

CLIMATE CHANGE ADAPTATION ON WATER
RESOURCE MANAGEMENT: A CASE STUDY OF
PAKOKKU TOWNSHIP, MAGWAY REGION, MYANMAR



A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Arts in Environment, Development and
Sustainability
Inter-Department of Environment, Development and Sustainability
Graduate School
Chulalongkorn University
Academic Year 2018
Copyright of Chulalongkorn University

การปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศเพื่อการจัดการทรัพยากรน้ำ: กรณีศึกษา ตำบล
ปึกโคะกู จังหวัดแม่ฮ่องสอน สาธารณรัฐสหภาพเมียนมาร์



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
สาขาวิชาสิ่งแวดล้อม การพัฒนา และความยั่งยืน สหสาขาวิชาสิ่งแวดล้อม การพัฒนาและความ
ยั่งยืน

บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2561

ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

Thesis Title	CLIMATE CHANGE ADAPTATION ON WATER RESOURCE MANAGEMENT: A CASE STUDY OF PAKOKKU TOWNSHIP, MAGWAY REGION, MYANMAR
By	Mr. Khin Maung Soe
Field of Study	Environment, Development and Sustainability
Thesis Advisor	SANGCHAN LIMJIRAKAN, D.Tech.Sc

Accepted by the Graduate School, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Arts

..... Dean of the Graduate School
(Associate Professor THUMNOON NHUJAK, Ph.D.)

THESIS COMMITTEE

..... Chairman
(Associate Professor Thavivongse Sriburi, Ph.D.)
..... Thesis Advisor
(SANGCHAN LIMJIRAKAN, D.Tech.Sc)
..... Examiner
(KALLAYA SUNTORNVONGSAGUL, Ph.D.)
..... External Examiner
(Associate Professor Kansri Boonpragob, Ph.D.)



จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

จันทน์ มั่ง โข : การปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศเพื่อการจัดการทรัพยากรน้ำ: กรณีศึกษา
ตำบลปึกโคะกู จังหวัดแม็กเวย์ สาธารณรัฐสหภาพเมียนมาร์. (CLIMATE CHANGE
ADAPTATION ON WATER RESOURCE MANAGEMENT: A
CASE STUDY OF PAKOKKU TOWNSHIP, MAGWAY REGION,
MYANMAR) อ.ที่ปรึกษาหลัก : อ. ดร.แสงจันทร์ ลิมจิรกาล

อุณหภูมิโลกสูงขึ้นในศตวรรษที่ผ่านมา ทำให้เกิดการเปลี่ยนแปลงสภาพภูมิอากาศ ผลกระทบของการเปลี่ยนแปลงสภาพภูมิอากาศต่อระบบธรรมชาติปรากฏหลักฐานมาตั้งแต่กลางศตวรรษที่ 20 ทรัพยากรน้ำเป็นผลกระทบหลักจากการเปลี่ยนแปลงสภาพภูมิอากาศ โดยเฉพาะบริเวณภาคกลางของสาธารณรัฐสหภาพเมียนมาร์ ที่ประสบปัญหาขาดแคลนน้ำ วัตถุประสงค์ของการวิจัยเพื่อศึกษาการปรับตัวและการดำเนินงานต่อการเปลี่ยนแปลงสภาพภูมิอากาศในการจัดการทรัพยากรน้ำ ที่เมืองปึกโคะกู จังหวัดแม็กเวย์ สาธารณรัฐสหภาพเมียนมาร์ ที่ประสบปัญหาขาดแคลนน้ำ โดยทำการศึกษาที่หมู่บ้านชินมากัน หมู่บ้านปานดินโซน หมู่บ้านปวงลวงกัน และหมู่บ้านจี เนื่องจากเป็นพื้นที่ที่มีความแห้งแล้งและขาดแคลนน้ำในช่วงฤดูร้อน ผู้ตอบแบบสอบถามจำนวน 61 คน ได้แก่ เจ้าหน้าที่รัฐท้องถิ่น เจ้าหน้าที่องค์กรนอกภาครัฐ และชาวบ้านท้องถิ่นด้วยการเลือกกลุ่มตัวอย่างแบบเจาะจง ข้อมูลที่ได้จากการสัมภาษณ์โดยใช้แบบสอบถามถึงโครงสร้างในพื้นที่ศึกษา นำมาวิเคราะห์เชิงพรรณนาและเนื้อหา การศึกษาพบว่าผู้ตอบแบบสอบถาม 98% รู้จักการเปลี่ยนแปลงสภาพภูมิอากาศ ทั้งนี้ 100% รู้จักผลกระทบจากการเปลี่ยนแปลงสภาพภูมิอากาศ เช่น การขาดแคลนน้ำจืด คลื่นอากาศร้อน และผลผลิตการเกษตรลดลง ในส่วนการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศนั้น เจ้าหน้าที่รัฐทั้งหมดเปลี่ยนมาใช้เมล็ดพันธุ์ที่ทนทานต่อการเปลี่ยนแปลงสภาพภูมิอากาศในภาคเกษตรกรรม 98% กล่าวถึงระบบชลประทานแบบประหยัดน้ำในภาคเกษตรกรรม และทำการศึกษาดินที่ดีเพื่อรักษาความชื้นของดิน เกษตรกร 90% อาศัยอยู่ในที่ที่เหมาะสมในสภาพอากาศที่รุนแรง โดยที่ 88% ต้องเปลี่ยนเมล็ดพันธุ์ที่ทนทานต่อสภาพภูมิอากาศเช่นกัน 100% ทำการไถพรวนและคราดดินก่อนฤดูมรสุม เปลี่ยนวันหว่านเมล็ดพันธุ์พืช สำหรับทางปฏิบัติในการจัดการทรัพยากรน้ำเพื่อการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศ ผู้ตอบแบบสอบถาม 92% ใช้น้ำอย่างมีประสิทธิภาพ 86% ใช้น้ำอย่างประหยัด 84% ลดการรั่วซึมของน้ำ เมื่อคำนึงถึงนโยบายที่เกี่ยวข้องกับการเปลี่ยนแปลงสภาพภูมิอากาศ ไม่มีนโยบายดำเนินการในพื้นที่ศึกษา ทั้งนี้ โปรแกรมการปรับตัวของเมียนมาร์ นโยบายแห่งชาติเมียนมาร์ และนโยบายที่เกี่ยวข้องกับน้ำของกรมพัฒนาชุมชน น่าจะมีความสัมพันธ์กับการเปลี่ยนแปลงสภาพภูมิอากาศในการจัดการทรัพยากรน้ำ ตัวอย่างเช่นการทำเกษตรที่เหมาะสมต่อสภาพภูมิอากาศและเทคนิคการชลประทานอย่างประหยัดให้แก่เกษตรกร ดังนั้นการนำเอาแผนงาน การลดความเสี่ยงต่อภัยพิบัติ การเตรียมความพร้อม การบรรเทาและการฟื้นฟู มาดำเนินการให้เหมาะสม เพื่อลดผลกระทบที่เกิดขึ้นและเพิ่มขีดความสามารถของผู้มีส่วนได้ส่วนเสีย



สาขาวิชา	สิ่งแวดล้อม การพัฒนา และความ ยั่งยืน	ลายมือชื่อนิติ
ปีการศึกษา	2561	ลายมือชื่อ อ.ที่ปรึกษาหลัก

6087591620 : MAJOR ENVIRONMENT, DEVELOPMENT AND SUSTAINABILITY

KEYWORD: Climate change adaptation; water resource management; Pakokku Township;
Myanmar

Khin Maung Soe : CLIMATE CHANGE ADAPTATION ON WATER RESOURCE
MANAGEMENT: A CASE STUDY OF PAKOKKU TOWNSHIP, MAGWAY REGION,
MYANMAR. Advisor: SANGCHAN LIMJIRAKAN, D.Tech.Sc

The Earth's temperature has increased in recent decades and the climate has changed. The adverse effects of climate change on natural systems have also become evident since the mid of the twentieth century. Water resources are mainly affected by climate change, particularly in the central part of Myanmar that faced with water shortage. The objective of the research is to study climate change adaptation on water resource management at the Pakokku Township, Magway Region, Myanmar. The four villages, namely Shin Ma Kan, Pan Tine Chone, Paung Laung Kan and Kyee were selected as the study area because of drought and water shortage in the dry season. The 61 respondents including local governmental officers, non-governmental organizations (NGOs) officers and local people were selected by using a purposive sampling method. An in-depth interview using a set of semi-structured questionnaire was used to obtain relevant data in the study area. Data obtained were analyzed using descriptive and content analysis. The study found that 98% of the respondents knew about changing the climate. 100% of them knew climate change impacts such as freshwater shortage, heat waves and crop production decreasing. Regarding climate change adaptation, 100% of government officers mentioned changing seed varieties resisting to climate change in agriculture sector. 89% of them mentioned water-saving irrigation in agriculture and making good tillage in farms to maintain soil moisture content. 90% of farmers mentioned living properly in extreme weather conditions, while 88% of them mentioned changing seed varieties resisting to climate change. 100% of people who work in livestock husbandries mentioned harrowing and ploughing before monsoon coming, and changing the sowing dates of crop plantation. Considering water resource management practices adapting to climate change, 92% of the respondents mentioned using water efficiently, 86% of them mentioned water saving, 84% of them mentioned reducing water leakage. Regarding the policies related to climate change adaptation, all respondents (100%) mentioned that there was no policy on climate change adaptation that being implemented by the government in the study area. However, Myanmar's National Adaptation Programme of Action, Myanmar National Water Policy and the water-related policy of Department of Rural Development would relate to climate change adaptation on water resource management. For examples, climate-smart agriculture and water-saving irrigation techniques. The study would recommend that the action plans on disaster risk reduction, preparedness, relief and rehabilitation should be implemented properly to reduce impacts and to enhance the capacities of all stakeholders.

CHULALONGKORN UNIVERSITY

Field of Study: Environment, Development and Sustainability Student's Signature

Academic Year: 2018 Advisor's Signature

ACKNOWLEDGEMENTS

I am heartily thankful to my thesis advisor, Dr. Sangchan Limjirakan for giving guidance and encouragement throughout the valuable research and thesis writing. I also would like to acknowledge my thesis committee members, namely Associate Professor Dr. Thavivongse Sriburi, Associate Professor Dr. Kansri Boonprakob, and Dr. Kallaya Suntornvongsagul. I wish to present my special thanks to all lecturers for their significant knowledge throughout my study.

I wish to express my thanks for the financial support of the Thailand International Cooperation Agency (TICA) for my study in Thailand. Thanks also go to a program officer of the Environment, Development and Sustainability (EDS) for his supportive facilities.

Importantly, I would like to express my deepest gratitude to my parents and my wife for their unconditional love, support and encouragement throughout this study. I sincerely acknowledge to all stakeholders in the study area, Pakokku Township, including government officers, non-governmental organization officers, and local people for their providing valuable information and suggestions to my research study.

Finally, I would like to deliver my special thanks to Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation, Myanmar for its supports for my study.

