from strong heavy rains which indirectly make the land less productive or unproductive.

The FGD participants relayed their experience when they were hit by great flashfloods and landslides that occurred in November 2004 caused by the typhoon. Flood waters washed out fertile soils, caused damages to farm roads, houses and several other infrastructures, loss of love ones and relatives and damages to livelihoods sources such rice fields, livestock and properties. Also, flood waters contaminated the local supply of drinking water leading to increased cases of waterborne-diseases and caused siltation of the river. The incident also created fears among residents of the communities (Table 4.9).

Table 4.9. Risk events/sources of vulnerabilities related to climate change hazards experienced in the study area which was aggravated by typhoon

Inherent vulnerabilities / Risks events	Rank	Cascading effects/risks
Flash floods/Floods	1	Denuded forests, washed out top fertile soils, damages to farm roads, houses and several other infrastructures , loss and damage to livelihoods sources (e.g. rice fields), death of livestock, flood waters contaminated the local supply of drinking water leading to water borne-diseases, siltation in the river, created fear and even loss of love ones and relatives
Landslides	2	Roads and houses were buried, reduction in the number of fishes being caught in the river, stream bank erosion and created fear
Intense rainfall	3	Siltation in the river and stream bank erosion
Intense heat	4	Dries up the irrigation/sources of water

Moreover, during the conduct of household survey, 95% (180) of the respondents relayed that heavy rainfall and typhoons are the climate extreme events experienced by the communities. Of which, 60% of the household respondents mentioned that their house roofs were uprooted and to some (50.3%) their whole house was destroyed due to typhoons especially during Typhoon Rosing (Typhoon Angela). Likewise, their planted crops were devastated and the people found it difficult to go to town due to bad road condition.

4.3.4 Loss and damage of land and forest degradation

In the field of climate change adaptation and disaster risk reduction, loss and damage is a new emerging concept (der Geest and Warner, 2015). The UNFCCC defined loss and damage concept as one of the "impacts associated with climate change in developing countries that negatively affect human and natural systems" (UNFCCC, 2012). Moreover, the Loss and Damage in Vulnerable Countries Initiative (LDVCI), defined loss as the negative impacts that cannot be repaired or restored (such as loss of geological freshwater sources related to glacial melt or desertification whereas damage was defined as the "negative impacts that can be repaired or restored (such as windstorm damage to the roof of a building)." Loss and damage is basically linked to mitigation and adaptation to climate change impacts and is categorized as avoidable through mitigation and adaptation, unavoidable through inadequate mitigation and adaptation efforts or unavoidable when loss and damage results are inadaptable (Verheyen, 2012 as cited in Suarez, 2015). Therefore, loss and damage is a result of insufficient ability to adapt to climate and that loss and damage is a real phenomenon with tangible consequences (der Geest and Warner, 2015).

The losses and damages can be further differentiated into economic loss and non-economic loss. Economic losses can be understood as the loss of resources, goods and services that are commonly traded in markets. On the other hand, non-economic losses is the remainder of items that are not economic; that is to say, that non-economic items are those that are not commonly traded in markets (Fankhauser et al., 2014).

During the FGD, the participants also identified some of the economic and non- economic losses and damages as a result of land and forest degradation associated to climate change (Table 4.10). Economic losses include decline in crop harvest by 30%, reduced in fish catch in the river, loss of soil fertility due to soil erosion leading to low crop yields, decrease in water flow due to a month-long intense heat and loss of livelihood sources such as planted rice crops, coconuts and livestock. Meanwhile, economic damages due to land and forest degradation include reduction of land area, damage to river, and damage to livelihood sources including the rice field areas. Non- economic losses include migration due to loss of livelihood sources leading to drop in labor force. Meanwhile, non-economic damage brought by land and forest degradation was the fear created among the communities.

Result of household survey showed that 50.3% (95 households) mentioned that destruction of houses was one of the major economic losses of land and forest degradation associated to climate change. The cost of losses ranged from PhP 10,000 to PhP200,000. This economic loss was due to typhoon that hit the area especially during the 2004 tragedy. Likewise, some (51.3% of the respondents) relayed that their planted crops were lost including their working animals like carabao. Household kitchen utensils and appliances such as TV, radio or karaoke set were also lost.

The decline in crop productivity was mentioned by the majority (86.2%) as result of land and forest degradation. Many of respondents (57%) mentioned that landslide in their respective farms or within the community were observed. Effects on health by extreme events were also reported. Among the respondents interviewed, there were eight family members who died because of the 2004 tragedy.

Table 4.10. Losses and damages identified by FGD participants as a result of land and forest degradation associated with climate change

	Losses	**Damages**	**Remarks**
Economic	Declined in crop harvest by 30% Reduced in fish catch in the river Loss of soil fertility leading low crop yields Decreased water flow due to intense heat Loss of livelihood sources	Reduction of land area Damage to river Damage to livelihood sources (rice field areas)	• For 17 kg seeds, the harvest before was 10 bags at 50kg/bag. Now, decrease to 5-6 bags • From 14 ha to 8.16 ha due to landslide caused by flood water
Non-economic	Migration due to loss of livelihood sources leading to drop in labor force	Created fear caused by disasters	

The World Meteorological Organization (2005) highlighted the losses and damages of land degradation associated with climate change are undermining of food production, famine, increased social costs, decline in the quantity and quality of fresh water supplies, increased poverty and political instability, reduction in the land's resilience to natural climate variability and decreased soil productivity.

Also, according to Gilliard et al. (2007) and Social Action Center 2006 as cited by Garcia (undated), the vulnerability to hazards/disasters such as flashflood, landslides and mudslides in the late 2004 coupled with land and forest degradation practices among the communities in the province of Quezon particularly in the municipalities of General Nakar, Infanta and Real resulted to major losses and damages to various sectors such as community/people sector, infrastructure, agriculture, forestry and coastal sectors. For example, the calamity that occurred in late 2004 brought heavy losses and damages to people's lives and their families. About 1,462 persons were confirmed dead while about 135,000 individuals had been displaced (Social Action Center, 2006 cited by Garcia, A. undated and Social Action Center 2014). There were 553 missing persons and 1,163 persons were injured (Gilliard et al., 2007). The number of families affected were about 12,007 in General Nakar, 1,067 in Infanta, and 5,786 families in Real (National Disaster Coordinating Council (2004) cited by Gilliard et al., 2007).

Accordingly, the municipality of Infanta was the hardest hit by the tragedy (Gilliard, et al., 2007). However, based on personal communication dated January 30, 2015 with Forester Jing F. Astejada, the Municipal Environment and Natural Resources Officer (MENRO) of General Nakar, his municipality (General Nakar) was the most devastated by the calamity. Remote and far flung communities affected were inaccessible and thus, communications and reports were limited.

Moreover, the said calamity resulted to losses and damages to physical infrastructures. Gilliard et al. (2007) indicated that churches, school buildings, and houses, among others, were submerged in muddy waters, while bridges collapsed and roads were washed out. Irrigation facilities were destroyed and telephone lines were down. The National Disaster Coordinating Council (2004) as cited by Gilliard, et al. (2007) reported that there were a lot of destroyed houses. Around 5,087 destroyed houses were reported in Infanta, 1,638 in Real and 3,116 houses in General Nakar. The four tropical depressions and typhoon events in late 2004 had an estimated amount of USD 23.6 million worth of damages.

In the same manner, the forestry sector was also affected by the calamity. Large quantities of logs and uprooted trunks were observed cascading down the Agos River which clogged below the Infanta-General Nakar Bridge thereby forcing the river to overflow massively and to divert toward abandoned channels of the floodplain (Gilliard et al., 2007). Timbers, logs and uprooted trees accounted for about 4 to 5 million cubic meters, affecting about 74% of the area or 188,332 has out of the 255,501 has of land (Social Action Center, 2014).

It is projected that if the current trend of forest destruction continues, irreversible damages like loss of biodiversity, more severe environmental disasters, decline in livelihood, displacement of indigenous communities and decline in productivity of both the upland and lowland areas, will follow. Thus, protection of the resource base has become a policy priority, whether in terms of improving crop management in the lowlands or more urgently, arresting soil erosion in the uplands (Briones, 2010).

Moreover, logs deposited by floodwaters on the seashore (Gilliard et al., 2007) and about 20,000 metric tons of mountain soils were brought down to Real, Infanta, and General Nakar in the province of Quezon and Dingalan in Aurora. The consequence of forest erosion is the siltation of Agos River, affecting the families in the area (Social Action Center, 2014).

Israel and Briones (2012) indicated that silts and sediments caused by floods tend to clog rivers, lakes, drainage systems, reservoirs, dams, irrigation canals and other inland water bodies. This in turn reduces the viability of these water resources for economic activities such as fishing, aquaculture, water storage, irrigation, water recreation, water transportation and many others.

Similarly, siltation and sedimentation of coastal areas also damaged the mangroves, coral reefs, sea grasses, estuaries, beaches and other marine ecosystems, rendering them less viable as providers of ecosystem goods and services for the population.

Agriculture is the primary socio-economic activity in the study area, specifically rice, coconut, vegetable and fruit production. The mudslides that struck in 2004 had buried the farmlands in the lower sections, thereby adding to the economic hardships of local communities. The lack of economic activities in the affected areas also pushed many residents to seek livelihood opportunities outside their communities. Many of them find seasonal jobs as tricycle drivers, casual labor in construction projects and as vendors. Women were also forced to leave their villages, ending up in domestic or service work elsewhere (Garcia, undated).

In 2004, agriculture (coconut, rice, corn, coffee, vegetables and livestock, fishing, hunting) and forestry provided income for 39% of the population in the Quezon Province (National Statistical Coordination Board, 2004 as cited by Gilliard et al., 2007). The damaged agricultural lands was about 36,146 ha (Social Action Center, 2006 as cited by Garcia, undated). The four tropical depressions and typhoons destroyed an estimated USD 66.7 million worth of corn, coconut and high-value commercial crops in the devastated areas. Experts calculated that the damages reduced the nation's Gross Domestic Product by at least 0.35 percentage points (Virola, 2004 cited by Gilliard et al., 2007). Meanwhile, the Social Action Center (2006) valued the corresponding production losses in crops, fruits, and vegetables resulting from the said event in 2004 at around PhP 600 million.

Thus, investment in reducing disaster risks associated with the adverse effects of climate change including the impacts related to extreme weather events and slow onset events like land and forest degradation is the key to minimizing losses and damages.

4.3.5 Forest flood regulation service quantification

Kanan watershed is one of the three contributing watersheds that discharge to Agos River. Its service area, which happens to be the flood plain also, covers two main municipalities: General Nakar and Infanta, Quezon (Figure 4.8).

Kanan watershed is rich in primary and secondary forests covering around 90% of the 38,985 ha total area (Kanan-Agos IEM Report, 2014). However, forest loss from deforestation and degradation is believed to aggravate flooding in the past decades. Pressure to the forest ecosystem in Kanan watershed is brought by a combination of socio-economic factors and institutional limitations (General Nakar FLUP, 2010).

The flood plain of Kanan watershed had a rough history from flooding and forest loss. The area is typhoon-prone being in the eastern part of the Philippines and also an area experiencing the most of north-east monsoon (Amihan). These reasons combined with forest loss worsened the past flood events especially the most devastating series of typhoons in 2004 where thousands of logs were discharged along with flash floods.

Forest ecosystem provides an array of services, both tangible and intangible, also known as provisioning and regulating services, respectively. One of its regulating function is flood prevention during extreme rain events like typhoons. The theory of forests acting as a sponge during rainy season have a mix interpretation from the research environment. There are two faces of the coin: one that affirms it via evidences (FAO, 2003; Calder and Aylward, 2006; Aquino et al., 2014; Rawlins et al., 2016) and one that says forest-flood link is still tenuous (Van et al., 2009). The two studies by Aquino and Rawlins in particular are pro-forest where both quantified the positive effect of reforestation in decreasing the impact of flood. The study area by Aquino is also a sub-tributary of Agos River while that of Rawlins is within the other side of the ridge.

Justifying the flood regulating effect of forests is complex as the scenario cannot be investigated in real situation. In fact, it has been categorized as a complex adaptive system (CAS) for human factors are integrated with the ecological system. Examples of anthropogenic causes of forest loss in Kanan watershed include continuous small-scale unauthorized logging, upland migration, agricultural conversion are (General Nakar FLUP, 2010).

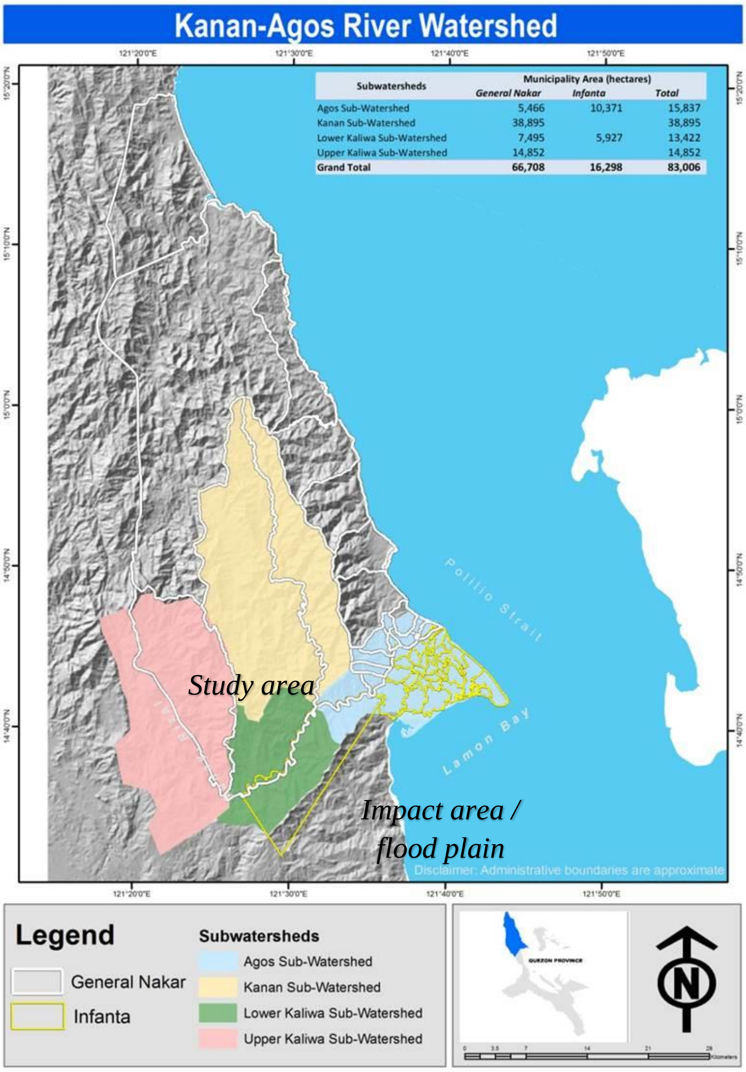


Figure 4.8. Study area overview

Source: Integrated Ecosystem Management, Kanan-Agos Watershed, DENR-FASPO

CAS can be better understood by performing spatial modelling that uses computers and software that re-creates the hydrologic systems in the watershed. Spatial temporal models can better simulate flood while integrating rainfall-runoff scenarios including water infiltration, curve number, and Manning's surface roughness coefficient. One nature of spatial temporal model is that there is no standard theory/framework that it adheres to, and this rationale also reflects the opposing forest-flood opinions.

For this study, an innovative multi-model quantification approach which is deductive in nature (theory-affirming) was sequentially done in three parts: water influx per scenario; flood modelling using cellular-automata technique; and GIS-based flood risk and damage cost quantification.

Below are the objectives of quantification model:

- To create five multi-models of flood regulation services of Kanan watershed (actual, 20%, 50%, 100% of Kanan forests removed, and climate change (CC) scenario); and

- To quantify the flood regulation service of forests using flood risk and damage cost avoided as physical and monetary indicator, respectively.

There were three main modeling steps undertaken for each of the four scenarios: (1) discharge model, (2) flood model, and (3) damage cost model.

Discharge model

The discharge results from the DREAM Flood Forecasting and Hazard Mapping (2015) was used to capture two key inputs for flood modelling: peak outflow or the highest discharge during the storm event; and lag time or the difference in time between peak rainfall and peak outflow. The selected flood event was a 1:50 year scenario since it is closely similar to the devastating storm event that occurred in the study area in 2004.

The reference model, however, used all watershed contributors discharging at the common outlet (Agos River). In other words, Kaliwa watershed discharge was merged with Kanan watershed. To properly account for the two discharges, the study by Adornado and Yoshida (2010) became the basis for proportioning the basin discharge to the two major watersheds.

Flood model

A cellular automata-based technique was implemented to capture both spatial and temporal requirements of a flood model. The Digital Elevation Model (DEM) which is the model's main input was acquired from Shuttle Radar Topography Mission (SRTM). The sinks or the gaps in DEM that can alter a hydrologic flow was filled using ***fill*** tool in ArcMap. The DEM was resampled into 100 m since the flood plain study area is basically homogeneous topographically.

The study of Rawlins et al. (2017) modelled a process-based scenario comparing the peak discharge and lag time difference of a forested and non-forested landscape in Marikina watershed and is adjacent to Kanan watershed. Its key findings were used as model inputs to account for the delay in flood water and the discharge increase in a non-forest scenario.