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

Khin Maung Soe

TABLE OF CONTENTS

	Page
ABSTRACT (THAI)	iv
ABSTRACT (ENGLISH).....	v
ACKNOWLEDGEMENTS.....	vi
TABLE OF CONTENTS.....	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LISTS OF ABBREVIATIONS.....	xii
CHAPTER I INTRODUCTION.....	1
1.1 Background and importance of the study	1
1.2 Research objective	4
1.3 Research questions.....	4
1.4 Scope of the study.....	4
1.5 Expected outcomes	4
1.6 Operational definition.....	5
CHAPTER II LITERATURE REVIEWS	7
2.1 Climate change adaptation.....	7
2.1.1 Climate change	7
2.1.2 Climate change impacts.....	8
2.1.3 Climate change vulnerability.....	9
2.1.4 Climate change adaptation	10
2.2 Climate change in Myanmar.....	12
2.2.1 Observed climate change in Myanmar	13
2.2.2 Projected climate change for Myanmar (2001-2100).....	15
2.2.3 Climate change vulnerable regions in Myanmar.....	15
2.2.4 Impacts of climate change on socio-economic sectors	16

2.2.5 Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change	19
2.2.6 Myanmar's Intended Nationally Determined Contribution-INDC for climate change mitigation	20
2.3 Water resources management	22
2.3.1 Water resource problems	22
2.3.2 Water resource management	24
2.3.3 Integrated water resources management	26
2.4 Water resource management in Myanmar	29
2.4.1 Water resource problems in Myanmar	30
2.4.2 Water resource management in Myanmar	32
2.4.3 Integrated Water Resources Management in Myanmar	34
CHAPTER III RESEARCH METHODOLOGY	36
3.1 Conceptual research framework	36
3.2 Study area	36
3.3 Data collection	39
3.4 Data analysis	40
CHAPTER IV RESEARCH RESULTS	41
4.1 Study area	41
4.1.1 Socio-economic conditions of the Pakokku Township	44
4.1.2 Climate information of the study area	46
4.2 General information of respondents	48
4.3 Climate change adaptation	51
4.4 Water resource management	58
4.5 Policy on climate change adaptation on water resource management	62
4.5.1 Respondents perspectives on climate change adaptation policy	62
4.5.2 Governmental policies on climate change adaptation and water resource management	63
CHAPTER V CONCLUSIONS AND RECOMMENDATIONS	65
5.1 Conclusions of the study	65

5.2 Recommendations.....	67
REFERENCES	69
APPENDIXES	75
VITA.....	102



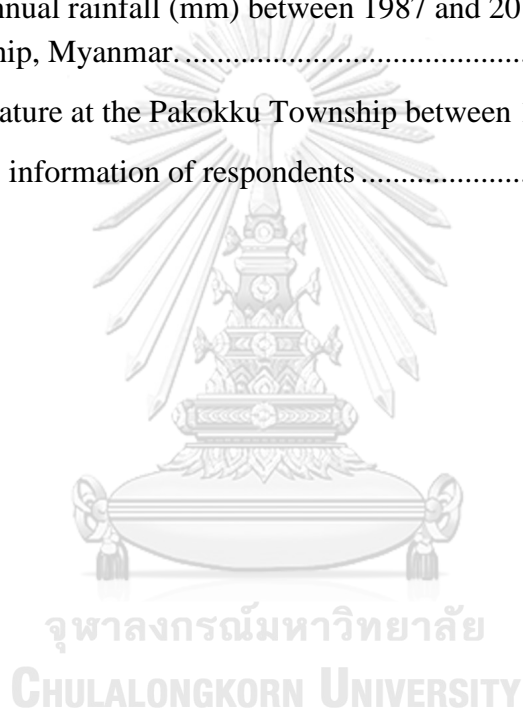
LIST OF TABLES

	Page
Table 4.1 Percentage and number of conventional households of drinking water sources in urban and rural area in Pakokku Township.	46
Table 4.2 General information of respondents	49



LIST OF FIGURES

	Page
Figure 3.1 The conceptual research framework on climate change adaptation on water resource management: A case study of Pakokku Township, Magway Region, Myanmar.	36
Figure 3.2 The study area; Pakokku Township (dark green shade), Myanmar.	38
Figure 4.1 The study area; Pakokku Township (dark green shade), Myanmar.	43
Figure 4.2 Total annual rainfall (mm) between 1987 and 2016 at the Pakokku Township, Myanmar.	47
Figure 4.3 Temperature at the Pakokku Township between 1987 and 2016.	47
Figure 4.4 General information of respondents.	51



LISTS OF ABBREVIATIONS

AR4	the Fourth Assessment Report
AR5	the Fifth Assessment Report
CCA	Climate Change Adaptation
CO ₂	Carbon dioxide
DMH	Department Meteorology and Hydrology
GAD	General Administration Department
GWP	Global Water Partnership
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LDCF	Least Developed Countries Fund
MOECAF	Ministry of Environmental Conservation and Forestry
NAPA	National Adaptation Programme of Action
TAR	the Third Assessment Report
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER I

INTRODUCTION

1.1 Background and importance of the study

Globally, people have affected on climate change due to greenhouse gas concentrations increasing. Human activities have largely caused climate change. The climate change effects include alterations in precipitation patterns, sea levels, heat extremes, drought, storms, monsoon cycles, ocean currents, sea surface temperatures, land ice mass and river flows (Horton et al., 2017). Based on the understanding of climate change facts have been accepted by the international communities, further researches have been conducted on its effects at the global, regional, and country-level scales. The Intergovernmental Panel on Climate Change (IPCC) has been leading scholarly voice on the subject, having released reports that include thousands of pages of data and analysis stemming from the most recent scientific reports. The IPCC is generally accepted as the most reputable authority on climate change and its impacts (Slagle, 2014).

According to the IPCC (2013), the Earth's temperature at the global scale has increased in recent decades. In the last 60 years, warming of the climate system is unequivocal. The atmosphere and ocean have warmed, the amount of snow and ice have decreased, and sea level has ascended. In Southeast Asia region, temperatures have also increased at a rate of 0.14 °C to 0.20 °C per decade since the 1960s, coupled with a rising number of hot days and warm nights, and a decline in cooler weather. In the coming decades, strengthened cyclones, sea level rise, temperature increases, drought and rainfall variability are expected to effect on agricultural growing seasons, decrease in sea and river fishery stock, and force human migrations.

Regarding the global and regional temperature trends, Myanmar has noticed nationwide warming since the 1950s. Climate change has all the earmarks of being negatively affecting Myanmar's natural resources and livelihoods of Myanmar people as a result of climate change. The impacts are aggravated in Myanmar in the light of its poor

circumstances and weak infrastructures (Kreft, Eckstein, Dorsch, & Fischer, 2016). Myanmar is recognized as a least developing country, the intensified negative impacts can possibly worsen strains to abandon the most vulnerable sectors of the population including the extremely poor, sick, young, and elderly. Furthermore, increasing temperatures, variable precipitation extremes, rising sea levels, droughts, floods, and great storms will affect on all aspects of life in Myanmar (Slagle, 2014). According to the Global Climate Risk Index 2015, Myanmar ranked the second most vulnerable country affected by climate change in the world calculated based on the recent 20 years (Kreft, Eckstein, Junghans, Kerestan, & Hagen, 2015). Additionally, Myanmar was also ranked as a second out of 183 nations most influenced by extreme weather events between 1995 and 2014 in the Global Climate Risk Index (Kreft et al., 2016). Recent extreme weather events, for example, Cyclone Nargis in 2008, extreme heat waves in 2010 and flash flooding in 2015 have had impacts on the society, ecology and economy of the nation (MOECAAF, 2012). Therefore, anticipated future climate change will further expose Myanmar to the negative impacts which predicted by some climate models (NAPA, 2012). Regarding Myanmar's National Adaptation Programme of Actions (NAPA) report, the temperature in Myanmar has increased on average by approximately 0.08°C per decade over the last six decades (NAPA, 2012). This trend is expected to continue in Myanmar, consistent with predictions globally and regionally. It is anticipated that the average temperature in the country will keep on rising, coming to at least 0.4°C by 2020 to a greatest of 3.5°C by the end of the century. On the other hand, changes in rainfall patterns are supposed globally and regionally in the coming decades, and data has demonstrated this to be the situation in Myanmar as well. In the latest six decades, rainfall had increased of 29 mm per decade (NAPA, 2012). The increased rainfall and temperature have not been consistent throughout the nation. These are consistent with the IPCC report in 2013 that changes in the global water cycle will not be uniform.

Myanmar relies heavily on the agricultural sector for income, livelihoods, and economic growth (MOECAAF, 2012). With an agricultural sector that weighs so heavily on the livelihood of Myanmar's people, climatic changes will have a disproportionately negative impact in the country (NAPA, 2012). Generally, the areas of the country where

the most vulnerable to climate change impacts are the Coastal regions, the Dry Zone and the Northern Hilly areas (MOECA, 2012). The dry zone exists in central plains of Myanmar which are encircled by mountains toward the east and west. Enveloping parts of Mandalay, Magway and Sagaing regions, it covers about 75,000 km² which represents 13% of the country's area. In 2014, the population of the dry zone were about 10 million out of total population of 51.4 million (Myanmar, 2015). The dry zone is the most water-stressed region of the country. Around 70% of households have access to safe water for domestic use, but seasonal water scarcity is very common (MNPED and MOH, 2011). A quarter of all households in this area revealed having insufficient water during the dry summer season (WFP, 2011). About one third of people draw their drinking water from protected wells and another third from pumped wells. More than one-third of the population does not have access to sanitation facilities. Mean annual rainfall in this area is quite low of about the lowest 500-1000 mm per year compared to the other parts of the country (Egashira and Than, 2006). Therefore, the scarcity of water always turns into a serious issue in this area (NCEA, 2010). Furthermore, temperatures run from a most extreme of 40-43 °C in the summer season (Egashira and Than, 2006). For both domestic use and agricultural use purposes, water resources in the dry zone in Myanmar need to be managed necessarily. Water resource management in this area is one of the crucial factors under the implementation of the Myanmar Climate Change Adaptation Policy.

The Myanmar's National Adaptation Programme of Action (NAPA) is the report to the United Nations Framework Convention on Climate Change (UNFCCC) on the status of its adaptation implementation programs. In this report, Myanmar has identified eight areas of vulnerability to climate change and prioritized adaptation projects within each area for which the Least Developed Countries Funds (LDCF) will be spent. These eight areas in priority order include: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy and Industry; and viii) Biodiversity. Research conducted in 2012 by the Myanmar government resulted in four priority projects in each area of vulnerability, totaling 32 specific projects (NAPA, 2012).

In this regard, the research on “climate change adaptation on water resource management: a case study of Pakokku Township, Magway Region, Myanmar” would provide information on the policy implementation processes of water resource management in the dry zone under the climate change adaptation of Myanmar. The research results would be useful to the government policy planners to make a good strategy, plans and programs of water resources management in the dry zone of Myanmar.

1.2 Research objective

- To study climate change adaptation on water resource management in Myanmar focusing at Pakokku Township, Magway Region, Myanmar.

1.3 Research questions

- What is climate change adaptation that being implemented in the study area?
- How are good and successful practices on climate change adaptation in the study area?

1.4 Scope of the study

- To achieve the above objective, climate change adaptation on water resource management in Myanmar will be studied.
- The research area will be at some villages selected in Pakokku Township, Magway District, Magway Region, Myanmar.
- Primary data will be collected from the study area and secondary data will be collected from the related Departments, such as Department of Meteorology and Hydrology (DMH) and General Administration Department (GAD), and other resources.
- The data will be analyzed by using both qualitative and quantitative methods.
- Research writing will be conducted as well as paper writing for publication.

1.5 Expected outcomes

- A suitable climate change adaptation for water resources management strategy in dry zone Myanmar.

- An appropriate recommendation would be introduced for further research relevant to climate change adaptation in the study area.

1.6 Operational definition

- **Climate change**

The United Nations Framework Convention on Climate Change (UNFCCC, 1992) defined climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”

According to the IPCC (2007b), climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

- **Climate change adaptation**

The United Nations Framework Convention on Climate Change (UNFCCC) defined climate change adaptation (CCA) as the needed modifications in response to the changes in social-ecological and economic systems in relation with climate change (UNFCCC, 1992).

Adger, Arnell, and Tompkins (2005) defined adaptation as “adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities.”

- **Water resources**

Water resources are natural resources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and

environmental activities. All living things require water to grow and reproduce. 97 percent of the water on the earth is salt water and just three percent is fresh water. Marginally more than 66% of this is solidified in glaciers and polar ice caps. The rest of the freshwater is discovered for the most part as groundwater, with just a little fraction introduced over the ground or in the air (USGS, 2009).

- **Water resource management**

Water resource management includes local, national and international activities, directed at either the short or the long term. It includes the whole set of scientific, technical, institutional, managerial, legal, and operational activities required to plan, develop, operate, and manage water resources (Hoekstra and Savenije, 2009).

- **Integrated water resource management**

The Global Water Partnership (GWP, 2000) defined Integrated Water Resources Management (IWRM) as “a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.”

The United States Agency for International Development (USAID, 2008) defined the IWRM as “a participatory planning and implementation process, based on sound science that brings stakeholders together to determine how to meet society’s long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits. The IWRM helps to protect the world’s environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve human health”.

CHAPTER II

LITERATURE REVIEWS

2.1 Climate change adaptation

People have experienced climate change in a few decades. The interconnection between the carbon dioxide (CO₂) in the atmosphere and longstanding atmospheric warming became prominent. The report of summary for policy maker, the fifth assessment report (AR5) of IPCC WG I, stated that warming of the climate system is the unequivocal. Since 1950s, many of the observed changes are unprecedented over decade to millennia. Human influence on the climate system is clear. It has been detected in warming of the atmosphere and ocean, in changes in global water cycle, decreasing in snow and ice, in global mean sea level rise, and in changes in some extremes (IPCC, 2013).

Emission of greenhouse gases especially come from burning of fossil fuels. Major fossil fuels which effect on global warming are natural gases, coal and oil. By trapping energy in the earth atmosphere, greenhouse gases create increased temperature in atmosphere. In actual fact, this process is necessary for all lives on the planet. Notwithstanding, the excessive warming atmosphere create a great number of the problems if higher percentages greenhouse gases is existed in the atmosphere. Ice melting and sea level rising are caused due to the global warming. Internationally, many communities are conducting the further research on climate change effect on the global, regional, and country-level scale since they have understood about the climate change facts. The Intergovernmental Panel on Climate Change (IPCC) has leaded scholarly voice on the subject that relates to changing of climate at the global level.

2.1.1 Climate change

Since the beginning of the industrial revolution, people used more fossil fuels and has caused changing the atmospheric composition. As a result, the atmosphere of the earth has gradually increased with carbon dioxide and enhancing greenhouse effect in the

earth. The greenhouse gases in the atmosphere trap the heat and make an increasing the global temperature. Addition to the carbon dioxide (CO₂), there are another sorts of greenhouse gases in the atmosphere, including methane, nitrous oxides and chlorofluorocarbons. People recognize climate change as the most urgent problem facing nowadays. On the other hand, people have already known that human activities make global warming.

There are many definitions of climate change which are defined by many sectors and scholars. The United Nations Framework Convention on Climate Change (UNFCCC, 1992) defined climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” According to the UNFCCC (2007), climate change is also defined as changes in distributional patterns of weather over different time periods that may range from a few years to several decades. Increasing average temperature of the Earth, an increase in sea surface temperature, changes in rainfall pattern and melting of glaciers are the most prominent effects of climate change. It refers to significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer. As the global temperature has changed, the ecosystems has been changed, and various kinds of birds and animals species have also changed quickly habitats. The prediction of the scientists are evident that increasing of ice melting and sea level rising, and changes in frequency of heat waves are the effects of climate change.

2.1.2 Climate change impacts

The ecosystem services, genetic resources, biodiversity and ecological system are altered by global warming (CBD, 2009). Economic, social and environment are already being affected by the impacts of the climate change. The impacts of climate change could be connected each other and aggravating the adverse effects and enhancing the problems. Climate change consists of complex interactions and changing livelihood of various impacts (IPCC, 2014). There have the visible effects on environment by global

warming. Glaciers become diminished, ice on rivers, lakes and sea end up prematurely, animals and plants assortment have altered and flowering time of the tree are sooner.

In 2007, the IPCC AR4 Synthesis report stated that “the impacts of climate change depend on the situations of natural and human systems, their environment and their specific locations”. Additionally, the IPCC report by WGII AR4 revealed that physical systems in all aspects of the world are being affected by climate change impacts, especially temperature increase in all regions (Rosenzweig et al., 2007). In recent decades, human and natural systems have impacted by climate changes throughout all over the world. The observed on the climate change impacts is robust and natural systems are most affected by them (IPCC, 2014).

Some ecosystems and human systems are affected by the impacts of the climate-related extremes such as heat waves, droughts, floods, cyclones, and wildfires. Additionally, significant vulnerability on these systems is also revealed. As the consequences, the impacts of such climate-related extremes make a change of ecosystem, food production decline and water supply problems. It also makes a damage to infrastructures and people settlement, human well-being, and mental health. These kinds of impacts may not be changed significantly without preparing for climate variability at all levels of development in some sectors of the countries (Wassmann et al., 2009). The impacts of the climate change may be varied which depends on the characteristics of human and natural systems, their specific situation and their pathways. Furthermore, climate change impacts will differ throughout regions, human populations, time and space. It relies on a large number of factors including the extent of mitigation and adaptation, and non-climate stressor (IPCC, 2007a).

2.1.3 Climate change vulnerability

From climate change perspective, vulnerability is defined in the third assessment report (TAR) of the IPCC WG II as “a function of the character, magnitude, and rate of climate variation to which a system is exposed, and its adaptive capacity” (IPCC, 2001).

Thereafter, the comprehension of the vulnerability has obtained increased complication as a diverse concepts with more concentration on the structural conditions of inequality and poverty. The fifth assessment report (AR5) of IPCC WGII also defined vulnerability as “the propensity or predisposition to be adversely affected through social risks, particularly in low economies” (IPCC, 2014). Vulnerability shifts as a result of the limit of gathering and people to diminish and manage the impacts of climate change. Among the key components deciding vulnerability are gender, age, health, social status, ethnicity, and class (Smit et al., 2001).

Füssel and Klein (2006) stated that Vulnerability to climate change as “the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change.” This may allude to the powerless system itself, e.g., low-lying islands and cities near the sea.

2.1.4 Climate change adaptation

Adaptation alludes to the way toward adjusting and to the states of being adapted. The term has determined implications specifically disciplines. In ecology, adaptation refers to changes by that an organism or one species end up fitted to its environment (Lawrence, 1995). The adaptation refers to change by people and aggregation with socio-economic frameworks in social science (Denevan, 1983; Hardsety, 1983). In history, people and societies have experienced in adaptation to climate change and climate change variability. Adaptation is becoming one of the crucial matters in some planning process, with more response actions.

According to Burton (1996), there are the main six logics to adapt to climate change. Those logics are as follows.

- 1) Climate change is not totally avoidable,
- 2) It is more effective and less cost when the people take precautionary action on adaptation,

- 3) Climate changes processes are occurring faster than the predictions of scientists,
- 4) Better adaptations can give the incredible benefits,
- 5) To avoid mal-adaptations,
- 6) Climate change can give not only adverse effects but also positive benefits.

Klein and Tol (1997) identified five generic objectives of adaptation as follows.

- 1) Investments for long term and insurance for robustness,
- 2) An increase in the ability to manage fragile conditions,
- 3) To withstand in very vulnerable conditions,
- 4) Reducing vulnerable conditions,
- 5) To increase climate change awareness and about its impacts.

The third assessment report (TAR) of the IPCC WG II defined adaptation as “adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change” (IPCC, 2001). The UNFCCC (1992) defined climate change adaptation as “the needed modifications in response to the changes in social-ecological and economic systems in relation with climate change”. Adger et al. (2005) defined adaptation as “an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities”. Adaptation therefore is a procedure by which individuals, communities and nations look to adapt to the consequences of climate change.

Lavell et al. (2012) defined climate change adaptation in human systems as “the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.” Adaptation process should approach various kinds

of knowledge, techniques. Like mitigation to climate change, adaptation to changing of the climate should be in the same role (Fankhuser, 1996; Smith, 1996).

2.2 Climate change in Myanmar

Myanmar is located between latitude of 9° 55" and 28° 15" N and longitude of 92° 10' and 101° 10' E. Bangladesh, India, China, Laos, Thailand are neighbor countries of Myanmar. It is covering 676,578 km² (MOECAAF, 2012). Myanmar has 15 governmental units which composed of 7 states and 8 regions, namely Kachin, Kayah, Kayin, Chin, Mon, Rakhine and Shan, Sagaing, Tanintharyi, Bago, Magway, Mandalay, Yangon, Ayeyarwady and Naypyidaw. Naypyidaw is new capital city of Myanmar. As the governmental unit, states and regions are divided into districts, townships, village tracts and villages.

According to the national census in 2014, Myanmar's population was 51.4 million. About 66% of people in Myanmar are living in rural area and the rest 34% are staying at urban area. Most of the people in Myanmar are staying in Ayeyarwady basin (MOIP, 2015). The economy of the country is mainly contributed by agriculture, forestry, and fisheries sectors. The majority of the rural dwellers are mainly depends in agriculture, fishing and working at livestock husbandries. Myanmar has various kinds of products such as woods, copper, tin, tungsten, iron, pharmaceuticals, oil and natural gas, and jade and gems (Hadden, 2008). The country has three main agro-ecological zones, namely central dry zone, coastal zone and northern hilly zone. It is in a tropical to subtropical monsoon climate (MOECAAF, 2012). There are three seasons in Myanmar, namely the hot season (mid-February to mid-May), the rainy season (mid-May to late October), and the cool season (late October to mid-February). Mean annual rainfall is the lowest in the central dry zone of around 600 mm and the Southern and Rakhine coastal regions get the highest rainfall with the range between 2,500-5,500 mm (Egashira and Than, 2006). Mean temperature ranges from 32°C in the coastal and delta areas to 21°C in the northern part of the country. The seasonal temperature in Myanmar has changed throughout the country. The temperature ranges of central dry zone used to be 40-43 °C in hot season and 10-15 °C in the cold season (Egashira and Than, 2006).