Five models (actual, 20% forests removed, 50% forests removed, all forests removed and CC scenario[11] + deforestation[12] scenario) were created. These models then generated: (1) influx/discharge and (2) time (number of ticks). The former is the peak stream flow during a storm event while the latter is the inundation spread dictator (the higher the influx, the more inundation). The interface of the model (done in Netlogo) is shown in Annex 1. The model is basically a rule and pixel-based model where water inundation and flow of a current pixel is carried over to its neighboring pixels from the rules considering surface elevation and surface roughness. The model concept is sometimes referred to as the "bathtub" model where the spatial system is divided into pixels that have a volume to be filled before spilling over into the next pixel. Litenberg (2016) showed the simple diagram of the water distribution scheme per pixel (Figure 4.9).

[11] 30% rainfall increase from "wettest possible" scenario (PAGASA, 2018) based on RCP 8.5 scenario, 90th percentile of the projections relative to baseline 1971-2000.
[12] 50% deforestation

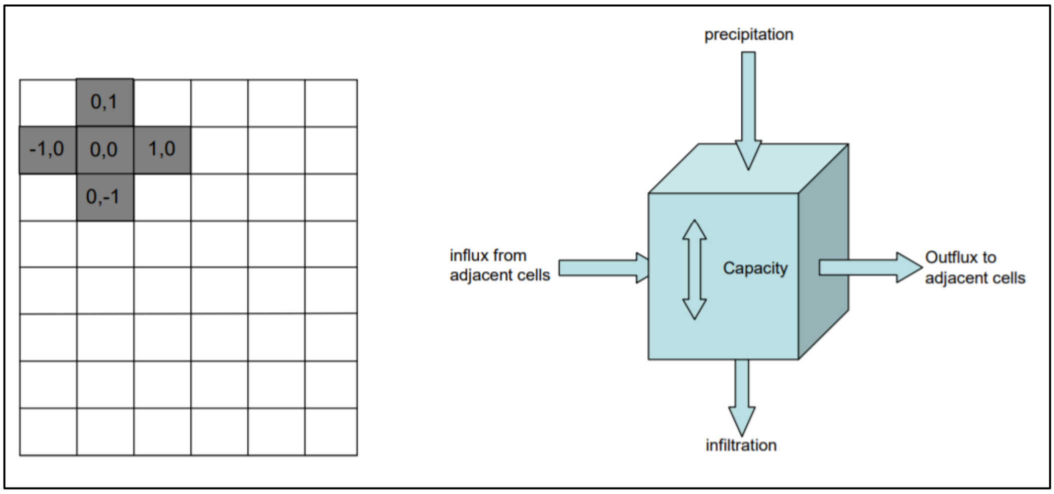


Figure 4.9. Diagram of a cellular automata model for flood showing water distribution scheme

Source: Litenberg, 2016

Damage cost model

The third main model for this study used a GIS-based model to generate flood risk and subsequently, damage cost due to flooding. The model builder of ArcMap was used to create an organized and controlled sequence of modelling steps.

Built-up areas

An unsupervised classification was done using k-means clustering method in R programming language to capture the built-up areas. The classification method is a grouping technique where pixels are assigned to clusters in an iterative way. The optical image used was Landsat 8 OLI in 2014.

Flood risk at household level

The flood inundation outputs for both actual and non-forest were transferred to a GIS interface for spatial manipulation. The maps, in raster form, were converted into a vector format and intersected with built-up areas. That step ensured that the flood risk map is exclusive to residential areas. The % flooded was derived by dividing the flooded area over the total area per barangay and the result was applied to the number of households per barangay. Next, a random point generator was assigned to the built-up areas to account for the number of inundated houses per barangay. The information of the houses came from the 2014 socio-demographic survey, matching with the classified built-up area. The number of households were derived with the assumption of 5.1 people per household which is a provincial threshold. The points scattered along the built-up areas were rectified using satellite view base map of ArcMap. It assured that each point was located at the center of the houses. Then, point density tool was applied to get a density map ha^{-1} among the points at the built-up areas. This step derived the number of household ha^{-1} or $pixel^{-1}$ that are flooded.

Damage cost computation

The flood damage ratio per flood height which was developed by a multi-agency effort in 2010 (Badilla et al., 2014) was used to set assumptions on flood cost per flood inundation height. That model was used also in deriving the flood regulation service of Laguna Lake (PhilWAVES Report, 2016). The model for computing flood damage was linear, meaning the higher the flood the higher the damage cost in built-up areas.

The number of households affected per barangay per flood height was derived to obtain the breakdown of flood risk (Annex 2). Then, to each flood risk pixel, the equation from the linear model on damage ratio and flood height was applied:

$$Y = 0.0614x * \text{flood height} * \text{house cost}$$

This basically resulted into PhP cost ha^{-1} or $pixel^{-1}$. The computed flood damage cost was done per flood height (0.5 m, 1 m, and 1.5 m). The assumed average estimate of house-and-lot used was PhP 800.00 m^{-2}, the value derived from the socio-economic results of this study.

Peak discharge and flood inundation

The flood models revealed that both peak discharges and inundation spread in a severe storm event increased when forests are removed. In other words, losing forests is linear to increasing flood. The results of flood scenarios for peak discharges and inundation spread as well as remaining forests are shown in Table 4.11. The inundated areas per scenario are shown in Figure 4.10.

Peak discharges rose by as much as 13% or 606 m^3 sec^{-1} increase if all Kanan forests are removed. Moreover, the rate of flood inundation spread was found out to be faster by 27% when there are no forests in Kanan watershed. This can be attributed to the relative amount of water discharged by Kanan than other contributing tributaries. It should be noted that Kanan has 6% more water contribution than Kaliwa watershed (Adornado and Yoshida, 2010). Moreover, Kanan has relatively larger forest area and % forest cover than Kaliwa watershed. When these are cut and converted into bare land as assumed, its hydrologic and topographic features (which is relatively more sloping) can hasten surface run off. Moreover, according to municipal reports, more flashfloods were experienced from the tributaries of Kanan watershed than from Kaliwa watershed.

There was an increase of peak discharges and flood inundation when 50% and 20% of Kanan forests are cut. For peak discharges, there were 3% and 5% or 103 and 223 m^3 sec^{-1} increase for the two scenarios, respectively. For the flood spread, there were 7% and 12% increase for the two scenarios, respectively. The results indicate that creating realistic forest loss scenario (i.e. 50% forest loss and below) is not exactly proportional to changes in peak discharges and affected flood area. In other words, removing half of Kanan forests did not result to 50% increase in peak flow. The results showed that even with 50% forests removal, the integrity of the forests to regulate flood remains. Removing half of forests resulted to flooding of 19,493 ha, an indication that the remaining forest has the capacity to regulate flood. It will be interesting to assess the "tipping point" for the maximum forest loss that will give the highest magnitude of change but requires more modelling efforts. At the current state of the Kanan watershed that has high forest cover, losing as much as half of its current forest cover cannot result in a significant decline in its flood regulation service. Another influencing aspect might be the soil characteristics of the Kanan watershed. Most mountain soils are clayish that can hold water even when there is loss of vegetation. The result of the 20% forest loss explains the water holding capacity of the soil and the regulating service of the forest, having minimal change in the two flood indicators.

The climate change scenario was the worst-case scenario where discharge increased by 32% and inundation spread doubled from the actual and increased by 76% when forests were cut down to as much as 50%. Results indicate that a 30% increase in typhoon precipitation is hazardous for a half-barren Kanan landscape.

Table 4.11. Different peak discharges and time equivalence of flood spread per scenario.

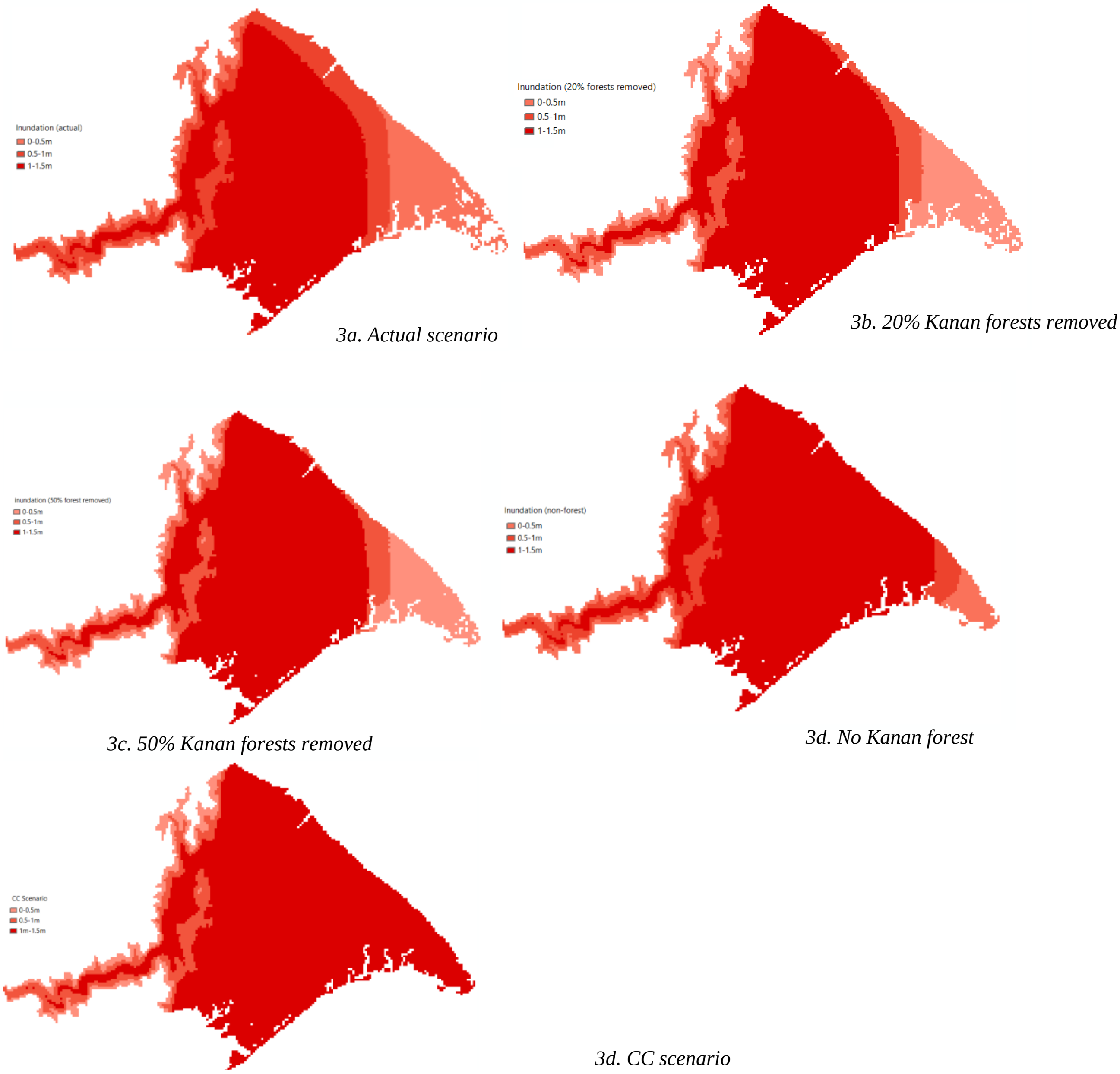
Scenarios	**Discharge (m3/sec)**	**Inundation Spread (ticks)**	**Remaining forests in Kanan (ha)**
Actual	3,887	400	38,985
Without 100% of Kanan forests	4,493	551	-
Without 20% of Kanan forests	3,990	430	31,188
Without 50% of Kanan forests	4,110	459	19,493
CC scenario	5,636	807	-

There was an increase of 125 ha of land inundated by flood in a non-forest scenario. While the land area has slightly increased, flood height appeared to have more significant effect with 85% of the flooded area inundated by 1.5 m from the same scenario. The same results were portrayed by the other two scenarios where increase in flood height causes more damage than increased in flooded area. This inundation and flood height changes per scenario will be discussed in detail in the flood risk section.

The three forest loss scenarios will cause inundation in those areas that are currently non-flooded and farthest from the actual flood model area. The inundation is caused by higher volume of influx water when there is more forest loss. Moreover, soil saturation is common to any typhoon event because of the non-stop precipitation causing relatively faster runoff in barren areas. This event is essentially a flash flood scenario where high volume of flood water comes to the flood plain at high velocity. Moreover, the more sloping topography of Kanan watershed can enhance the volume of flood water due to gravity pull. Since the flood plain is almost saturated with just one main discharge point to the ocean, the consequence will be increased flood water height.

The CC scenario seems to be the worst-case scenario since it is a combination of extreme rainfall and deforestation events. The scenario with increased typhoon rainfall by as much as 30% resulted to a linear and faster spread and inundation of the flood plain.

It should be noted that the model is a straightforward bathtub model where water distribution is based on elevation and surface roughness. If actual on-site parameters will be included like drainage system, the result may differ, like worsen if drainage systems are clogged or insufficient. This could be one advantage of process-based models for flood modelling, using commercially available software.



3a. Actual scenario

3b. 20% Kanan forests removed

3c. 50% Kanan forests removed

3d. No Kanan forest

3d. CC scenario

Figure 4.10. Flood inundation in a storm event for the different scenarios.

Damage avoided model

Households at risk

There are increases in households affected by inundation and flood height (Table 4.12). Based on the results of the scenarios, more households are flood-affected with increased forests removal. Almost ¾ of the total households are affected by flood in a non-forest scenario. With CC scenario, total households affected increased by 3%. Around 3% and 10% of households are affected when 20% and 50% of Kanan forests are removed. For increase in flood height, there are 17% and 20% more households affected in the two scenarios.

The results show that there are more households affected by increase in flood height than by area of inundated by flood. This can be translated to flood getting deeper with increased loss of forest. There is only one main discharging point and that is the Agos River, which may not be able to discharge the large volume of water in a short period of time. This phenomenon is more evident for extreme typhoon events where most of the flood plain are already inundated even at actual scenario (current land cover). In less rainy event, this would change and flood inundation could be more sensitive to forest loss.

Table 4.12. Percent increase (%) in households affected per scenario for flood inundation and height.

Model	Households affected by inundation (number)[13]	% increase	Households affected by flood height increase	% increase
Actual	8,650	-	8,650	-
20% forests removed	8,909	3%	10,422	17%
50% forests removed	9,601	10%	10,813	20%
100% forests removed	13,099	34%	13,099	34%
100% forests removed + CC scenario	13,099	34%	13,575	37%

The inundated areas relative to flood height are shown in Figure 4.11. Areas with highest population or most dense areas are observed from barangay Poblacion of Infanta. The map also shows that the affected areas are usually within the roadsides. Since the flood plain is always the low-lying areas and the discharge is through the Agos river only, water is being pushed towards the whole lowland of Infanta and in the low-lying part of General Nakar on the other side of Agos river. This can also be an indication of urbanization, especially in Infanta where residential houses are increasing and are even extending near the outskirts of the municipality.

Damage cost model

There was a total of PhP 548 M damage cost from flood in the the actual flood scenario. This estimate is below the 2004 damage estimate with PhP 678 M (wikepedia.org) and higher than the PhP 207 M estimated by Project NOAH. The two different estimates cannot be compared as the metadata of the two sources are unavailable. However, one reason why the results of this report is below the Wikipedia report is that this model did not include other damages (especially from agriculture sector) other than damage to houses. On the other hand, the estimate in this study is higher than the report made by Project NOAH since it used the actual damages in 2004 whereas this model used the actual built-up areas in 2014. A ten-year gap have a substantial increase in the number of houses.

[13] Total households of the flood plain is computed as 17,914

The damage costs increased up to PhP 81, PhP 311, PhP 644, and PhP 679 M for the other four scenarios, respectively (Table 4.13) . The main reason for this increasing trend is the increase in flood water height due to a higher influx of water and saturated flood plain. It should be noted that the flood damage cost is linear to flood height and if flood hits at 1.5 m in height, there is more damage assumed. The results indicated that barangays with higher household density have incurred more damage cost. These barangays that incurred the highest damage cost were also those that are near the Agos river namely: Comon, Banugao, Bantilan, Anoling, and Poblacion 39. Moreover, those non-center barangays namely Libjo, Lual, Boboin, and Abiawin in Infanta also sustained high damage cost. This justifies that even the houses that are far from the Agos river, can still be reached by flood water. On the other hand, there are outskirt barangays like Binulasan and Dinahican that experienced the least cost of flood damage. One reason for this is the buffer effect from all barangays prior to the two as flood influx and volume can be reduced by land buffers. For example, rice fields can absorb flood water especially those with irrigation canals which can store more water.

Noticeable from Figure 4.11 are the barangays near the Agos river and municipality centers which are more affected by forest loss increase compared to the farthest barangay (more pixels turning red). These barangays had more damage even at 20% forest loss scenario. The changes in flood volume affects those areas near the Agos river first and aggravates if there are minimal flood control structure

Table 4.13. Breakdown of flood damage cost per barangay for the flood scenarios.