Myanmar has four main rivers across the country namely, Than Lwin, Sittaung, Ayeyarwady and Chindwin and it has plentiful of water resources (Facon and Ti, 2012). Regarding water usage of Myanmar, 89 % of use for agriculture sector, 10% for domestic use purpose and only 1 % for industrial purpose (Oo, 2015). Among many sectors, agricultural sector is the most predominant sector in Myanmar (Central Intelligence Agency, 2017). Approximately, 60 different aspects of crops are grown in Myanmar and rice is the stable food crop (Hadden, 2008). Additionally, peas and beans, sweet potatoes, cassava, garlic, potatoes, and onions are also grown in Myanmar. Most of crop plantations in Myanmar is rain-fed agriculture because the availability of irrigation in Myanmar is still in small percentage as 18% in 2007 (UNESCAP, 2011).

According to Leimgruber et al. (2005), approximately 49 % of the total land area of Myanmar is forested. It is therefore rich in natural forest. In terms of forest types, that are vary according to the situation of geography and weather conditions. The forest sector is one of the crucial sector for economic development and socio-economic and for their livelihoods providing in carbon sequestration, micro-climates regulation, conserving top soil from erosion, and so on. Access to clean drinking water and sanitation and lack of proper diet are the main health risk of Myanmar (Lateef, 2009). Climate related hazards and extreme weather events, deforestation and diminishing water resources, are the main environmental stresses of Myanmar. Both anthropogenic and natural pressures are the root causes of these environmental causes (NAPA, 2012).

2.2.1 Observed climate change in Myanmar

According to Myanmar's NAPA (2012) report, observed climate variability and changes in Myanmar as follows:

- 1) Increasing the temperature by 0.08 °C per decade as the mean temperature of the country
- 2) Increasing the total rainfall over most regions of the country
- 3) Decreasing the southwest monsoon period

- 4) Increasing the frequent extreme weather events such as flash floods and drought

Observed temperature changes: In Myanmar, temperature has increased by 0.08 °C per decade since the mid of twentieth century and the country get more hotter day and less cold day (Wassmann et al., 2009). According to the NAPA (2012) report, Myanmar experienced extreme heat waves between 1951 and 2000.

Observed rainfall changes: During six decades starting from 1951, Myanmar has got more rainfall by 29 mm per decade and the trends of rainfall pattern were variable over the period. Sagaing region have experienced getting the highest rainfall increasing by 215 mm per decade according to calculation based on the data between 1951 to 2010. Moreover, southwest monsoon period in Myanmar become shorter (DMH and UNEP, 2009). Based on the NAPA (2012) report, the period between 1991 and 2004, around 30 extreme rainfalls have occurred throughout 16 monitoring stations in the country (NAPA, 2012).

Observed climate related hazards and extreme weather events: According to the report of Department of Meteorology and Hydrology and United Nations Environmental Programme (UNEP and DMH, 2009), changes in extreme weather events and climate hazards in Myanmar are:

- 1) Drought events are increasing
- 2) Frequently strong wind and cyclones
- 3) Variability of rainfall
- 4) Flooding all over the country and strong surge in coastal region
- 5) Heat waves

According to the Myanmar Initial National Communication under the UNFCCC, drought happens in frequently in Myanmar during the year 1980s and the 1990s. Severe

droughts had increased from the year 1990 to 2002. Severe drought reduced water sources in nationwide in 2010. As a consequence, decreased agricultural yields, water shortage problems occurred (MOECAAF, 2012). Cyclone trends are also changing in Myanmar. Since 2000, Myanmar has experienced the strong cyclones yearly (Department of Meteorology and Hydrology, 2009). Myanmar has the bad experiences with extreme cyclone such as cyclone Mala (2006), cyclone Nargis (2008) and cyclone Giri (2010). In Longlon, it got 434 mm of rainfall fell in a single day breaking the highest 24-hour rainfall record in Myanmar (Department of Meteorology and Hydrology, 2009). 12 main floods were occurred in the country between 1910 and 2000 (UNESCAP, 2011). Moreover, heat waves are occurring in the country frequently (MOECAAF, 2012).

2.2.2 Projected climate change for Myanmar (2001-2100)

According to Myanmar's NAPA (2012) report, the vulnerability and projected climate change for Myanmar as follows:

- 1) Keep increasing temperature
- 2) Increasing drought period
- 3) Rainfall variability keep changing
- 4) Flash flood increasing
- 5) Extreme weather events such as cyclones and strong winds, and drought were keep changing

2.2.3 Climate change vulnerable regions in Myanmar

Lian and Bhullar (2011) presented that Myanmar is very vulnerable to climate change as a result of the compounding factors. These factors are employment and the national income which is dependent on climate-sensitive sectors such as agriculture, forestry and natural resources. It is one of the factors that high population density in the coastal zone area may be exposed to long-term climate change effects such flooding and strong surge because of sea level rise (World Vision, 2008). Other factors are countries situation which would reduce the capacity of the country to response (Yohe and Tol, 2002). Anticipated climate change in Myanmar may affect the whole financial sources

of the country. The most vulnerable areas are the northern hilly area and the central dry zone. And the health sector is the most vulnerable sector (MOECAAF, 2012).

Vulnerability of the people may differ from each other because it changes depending on their income, livelihood and educational background (DMH and UNEP, 2009). Farmers in Myanmar would be generally influenced by the increased of intensity and seriousness of flash floods and droughts. Fisher folks would be influenced by the impacts of extraordinary climate occasions on fish stocks. Poor family households with limited access to basic access for livelihoods would be increased vulnerability. In addition, children and women would be particularly defenseless as they have been seen to be more vulnerable to the financial problems and additionally threat of ruthlessness after extraordinary climate occasions and poor households would experience problems to send their children to class for their education (DMH and UNEP, 2009).

2.2.4 Impacts of climate change on socio-economic sectors

Agriculture sector: According to Wassmann et al. (2009), Myanmar's agriculture is the most vulnerable sector to changing of climate. The anticipated increased temperature would have the adverse effects on agricultural and food production. Higher temperatures would lessen yields of potential crops. Variability of precipitation would also affect agricultural production. According to the synthesis report of AR4 IPCC (2007b), climate change has influence on agriculture in South East Asia countries because of the following changes:

- 1) Rainfall pattern change may affect on water management sector.
- 2) Crop productions in Myanmar would be impacted by changing of climate.
- 3) Temperature and humidity changes may impact on potential crops production of Myanmar.

The extreme rains and flash floods would result in yield losses the effect of crop damage. In agriculture sector, increasing the temperature would rise the infections of diseases, spread of insects and population of rodents (Karim, 1996). According to

Gerald (2009), climate change would bring the following impacts to South East Asian nations:

- 1) Potential crops for food security such as rice, wheat and millets may be affected.
- 2) Huge declines for inundated crops.
- 3) Increase in extra cost increases for potential agricultural crops.
- 4) Lost for the domestic animals would be higher and it will bring higher meat costs for consumer.

Forest sector: Climate change has significant effect on management of forestlands in Myanmar. In certain regions, climate change transforms the forest grade from good forest to less beneficial grasslands (Tun, 2006). The anticipated increase in droughts and outrageous day temperatures would increase evapotranspiration from the canopy of trees causing increased moisture stress. This would increase the vulnerability of forests to fires (Department of Meteorology and Hydrology, 2009).

Public Health sector: Increasing temperatures would make ideal conditions for diseases spread. Moreover, increasing temperatures have some adverse effects on humans with stress, dehydration, and so on. Higher temperatures would also reduce the development time interval for pathogens and thereby increase transmission rates e.g. mosquito-borne diseases such as malaria and dengue would increase (Kovats and Akhtar, 2008). Insects, bats and rodents populations which response to climatic change effect are predicted to have negative effects on the spread of a range of diseases (DMH and UNEP; Kovats and Akhtar, 2008). According to Lian and Bhullar (2010), the water resources is the main concerned about climate change for human health. An increase of drought would water access to the people and it can increase lack of drinking water. Kovats and Akhtar (2008) said that increases of droughts would decrease on both of water availability and water quality.

Water resources sector: Climate change has the impact on water resources, water cycle, and water supply. South west monsoon cycle changing in Myanmar would cause on flash floods and drought. This can contaminate water resources, disintegration and restrict renewal of water canals (DMH and UNEP, 2009). Due to the flash floods and inundation of sea water, the water resources in the lower part of Myanmar may be impacted heavily. Moreover, increases in drought events would enhance use of ground water resources for agriculture (NAPA, 2012).

Coastal Zone sector: Myanmar is also vulnerable to rising sea-levels because it has low-lying coastlines areas. In this manner, rising sea level and related effects would undermine coastal ecosystems, agricultural lands and infrastructures. Rising sea-levels would likewise undermine ground water tables and impacts on freshwater water supplies (NAPA, 2012).

Biodiversity sector: This is evident that the biodiversity in Myanmar have been affected by climate change. Some migration of birds species and loss of habitats are happening (Maung, 2009). Additionally, flowering time of the plants are occurred. And also forest types has also changed and it probably going to affect freshwater biodiversity. Marine ecosystems have been affected by sea surface temperature rise and it would also affect on all living things in the sea and ocean (OneWorld, 2010).

Energy, Transport and Industry sectors: Myanmar hydropower sector would be impacted by climate change. Especially, intense rain fall in a short period can damage to the structures of hydropower projects and would rise cost for maintaining. (Pattanapanchai, Shah, & Annandale, 2002). Transport sectors in Myanmar would likewise be affected. Industry would likewise be influenced. Besides, climate extremes would bring about significant impact on socio-economic sectors, for example, a drop in work and modern profitability w(NAPA, 2012).

2.2.5 Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change

In 2012, Myanmar submitted the National Adaptation Programme of Action (NAPA) to the UNFCCC to fulfill its actions on climate change. The executing agency of Myanmar's is the Department of Meteorology and Hydrology (DMH) of Ministry of Transport.

Goal and objectives: The goal of Myanmar's NAPA was to identify and prioritize activities to address Myanmar's immediate and urgent adaptation needs for implementation in Myanmar. The objectives of the Myanmar's NAPA as follows:

- 1) to observe and communicate climate change in Myanmar
- 2) to make a prioritization on adaptation projects
- 3) to assist Myanmar in achieving its national development goals and strategies including the Myanmar Agenda 21, the National Sustainable Development Strategy (2009)
- 4) to communicate immediate climate change adaptation need

The eight main sectors of Myanmar's NAPA selected as the priority levels are agriculture, early warning systems and forest, public health and water resources, coastal zone energy and industry, and biodiversity. The Government of Myanmar had taken several steps to focus on the impact of environmental stresses in all sectors. These include policies, strategies, plans and programmes that focus on sustainable development, sustainable utilization of natural resources, forest conservation, disaster risk reduction, and environmental protection (DMH and UNEP, 2009). These strategies would related to climate change adaptation as they encourage sustainable development of socio-economic sectors and this sustainable aspect overlaps in general with adaptation strategies for reducing climate change impacts.

Furthermore, the supporting policies and planning frameworks that were considered in prioritizing and designing NAPA adaptation projects are:

- 1) The National Environment Policy (MOECAF, 1994), and
- 2) The Myanmar Action Plan on Disaster Risk Reduction, Preparedness, Relief and Rehabilitation which is an updated version of the above MAPDRR plan.

The main treaties and agreements that were considered when prioritizing NAPA Adaptation Projects are the United Nation Framework Convention on Climate Change (UNFCCC-1992), Convention on Biological Diversity (CBD - 1994), the Kyoto protocol (1997), the United Nations Convention to Combat Desertification (UNCCD – 1997), The Hyogo Framework for Action (HFA); and The ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries and Forestry towards Food Security (AFCC).

2.2.6 Myanmar's Intended Nationally Determined Contribution-INDC for climate change mitigation

According to vulnerability assessment report by Kreft et al. (2015), Myanmar positioned the second most vulnerable country in the world to climate based on 20 years data. Climate models predict further negative impacts of climate change would have further expose to Myanmar (NAPA, 2012). With the biggest breadth of tropical forest in South East Asia, Myanmar is now a net greenhouse gas sink and it retains more greenhouse gases than it emits (MOECAF, 2012). Currently, Myanmar is in the time of industrialization and rapid urbanization which would prompt more greenhouse gases emission. The procedure of socio-economic development increase expanding in services, products and infrastructure development, especially in energy, agriculture, industry, human settlements and environmental resources sectors, which would also produce more greenhouse gases (MOECAF, 2015). Myanmar therefore has proposed to implement a progression of policies and actions to keep up the congruity among development and reducing climate change impacts. The Ministry of Environmental Conservation and Forestry (MOECAF) has served as the INDC focal point to encouraging the contributions from other line ministries. As party of the UNFCCC, Myanmar displayed its upgraded mitigation actions, policies, strategies and adaptive efforts on climate change. In INDC, Myanmar has recognized mitigation actions and

policies in the essential zones of forestry and energy. It is supplemented by supporting policies from other sectors.

Mitigation contribution of Myanmar's INDC

Myanmar is willing to undertake mitigation actions in line with its sustainable development needs, conditional on availability of international support, as its contribution to global action to reduce future emissions of greenhouse gases. As the mitigation actions, Myanmar's INDC focuses on forestry sector and energy sector. In the actions of energy sector, renewable energy sectors (hydroelectric power and rural electrification) and energy efficiency (industrial processes, cook-stove) are included. These actions would result in significant reductions in greenhouse gas (GHG) emissions. In addition to mitigation actions, Myanmar will also implement a number of climate change mitigation policies and strategies that intended in INDC.

Fair and ambitious of Myanmar's INDC

Myanmar is committed to take actions set out in INDC in order to limit growth of its GHG emissions in future to create harmony and balance between economic development and environmental sustainability. A series of strategies are also under development including the National Climate Change Strategy, a National Energy Master Plan, an Energy Efficiency Strategy and a Green Economy Green Growth Strategy. Myanmar is already implementing projects that will inform these strategies which will result in significant direct emissions reductions and indirect emissions reductions through demonstrating technologies and processes (MOECAAF, 2015).

Implementation of Myanmar's INDC

The INDC had been prepared through the review of key documents and a government drafting and validation process with all line ministries (MOECAAF, 2015). As a Least Development Country (LDC), Myanmar requires further capacity-building along with

access to technological and financial support from the international communities to implement the INDC. The success of the mitigation and adaptation activities in Myanmar is wholly dependent on receiving sufficient technology transfer, capacity building and financial support from developed and more experienced countries, international agencies, donors, and the wider international community (MOECA, 2015).

2.3 Water resources management

Water resources are potentially useful natural resources. It is used in many fields including environmental, recreational, agricultural, industrial and household activities. All living things in the world need water for their survival, growth and reproduction (Oki and Kanae, 2006). About 70 % of the earth's surface is covered by water. Of the total volume of water, about 97 % is saline water and only the remaining 3 % is fresh water. About two third of total fresh water is not in available form because they are solidified in polar ice caps and glaciers. And some of fresh water resources are situated as the ground water and some are in vapour form in the atmosphere. Therefore, the available fresh water resources is a small part of total global water volume (USGS, 2009). Water circulate naturally unlike other natural resources (Oki and Kanae, 2006). In the natural water resources elements, Atmosphere, ocean, sea, rivers, lakes, wetlands, aquifers, stream channels, watersheds are included in the element of natural water resources.

2.3.1 Water resource problems

Water is the crucial resources for all living things. According to Gleick (2000), population growth, undertaking economic development activities and upgraded life style changes have always been projected to increase. Globally, the availability of clean and fresh water is the imperative to support social and economic development. The rapid growth of the population and the needs of the development processes in arid and semi-arid countries are quickly quickening the demand for water (Kirmani and Guy, 1997). It has been proposed that the rising demand for water and the degradation of its

quality, speaks to the most genuine risk to the arrangement of different goods and services required by society (FAO, 2000).

In the report of technical advisory committee (TAC no. 4) of the Global Water Partnership by Agarwal et al. (2000), the overall problems of water resources are stated as follows.

- 1) **Resource under pressure:** Fresh water resources of the world are under pressure. Rapid growth of population, expanding economic development and enhancing living standard lead to expanded rivalry for and clashes over the limited freshwater resources. Absence of pollution control measures debases water resources.
- 2) **Populations under water stress:** It is assessed that nowadays 33% of the total population in the world are experiencing medium to high water pressure. This proportion is leading to increase to 66% by 2025.
- 3) **The impact of pollution:** There has a closed connection between the cause of water pollution and human activities. In industrial activities, agriculture and the basic needs of all living things, large amount of waste water are produced causing pollution to clean water body. Accessibility of the downstream water users is affected by water contamination. Polluted water threatens functions of aquatic ecosystem and people health and make an increasing competition for quality water and adequate quantity of water. Additionally, water pollution also makes reducing the availability of clean water assessment of downstream users.
- 4) **Water governance crisis:** The problems that identified with the water resources are disturbed by inadequacies in water management. Approaches by sectors to deal with water resources management have dominated and are still prevailing. Also, water management is normally left to top-down establishments, the authenticity and viability of which have increasingly been addressed. Therefore, inefficient governance and competition for limited resource cause the overall problem in water resources management.

2.3.2 Water resource management

Servats and Ferrari (2010) mentioned that water management processes are becoming continuous and complex. Water resources have been impacted by factors such as climate change, economic development, population increasing and demographic changes. It is important that people need to manage renewable freshwaters properly due to the growth of pressure on water resources. Moreover, the United States Agency for International Development (USAID, 2008) indicated that water-related tensions emerge on different geographic scales but it is the interplay of these tensions with a number of political, socioeconomic, environmental, and cultural factors that determine whether violent conflict will result.

According to Hoekstra and Savenije (2009), people from different professional backgrounds have different views on water resources management. They seldom have the same methods. The meaning of water resources management therefore can differ depends on the people where they live and who they are. There has emphasized on surface water in those people living in humid areas. To those people who live in an arid country, water resources management means drought relief, irrigation, and so on. Water resources management, actually, includes all point of views. Water resources management has many objectives, many sectors, and multi-disciplinary. Local, national and international activities, directed at either the short or the long term are also included in the term of water resources management. Moreover, it includes the whole set of scientific, technical, institutional, managerial, legal, and operational activities.

Water management in history

Hoekstra and Savenije (2009) stated that water management processes are most likely as old as mankind. Some recorded compositions and archeological research have shown that numerous old developments could prosper techniques for dealing with their water resources. In 1987, the World Commission on Environment and Development (WCED), the Brundtland Commission, was held by the United Nations. In this commission, people started to talk about the need for sustainable water resources

management for water sector. The meaning of sustainable water resources is a type of management that guarantees all humans are provided with their basic water needs but also ecosystems continue to be provided with a proper amount of water to maintain their function.

In 1992, the Dublin principles on water management were established and promulgated in this conference (GWP, 1996). The general objective of Dublin principles is to make sure that adequate supplies of good quality water are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to utilize limited water resources and to safeguard those resources against pollution. Then, it continues that the widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. The acknowledgment of the Dublin principles can be viewed as the official dispatch of integrated water resources management in all over the world. The principles one and two are fundamental components of integrated water resources management.

In 1996, the Global Water Partnership and the World Water Council was founded and it has helped integrated water resources management programs by a joint effort with governments and existing systems and by forging new collective courses of action. It is stated that “watercourse states shall utilize an international watercourse in an equitable and reasonable manner” and that “watercourse states have both the right to utilize the watercourse and the duty to co-operate in the protection thereof” in the article 5 of the international water law that was set in 1997. Article 7 indicates that “watercourse states shall take all appropriate measures to prevent the causing of significant harm to other watercourse states” (Hoekstra and Savenije, 2009).

Water resource management at the twenty-first century

Hoekstra and Savenije (2009) reported that the degree and multifaceted nature of water resources management has widened because of an increasing pressure on water. Until 1996, water resources were generally overseen independently, and often autonomously. The singhts on water quality, groundwater, water supply and sanitation, water system, and hydropower, are normally separately. Nowadays water resource management goes for integrated managing in a multi-sector, composed, interdisciplinary, participatory, straightforward, and adaptable way. The term for such kind of approach is called for integrated water resource management.

2.3.3 Integrated water resources management

The goal of the integrated approach to water resources management is to guarantee increased coordination between water chiefs and the different advancement organizers in planning development. According to the IWRM principles, a wide range of water resources are to be considered when developing applicable arrangements and choices on water management and insurance. The Global Water Partnership (GWP) is an international network for water and its vision is to be a water secure world (GWP, 2000). It advanced the implementation of sustainable development in relation to water resources through the paper. The GWP defined the IWRM as “a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.”

These decision and actions relate to situations such as river basin planning, organization of task forces, planning of new capital facilities, controlling reservoir releases, regulation floodplains, developing new laws and regulations. The decision-making processes are often lengthy and involves many participants and it is a process which can assist the efforts of the countries to deal with water issues in a cost-effective and sustainable way. The United States Agency for International Development (USAID, 2008) defined the IWRM as “a participatory planning and implementation process,

based on sound science that brings stakeholders together to determine how to meet society's long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits. The IWRM helps to protect the world's environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve human health". The Dublin Principles are a particularly useful set of the IWRM processes (Agarwal et al., 2000). The IWRM has been taken up in various geologies and contexts (Swatuk, 2005). The IWRM looks to integrate the amount and nature of all wellsprings of water within river basins with various client parts within the more extensive structure of national improvement planning (Muller et al., 2009).

The Dublin Principles

According to Agarwal et al. (2000), the Dublin Principles are the particularly useful set of principles for the Integrated Water Resources Management. The four Dublin Principles (GWP, 1996) are as follows.

- 1) Fresh water is a finite and vulnerable resource, essential to sustain life, development and environment.
- 2) Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.
- 3) Women play a central part in provision, management and safeguarding of water.
- 4) Water has an economic value in all its competing uses and should be recognized as an economic good.