Flood damage cost (PhP in millions)												
Barangays	*actual*	*20% forest removed*	*50% forest removed*	*100% forest removed*	*CC Scenario*		**Barangays**	*actual*	*20% forest removed*	*50% forest removed*	*100% forest removed*	*CC Scenario*
Abiawin	15	16	21	35	47		Ilog	16	18	26	27	27
Agos-Agos	16	15	16	22	22		Ingas	19	20	22	22	22
Alitas	4	4	4	6	6		Langgas	5	6	8	9	9
Amolongin	7	7	7	7	7		Libjo	25	33	34	49	49
Anibong	2	3	4	7	7		Lual	14	14	17	21	21
Anoling	20	25	29	61	61		Maigang	4	4	4	4	4
Antikin	3	3	3	5	8		Maypulot	2	6	7	9	9
Bacong	8	8	8	8	8		Minahan Norte	1	2	2	2	2
Balobo	2	4	4	5	5		Minahan Sur	1	3	5	5	5
Banglos	3	5	5	5	5		Miswa	20	26	33	38	38
Bantilan	41	42	65	74	74		Pamplona	1	2	2	3	3
Banugao	38	43	72	144	144		Pesa	0	1	1	2	2
Batangan	5	12	12	14	14		Pilaway	25	21	21	32	32
Batican	10	12	15	15	15		Pinaglapatan	2	4	4	11	11
Binonoan	8	13	13	13	13		Poblacion	12	16	16	24	24
Binulasan	11	13	17	19	26		Poblacion 1	11	7	8	10	10
Boboin	22	25	35	37	37		Poblacion 38	18	19	19	20	20
Catablingan	17	18	19	20	20		Poblacion 39	28	29	30	43	43
Catambungan	8	14	14	16	16		Pulo	2	2	2	2	2
Cawaynin	4	5	4	7	7		Silangan	10	8	8	12	18
Comon	42	51	145	243	243		Tongohin	6	9	9	9	9
Dinahican	21	23	47	57	65		Tudturan	2	2	2	3	3
Gumian	17	17	17	17	17		**Grand Total**	**548**	**629**	**859**	**1,192**	**1,227**

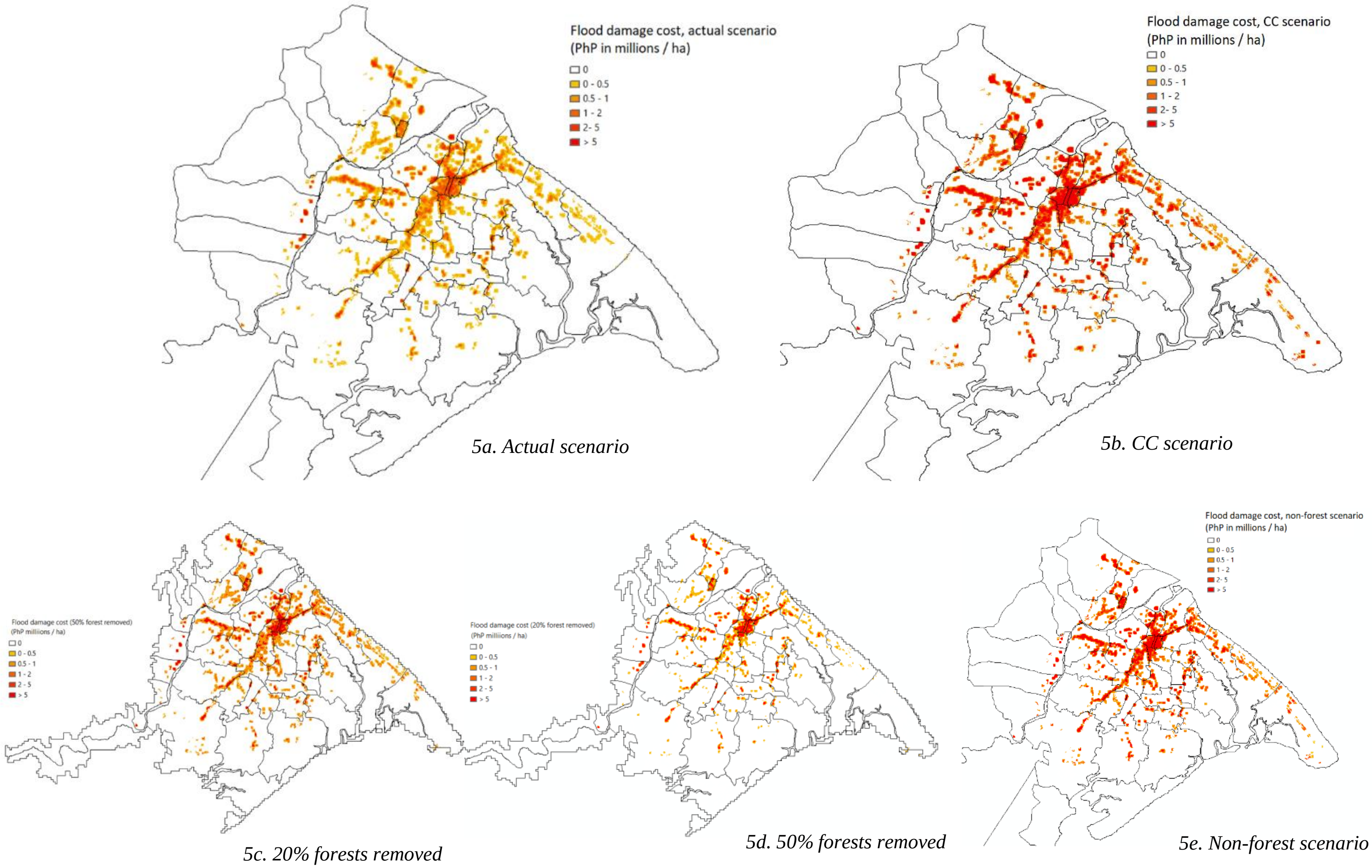


Figure 4.11. Maps of flood damage cost showing the cost per pixel/hectare of all the scenarios

4.4 DISCUSSION

The Intergovernmental Panel for Climate Change (2007) defines "adaptation" as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Climate change adaptation reduces the vulnerability and its adverse impacts. To effectively reduce vulnerability, climate change adaptation must form part of a holistic response which aims to build resilience of communities and building capacity to withstand the range of shocks and stresses that they are exposed to, particularly of the most vulnerable people; and, in some cases, on reducing exposure or sensitivity to climate impacts (CARE International, 2009).

Humanity has adapted to its changing environment since the beginning of time. Societies have practiced various measures to adapt to the impacts of weather and climate. Some of these include crop diversification, irrigation, water management, disaster risk management, and insurance (Cuevas, 2012).

In the case of General Nakar, there are current and potential adaptation strategies to land and forest degradation to prepare the population and prevent similar catastrophes that happened in 2004. Current adaptation include nursery and agroforestry establishment, establishment of evacuation center, adoption of soil and water conservation (contour farming) in their respective farms, formation of Barangay law enforcement team and development of ecotourism for livelihood (Table 4.14). Also, some of the identified potential adaptations include establishment of riprap along river banks and enhancement of ecotourism activities such as development of water fall and water rafting activities along water systems. These adaptation strategies will divert the people from timber poaching, kaingin system and illegal logging which lead to land and forest degradation. The effectiveness of these adaptation strategies, however, in minimizing loss and damage associated with climate change has not yet been fully ascertained and should be the subject of subsequent investigations.

Also, community adaptation includes installation of early warning system (EWS). Social Action Center (2014) and Garcia (undated) indicated that General Nakar was the pilot project on installing early warning systems in 2009.

However, during the FGD in the study areas, the participants also relayed that there are barriers and limitations that may impede the process of adapting to land and forest degradation associated with the changing climate. These include the lack of funding, weak governance, lack of other livelihood opportunities, and lack of technical skills.

Table 4.14. Current, potential and barriers to climate change adaptation

Current Adaptation	Potential Adaptation	Barriers to adaptation
Nursery and agroforestry establishment	Rip rap along the river banks	Lack of funds Weak governance
	Irrigation canal	
Evacuation center		
Adapt soil and water conservation (contour farming)		
Formation of Barangay law enforcement team		Weak governance
Development of Ecotourism as livelihood opportunities	Development of falls and water rafting	Financial

According to Garcia et al. (undated), after the 2004 flashflood that inflicted great harm to thousands of families had change the people’s mindset in disaster preparedness and response. People started to show intense desire, concern and interest in protecting their community and properties. People showed comparatively greater solidarity among them to prevent the disastrous impact of future calamity. Also, local people’s initiatives to protect their community can take on more systematic steps by strengthening their competence in using local knowledge.

Also, during the household survey, the respondents identified preparations and planning strategies in relation to household, community and local government units (LGU) in order to avoid the losses and damages due to land and forest degradation associate with climate change (Table 4.15).

Table 4.15. Household, community and LGU planning and preparedness strategies to land and forest degradation associated to climate change in order to avoid disaster and loss and damage.

Household level	Community level	LGU level
Be prepared, vigilant and alert always Always prepare a disaster kit (food, medicine, clothes and flashlights) Always boil water for safety especially during calamity Be updated or informed with climate related news on the radio, TV, etc. Stop cutting of trees Plant more trees Share information to their neighbours	Helping each other especially during calamities/disasters (*Bayanihan*[14]) Establish communication system among the household regarding calamities Tree planting Being united	Prepare and provide relief goods (relief operation) Prepare evacuation centers/sites Provide early warning systems Information and education dissemination Provide livelihood projects Provide capacity building (technical /social) Secure enough fund for the calamity

Programs and Policies relevant to land and forest degradation and the entry points for mainstreaming CCA and DRR in local development plans

During the focus group discussion, the participants relayed the various LGU support and programs to enhance community adaptation (Table 4.16). The communities within the Kanan watershed are part of the national greening program (NGP) of the Philippine government. The program provided great support for the communities since they earned income and an avenue of rehabilitating their forest lands. Aside from the NGP project, the communities also received fruit bearing trees from the LGUs. Technical (e.g ginger production training) and leadership trainings were also provided. In the same manner, the LGUs are currently providing alternative livelihood technologies such as food processing for banana and cassava particularly for women. Also, tour guide trainings are conducted and development of the ecotourism projects in the communities is given.

[14] community volunteerism

Table 4.16. Assessment of the LGUs' support to enhance local adaptation

Type of LGU support to enhance local adaptation	Assessment of effectiveness Scale from 1-10*		Justification/reason for the rating **
	Barangay 1 Pagsangahan	Barangay 2 Mahabang lalim	
Support for document	9	9	Very good (Brgy 1 & 2)
preparation for NGP	4	7	Good (Brgy 1) and Very
Material support (fruit	6		good (Brgy 2)
bearing trees)	6	5	Good (Brgy 1&2)
Technical training (ginger	9		Good (Brgy 1)
production)			
Leadership training for			
farmers	10	5	Very good (Brgy 1)
Provision of livelihood	10		Good (Brgy 2)
opportunities (food			
processing e.g banana and			
cassava chip for women.			
Tour guide training			
Development of ecotourism			Excellent
– falls, summit, tricking,			Excellent
hiking, bird watching			

* 1 – least effective to 10- most effective

** 1-3 poor, 4-6 good, 7-9 very good, 10 excellent

The participants have also identified the types of policies and programs regarding land and forest degradation (Table 4.17). These included the implementation of the Executive Order Number 26 which is the National Greening Program which is initiated by National agencies like the Department of Environment and Natural Resources (DENR) and the Municipal Environment and Natural Resources of the LGU. According to the participants from Barangay Pagsangahan, implementation of EO 26 was either weak or no action was done. Some loggers are armed and one even mentioned that he has DENR clearance. Also, the local government units created the Barangay Law Enforcement Team (BLET). According to respondents from Pagsangahan, a low score was given to the program because of its being ineffective due to the low honorarium given to the team. In addition, no action was done despite the many reports submitted related to garbage disposal. According to the MENRO, enforcement of proper garbage disposal is under the jurisdiction of the barangays. It was mentioned that trash comes from Tanay, Rizal and goes to Pagsangahan via the Agos River.

Table 4.17. Effectiveness rating of policies and programs related to land and forest degradation

Government policies and programs	**Score/Rating**	
	Barangay 1 Pagsangahan	**Barangay 2 Mahabang lalim**
LOA or letter of agreement sourced from EO 26 by DENR	3	8
Barangay Law Enforcement Team (BLET)	5	8
National Greening Program	8	8
Barangay Forest Program (rated by DENR & MENRO)	2	4
Agroforestry	3	5
Ecotourism	8	On-going

* 1 – least effective to 10- most effective   ** 1-3 poor, 4-6 good, 7-9 – very good, 10 excellent

Various government and non-government institutions provided assistance to the implementation of projects geared towards reduction of threat to the remaining forest while providing for livelihood opportunities for the settlers within the Kanan watershed. For instance, Haribon Foundation implemented project such as Integrated Biodiversity Area Monitoring System (IBAMS), agroforestry and conducted valuation study. Meanwhile, Child Fund had projects on empowering children, youth and communities to become environmental protectors. The University of the Philippine Los Baños on the other hand, had promoted the conservation farming village for soil conservation and community livelihood. Also, there was a support related to women project while the local government units promoted the bio-intensive gardening.

Moreover, the results of this study can be integrated in the local comprehensive land use plan (CLUP), comprehensive development plan (CDC) and local climate change adaptation plan (LCCAP) of the municipality as way of mainstreaming the CCA and DRR in local development plans.

4.5. CONCLUSIONS

Land and forest degradation results from a number of interacting processes which include the climatic and human factors. Poverty or having low income is the main cause of land and forest degradation in the study area. This leads to illegal logging and *kaingin* making (shifting cultivation). Likewise, lack of alternative livelihoods, weak governance and climate related extreme events such as typhoons, flash floods/flooding, and landslides are some of the mentioned causes. Thus, the persistence of these issues continues to threaten the remaining forest and its sustainability thereby contributing to the cycle of poverty, soil erosion or environmental degradation and increasing household vulnerability.

The findings also showed that households' vulnerability to land and forest degradation associated with climate change are from low to moderate vulnerability where majority, however, are moderately vulnerable. This implies that proactive interventions such as awareness campaign on the importance of Kanan watershed, policies related to kaingin, and farming systems improvement should be strengthened to avoid future disaster risks.

Land and forest degradation associated with climate related risks had cascading risk to various sectors such as the local communities, infrastructure, agriculture, forestry and coastal sectors. Consequently, this degradation has economic and non- economic loss and damage implications. Economic losses include destruction of houses and cost of losses ranges from PhP 10,000 to PhP 200,000. Also, included are the decline in crop harvest by 30%, reduced fish catch in the river, loss of soil fertility due to soil erosion leading to low crop yields, decrease in water flow due to a month-long intense heat and loss of livelihood sources. Meanwhile, economic damages include damaged river canals, and livelihood sources and planted crops were lost even their working animals like carabao. Household kitchen utensils and appliances such as TV, radio or karaoke set were also lost. Non- economic losses include migration due to loss of livelihood sources leading to drop in labor force and even loss of loved ones and relatives. Another non-economic damage brought by land and forest degradation was the fear created among the communities.

As disasters related to climate risks hit degraded ecosystems including deforested areas, more pressure is exerted on jobs and the economy thereby increasing the social vulnerability of poor communities.

Although finding solution to reduce land and forest degradation remains a challenge, hence, several adaptation strategies were identified. Identified planning and action strategies identified include nursery and agroforestry establishment, establishment of evacuation center, adoption of soil and water conservation practices (contour farming) in their respective farms, formation of barangay law enforcement team and development of ecotourism as source of livelihood. Also, some potential strategies include establishment of riprap along river banks and enhancement of ecotourism activities such as development of water fall and water rafting. These strategies will divert the people from timber poaching, kaingin system and illegal logging activities that contribute land and forest degradation. The effectiveness of these adaptation strategies in minimizing loss and damage associated with climate change, however, remains to be ascertained and will be the subject of subsequent investigation.

More so, government institutions are providing assistance and support to the adaptation mechanisms of the communities such as the national greening program (NGP), agroforestry and provision of alternative livelihood opportunities.

For the modelling part, the study concludes the following:

- Forests can regulate severe typhoon peak discharge by reducing volume by as much as 606 m^3 sec^{-1} or 13% discharge increase. The rate of flood spread becomes 27% and 31% higher also in a non-forest condition and CC scenario, respectively.
- Removing 20% and 50% forests show linear reaction to flood indicators having 3% and 5% more peak discharges. Same scenarios can also increase flood spread by 7 and 12%.
- The effect of forest loss is more evident in flood height increase than inundated area increase in an extreme typhoon event.
- For inundation, additional 3 and 10% of households can be affected when 20% and 50% of Kanan forests are removed. For flood height increase of the same 2 scenarios, there can be 17% and 20% more households affected. The CC scenario has the same HH affected with non-forest scenario (34%) but with 3% more in flood height.
- The partial forest loss scenarios reflect the integrity of forests to provide flood water regulation. Forest loss is not exactly proportional to flood indicator increase.
- Because of the forests in Kanan watershed, hundreds of millions (PhP) of flood damage cost can be avoided. Kanan forests can save as much as 679 million pesos together with the assumption of proper climate change adaptation and mitigation.