Principle I: Water as a finite and vulnerable resource

The freshwater is a limited resource arises as the hydrological cycle on average yields a fixed quantity of water per time period. The freshwater resource needs to be maintained to ensure that the desired services. People can clearly affect the productivity of the water resources. Mining of groundwater, polluting surface water and groundwater and changing land use can impact on water resources. Specific policy and

rule for the water resources management to insure conserving water. There is also a need for proper policies and mechanisms which ensure that economic sector decision makers take water costs and sustainability into account when making production and consumption.

Principle II: Participatory approach

In water sector, everyone should be a stakeholder. To reach real participation, all stakeholders should be involved in the decision-making process. This means local people from communities come together to make water supply, management actions. A participatory approach is the only means for receiving long-lasting consensus and common agreement. National, regional and local levels governments have the responsibility for making participation as possible as they can. Participation is a manner that can be used to pursue an appropriate balance between a top-down and a bottom-up approach to the Integrated Water Resource Management.

Principle III: The important role of women

Women must be taken account to involve water management sector. Women's participation as decision-makers had gender hierarchies and roles within different cultures leading to the existence of communities that ignore or impede women's participation in water management. Therefore, special efforts must be made to ensure women's participation at all organizational levels. There is a need to ensure that the water sector as a whole is gender aware, a process which should begin by the implementation of training programs for water professionals and community or grass root mobilizers.

Principle IV: Water as an economic good

To extract the maximum benefits from the available water resources there is a need to change perceptions about water values and to recognize the opportunity costs involved in current allocative patterns. Water pricing is applying an economic instrument to

affect behavior towards maintaining and water use efficiency, to provide incentives for demand management, ensure cost recovery and to signal consumers' willingness to pay for additional investments in water services. The economic value which depends on the user and the way it is used, include: value to direct users of water, net benefits from water that is lost through evapotranspiration or other sinks, and the contribution of water towards the attainment of social objectives. The balance of water supply and demand may come from the pricing of water. There is a clear need for operational economic concepts and instruments that can contribute to management by limiting the demand for water. In order for water resources management, agencies and water utilities to be effective there is a need to ensure that they have adequate resources to be financially independent of general revenues. Thus, as a minimum, full supply costs should normally be recovered in order to ensure sustainable investments.

2.4 Water resource management in Myanmar

Water resource management in Myanmar has a plenitude of natural resources such as water, industrial minerals and timber, and gemstones (MOECAAF, 2012). Myanmar is also a country endowed with abundant water resources (Nesheim, Wathne, Ni, & Tun, 2016; Oo, 2015). The catchment area of Myanmar is eight principle river basins contain around 737,800 km² (Nesheim et al., 2016). There are transboundary waterways that most water property are inside the country wide fringes (Meel et al., 2014). As Myanmar mainly depends its economy on agriculture, water utilization for agricultural sector is around 89%, domestic use is around 10%, and industry use is just 1% of the aggregate water use (NAPA, 2012). The aggregate utilization of the country's water resources is just around 5% of the potential water resources. Unmistakably the physical potential for facilitate improvement of water resources in Myanmar is very substantial. However, it does not imply that Myanmar is free from water related problems, for example, floods and water scarcity (Meel et al., 2014).

Generally, Myanmar is split into the mountainous vicinity, the valuable Dry region, the Ayeyarwady delta and the coastal quarter (MOECAAF, 2012). With the excessive majority of the rainfall falling within the mountainous place, they represent the biggest

water sources. The fundamental issues are deforestation, hydropower and mining through inadequate watershed control. The central Dry zone region is a standout amongst the most food insecure, water stressed and climate sensitive region in Myanmar. The second highest number of populations in Myanmar is the central Dry zone yet stays one of the least developed. Deforestation, erosion and sedimentation add to the problems (Meel et al., 2014). The essential water resource management issues of the delta region are cyclone hazard, agriculture and aquaculture in perspective of freshwater accessibility and salinization. Mangroves vanish quickly in this area. In the rural area, the technique for drinking water supply was collecting rainwater (Meel et al., 2014). Moreover, Myanmar has around 2,832 kilometers of coastline on the Andaman sea. The coastline was separated into three areas including the west coast (Rakhine State), the Ayeyarwady delta and the south coast along the Mon State and Tanintharyi Region. Particularly in the delta area, the degradation of the mangroves is one of the serious issues (MOECA, 2012).

2.4.1 Water resource problems in Myanmar

Water resource problems in Myanmar such as overseas investment and increasing of population lead to unsustainable usage of natural resources that negatively impact on biodiversity, water quality and quantity causing a weight especially on poor people in Myanmar (MOECA, 2012). The environmental enactment for the sustainable utilization and for the insurance of the country's natural resources has as of not long ago been exceptionally frail. The country has needed environmental standards and a framework for environmental impact assessments (EIA) which are essential for sustainable development and natural resources management (Nesheim et al., 2016).

In Myanmar, rainfall is unevenly distributed prompting harm related floods, flash floods, water shortages and droughts. Mining and logging activities along the upper area of river basins cause erosion and sedimentation. Rainwater in deforested areas bring along a lot of sediment towards streams and rivers. Throughout the years, overwhelming deforestation has occurred in all part parts of the country. Rainfall increasing has brought about higher floods with shorter span and expanded

sedimentation in the lower parts of streams and rivers. This is appeared in negative consequences for the operational existence of hydropower and irrigation supply reservoirs by lessening their storage capacity. An imperative aim is for rainwater to be consumed by good forests and forest soils for resulting filling groundwater sources. Industrial development, the utilization of agrochemicals, mining, and inadequate wastewater treatment plants and accumulation of waste put a high weight on water quality in rivers, streams and lakes. Lack of legal planning framework and a participatory approach in the laws in the former time have progressively been risky for the governance of water resources in Myanmar (Nesheim et al., 2016). Moreover, protection for saltwater intrusion is yet limited condition. Moreover, protection of salt water intrusion is yet limited condition. Groundwater is progressively being utilized and will require additionally consideration on the collection of trustful data and data analysis of legitimate management of groundwater all over Myanmar (Meel et al., 2014).

Impacts of climate change: Socio -economic developments are one of the main external driving forces that would affect human activity, land use, and on water resource pressures. Apart from that, the impacts of climate change need to be consulted. There are various kinds of climatic conditions in Myanmar, the distribution of rainfall is unequally. There was an uneven distribution of rainfall over the country prompting floods, flash floods and furthermore essential, to water shortages and droughts (MOFA, 2015).

Longer droughts and water shortage: In Myanmar, moreover, the water shortage in urban areas has increased alongside population increase and urbanization (MOFA, 2015). Myanmar is a country with very irregular spread of rainfall due to geographical locations and also the seasons. The irrigation schemes in the central Dry zone can reduce fresh water need for rice and other crops production. In present, fresh water shortage is frequent problem in the dry zone area (Oo, 2015). Shorter south west monsoons will seriously impact the already strained irrigation practice. The scenario results in an increasing demand for water in the agricultural areas as well as the regions

in urban areas. In the central dry zone and the delta regions, it had the highest rate of water demand (MOFA, 2015). Climate change increases the vulnerability and the demands on water resources management (MOFA, 2015). Climate change adds to the vulnerability and the demands on appropriate water resources management (Meel et al., 2014). There are increasing weight on use of surface water and extraction of groundwater in Myanmar. Control and management of surface water and groundwater are, therefore, critical for practical improvement of the nation in future (MOFA, 2015).

2.4.2 Water resource management in Myanmar

Before 1989, there was no governmental agency who responsible for the control of pollution discharge and its impact and water conservation in Myanmar. In 2011, Ministry of Forestry (Ministry was renamed as Ministry of Environmental Conservation and Forestry, MOECAF) was revamped to have responsibility for environmental matters. The degradation of natural environments is responsible by the MOECAF in monitoring all development activities which might occurred (Meel et al., 2014; MOECAF, 2012). The National Water Resource Committee (NWRC) assumes liability for the national water resource management in order to encouraging more organized approach.

The National Water Resource Committee (NWRC): To assume liability for the management of national water resource and to encourage for a more organized approach, the Myanmar National Water Resources Committee (NWRC) was established by a presidential degree in 2013. The NWRC is an apex body that changes the segregated pattern of piece-wise and often overlapping water resources development and management by different government departments and line agencies into one united coordination mechanism. This united coordination team supervises, monitors, directs and supports all water related activities prompting comprehensive water administration (Oo, 2015). The general mandate of the NWRC is institutional fortifying including plan of appropriate national water policy, law, a national water framework directive, and capacity building to related stakeholders (Nesheim et al., 2016). The NWRC will draw up and implement an integrated water management

system, and develop a national integrated water management strategy, a national water resources policy, a water framework directive and a water law. It is seek ways to earn revenue by utilizing water resources, set up a water resources decision support system and databank, promote international collaboration on water sectors and establish a water resources trust fund (National Water Resource Committee, 2014).

The vision of Myanmar on water resources management adopted by the NWRC. The vision of Myanmar is to become a water efficient nation in 2020 with well-developed and sustainable water resources based on fully functional integrated water resources management system. The entire populace will benefit from gradually increasing income, better quality of life, greener environment, peace and stability due to efficient use of water and fair, transparent and inclusive allocation of water to many competing functions such as agriculture, forestry, mining, manufacturing, power generation, recreation, tourism as well as protection of water resources such as groundwater recharge and environmental flow in rivers. This vision is driving for integrated-water development, management of resources. Setting up for any possible future development could accomplished this objective.

The National Water Policy (NWP) development: The National Water Policy (NWP) was prepared by expert group under the National Water Resources Committee. The NWP is the first integrated water policy for the watersheds, rivers, lakes and reservoirs, groundwater aquifers and coastal and marine waters of Myanmar. The objective of the NWP is to take cognizance of the existing situation, to propose a framework for creation of a system of laws and institutions and for a plan of action with a unified national perspective including the Myanmar Water Framework Directive (MWFD). The NWP an umbrella and as guidance as follows,

- 1) all further water resource policy development or issues that relate to or have an impact on Myanmar's water resources;
- 2) further development of legal instruments and a system of institutions to protect and manage Myanmar's water resources;

- 3) strategies, master plans, development plans and projects that relevant to or have an impact on Myanmar's water resources.

The National Water Framework Directive (NWFD): The NWFD is a extensive policy framework acquired by the NWRC, which emphasize the principle of the River Basin Management approach and the development of River Basin Management Designs (Nesheim et al., 2016). There are seven key principles of the NWFD as follows:

- 1) Good status i.e. clean and sufficiently stored for all ground water and surface water
- 2) National Water Budget
- 3) The ecological and chemical status
- 4) Cooperation between the Union Government and the States and Divisional Governments
- 5) Spatial management of river basins
- 6) Transgressions
- 7) Restructuring

2.4.3 Integrated Water Resources Management in Myanmar

In 2013, the Government of Myanmar was supported by the Ministry of Infrastructure and Environment of Netherlands to develop the strategy of Integrated Water Resources Management (IWRM) through a Memorandum of Understanding (MoU) with the Myanmar Ministry of Transport. The MoU started with started with the strategic survey by Ministry of Infrastructure and Environment of Netherlands and Myanmar Government in implementing the goal of the national water resources management policy in 2014 (Oo, 2015).