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Internet Links

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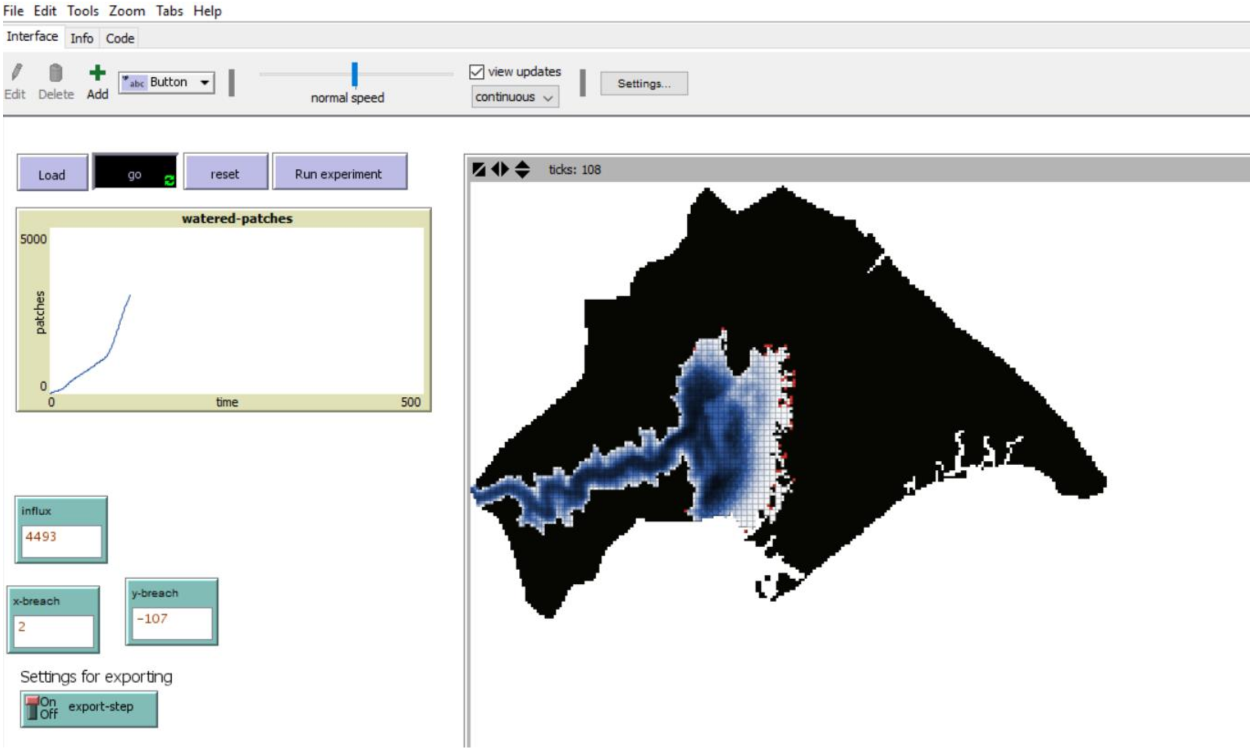
ANNEXES (1-3)

Annex 1. Netlogo interface and the flood model.



Annex 2. Household affected by flood inundation for all scenarios.

			Inundated households (100% forests removed)					Inundated households (50% forests removed)					Inundated households (20% forests removed)				
Barangay	Population	Households	0.5m	1m	1.5m	Sub-total	% affected	0.5m	1m	1.5m	Sub-total	% affected	0.5m	1m	1.5m	Sub-total	% affected
Abiawin	1967	386	66	135	91	292	76%	66	38.75	26.05	131	34%	66	11	7	85	22%
Agos-Agos	2561	502	42	136	108	286	57%	42	39	31	112	22%	42	11	9	62	12%
Alitas	1177	231	66	48	1	115	50%	66	14	0	80	35%	66	4	0	70	30%
Amolongin	912	179	20	94	28	143	80%	20	27	8	55	31%	20	8	2	30	17%
Anibong	1077	211	71	79	18	168	79%	71	23	5	99	47%	71	6	1	79	37%
Anoling	3482	683	93	205	104	401	59%	93	59	30	181	27%	93	17	9	118	17%
Antikin	926	182	45	109	17	171	94%	45	31	5	81	45%	45	9	1	55	30%
Bacong	1160	227	62	97	19	178	78%	62	28	5	96	42%	62	8	2	72	32%
Balobo	639	125	16	21	46	83	66%	16	6	13	35	28%	16	2	4	21	17%
Banglos	875	172	14	99	58	170	99%	14	28	17	59	34%	14	8	5	27	16%
Bantilan	3440	675	22	299	352	673	100%	22	86	101	209	31%	22	25	29	76	11%
Banugao	2870	563	10	102	443	555	99%	10	29	127	166	29%	10	8	36	55	10%
Batangan	1639	321	28	21	160	210	65%	28	6	46	80	25%	28	2	13	43	13%
Batican	1000	196	23	115	51	189	96%	23	33	14	71	36%	23	9	4	37	19%
Binonoan	1780	349	75	132	59	267	76%	75	38	17	130	37%	75	11	5	91	26%
Binulasan	3179	623	156	146	1	303	49%	45	42	0	87	14%	13	12	0	25	4%
Boboin	1977	388	7	228	151	386	99%	7	65	43	115	30%	7	19	12	38	10%
Catablinga	2494	489	16	175	154	345	71%	16	50	44	110	23%	16	14	13	43	9%
Catambun	2043	401	95	238	21	354	88%	95	68	6	169	42%	95	20	2	116	29%
Cawaynin	601	118	-	78	40	118	100%	-	22	11	34	29%	-	6	3	10	8%
Comon	3398	666	5	276	381	663	99%	5	79	109	194	29%	5	23	31	59	9%
Dinahican	11010	2,159	711	189	-	901	42%	204	54	-	258	12%	58	16	-	74	3%
Gumian	4903	961	133	106	118	358	37%	133	30	34	198	21%	133	9	10	152	16%
Ilog	2468	484	31	251	189	471	97%	31	72	54	157	33%	31	21	16	67	14%
Ingas	2121	416	16	307	85	408	98%	16	88	24	128	31%	16	25	7	48	12%
Langgas	1154	226	64	45	6	115	51%	64	13	2	78	35%	64	4	0	68	30%
Libjo	2758	541	70	245	158	473	87%	70	70	45	185	34%	70	20	13	103	19%
Lual	1213	238	30	79	124	233	98%	30	23	36	88	37%	30	7	10	47	20%
Maigang	3035	595	62	38	241	341	57%	62	11	69	142	24%	62	3	20	85	14%
Maypulot	904	177	8	163	6	177	100%	8	47	2	57	32%	8	13	0	22	13%
Minahan N	448	88	2	0	19	22	25%	2	0	6	8	9%	2	0	2	4	4%
Minahan S	1616	317	67	54	2	124	39%	67	16	1	83	26%	67	4	0	72	23%
Miswa	2066	405	51	147	150	348	86%	51	42	43	136	34%	51	12	12	75	19%
Pamplona	1911	375	18	145	191	354	94%	18	41	55	114	30%	18	12	16	45	12%
Pesa	1149	225	29	7	14	50	22%	29	2	4	35	16%	29	1	1	31	14%
Pilaway	2265	444	7	217	196	420	95%	7	62	56	125	28%	7	18	16	41	9%
Pinaglapat	1204	236	-	236	1	236	100%	-	68	0	68	29%	-	19	0	19	8%
Poblacion	1281	251	16	206	22	244	97%	16	59	6	81	32%	16	17	2	34	14%
Poblacion	863	169	2	68	99	169	100%	2	19	28	50	30%	2	6	8	16	9%
Poblacion	1723	338	9	159	169	336	100%	9	45	48	103	30%	9	13	14	36	11%
Poblacion	2450	480	30	220	223	473	99%	30	63	64	157	33%	30	18	18	66	14%
Pulo	1004	197	54	60	11	125	64%	54	17	3	75	38%	54	5	1	60	31%
Real	500	98	13	9	0	22	22%	13	3	0	15	16%	13	1	0	13	14%
Silangan	1008	198	18	155	21	194	98%	18	44	6	69	35%	18	13	2	33	17%
Tongohin	2642	518	62	152	150	364	70%	62	44	43	148	29%	62	12	12	87	17%
Tudturan	466	91	10	64	-	74	81%	10	18	-	28	31%	10	5	-	15	17%

Annex 3. Acronyms and glossary of terms.

Acronyms used:

CAS – Complex Adaptive System

DENR – Department of Environment and Natural Resources

FLUP – Forest Land Use Plan

GIS – Geographic Information System

IEM – Integrated Ecosystems Management

NOAH – Nationwide Operational Assessment of Hazards

Glossary of Terms:

Complex Adaptive System – An approach to model Socio Ecological Systems that can capture non-linearity, dynamism, and self-similarity using bottom-up approaches like Agent-based modelling and Cellular Automata.

Flood inundation – flooded area (ha)

Netlogo – a modelling software for Complex Adaptive System capable of modelling Cellular Automata and Agent-based models with a programming and graphical interface.

Spatial Temporal Model – A type of model that both accounts for space and time components.

Unsupervised classification – Classifying land features without use of training data

CHAPTER 5

CASE STUDY OF QUANG NGAI PROVINCE, VIETNAM

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5.1 INTRODUCTION

Climate change on a global scale has made the natural disasters in Vietnam be aggravated by an increase in the frequency, magnitude and impact level of extreme weather events. Climate change has a strong impact on many important fields such as water resources, agriculture, public health, energy, transportation etc.

Meanwhile, located in the Central Coast, Quang Ngai is a coastal province with diverse terrains and a 144 km coastline. This can be seen as an advantage to help Quang Ngai take advantage of opportunities to develop and diversify the economy of the province. Due to the characteristics of terrain and climate, it is also often affected by natural disasters such as typhoons, floods and droughts, causing significant damage to the lives and livelihoods of local communities. In addition, in recent years, the climate of Quang Ngai province has changed fundamentally due to the impacts of climate change such as increasing and uneven distribution of rainfall in rainy season, decreasing and uneven distribution of rainfall in the dry season, the possibility to increase temperature will impact significantly on production and life of people.

In order to cope with climate change and sea-level rise, Quang Ngai and functional sectors have directed and implemented practical action programs. Before the unpredictable impact of climate change and the implementation of Resolution No. 24-NQ/TW on 3 June 2013 of the Party Central Committee XI on actively responding to climate change, strengthening the management of natural resources and environmental protection. The Provincial Party Committee has promulgated Action Plan 42-CTr/TU until 2020 to actively respond. Based on this, in the past years, the response to climate change, natural disaster prevention, natural resources management and environmental protection in the province has been implemented by the sectors. Quang Ngai province has set up the Steering Committee and promulgated action plan to cope with climate change in the 2011-2020 period; Establishment of flood and storm control committees and disaster relief from provincial to grassroots level; Step by step investing, upgrading equipments for forecasting, warning of natural disasters.

Therefore, the implementation of the report "Integrating climate change adaptation, disaster risk reduction and loss and damage to address emerging challenges due to slow onset processes in Quang Ngai Province" is truly necessary, contributing to strengthen the response in general, adaptation in particular to climate change, jointly mitigating the risks and vulnerability caused by climate change, in order for economic development of Quang Ngai.

5.2. APPROACH

5.2.1 Types of natural disasters

Major natural disasters in the period from 1999 to 2014 were as follows:

Table 5.1. Main natural disasters in the period from 1999 to 2014 in Quang Ngai province

Types of natural disasters	**Description**
Storms and tropical depressions	102 typhoons and 71 tropical depressions, of which 2004 was the year having the least number of disasters with 5 typhoons and 4 tropical depressions, 2009 was the year having the highest number of disasters with 11 typhoons and 4 tropical depressions.
Floods, inundations	64 floods appeared in Quang Ngai, 2006 was the year having the least number of disasters with 4 floods, the most floods occurred in 2007 and 2008, with 7 floods each year. Especially in the years 1999, 2009 and 2013 there were historical floods on major rivers in the province.
Drought	The cycle occurs on average every 3-4 years, which has a great impact on agricultural production and water shortage for agriculture, industry, daily life and other economic sectors.
Landslide	Every year in the province, there are frequent landslides or high risk of landslides (river banks, coasts, mountains), bad impacts on people's lives and socio-economic conditions of the locality

Source: Report on the Implementation of Disaster Prevention and Mitigation Policies in Quang Ngai Province by the People's Committee of Quang Ngai (2014)

According to the Action Plan to respond to climate change in Quang Ngai province, types of natural disasters that often occur in the province include: typhoons, tropical depression, floods, flash floods, landslides, northeast monsoon, thunderstorms, tornados, lightning, drought, forest fires, saltwater intrusion and sea-level rise. List of natural hazards as well as the danger levels rating for Quang Ngai are illustrated in Table 5.2.

Table 5.2. List of the natural hazards that often occur in Quang Ngai province

No.	Name of natural disasters	Danger levels				Rating
		Very high	High	Medium	Low	
1	Typhoons, tropical depression	x				I
2	Floods, floodings	x				
3	River, shoreline erosion		x			II
4	Mountainous landslides		x			
5	Northeast monsoon		x			
6	Thunderstorms, tornados, lightning		x			
7	Flash floods		x			
8	Sea-level rise			x		III
9	Drought			x		
10	Saltwater intrusion			x		
11	Hot dry wind				x	IV
12	Deep freeze, damaging freeze				x	

No.	Name of natural disasters	Danger levels				Rating
		Very high	High	Medium	Low	
13	Hail				x	
14	Fog, salty frost				x	

Source: Project "Management of Disaster Risk at provincial level, activities of planning and processes of disaster risk assessment in the province of Quang Ngai"

5.2.1.1 Storms, Tropical Depressions, Floods, Flash floods

According to Table 5.2, the highly threatened natural disasters in Quang Ngai province are storms, tropical depression and floods. On average, there are 1.04 typhoons going into mainland or directly affecting and there are 3.24 typhoons indirectly affecting Quang Ngai. The greatest impact of the storms is winds and heavy rains affecting significantly livelihoods, agricultural production and aquaculture. In terms of rain and wind intensity of level 6 or above, there is a storm or tropical depression affecting directly. If the effects of rain (direct and indirect) are merely considered, there are 4 typhoons or tropical depressions affecting Quang Ngai province. Typhoons and tropical depressions usually occur in the months of May to December. In recent 5 years, tropical depressions has appeared in January and February; typhoons has also appeared earlier (in April). The direction of the storms is usually East - West and Southeast - Northwest, wind levels are 9 and 10, especially 12. 2009 has been the most stormy year in the East Sea, and the time of having a direct typhoon in Quang Ngai in the last 10 years.

Table 5.3. Number of storms and tropical depressions affecting directly to Quang Ngai

Year	*The number of storms on the East Sea*	*The number of tropical depressions on the East Sea*
2006	10	5
2007	7	3
2008	10	7
2009	11	4
2010	6	4
Total	44	23

Source: Quang Ngai Irrigation and Flood Control and Prevention Department, 2012

According to statistics from 1964 to date, there have been 22 storms in Quang Ngai (and old Nghia Binh), especially in 2007: 5 storms; 2008: 7 storms; 2009: storms. Storm No.2 (Typhoon Chan Chu) was in 2006 and Storm No. 9 was in 2009, which were the strongest storms causing the most damage. Particularly, the storm No. 9 in 2009 was a historic storm in the past 80 years, having many developments and great harm in the province.

Quang Ngai is one of the provinces affected by the tropical depressions, especially the one in November 2010. Tropical depression is accompanied with heavy rain causing floodings, many parts of the province faces inundation, traffic jams, cracked mountain and many areas at risk of isolation (Quang Ngai Department of Science and Technology, 2008).

Every year, there is 5- 7 major floods exceeded alert level II in the great rivers in Quang Ngai. Particularly, there were floods exceeded alert level III from 1 - 2.6 m or twin floods with many peaks, lasting several days caused severe flooding in low-lying areas and coastal plains. Floods, inundations are the most dangerous type of disaster, severely affecting and causing greatest damage to the socio-economic life of the province. Some of the major floods, such as the historic floods that occurred in late November, early December 1999; in late October, early November 2003; in mid-November 2007; on 29-30 September 2009 (due to the impact of typhoon No. 9).

Heavy rains often cause flash floods resulting in seriously erosion with hundreds of thousands of cubic meters of rock in many road routes from the district center to Son Long, Son Lap, Son Tan, Son Tinh, Son Mua communes, consequently traffic jams are serious. Flash floods often arise unexpectedly, occurs in a narrow scale, but very intense and causes serious damage to people and property. Flash Floods currently are unpredictable and prevention is very difficult (Quang Ngai Statistical Department, 2010; Quang Ngai Department of Science and Technology, 2008).

5.2.1.2 Landslides, northeast monsoons, thunderstorms, tornados, lightning

Landslides

The high risk groups include landslides, northeast monsoons, thunderstorms, tornados and lightnings. According to Quang Ngai Department of Agriculture and Rural Development (2011b), the situation of riverbanks and the coastal landslides is pretty complex (currently with 60 places of high risk). The rate of landslides varies depending on the characteristics of each river system and structural geology. The average erosion speed is from 5 ÷ 10 m/year, especially some areas of up to 20 m/year with a total length of these erosion segments is 65.25 km riverbanks and 45.3 km coastline. Affected areas are in the basin of four major river systems of Quang Ngai: Tra Bong, Tra Khuc, Tra Cau, and Ve rivers as well as the coastal areas of districts: Son Ha, Binh Son, Son Tinh, Tu Nghia, Quang Ngai City, Mo Duc, Duc Pho, Nghia Hanh, and Ba To.

In addition, mountain landslide is also a type of natural disaster that occurs mostly in all mountainous districts of the province. Due to the traditions of the people living in the area, they live in riverside and coastal areas (the further going downstream, the more crowded the population is, especially in the delta). Therefore, the number of households, people, infrastructure services, etc. are affected by shoreline erosion. At present, there are 75 points having risks of mountain landslides, of which 21 are in high risk in Ba To, Tra Bong, Tay Tra, Minh Long, Son Ha, Son Tay districts.

The northeast monsoon (cold fronts)

Northeast monsoon usually affects Quang Ngai weather from October of the previous year to March of the following year. The annual average of 14 to 15 Northeast monsoon spells affecting the province. The northeast monsoon blows back often associated with tropical disturbances in the south part of East Sea such as tropical cyclones, tropical depression, and tropical convergence zone causing heavy rain, which lasted several days formed the major floods, causing serious flooding (Pham and Phan, 1993). A historic flood was in 1964, particularly large floods in 1999, 2003, 2007 by heavy rain under this weather patterns. In the period from January to March, the northeast monsoon intense overflow caused heavy rain, inland and then flooding resulting in damage to winter-spring rice. Strong winds offshore will affect activity of marine economy (Quang Ngai Statistical Department, 2010).

Thunderstorms, tornados, lightning

In recent years, the province faces more frequent thunderstorms, tornados, lightning sharply, causing significant damage to persons, property and production activities of the people, especially for agricultural production. In Quang Ngai, the annual average of thunderstorms is 85-110 days with occurring most in mountainous areas whereas less figure in the island. In 2008, there were 10 thunderstorms and tornados, even strong cyclones occurred in March, May, June, July, October and November. Within the first 6 months of 2009, Quang Ngai witnessed three strong cyclones accompanied with heavy rains in March and April.

5.2.1.3 Droughts, wildfires

Medium-sized-level dangerous natural disasters include drought, sea-level rise, and saltwater intrusion. Drought is an abnormal dry weather phenomenon in an area due to a long period of no rain or insignificant rainfall. In Quang Ngai province, there are two periods of drought and forest fires that often occur in July and August. Drought does not occur frequently every year, it has a recurring cycle every 2 to 3 years. As drought is not predicted on the river systems, the prevention is still passive, with serious impact.

The degree of droughts due to the terrain, geological conditions, water conditions (Quang Ngai Department of Natural Resources and Environment, 2011a), therefore, these areas likely to occur with the highest level in Quang Ngai are:

- The no irrigation works (or have but a small irrigation works, located in the mountains with steep slopes so that difficulty for gravity irrigation) such as districts of Son Tay, Son Ha, Tra Bong, Tay Tra, Minh Long, Ba To and Ly Son island district.

- The western lowland districts including Binh Son, Son Tinh, Tu Nghia, Mo Duc, Duc Pho and Nghia Hanh (usually high elevation then difficult to control irrigation by gravity from the existing irrigation works and/or a little of works for motive irrigation).

- The east side of (sea border) districts of Binh Son, Mo Duc and Duc Pho due to salt water intrusion as well as the southern part of Duc Pho district due to hilly terrain with steep slopes).

A prolonged drought combined with the hot dry Southwest winds create very high fire risk at danger alarm level. Forest fires destroy the ecological environment on a large scale, seriously affect the microclimate when large forest fires occur. Every year, from April to August, the hot dry Southwest winds make impact on air temperature of over 370C and low humidity, the situation is not prolonged rain caused widespread drought spells in the lowland coastal plains and midlands (Pham and Phan, 1993). Gió Tây Nam khô nóng cũng là nguyên nhân của những vụ cháy rừng. Cháy rừng hủy hoại môi trường sinh thái trên diện rộng, ảnh hưởng nghiêm trọng đến vi khí hậu khi diện tích rừng bị cháy lớn.

Although the work of planting, nurturing and regeneration of forest has been paid more attention, the inspection of violations of forest law and forest fire prevention has been strengthened resulting to step by step limit the cutting, burning the forest. However, the total area of burnt forest remained high. In 2001-2005, there were 271.9 hectares of fire and 92.4 hectares of cleared forest; In the years 2006 - 2008, the forest area was 117.74 ha, of which 86,98 ha was burned in 2006; The forest was cleared of 85.7 ha. The number of forest areas damaged during the period 2000-2010 is shown in Figure 5.1. Due to hot weather, the carelessness of people and slash-and-burn agriculture, some forest fires have occurred such as the fire of 10 ha of forest in Tra Ong village, Tra Xuan commune (2010) and fire of 20 acres of acacia and eucalyptus forest of Pho Phong and Duc Pho communes (2011).

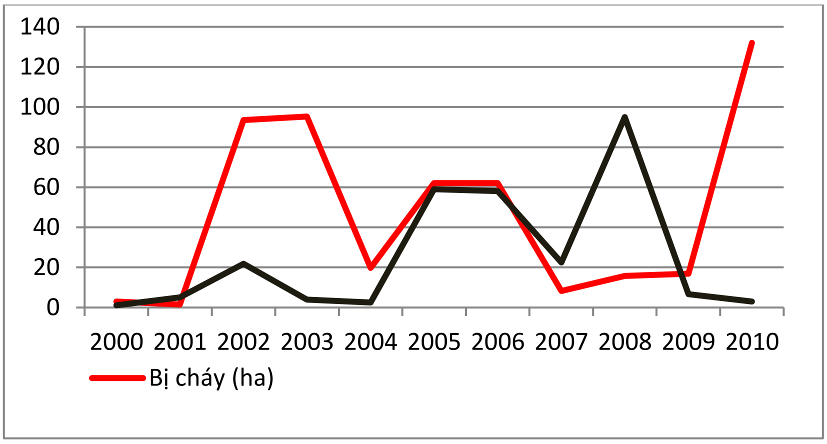


Figure 5.1. Area of damaged forest during 2000-2010

Source: Quang Ngai Statistical Yearbook 2005 and 2010

In the coming time, climate change could increase the number and extent of losses of forest fires and reduce the value of forestry production in Quang Ngai. Increasing temperatures can also facilitate the growth of new pests, or alter the frequency and extent of damage caused by pests and diseases to the forest. This will adversely affect forestation activities in Quang Ngai province.

5.2.1.4 Heavy Cold, damaging cold, fog, tsunami

Located in Central of Vietnam Central, Quang Ngai rarely has neither cold weather damage, nor hail occurring. The province is also rarely affected by hail, if any, in Tra Bong, Son Ha, Minh Long and Ba To districts.

In contract, fog occurs more often in mountainous areas, according to statistics (Pham and Phan, 1993; Quang Ngai Statistical Department, 2011), the average years of foggy days in the mountains is 49 days, 15 days in plains, and only 4 days in Ly Son island district. Intense fogs will affect traffic operations on land, river and sea. Fog has a strong influence on the growth and development of plants.

Tsunamis have not yet appeared in Vietnam, but many of the coasts are still vulnerable to tsunamis caused by earthquakes in some countries in the region. This is a potential danger that has been warned by scientists to potentially directly threaten areas of the population, infrastructure, land and coastal ecosystems.

5.2.1.5 Sea-level rise and saltwater intrusion

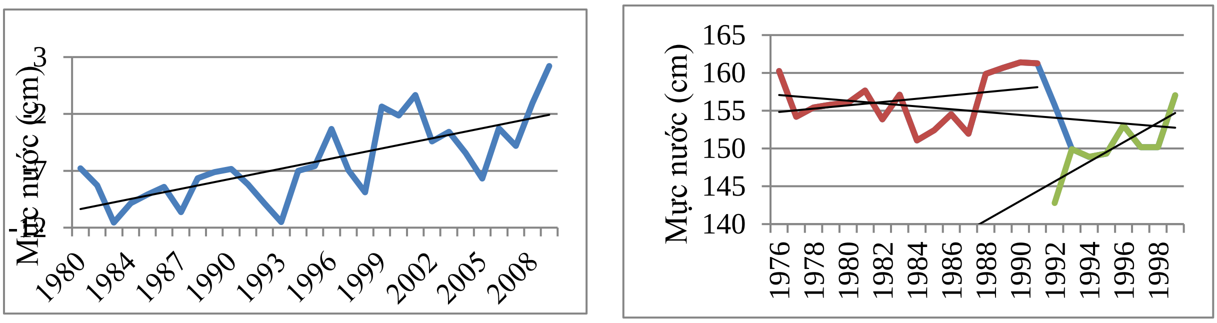
Although sea-level rise and saltwater intrusion are among the medium-level endangered natural disasters in Quang Ngai Province (Table 5.2), due to lack of data, time and funding, in the slow onset processes in the province, the report focuses on analyzing only two issues as follows:

Sea-level rise

<u>Expression of climate change on sea level</u>

Quang Ngai province has a coastline of about 144 km in length with vast territorial waters of 11,000 km^2 and 6 inlet. However, in the area of Quang Ngai province there is no oceanographic measurement stations. Thus, to evaluate the expression of climate change on sea level in the area, the report used tidal water level data at 2 oceanographic measurement stations of the neighborhood which are Son Tra station in the city of Da Nang and Quy Nhon station in the province of Binh Dinh. At oceanographic stations, water level data is at every hour. However, for climate change, the assessment should be carried out for a long period, so the report evaluated based on the monthly average values.

Under the impact of climate change during the past period, it could be seen that average annual water level at Son Tra station had strong variation, meanwhile at Quy Nhon station it changed very unstably. At Son Tra station, the average annual water level tended to rise rapidly, especially during the period from 1993 to 2009. For Quy Nhon station, it tended to decline strongly for the period 1976-1999. However, given separately for each period of 1976-1991 and 1992-1999, the average annual water level tended to rise rapidly, especially during the period from 1992-1999 it had a very strong uptrend. At Son Tra station, the monthly average water levels also had a very strong upward trend over the years, there was only a slight upward trend in February and October. Meanwhile, at Quy Nhon station, the monthly average water levels also had a downtrend over the years, only in November it had a slight decrease and in September and October it increased slightly. Changing trends in the average annual water levels in the period 1980-2009 at Son Tra station and in the period 1976-1999 at Quy Nhon station are shown in Figure 5.2.



(a) (b)

Figure 5.2. Changing trends in average annual water levels at Son Tra (a) and Quy Nhon (b) stations

<u>Sea-level rise scenarios</u>

Based on the results of scientific and technological project of Assoc. Prof. Dr. Huynh Thi Lan Huong (2015), the oceanographic characteristics of the area from Hai Van Pass to Dai Lanh Cape (named region 4), where the waters cover the area of Quang Ngai, were used to assess the expression of sea-level rise. Sea-level rise scenario was developed for the coast from Hai Van Mountain Pass to Dai Lanh Cape including Quang Ngai with three scenarios: A1F1 (high emissions scenario), B2 (average emissions scenario) and B1 (low emission scenario) (MONRE, 2009b, 2012).) The relative sea-level rise for the area was developed following to the global average sea water level in the future and in the past including monitoring data from oceanographic stations and satellites according to linear equations. The relative sea-level rise scenarios for the area of Quang Ngai are respectively presented in Table 5.4 and Figure 5.3.

In the early 50th century, sea-level rise at a slower rate than the later 50 years of the century (about 20-30 cm/50 years). According to the high scenario, sea levels tend to rise faster than the low scenario and average scenario, by the mid-21st century, sea-level rise is of about 27-29 cm. At the end of the century, the highest sea-level rise due to climate change for the region of from Hai Van Pass to Dai Lanh cape is around 83-97 cm for the high scenario and 52-65 cm for the low scenario, 61-74 cm for the average scenario.

Table 5.4. Sea-level rise scenario for Region 4 including Quang Ngai (cm)

Decadal	Sea-level rise (cm)		
	A1FI	B2	B1
2020	8-9	8-9	7-8
2030	13-14	12-13	12-13
2040	19-21	18-19	17-18
2050	27-29	24-26	22-25
2060	36-40	31-35	29-33
2070	47-53	38-44	35-41
2080	58-67	45-53	41-49
2090	70-82	53-63	47-57
2100	83-97	61-74	52-65

Source: MONRE, 2012

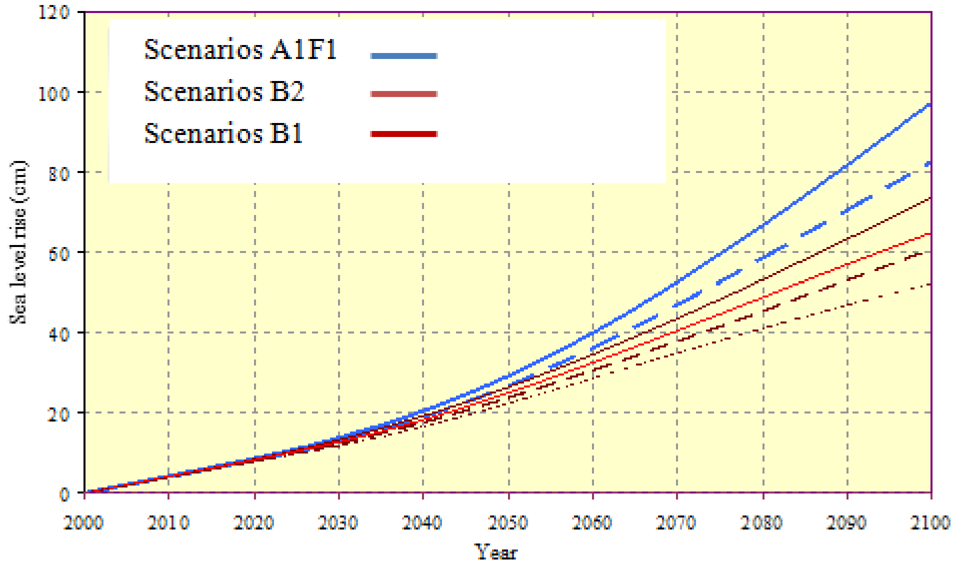


Figure 5.3. Sea-level rise scenario caused by climate change for the coastal area of Quang Ngai province (cm)

Source: MONRE, 2012

5.2.1.6 Saltwater intrusion

Saltwater intrusion developments on rivers

In Quang Ngai, the period of maximum saltwater intrusion is in April, July and August when the river flow discharge is most exhausted. Meanwhile, January, February and September are the transition time between flooding and drought seasons when plenty of upstream water or additional large rainfall resulting in low saltwater intrusion during this time. Thus, the salinity of the river is divided into two types in two seasons: In flood season (X-XII) there is big upstream flow discharge, tidal current is less likely to penetrate deep into the river; therefore, salinity in the rivers is greatly reduced, especially in X, XI river water is barely salty. In dry season (I-IX) there is small upstream flow, larger and relatively stable salinity intruded into rivers.

Saltwater movements along the rivers in Quang Ngai are very complex, the more going to upstream the more the salinity is decreasing. This distance is different in each river because it depends on many factors such as the salinity of coastal water, estuarine tidal regime, slope of the river, the flow discharge from upstream going down and activities of irrigation works. In addition, the process of saltwater intrusion into the rivers is influenced by factors such as wind regime, waves.

Areas affected are coastal plains and major river estuaries, such as the East of Binh Son district (Sa Can mouth), East of Son Tinh, Tu Nghia, and Mo Duc districts (Cua Dai mouth, Mo mouth), and Southeast of Duc Pho district (My A and Sa Huynh mouths) (Quang Ngai Department of Natural Resources and Environment, 2011c).

The development of saltwater intrusion in Tra Bong river is complicated, with salinity in many tributaries in downstream is affected directly fromm Sa Can mouth. In Tra Khuc River, the distance that is affected by tide and saltwater intrusion is less than that in Tra Bong river. Ve river is tidally affected from 2 river estuaries: Co Luy mouth and Duc Loi mouth (Lo mouth), with the distance that is affected by tide and saltwater intrusion into the rivers is the most remote compared to other rivers in the province.

Shortage of rainfall at the end of 1995 caused drought and lack of water for people's daily production in 1996. Water levels in rivers were lower than the average value of many years, with deeper saltwater intrusion. Drought in 1996 is considered to be relatively severe in Quang Ngai. On the other hand, there are full input data in 1996 (meteorological, hydrological, topographic and salinity data) and the data used to calibrate and validate to calculate saltwater intrusion in Quang Ngai province. Thus, 1996 was chosen as the base year (base period) to calculate saltwater intrusion under climate change and sea-level rise scenarios for the river systems of Ve - Tra Khuc in Quang Ngai province.

Impacts of climate change on saltwater intrusion

According to the medium scenario of the Institute of Meteorology, Hydrology and Climate change (IMHEN) launched, in 2020 the average annual temperature in Quang Ngai province will increase by 0.5°C, sea level will rise 8-9 cm; rainfall in the dry season will reduce 1-2% in comparison with that of the period 1980 - 1999 (MONRE, 2009, 2012). It means that, if no timely measures are taken, mangrove area will continue to increase in the future.

In recent years, many estuaries in Quang Ngai have been faced serious saltwater intrusion in the dry season due to the effects of climate change (rainfall is lower than the average of many years, the river water level lowered, the flow rate of decline, accompany with the water demand of the industry economic rise). In Quang Ngai, climate change has caused prolonged drought, combined with reduced upstream flow during the dry season, high sea-level rise caused deeper saltwater intrusion inland, rising salinity and prolonged period of saltwater inundation, significantly affected on the lives and production of residents especially agriculture.

Salinity distances of 4‰ that intrudes into rivers of Tra Bong, Tra Khuc and Ve rivers in Quang Ngai province under climate change scenarios were calculated for four periods of 2020-2039, 2040-2059, 2060-2079 and 2080-2099. Overall, it is likely to increase in all periods of climate change scenarios compared to the base period. The increasing levels of salinity distance of 4‰ compared with the base period differ between the rivers and the periods of the scenarios. The increasing levels of Tra Bong river is the most and that of Ve river is the least in all the periods of climate change scenarios. The salinity distance of 4‰ increases quite evenly compared to the base period in the early period of 2020-2039 and 2040-2059, the increasing levels tend to differ markedly in the late periods of 2060-2079 and 2080-2099.