The outcome of the Myanmar integrated water resources management policy is “to develop, share and manage the water resources of Myanmar in an integrated, holistic and socially inclusive manner, to contribute significantly to the poverty alleviation, to the green growth and sustainable development of the nation, by providing access to

water of equitable quantity and safe quality for all social, environmental and economic needs of the present and future generations” (Meel et al., 2014; National Water Resource Committee, 2014). There is no information about current status of the socio-economic planning, population growth, and climate change impacts on water resources supplies and demands in Myanmar. Therefore, the implementation of the IWRM would be comprehensively needed in adjusting any changing conditions. The design of the project was conducted by Netherlands and Myanmar (2014) and outlined the guiding principles for the IWRM which were based on its National Water Policy of Myanmar. The general information of the IWRM follows the basic concept of the theory and strategy consisting triple-bottom line: planning, development and management of water resources need, all elements of the water cycle, good governance through transparent informed decision making, fair and transparent allocation of water, prioritization: water, after meeting the pre-emptive needs, and also water quality and quantity

CHAPTER III

RESEARCH METHODOLOGY

3.1 Conceptual research framework

The research aimed to study climate change adaptation on water resource management in the Dry Zone at the Pakkokku Township, Magway Region in Myanmar. The conceptual research framework was designed relevant to the research objective as shown in Figure 3.1.

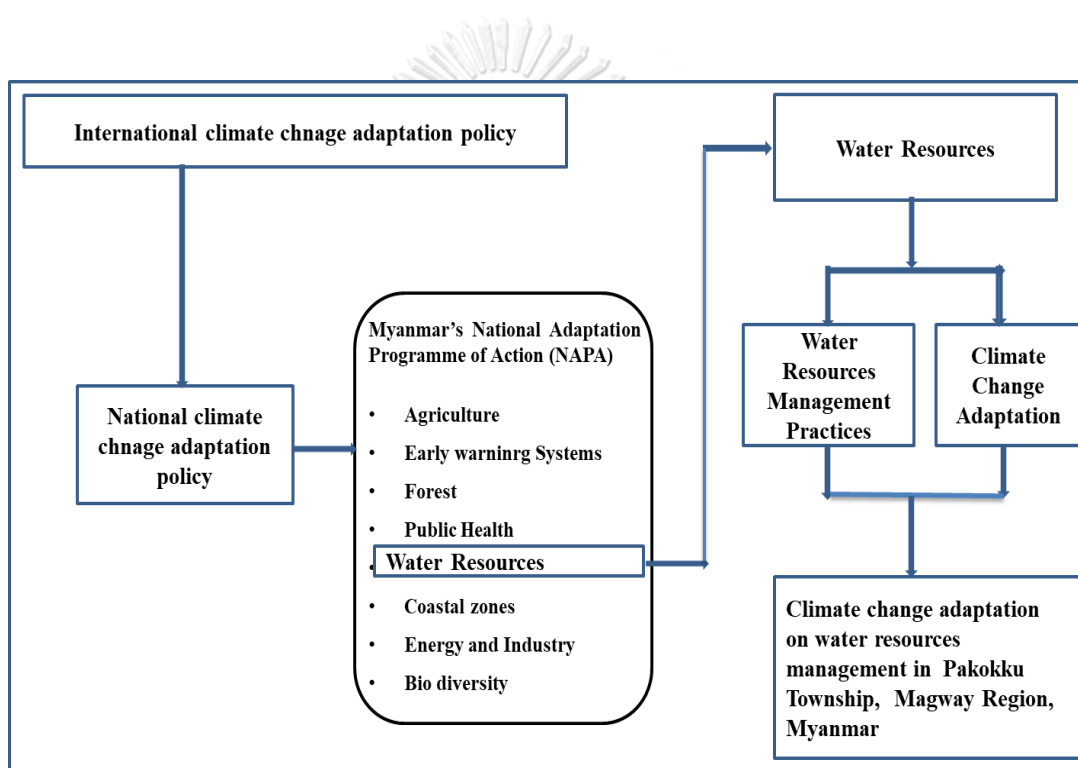


Figure 3.1 The conceptual research framework on climate change adaptation on water resource management: A case study of Pakokku Township, Magway Region, Myanmar.

3.2 Study area

Study area was located in Pakokku Township, Magway Region, Myanmar. This township was one of the six townships in the Magway Region. The study area was dry and had few natural resources due to geographical setting. There were 55 villages tracts in Pakokku Township and it had the highest population density among the townships in Magway Region with 290,193 people in 2014 (Department of Population, 2015).

Fee et al. (2017) reported that this township has been conducted the vulnerability assessment on scenarios for buildings resilience during 2016-2030 by Myanmar Climate Change Alliance (MCCA).

Pokokku Township is located at the latitude between 20° 54' 45" N and 21° 29' 40" N and the longitude between 95° 14' 00" E and 95° 10' 21" E with the altitude of 64.52 m above the mean sea level. Pakokku's economy was not well diversified. Over 46 % of people depended on agriculture for their livelihood. Agriculture in Pakokku was highly climate sensitive (Fee et al., 2017). Pakokku Township was in a dry land ecosystem and was dependent on the Ayeyawady Dry Forests.

There were irrigation infrastructures in the township including 6 dams which were either in disrepair, relied on seasonal rainfall and had to water flow in the dry season. This requires water to be pumped. Water sanitation and its facilities were still lacking in the township (Fee et al., 2017). The study area is presented in Figure 3.2.

According to Fee et al. (2017), climate change projection of Pakokku Township as follows:

- The temperature in Pakokku Township is expected to rise over the coming decades; annual average temperatures could rise by 1.2-2.7°C.
- Warming in the hot season (March-May) and cool season (November-February) is projected to slightly exceed warming in the wet season (June to October).
- Climate models suggest an increase in total rainfall for Pakokku, with more rain during the wet season.
- In the cool season, climate models suggest that Pakokku may be more likely to see a decline in rainfall, than an increase.

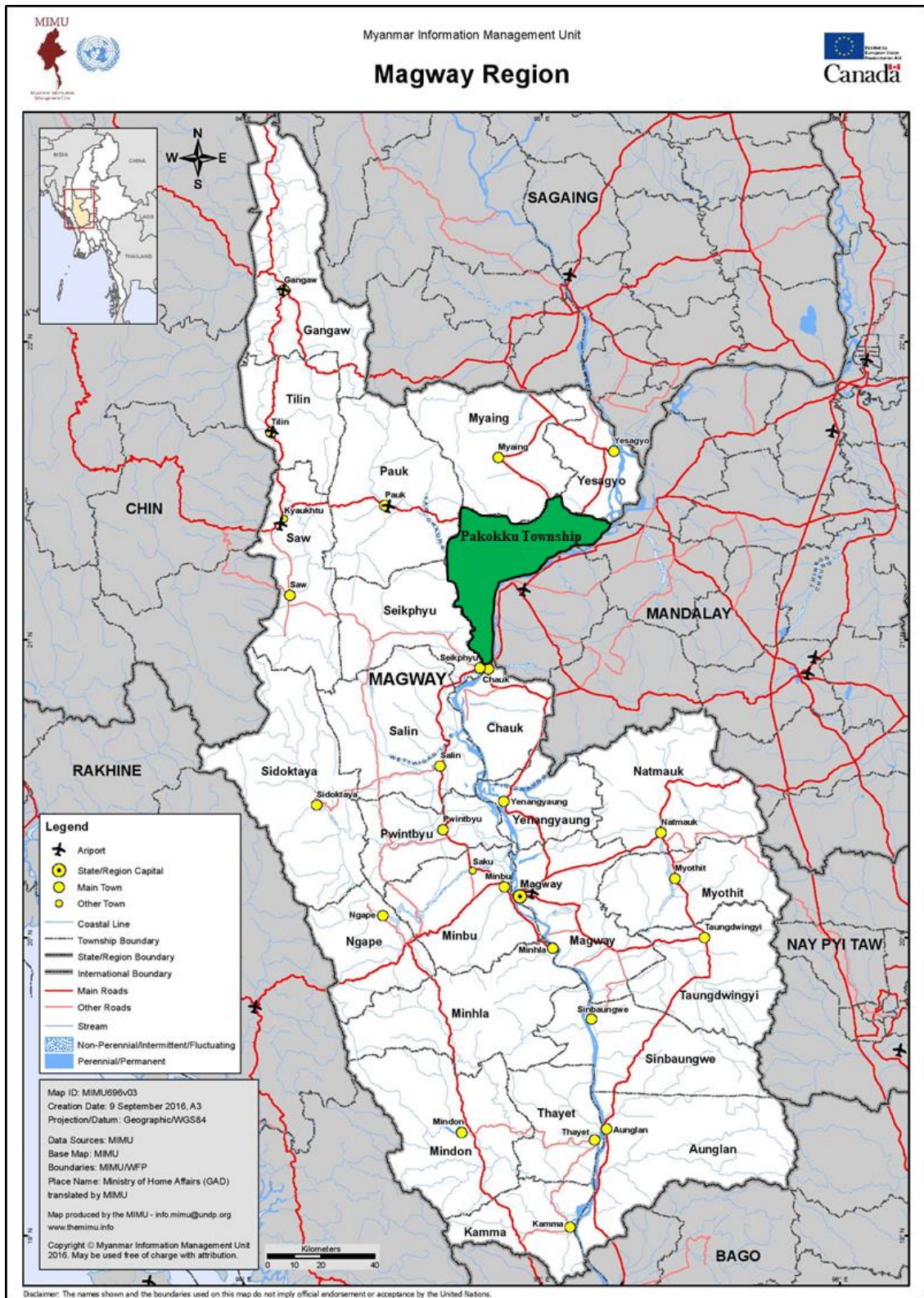


Figure 3.2 The study area; Pakokku Township (dark green shade), Myanmar.
 Source: Myanmar Information Management Unit (2018)

According to vulnerability assessment report by Fee et al. (2017), the vulnerability index in Pakokku Township were as follows.

- (a) Village tracts along the western border of the township and those located by the river have the greatest levels of vulnerability.
- (b) Vulnerability levels are high throughout the township, with especially high levels of vulnerability defined above. This means that actions to adapt to climate change are needed throughout the township, with an initial focus on the highly vulnerable village tracts.

3.3 Data collection

This research used both qualitative and quantitative research approaches for data collection at four villages, namely Shin Ma Kan, Pan Tine Chone, Paung Laung Kan and Kyee, Pakokku Township, Magway region, Myanmar. The instruments of data collection were as follows;

1) Desk study

Various literature sources were used as for the document of the climate change adaptation and water resource management. This included journal articles, academic research papers, edited books and book sections, and project reports. The databases were used as references for this research.

2) Direct observation

Field visit was a significant method to identify the overall basis of limitation and performance information at the field area. The purpose of this instrument was to assess data of the variability and change of the study for supporting this research toward improve and understand of study area system. Field visit was conducted in the study area.

3) In-depth interview

In-depth interviews were conducted with a semi-structured questionnaire in the study area. The respondents who provided their views on climate change adaptatin and water

resources management included government officers, non-governmental organization officers, farmers, teachers, employee, livestock husbandries and traders.