Similarly, the salinity distances of 1‰ that intrudes into rivers of Tra Bong, Tra Khuc and Ve in Quang Ngai province are the same and tend to increase in all periods of climate change scenarios compared to base period. The increasing levels of the salinity distance of 1‰ in Tra Bong, Tra Khuc and Ve rivers do not differ from each other much, and the largest increasing level is in Tra Bong River and the smallest value is in Ve river.

The larsgest salinity distances that intrudes into rivers of Tra Bong, Tra Khuc and Ve in Quang Ngai province tend to increase compared to the base period, however the increasing levels are different in rivers and the periods of scenarios.

5.2.2 Risks caused by natural disasters and climate change

From the results from the survey in Quang Ngai province, and the scientific and technological Project of Assoc. Dr. Huynh Thi Lan Huong (2015), analyses of vulnerability, risk mitigation and disaster resilience in Quang Ngai Province are as follows:

To assess the risks posed by climate change for Quang Ngai province, firstly, it needs to build development scenarios for the province, which is development scenario in the development planning. The next step should develop climate change scenarios to the calculated year in order to determine the damages, risks due to climate change of sectors and fields. Vietnam have made reports of assessment of the impacts of climate change on sectors in regions, on which it can be based to implement and calculate risk indicators according to the formula. Risk assessment is divided into 5 levels, indicators of damages or risks caused by climate change are usually calculated according to percentage of that field. For example, in the transportation sector, namely damaged motor vehicles amount will be counted against the total number of motor vehicles in the province area. 5 assessment levels are devided into the following:

Table 5.5. Level of risk assessment

Levels of damages and losses	Assessment	Points
0-20%	Low	1
20%-40%	Medium low	2
40%-60%	Medium	3
60%-80%	Medium high	4
80%-100%	High	5

Results of calculating Risk reduction index for Quang Ngai Province is shown in Table 5.5 and Figure 5.4. Capacity of Risk reduction of districts/cities in Quang Ngai province is relatively low. Only mountainous district of Ba To has high Risk reduction index, meanwhile the rest have meidum and low levels. Although being a mountainous district, with difficult socio-economic conditions and indicators of socioeconomic, ranked No. 13 out of 14 districts, Ba To district has given much resources for investment of risk reduction of natural disasters and adaptation to climate change. Ba To has the highest forest covery rate in the province, with the rate of new plantations in 2013 was also high. In addition, although there is no project in the portfolio of projects under the Action Plan to adapt to climate change, this is the only locality that has local plan for climate change adaptation and establishment of steering committee of climate change adaptation projects, and some projects to enhance adaptability to climate change, with the support of the PLAN organization. The district with the lowest risk reduction index is Son Tinh (0.25). Son Tinh district is located in the plains of Quang Ngai province, with relatively high level of socio-economic indicators, ranked No. 5 out of 14 districts. However, like most of the other delta districts, the forest covery rate of Son Tinh is not high, resulting in the low index of Environment and Natural Resources, plus the absence of the project or plan on climate change adaptation leading to total low risk reduction index.

Table 5.6. Risk Reduction Index in Quang Ngai

Areas/Localities	Natural resources and Environment	Socio-Economic	Policy and management	Risk reduction Index	Ranking
Quang Ngai city	0.00	0.70	0.36	0.35	7
Binh Son	0.29	0.56	0.36	0.41	4
Son Tinh	0.17	0.57	0.00	0.25	14
Tu Nghia	0.33	0.67	0.00	0.33	9
Nghia Hanh	0.40	0.54	0.00	0.31	12
Mo Duc	0.56	0.58	0.00	0.38	5
Duc Pho	0.46	0.49	0.00	0.32	11
Tra Bong	0.81	0.48	0.00	0.43	2
Tay Tra	0.36	0.52	0.00	0.29	13
Son Ha	0.44	0.49	0.36	0.43	3
Son Tay	0.48	0.57	0.00	0.35	8
Minh Long	0.59	0.37	0.00	0.32	10
Ba To	0.72	0.48	1.00	0.73	1
Ly Son	0.58	0.53	0.00	0.37	6

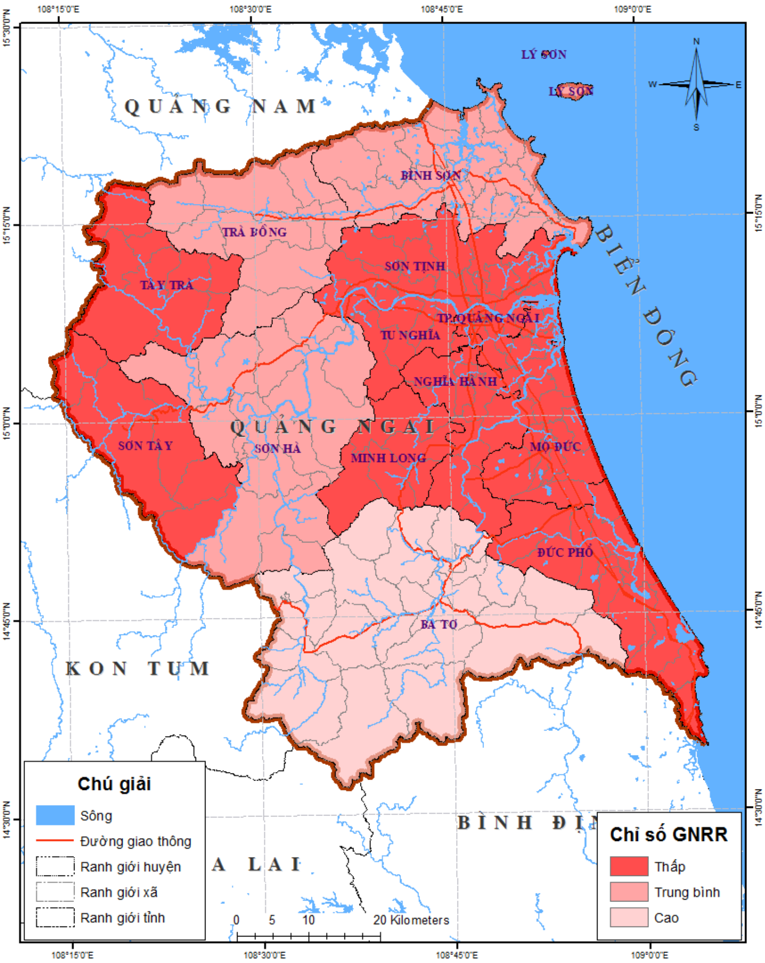


Figure 5.4. Map of Risk reduction in Quang Ngai Province

5.2.3 Vulnerabilities to slow onset processes and cascading risks

Overall, Quang Ngai province is likely to have low vulnerability to the effects of climate change. In particular, Ly Son island district is sensitive too maritime disaster. The district is potentially most vulnerable to climate change.

The set of indicators of vulnerability with normalized value of the index of exposures (E), sensitivity (S) and adaptive capacity (AC) for each district of Quang Ngai province was calculated. To be easy in comparing vulnerablity due to climate change between the districts of Quang Ngai, vulnerablity was divided into 3 levels (CVI) in the range from 0 to 1 as follows:

1: Low vulnerablity (CVI <0.35)

2: Medium vulnerablity (0.35 ≤ CVI <0.75)

3: High vulnerablity (CVI ≤ 0.75)

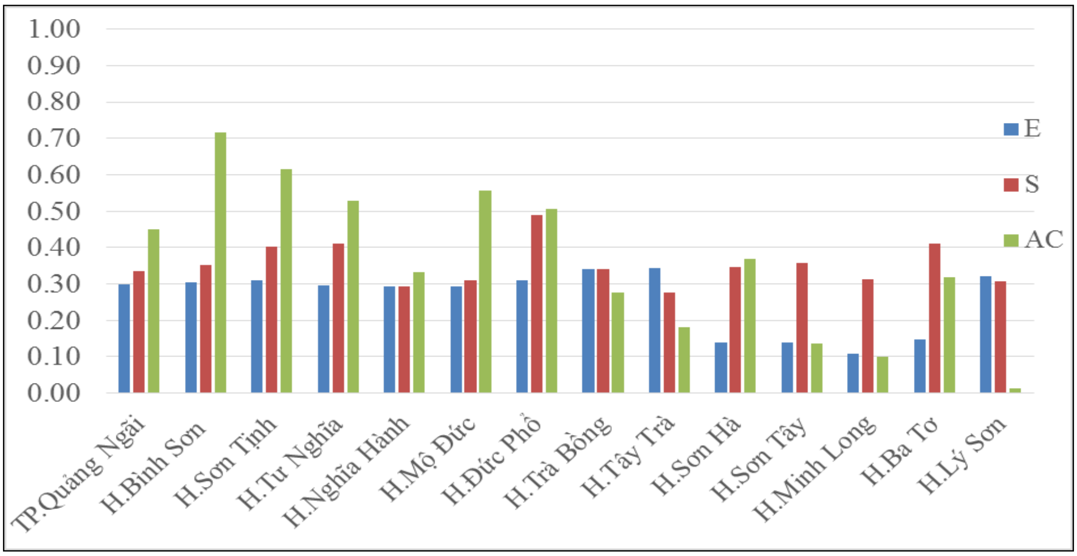


Figure 5.5. Comparison of the value of E, S, AC between districts in Quang Ngai province in the current conditions

According to the calculated results as shown in the Figure 5.5, in the current climate conditions and socio-economic status (2013), Quang Ngai province is likely to be potentially low vulnerable to the impacts of climate change. Binh Son and Mo Duc districts is at low level of vulnerability while the remainers are at medium level of vulnerability. Considering more about the extent of exposures, sensitivity and adaptive capacity, it can be seen that the Tra Bong and Tay Tra Districts have highest index of exposures to climate change. Meanwhile Duc Pho and Ba To districts are the most sensitive places. Binh Son district has the highest adaptive capacity index in the province because it is a coastal district having Dung Quat economic zone with the first oil refinery of Vietnam which is located in the central key economic zone. Its socio-economic situation has been having much rapid progress.

Ly Son district has the highest vulnerability index to climate change in the province due to adaptive capacity is the lowest (0.01), the index of exposure and sensitivity is relatively high (respectively 0.32 and 0.31). Ly Son island district is separated from Binh Son District of Quang Ngai province. The people on the island live off fishing and growing garlic. However, the coastal sand mining to plant garlic and onions have caused significant damage due to cavitation phenomena. On the other hand, the facilities on the island are limited and people have not yet accessed to information on climate change leading to adaptive capacity of the district is the lowest in the province. This raises the government and people of many challenges in finding and implementing solutions to prevent and respond effectively to natural disasters and climate change.

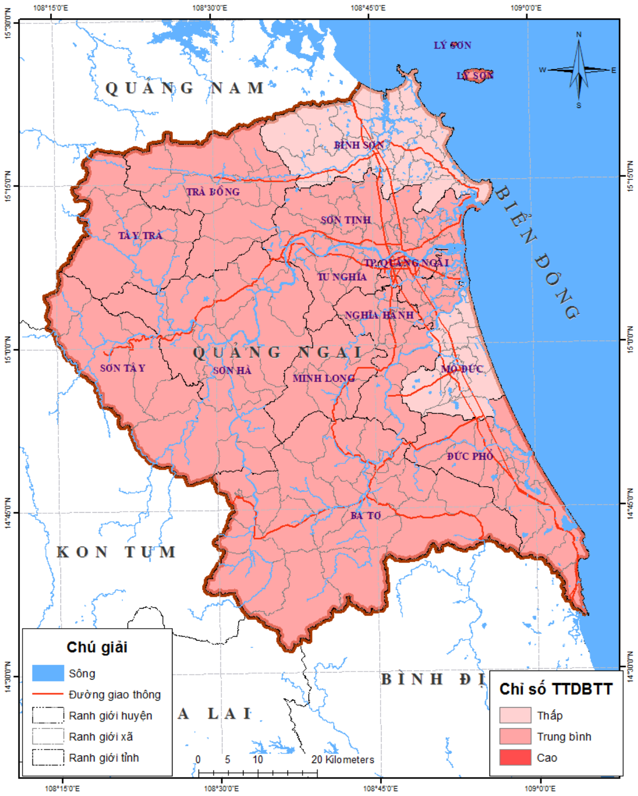


Figure 5.6. Map of vulnerability for the districts in Quang Ngai province, 2013

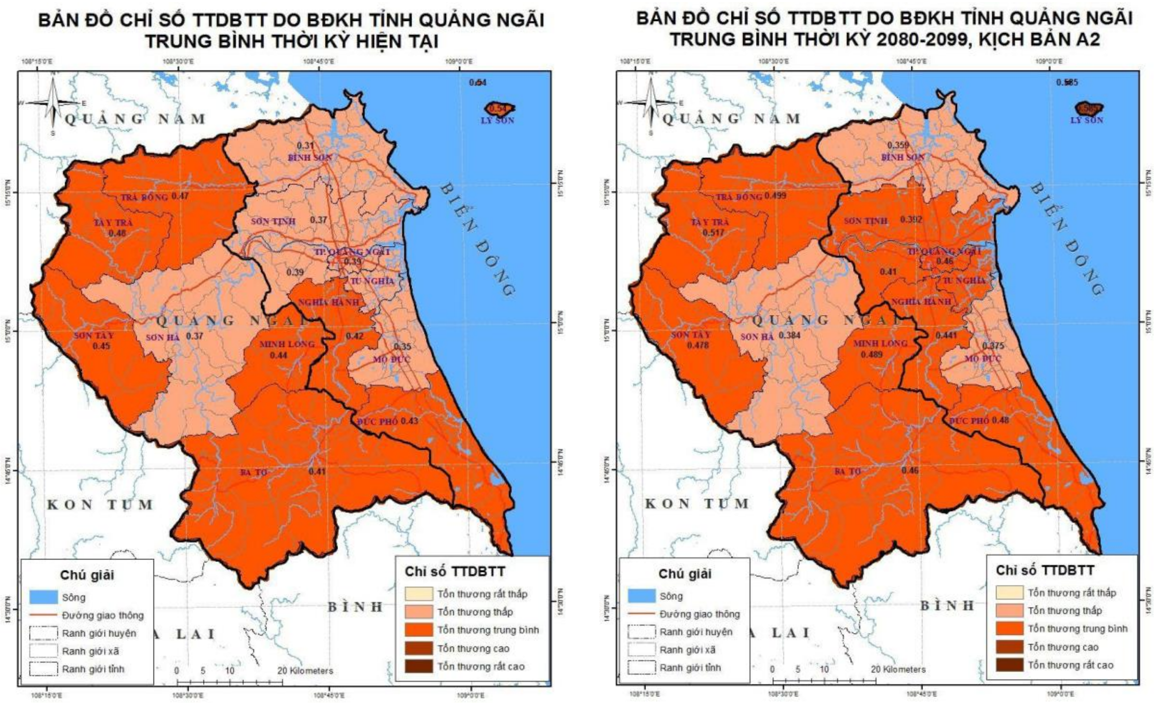


Figure 5.7. Map of vulnerability for Quang Ngai Province during the period: (a) at present; (B) 2080-2099 under the climate change scenario A2

Figure 5.6 shows Map of vulnerability on average of periods for Quang Ngai province at present. By 2099 (Figure 5.7), vulnerabilities of all districts and cities of Quang Ngai province have increasing trend. Especially, the plains districts tend to rise higher, districts of Son Tinh, Tu Nghia and Quang Ngai city moves from a low vulnerability level (0.37; 0.39 and 0.39) to medium level (0.4; 0.46 and 0.47).

5.2.4 Disaster resilience of the natural environment

To identify indicators to measure the resilience of the natural environment, it is necessary to determine the characteristics of a natural environment which is tolerant to climate change. Based on the references, this study has synthesized the characteristics of the natural environment tolerant to climate change including: The diversity of the natural environment; Flexibility in the management of the natural environment; The natural environment that can continue to provide ecosystem services.

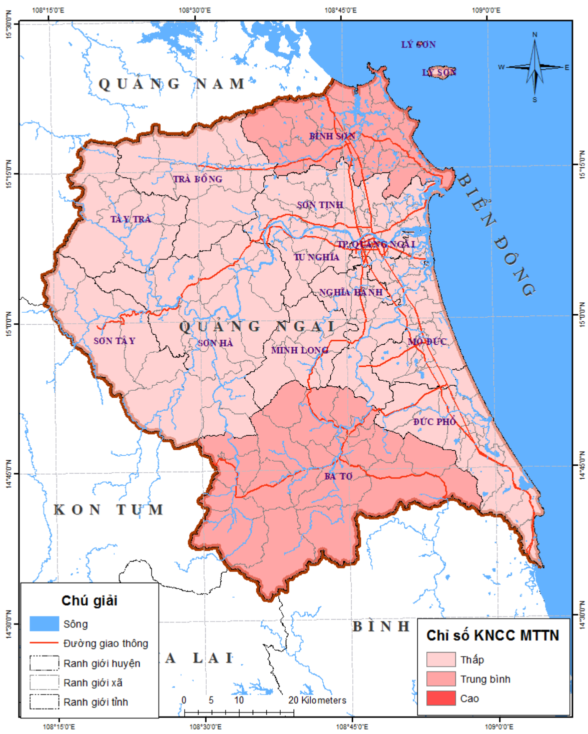


Figure 5.8. Map of the index of resilience of natural environment of the districts and Quang Ngai city

Calculation results of the index values and resilience to disasters in Quang Ngai Province is shown in

Table 5.7 and Figure 5.8. It can be seen that the resilience of natural environment of Quang Ngai province is at medium level and priority areas of the province to increase resilience is flexible management of natural environment and enhancement of the diversity of the natural environment because these indices are the lowest in three key indicators. Quang Ngai Province can strengthen the flexible management of natural environment by building more national parks and protected areas, and integrating climate change into plans for environmental protection and construction for new environment. Besides, Quang Ngai can also enhance the diversity of the natural environment by planting more forests, increasing the area of green infrastructure, etc. Besides, based on the figures, we can see that resistance of natural environment in 2 districts of Binh Son and Ba To achieves medium level which is higher than that of remaining districts and the Quang Ngai city. So, over the upcoming period, Quang Ngai Provincial People's Committee should also focus on investment in order to enhance the resilience of natural environment in the districts of Tra Bong, Tay Tra, Son Tinh, Tu Nghia, Nghia Hanh, Son Tay, Son Ha, Minh Long, Mo Duc, Duc Pho and Quang Ngai city.

Table 5.7. Values of Index of resilience of natural environment of Quang Ngai province

Index of resilience of natural environment	Value of index in 2013
1. The diversity of the natural environment	0.16
1.1. The area of semi-natural environment	0.25
1.2. The variety of vegetation	0.13
1.3. Regenerating coastal habitat	0.07
2. flexible management of natural environment	0.1
2.1. Integrating climate change	0.2
2.2. Conservation area	0.00
3. Ecosystem services	0.38
3.1. Support Services	0.814
3.2. Providing Services	0.11
3.3. Regulatory services	0.33
3.4. Cultural services	0.28
Resilience of natural environment	0.14

5.3 RESULTS

According to the Report of Quang Ngai Provincial People's Committee (2014) on the Implementation of Disaster Risk Reduction and Mitigation Policies in Quang Ngai Province, the total economic loss of the Province for the period 1999-2013 was 9455.21 billion VND. The impact of natural disasters on the socio-economy in the period 1999 to 2013 can be counted as: Number of dead, missing people was 473; injured people was 1,334; collapsed, washed away houses was 8,748; roof-lost, damaged houses was 83,850; damaged classrooms and clinics was 5,448; sank, damaged ships was 759.

According to the report of the Central Steering Committee on natural disaster prevention and control, in 2016, in the whole country, the situation of natural disasters has changed complicatedly. Central and the Central Highlands provinces were affected by the long historic droughts. From mid-October to the end of the flood season in the year, there were 5 consecutive big floods on a large scale with extreme, abnormal and prolonged intensity. The total rainfall in two peak months was larger than the average value of the whole year in many areas, especially in some areas rainfall were larger than 2,500mm which is 2,729mm such as Minh Long in Quang Ngai province. There were also severe flooding. Many roads were divided by floods, landslides, resulting to production stagnation, people’s living conditions in disaster areas were extremely difficult and had heavy losses. In Quang Ngai, heavy floods from 13-17 December 2016 caused severe flooding in most of the delta districts of the province; The water level of big rivers such as Ve river was from 0.7-1.3m above the alarm level 3, reaching the historic flood peak in 2013. Around 300 hamlets, residential quarters and residential areas were completely divided; Nearly 20,000 houses, more than 1,000 hectares of rice and crops flooded, damaged; Many works of health, education, traffic, irrigation were damaged and had landslide, the province has relocated nearly 5,000 households in flooded areas to a safe place.

In general, according to the scientific and technological Project of Assoc. Dr. Huynh Thi Lan Huong (2015), losses and damages caused by natural disasters and climate change in sectors in Quang Ngai province are as follows:

5.3.1 Water resources

Losses and damages are most apparent in water resources through flooding in Quang Ngai province. In 1999 the Central region experienced a historic flood, which began on the night of December 1, 1999, and lasted for a week. The region (from Quang Tri to Binh Dinh) sank in the sea, most fierce was in Thua Thien - Hue and Quang Nam. Causes of heavy rain were the simultaneous synthesis of many weather patterns: cold north air enterred, encountering the lower range of the equator through the Central region, wind from the east was active, at the same time there was a tropical low pressure near the shore. Particularly in Quang Ngai, heavy rains lasted continuously causing floods on rivers to rise. Major floods in early December 1999 caused widespread flash flood and severe, widespread, long-lasting flooding in Quang Ngai province. The flood in December 1999 caused the biggest flooded area of 59366 hectares in Quang Ngai Province, of which 52285 hectares were above-1-m-deep inundated, above-2-m-deep inundated area of 43,407 hectares, 34656 hectares were above-3-m-deep inundated, 26030 hectares were above-4-m-deep and the flooded area of 5m deep was 17217 hectares.

According to climate change scenarios (A2, B1, B2) (MONRE, 2009b, MONRE, 2012), the largest inundated area in periods of the Quang Ngai province has increased significantly compared to the baseline (1999) which increased from 2279 to 5642 ha corresponding to 3.82 - 9.46% of the total area of the province. However, the uptrend between scenarios is not the same. The total area of greatest flood risk (A2 scenario in period 2080-2099) is 65307 ha. According to scenario B1, the flooded area of the province tends to increase gradually over time. In the districts, the flooded area of 2 districts of Binh Son and Mo Duc has increased significantly over time. Tu Nghia district has an flooded area suddenly changed in the late period. The flooded area of Duc Pho district tended to decrease over the periods under the B2 scenario, in the first three periods, the flooded area of the whole province increased, then increased dramatically in the late period. In the districts, inundated areas increased evenly over time. Particularly in Binh Son district, in the last phase of the scenario, inundated area increased dramatically; In scenario A2, the uptrend of flooded area is similar to that of scenario B2, but in the first three periods, the changes of the flooded area is less than that of the first 3 periods of B2 scenario compared to the baseline.

5.3.2 Soil resources

The loss and damage to land resources in Quang Ngai Province is reflected in the deterioration of land quality, which is of average level in comparison with the whole country. Changes of climate, weather such as rain, sunshine, temperature, wind, storms, sallwater intrusion and drought have caused the land to lose its original characteristics and properties, becoming the soil which has characteristics and properties that are not conducive to the growth and development of agricultural and forestry crops, or for other uses. Typical types of soil degradation include salinity and acidity, erosion and accretion, degradation, hardening and desertification in soil.

In Quang Ngai, sea-level rise will entail deep saltwater intrusion in coastal estuaries and plains of Son Tinh, Tu Nghia, Mo Duc and Duc Pho, resulting in soil area which is saltwater intruded increase. Low and medium saline soils are regularly distributed in the average terrain of 0.8 to 1.2 m away from the sea and large rivers. This type of land is cultivated for a long time, in dry season it is vacant, the evaporation is very strong, so the soil has been compacted at a depth of 80 - 100 cm. Soils with deep saline in periods are distributed in lower terrains, when tide is overflowing, making the deep saline soil layer be difficult to wash quickly in early rainy season.

In addition, natural disasters and climate change cause more disturbance to the regime of rain and sunshine, leading to more heat, changed rainfall, nutrients in lost soil is higher during long rains since rainfall amount and intensity in rainy season increase resulting to erosion and washing away of soil and rock layers, soil degradation is aggravated. The erosion occur mainly in the hills, where the slope is relatively high, the vegetation is poor and the mountainous areas where the terrain is strongly separated have high slope. The amount of soil loss due to erosion is usually very large and depends on the slope, the slope length, the status of ground surface. The eroded soil occupies 1.88% of the natural soil area in the province.

According to the survey on the assessment of erosion and accretion of coastal areas of Quang Ngai province by the Institute of Geology, the accretion in the estuaries has developed seriously such as Dai gate (Tra Khuc river), causing the congestion of waterway transportation, which is difficult for ships in and out. Especially when the estuaries are accreted, the flood water run down quickly and do not drain, causing serious flooding in the residential areas of Quang Ngai.

Quang Ngai is also the area of rapid desertification. The extent of impact is also wide due to prolonged drought, leading to land degradation to become exhausted and hardened which further can not be used for production. The soil of this area has low fertility, most of the area is sloping land (about 80%), concentrated in mountainous and semi-mountainous areas. The deforestation and burning of forests for cultivation are complicated and the main causes leading to desertification and degradation of the ecological environment in the areas.

5.3.3 Agriculture

Quang Ngai Province's total agricultural area flooded in 1999 was 29132 hectares, of which 26292 hectares of paddy land were flooded, the area of cultivated for food crops was 2840 hectares. Mo Duc and Duc Pho districts have the largest area of flooded agricultural land in the province with an area of over 6000 ha.

The agricultural area which would have the largest flooded risk under A2 scenario in period of 2080-2099 is 31977 ha, accounting for 6.21% of the total area of the province and 23.5% of the total agricultural land area. In particular, the paddy area having flooded risk is 28890 ha equivalent to 39.76% of the total area of rice.

Natural disasters and climate change negatively affect crop yields. For spring rice, in deltas and mountainous areas, under the impact of climate change, the grain productivity of the delta will 1-11% decrease and in the mountains it would 1-9% decrease. Due to the farming practices in two different regions, in mountainous areas the production is mainly based on natural water, the irrigation system is underdeveloped ... leading to changes in temperature conditions, precipitation so that crop yields will be strongly affected. Under the impact of climate change, the summer-autumn rice is similar, the increase of temperature and rainfall leads to significant decrease of the grain yield depending on each period in the period 2020-2100. For both plains and mountainous areas, it can be seen that the fall in grain yield in spring and summer seasons is also different. In particular, in summer-autumn the crop yields decrease more than that in the spring season. In summary, climate change which will take place in Quang Ngai mainly will develop with rising temperatures during the winter months and changing the distribution of temperature and precipitation. The impacts of climate change on agricultural production are mainly reflected in the decline in rice yield.

5.3.4 Forestry

Due to climate change, rising temperatures will affect the spatial distribution of plant species as the species will tend to move to cooler areas or higher altitudes. According to the report of Climate change scenarios and sea-level rise for Vietnam (2009), by the end of the 21st century, the annual average temperature in the northern climatic regions may increase faster than that in the southern climatic zones. Therefore, the forests of Quang Ngai Province may move gradually southwards as the temperature in this area increases less.

In addition, rising temperatures may increase the evaporation rate so that the amount of water available can be reduced, leading to water shortages in the forest and changes can be made in the composition in forest species. Plants that are adaptive to water shortages (such as conifers) will be better adapted.

In addition, rising temperatures can increase the frequency and severity of forest fires. In recent years, due to hot sunshine, the carelessness of the people and slash-and-burn agriculture, many forest fires have occurred in Quang Ngai province, such as the 10 ha forest fire in Tra Ong village, Tra Xuan commune (2010) and the fire of 20 ha of acacia and eucalyptus forests of Pho Phong and Duc Pho communes (2011). Total burned forest area is large; in the 2001-2005 period the fire made 271.9 ha burned forest; cleared forest of 92.4 ha; In the years 2006 - 2008, the burned forest area was 117.74 ha, of which 86,98 ha was burned in 2006, cleared forest was 85.7 ha. In 2012, the forest area burned in the whole province was 63.7 ha, increased by 1.7 ha compared to that in 2005.

Table 5.8. Area of fired forest in Quang Ngai province for the period of 2005-2012 (Unit: ha)

Year	Area of fired forest
2005	62.0
2006	62.0
2007	8.2
2008	15.7
2009	16.9
2010	132.0
2011	59.2
2012	63.7

Source: Statistical Yearbook 2012

In addition, due to the impact of climate change, changes in air temperature, humidity and precipitation affect the number of days where there is a high risk of forest fire. The number of days with high risk of forest fire between mountainous and coastal plain areas is different. In most scenarios and periods, the number of days with high risk of fire in coastal areas is higher than in mountainous and central Quang Ngai.

5.3.5 Biodiversity

Climate change together with changes in temperature, rainfall, sea-level rise and extreme weather events will have a large negative impact on terrestrial and aquatic biodiversity in Quang Ngai province. When climate change occurs, new species will be formed. The reorganization of species composition may affect ecosystem functions, but these effects are yet to be clarified. Many species can be dispersed quickly enough to adapt to climate change as long as they can be dispersed through continuous, unadulterated natural systems. This underscores the importance of dispersing natural ecosystems.

Changes in temperature and seasonal variations in the year may adversely affect many species, especially migratory species. The invasion of alien species into the natural system is a global problem which is likely to be aggravated by climate change. Climate change can damage/diminish many species due to the loss of their favorable environment and the increased pressure of land use change. Biosphere structures will become simpler with fewer ecosystems. Significant different impacts of climate change on species composition occur in different areas due to differences in local impacts on soil, land use and topography.

Climate change causes the decline of ecosystems in accordance with the cold climate as well as negative impact on the plant and animal species of the ecosystem. In contrast, the decline in biodiversity, especially the decrease in forest area, has accelerated global climate change.

5.3.6 Aquaculture

The sea of Quang Ngai has a large island which is Ly Son (Cu Lao Re) and a small island named Be Island. At the edge of the island, there are many reefs and coral reefs that form a remarkable marine ecosystem and abundant aquatic resources that can exploit and preserve many valuable marine species.

The increase in atmospheric CO2 levels is acidifying in the oceans, making it difficult to form shellfish of marine organisms such as shrimp, oysters and corals (also known as calcification). Many important marine animals such as plankton - which form the basis of the sea food chain - has calcium shell. Therefore, the entire marine food chain will be altered, leading to the distribution, stock and composition of fish species will be altered, causing complex impacts on the sea, estuaries, coral reefs and mangroves and seagrass which are the habitat of many fish species, affecting fishing and tourism services.

Climate change can affect coastal currents in the Quang Ngai areas, altering fish stocks that are brought to shore, directly affecting fishing activity and productivity, and the total value of fishery production of the province.

The increase in sea level can facilitate the development of warm-water fish species, resulting in the migration of these species to Quang Ngai's coastal area, which would compete the habitats of native fish. At the same time, the marine species with high economic value in Quang Ngai's sea area may not be compatible with rising water temperatures, which may result in migration to other areas, resulting in damages to activities of seafood exploitation and processing. In the longer term, if the temperature continues to rise and exceed the optimum temperature threshold for the growth of aquatic species, it can cause damage to coastal aquaculture in Quang Ngai province.

Seasonal water flow discharge affects water levels in lakes, such as two relatively large natural lagoons which are An Khe and Lam Binh lagoons (Duc Pho district). Changing seasonal water levels also affects the flow of rivers, the level and duration of flooding and sea level, so they play an important role in maintaining the lives of fishes in the tropics. Changing the rain regime also leads to water shortages in critical periods in the life cycle of aquatic species, threatening the health of aquatic species and marine biological diversity.

5.3.7 Transportation

Impacts and damages caused by natural disasters and climate change to traffic, including: Transport infrastructure destruction (heavy rain, big floods destroying bridges, roads, dykes ...); High temperature creates wear and tear of engine energy increases transportation costs. Climate change also hinders traffic, such as heavy rain, which causes floods and landslides, causing serious damage to the roads, obstructing and affecting the circulation of vehicles; threatening national highways close to the coast, dykes combined with coastal roads. In addition, climate change also causes floodings and landslides such as roads and railways, changing lanes, waterway traffic due to droughts, floods, riverside landslides. This causes difficulties for waterway transportation and port operation in the context of sea-level rise, increasing the frequency and intensity of storms, floods and storm surges.

There are some typical floods in Quang Ngai Province. November 2010 occurred three successive floods, continuously causing damage to the road surface on the provincial roads, causing landslides and damage particularly on Highway 24 and 24B and other roads. In November 2013, due to the impact of tropical depression, the province had heavy rain causing floods, great damage to traffic works, especially on the Highway 24, 24B and 24C. The mountain slides, erosion of bridges have caused traffic jams for many hours. In March 2015, an seasonable flood in Quang Ngai province caused great damage to the transport system. Significant routes such as the National Highway 24 have occurred landslides in many places at Vi O Lac mountain pass, underground sewers in Ba Lien commune (Ba To district); the provincial road was landslided, damaged, particularly Ba To - Ba Ba - Ba Nam (Ba To district) was damaged at 37 sites. Ba To - Ba Trang route (Ba To district) has also landslided at the site of Treo village with a length of about 10m; a temporary bridge was washed away in Nghia Hanh district.

The lengths of the flooded roads of all scenarios which are increased compared to the baseline in 1999 are over 90 km, accounting for 50% of the total highway section in Quang Ngai province. Under the high emission scenarios (A2), there are about 93 km of flooded highways caused by floods during the periods of 2020-2039 and 2080-2099, the number of inundated roads will rise to 4%. Under the other two scenarios B1 and B2, the number of flooded highways increases by 1-2% in the period of 2080-2099 compared to 2020-2039. For all scenarios, in the period 2060-2079 to 2080-2099, the number of km of affected roads increases faster than that in other periods. In addition, compared to the baseline scenario, in all three scenarios B1, B2 and A2, the number of km of inundated railway sections tends to increase over time. The number of kilometers of railways in the high emission scenario (A2) is the fastest growing and the slowest increase is in the low emission scenario (B1).

5.3.8 Industry and Commerce

Quang Ngai Province has industrial parks of Tinh Phong, Quang Phu, Pho Phong. Production facilities are mainly located in the coastal areas and in Mo Duc, Duc Pho districts. The province has 12 industrial clusters, of which 8 may be affected by inundation, such as industrial cluster of Son Tinh, craft village clusters of Tinh An Tay, Yen Phu, Thien But, La Ha, Dong Dinh and Quan Lat.

An increase in rainfall, typhoons, floods, etc., could cause industrial facilities to be flooded for prolonged periods of time, traffic jams, mountain cracks and even more isolated areas. Extreme weather events such as winds, lightning, heavy rain damage the power transmission system, urban lighting and power stations, resulting in power outages and increased production and repair costs. Large rains can cause flash floods, erosion of river and coastal bank, direct impacts on industrial parks and clusters on the banks of the Tra Khuc River such as interregional industrial parks of Nghia Ky, Nghia Dieu- Hanh Thuan, Yen Phu, Quang Phu, causing damage to people and property, affecting the industry, increasing human costs and efforts to respond to situations, causing environmental pollution caused by the release of chemicals from factories when flooding occurs. Quang Phu and Tinh Phong industrial park are likely to be affected by flooding. Phong Phu industrial park could not be affected. Most seaports are filled up and narrowed, making it difficult for vessels to come in. Every year, the state and people have to spend a lot of money and effort to clear the flow and dredge the canal. Materials for the industry, especially the food processing, textile and garment industries, will be significantly impaired because of inadequate supply from flooded areas. Petroleum products purchased at Dung Quat to warehousing and sold to the market were priced higher than imports.

Deep flooding level in industrial clusters under scenarios over time tends to increase and deeper than baseline scenarios. For Son Tinh industrial cluster, according to the A2 scenario, from 2020-2039 to 2060-2079, the deep flooding level would be reduced to that of the base period; By the end of 2080-2099, the deep flooding level in this industrial cluster would rise again, exceeding the depth of the 2020-2039 period. At Quan Lat industrial cluster, it can be seen that the deep flooding level of B2 and B2 scenarios would decline sharply between 2040-2079 and rise again in 2080-2099. According to 3 scenarios, two industrial clusters of Quan Lat and Sơn Tinh, are likely to be the deepest flooded (All flooded of 600 cm) compared to other industrial clusters.

Increasing temperatures increase the energy consumption of the industries, the cost of ventilation and cooling the mines and reduce the efficiency and yield of power plants, causing overloading and damage. Power supply equipment, reducing the thermal power generation capacity and causing water shortage to the cooling system of the power plant.

The rise in sea level leads to greater impact of wave energy, increasing coastal erosion, erosion rates, reducing the durability of port construction structures, impacting on seaport infrastructure related to the elevation of the wharf, causing economic loss to individuals and organizations involved in port operations. The increase in sediment deposition, the frequency of sedimentation leads to the decreased and unstable channel depth, affecting on navigation, increasing the cost of dredging maintenance. Unusual fluctuations of floods and storms slow down the progress of cargo and shipment release, leading to scheduling delays, especially for container liners. The cargo must be stored at the port for a longer time and may cause traffic jams at the port, leading to an increase in the loading area of the cargo yard. In addition, climate change can negatively impact trade, investment and integration through the port system.

5.4 DISCUSSION

5.4.1 Integrated policies

5.4.1.1 Climate change adaptation

Quang Ngai's leadership has focused on promoting research and implementation of projects related to climate change in the province. Some integrated policies on adaptation to climate change in the province are shown in Table 5.9.

Table 5.10. Integrated policies on climate change adaptation in Quang Ngai province

Date	Unit of issue/Sponsor	Decision/directive/project	Content
17/6/2011	Quang Ngai People's Committee	Directive No. 22/CT-UBND	On strengthening disaster prevention and search and rescue in 2011 in Quang Ngai province to actively prevent natural disasters, climate change and sea-level rise.
27/12/2011	Quang Ngai People's Committee	Decision No. 2068/QD-UBND	The Action Plan to Respond to Climate Change in Quang Ngai Province for the period 2011-2020 (based on the Prime Minister's Decision No. 158/2008/QD-TTg dated 2 December 2008 approving the Program of national targets to cope with climate change). In particular, the requirements of scientific and technological tasks are clearly defined as studying the impacts of climate change on Quang Ngai province and proposing solutions.
09/11/2012	Quang Ngai People's Committee	Decision 1776/QD-UBND	The plan of research and application of science and technology of Quang Ngai province in the period 2011 - 2015, orientation to 2020. In which, there is *"The program of basic investigation of natural resources and environment; To study the application of science and technology in the management of the sea and islands and the development of the marine economy"*.
13/4/2013	Standing Office of Steering	Launching the Project on Capacity building of Children-centered	The goal of the project is to improve adaptability for children and vulnerable communities, help them actively develop the

	committee for flood and storm control and search and rescue of the province. Sponsored by Australian Agency for International Development and Plan	Climate Change Adaptation.	plans to coping and managing negative impacts due to climate change. The project was implemented in Ba To, Ba Dinh, Ba Ba and Ba Xa communes of Ba To district. The main activities of the project include: collecting information related to the impacts of climate change; Develop education materials on climate change.

5.4.1.2 Disaster risk reduction

According to the Report on the Implementation of Disaster Prevention and Mitigation Policies in Quang Ngai Province by the People's Committee of Quang Ngai (2014), programs and policies from the Government and local authorities of Quang Ngai Province on prevention and mitigation of natural disasters as follows:

Table 5.11. Integrated Disaster Risk Reduction Policies in Quang Ngai Province

Date	Unit of issue/Sponsor	Decision/directive/project	Content
19/11/2008	Quang Ngai People's Committee	Plan No. 3378/KH-UBND	Implementing the National Strategy for Natural Disaster Prevention and Mitigation of Quang Ngai Province from 2008 to 2020.
12/10/2010	Quang Ngai People's Committee	Decision 164/QĐ-UBND	Comprehensive disaster risk management plan in Quang Ngai province up to 2020
17/5/2008	Quang Ngai People's Committee	Decision 142/QD-UBND	Regulations on flood and storm control and search and rescue in the province
16/8/2007	Quang Ngai People's Committee	Decision No. 1800/QD-UBND	Integrated Flood Risk Management Plan in the floodplains of major rivers in the province.
24/11/2010	Quang Ngai People's Committee	Decision No. 191/QD-UBND	A number of policies to support people's living, production and mechanisms to overcome socio-economic infrastructure damaged by natural disasters in the province.
12/7/2011	Quang Ngai People's Committee	Report No. 67/BC-UBND	Provincial People's Committee organized the inspection and assessment of the implementation of the Ordinance on Flood Prevention for the period 2006-2011
29/11/2006	Quang Ngai People's Committee	Dyke Law No. 79/2006QH11	The province has completed and approved the project of planning, adjusting and draining flood of Tra Khuc river (section from downstream of Thach Nham dam to Dai estuary) in 2012 and formulating temporary regulations on management, protection and use of dykes in the province

17/5/2008	Quang Ngai People's Committee	Decision 142/QD-UBND	Regulations on Flood and Storm Control and search and rescue
16/4/2012	Quang Ngai People's Committee	Decision 01/BCH	Plan for search and rescue in the period 2012-2015
13/6/2013	Quang Ngai People's Committee	Decision No. 820/QD-UBND	Planning of Implementation for the Project on community awareness raising and community-based disaster risk management in the province.
1/8/2011	Quang Ngai People's Committee	Official Letter No. 2129/UBND-NNTN to the Ministry of Natural Resources and Environment	Propossal on build a tower system for disaster warning (11 towers) along the coast and Ly Son district of the province.
12/10/2010	Quang Ngai People's Committee	Decision No. 164/QĐ-UBND	Plan for Integrated Disaster Risk Management in Quang Ngai Province up to 2020.

5.4.2 Strategic plans

5.4.2.1 Climate change adaptation

In order to cope with climate change, in 2011, Quang Ngai province has developed an Action Plan to Respond to Climate Change in Quang Ngai in period of 2011-2020, in which to assess the impacts of climate change on the development of sectors: natural resources and environment, agriculture, forestry and biodiversity, fisheries, transportation, industry and energy, construction, public health, tourism and the administrative area. Afterwards, it has proposed a list of priority programs and projects responding to climate change. At the same time, the province has carried out synchronous solutions for affected sectors and localities. The mainstreaming of the Action Plan in Quang Ngai can be summarized as follows.

The key task to be implemented immediately is to assess the impact of climate change and sea-level rise on sectors, areas and localities throughout the province. On the basis of existing national and international studies, the study of trends, manifestations of changes in elements and climatic phenomena in Quang Ngai province and detailization of scenarios of climate change and sea-level rise is based on national published scenarios which have been made. At the same time, the implementation of studies assessing the impact of climate change and sea-level rise on sectors, areas and localities has also been conducted. The completion of the database on the impacts of climate change and response solutions for Quang Ngai province, particularly by sector and locality, should be considered as a target for the province by 2020.

Then, it is necessary to develop and select appropriate solutions to cope with climate change for Quang Ngai province in each sector. The province has basically completed the establishment of a methodological basis, approach and identification of major measures to cope with climate change and implemented a number of projects, activities and solutions to cope with climate change for sectors, aeras and localities that are sensitive and vulnerable. From now to 2020, Quang Ngai province should continue to update, select and complete solutions to cope with climate change for sectors, areas and localities throughout the province and carry out tasks and projects, selected solutions to climate change.

Raising awareness and developing human resources is the third task that Quang Ngai needs to do in its strategic planning for climate change adaptation and disaster risk reduction. The province needs to strengthen propaganda activities, raise awareness and responsibility for all levels of government, departments, mass organizations and people in the province on climate change and accelerate the training on climate change and respond to climate change. For the tasks and targets to be achieved by 2020, the province needs to develop, update and disseminate widely the documents and facilities to serve raising awareness about climate change which is appropriate to the province. Quang Ngai also has to continue to develop and implement effectively plans, activities and projects to improve capacity, awareness on climate change and respond to climate change. The development and implementation of training plans to attract and develop human resources in the field of responding to climate change. The province can initially introduce extra-curricular teaching on climate change, impacts and adaptation measures in schools in the provincial education system. Quang Ngai province strives to have more than 80% of the population and 100% of officials and civil servants in basic knowledge and understanding of climate change by 2020 and its impacts.

Quang Ngai province must make good use of and strengthen the international funding sources, including: finance, technology transfer through co-operation and donation; To build and develop a mechanism of cooperation between Quang Ngai and international donors in implementing the programs and projects of the Plan; To expand relations and cooperation on climate change response to donors and international organizations; To formulate and finalize legal documents of the province on mechanisms and policies to encourage investment in Clean Development Mechanism projects, environmentally friendly technology transfer to facilitate foreign partners to invest in these projects in the province.

Another task is to integrate climate change into strategies, programs, master plans, plans for socio-economic development, sectoral and local development. Quang Ngai needs to consider the potential impact of climate change and its response to the development, adjustment and implementation of strategies, programs, plans and plans for sector, local and socio-economic development. Based on the master plan for socio-economic development of the province up to 2020, sectoral plans up to 2015, in the process of supplementation and adjustment, it is needed to be reviewed, taking into account all aspects related to climate change and sea-level rise, promote detailed planning, pay attention to sectors and areas that are strongly impacted and vulnerable by climate change and sea-level rise. In addition, the province should update climate change scenarios and sea-level rise; improve the quality of planning and effectiveness of state management of planning to meet the climate change and sea-level rise. Regarding the planning, Quang Ngai has to take into account the climate change and sea-level rise in the process of development planning of the sector, socio-economic development at all levels and localities, noting on fields, areas vulnerable to climate change and sea-level rise. The strengthening of measures for implementation, checking, monitoring and support in the annual implementation process, five-year plans at all levels and sectors in the context of climate change and sea-level rise is also needed to be fully implemented.

Finally, Quang Ngai needs to develop and implement the programs and projects of the Plan. Provincial authorities should organize the development and implementation of a number of programs and projects to cope with climate change in Quang Ngai province for some prioritized and the most vulnerable areas. In the next stage, it is necessary to learn lessons from previous years to comprehensively and effectively implement for the sectors and localities.

5.4.2.2 Disaster Risk Reduction

In order to establish and implement a comprehensive risk management framework for post-disaster prevention, mitigation, reconstruction and institutional strengthening in disaster risk management, in 2010 Quang Ngai Provincial People's Committee issued the Integrated Disaster Risk Management Plan in Quang Ngai province up to 2020 (Decision 164/QĐ-UBND dated 12/10/2010) with the total implemented capital of nearly 10,000 billion VND. The goal of the plan is to minimize the loss of people and property in times of natural disasters and ensure a stable and sustainable development of the economy, society, security and defense. According to the Steering Committee for Flood and Storm Prevention and Search and Rescue of the province (assigned by the Quang Ngai Provincial People's Committee to organize and assess the implementation process), this plan will be an important legal basis to carry out the prevention and mitigation of natural disasters in the province and for the Government and national as well as international organizations to invest in the prevention and mitigation of natural disasters to ensure socio-economic development in the period from now to 2020.

One of the main contents of the plan is to provide information relating to natural disaster risk issues in the province such as the current status of natural hazards as well as issues related to natural disaster management; Assess and prioritize issues related to disaster risk management, as well as describe detailed solutions to priority issues and implementation procedures, including the investment plan of disaster prevention works.

In addition, the plan provides atlas maps, which summarize the most natural conditions, climate, population, natural hazards and other factors involved in the management of existing infrastructure and project proposals related to disaster risk management. This is also a simple tool that easily supports people and government to refer, use in order to deal with natural disaster risks.

In addition, through the above plan, the principles of natural disaster risk management will be incorporated in the planning process for socio-economic and sectoral development, and disaster management in line with the objectives of the National Strategy. On the other hand, planning will also bring improvements in development standards, increase in community awareness, and improvement of local infrastructure investment.

According to the Provincial Steering Committee for Flood and Storm Prevention and Search and Rescue, Quang Ngai is regularly affected by many natural disasters, especially storms and floods, which cause serious damage to life and property. The prevention and mitigation of damage caused by natural disasters is extremely urgent now and requires the most thorough preparation of all resources to actively respond to all natural disasters.

To actively respond to natural disasters in the coming years, the Committee requires central and local ministries and agencies to focus on implementing the Law on Natural Disaster Prevention and Control and implement the Prime Minister's Directive on Strengthening Natural Disaster Prevention and Search and Rescue Activities for 2016-2020. Specifically as follows:

Institutionally, it is necessary to accelerate the implementation of the Law on Natural Disaster Prevention and Control related to the formulation and updating of natural disaster prevention and control plans and plans for response to natural disasters according to each level of disaster risk, focusing on developing plans and detailed plans to respond to major local natural disasters such as strong storms, typhoons and coastal provinces, floods and rains particularly in river basins, hot and long-lasting droughts in Central provinces, the Central Highlands and the South region, landslides on a large scale in mountainous provinces, river bank and coastal erosion.

To promote the implementation of the Scheme for Community Awareness Raising and Community Based Disaster Risk Management. To continue implementing effectively programs, projects on natural disaster prevention and mitigation such as investment in consolidation and upgrading of dykes, dams, storm shelters, Tsunami warning, reservoir information monitoring system.

To develop and implement Scheme for a national capacity building program on natural disaster prevention and control, focusing on the enhancement of equipment, material facilities, and the building of professional forces to prevent natural disasters; promote the dissemination and propagation of natural disaster warning and directional documents of all levels of government to each hamlet and people, especially in remote, mountainous areas, island in order to be ready to cope with abnormal and extremes situations.

5.5 CONCLUSIONS

The report outlines general meteorological and typical natural disaster characteristics in Quang Ngai province. Since then, the risks caused by natural disasters and climate change have been analyzed. According to Quang Ngai Province's Action Plan for Responding to Climate Change, natural disasters which often occur in the province, including typhoons, tropical despressions, floods, flash floods, landslides, Northeast monsoon, thunderstorms, tornados, lightning, droughts, forest fires, saltwater intrusion and sea-level rise. Although they are not high-and-very-high risk types of disaster, for a number of reasons, the report has selected two phenomena of sea-level rise and saltwater intrusion which are typical slow onset processes for the study area.

Due to the slow onset processes and risks in Quang Ngai province, vulnerability has been analyzed and clarified. In general, Quang Ngai is little likely to be vulnerable to the impacts of climate change. In particular, Ly Son Island is a place sensitive to natural disasters on the sea and most vulnerable to climate change. The vulnerability index with the normalized value of the index of exposures, sensitivity and adaptive capacity for each district of Quang Ngai has been calculated with three levels of vulnerability to be easy in comparison of vulnerability due to climate change among districts in the province.

In addition, the disaster resilience of the natural environment in Quang Ngai Province has been reported with medium results. The priority area of Quang Ngai Province to increase resilience is the flexible management of the natural environment and the strengthening of the natural environment diversity since at the present, these indicators are the lowest among the three major indicators. Quang Ngai Province can enhance the flexible management of the natural environment by building more national parks and protected areas, and integrating climate change into existing and new environmental protection plans. Furthermore, Quang Ngai Province can also enhance the diversity of its natural habitat by planting more forests and increasing the area of green infrastructure.

The losses and damages caused by natural disasters and climate change in Quang Ngai province are very high each year. Areas such as water resources, soil, agriculture, forestry, biodiversity, fisheries, transportation and industry are severely damaged and lost. Therefore, the report shows that the strategic planning for climate change adaptation and disaster risk reduction in Quang Ngai is very necessary, in addition to a comprehensive list of relevant policies.

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