3.4 Data analysis

Collected data and information were analyzed by means of qualitative and quantitative methods as follows.

- (a) Secondary data related to temperature and rainfall collected from Department of Meteorology and Hydrology, Pakokku District, Myanmar, were analyzed by using statistical analysis method.
- (b) Information and practices from in-depth interviews were analyzed by using descriptive and content analysis approaches.



CHAPTER IV

RESEARCH RESULTS

4.1 Study area

The study area composed of the four villages, namely Shin Ma Kan, Pan Tine Chone, Paung Laung Kan and Kyee which are located in Pakokku Township, Pakokku District in Magway Region of Myanmar. Pakokku Township is located in the latitude between 20° 54' 45" N and 21° 29' 40" N and the longitude between 95° 14' 00" E and 95° 10' 21" E at the altitude of 64.52 m above the mean sea level. The area of Pakokku Township is 1258.3 km² (Department of Population, 2017) . The width is 54.71 km from east to west and 17.70 km from south to north. This area is the hottest area in the dry zone of Myanmar located between the Shan Plateau and the Rakhine Mountains (General Administration Department, 2017) . The study area is shown in Figure 4.1.

The four villages were selected depend on their situations in which the villages are drought, and water stress area because the areas get the highest temperature range and the lowest rainfall range. The scarcity of water always turns into a serious issue in those areas. Therefore, water resources in those villages need to be necessarily well managed under climate change.

1) Shin Ma Kan village

Shin Ma Kan village is located in the west of Pakokku city of about 26 kilometers. The village has 220 households with a population of 994. Shin Ma Kan village is dry and used to face drought. A carrier of the villagers are farmers, casual labours, livestock husbandries, and traders. The farmers are the majority of group in the village accounting to 120 households. Their crops are groundnuts, sesame, cotton, green gram, corn, and pigeon pea, which are dependent only on rainfall. Some villagers of the village have migrated to other places. There are two village ponds and two deep well as the main source of water use in the village.

In 2014, Shin Ma Kan village formally established the village water committee for piping network and water metering system to allocate water from the deep well to the households. In 2017, the Department of Rural Development built a deep well and a water tower tank in the village in order to reduce household water shortage.

2) Pan Tine Chone village

Pan Tine Chone village is located in the north of Pakokku Township of about 11.27 kilometers far from the Pakokku city. It has 455 households with a population of 2132. They are farmers, traders, workers, casual labours, and livestock husbandries. The majority of the villagers are farmers. General crops in the village are groundnuts, sesame, cotton, green gram, corn, and pigeon pea. Water shortage was a common problem in the village. In 2016, the Department of Rural Development and UN-Habitat built a large water storage tank of 53 cubic meters with a big bio-sand filter near the village water pond. A piping network was also built to allocate water to all households in the village.

3) Paung Laung Kan village

Paung Laung Kan village is located in the northeast of Pakokku Township of about 9.7 kilometers far from the Pakokku city. It has 275 households with a population of 1375. Most of the villagers are farmers and the rest are working as casual labours, flower planters, and traders. The farmers grow groundnuts, sesame, rice, green gram, and corn. The farmers use water for their crops from rainwater and water from the Kyee river pumping project which was started in 2008. The project provided water to use both households and agricultural purposes

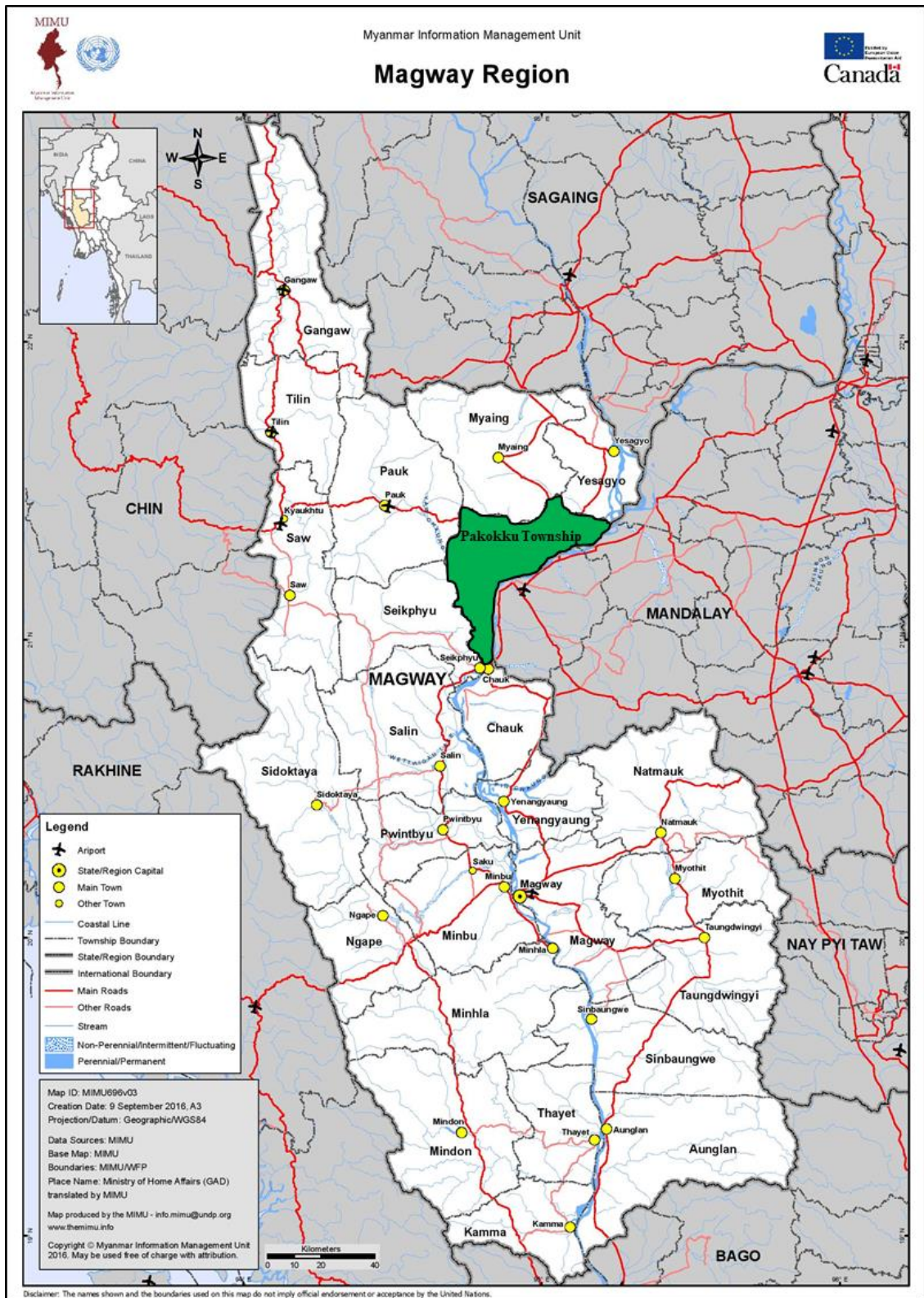


Figure 4.1 The study area, Pakokku Township (dark green shade), Myanmar
 Source: Myanmar Information Management Unit (2018)

4) Kyee village

Kyee village is located in the north of Pakokku of about 8.1 kilometers far from Pakokku city. It has 351 households with a population of 1473. Farmers, traders, weaving, are the occupations of the villagers. General crops in the villages are groundnuts, sesame, green gram, corn and pigeon pea. For agriculture, rainwater was the only source of water. Water shortage turned into a common problem in the village.

There are two village ponds which are the main source of households water use in the Kyee village. In 2009, the village formally established the village water committee for piping network and water metering system to allocate water from the village water ponds to the households. A pumping station was installed on the bank of the village water pond and allocate water to households. In 2013, UN-Habitat funded to renovate village water ponds to get more storage capacity.

4.1.1 Socio-economic conditions of the Pakokku Township

Pakokku Township is located in the west bank of the Ayeyarwady River and it is one of the strategic points of economic development. It has a dry land ecosystem, which is located in the central Dry zone of Myanmar (Fee et al., 2017). The total population of Pakokku Township is 290,139, comprised of 130,741 males and 159,398 females (Department of Population, 2015). The population density of Pakokku is 231 persons per square kilometer. The majority of the people in the township live in rural areas with only 31.3% living in urban areas (Department of Population, 2017).

People in the township are mainly working in farming, livestock, industry, cottage industry, trading, as their carriers. Over 46 percent of the total population in Pakokku Township depends on agriculture for their livelihoods (Department of Population, 2015). Regarding transportation, both land route and riverine route are moderately good and can be accessed. There is also a big bridge across the Ayeyarwaddy River in the Pakokku Township that can access easily to other parts of Myanmar. The bridge enhances a transportation network to the upper and lower

Myanmar. This makes a convenient connection to the borderlines of India and China. The Pakokku industrial zone was also been developed in the Pakokku city. The main products of Pakokku Township are various kinds of pea and bean and oilseed crops (General Administration Department, 2017) .

Pakokku Township has 19 high schools, and 33 middle schools under the Department of Basic Education, Ministry of Education, Myanmar. Moreover, higher educational institutions such as Pakokku University, Technological University, Computer University, Education college, Nursing Training school, and School of Industrial Training and Education are in this township. The literacy rate of their people who are aged of 15 and over in Pakokku Township is 91.2%. The people who are aged of 25 and over, the study found that 20.7% completed a primary school and only 9.7% graduated from university and college (Department of Population, 2017).

In Pakokku Township, 27.7% of the employed people are of age between 15 and 64. They are skilled in agricultural, forestry and fishery workers. The proportion of employed persons who are working in the industries of agriculture, forestry, and fishing is the highest with 37% (Department of Population, 2017) .

In the township, 84.9% of households have accessed drinking water from tap water, tube well, borehole, protected well, protected spring and bottled water and water purifier. About 56.8% of households have electricity use in Pakokku Township and 42.6% of households in rural area in the Pakokku Township have electricity use (Department of Population, 2017). Drinking water accessed by conventional households are presented in Table 4.1.

Table 4.1 Percentage and number of conventional households of drinking water sources in urban and rural area in Pakokku Township.

Source of drinking water		Total	Urban	Rural
Tap water and Piped water		15.5	23.6	12.2
Tube well, borehole		61.4	63.5	60.6
Protected well, protected Spring		5.5	1.6	7.0
Bottled water and Water purifier		2.5	3.3	2.2
<i>Total improved drinking water</i>		84.9	92.0	82.0
Unprotected well and unprotected spring		1.2	0.2	1.5
Pool, Pond, Lake		3.8	0.3	5.2
River, stream, canal		7.0	0.1	9.7
Waterfall, Rain water		0.3	-	0.6
Other		2.8	7.4	1.0
<i>Total unimproved drinking water</i>		15.1	8.0	18.0
Total	Percent	100.0	100.0	100.0
	Number	66,340	19,069	47,271

Source: Department of Population (2017)

4.1.2 Climate information of the study area

The weather of Pakokku Township is dry. The highest temperature recorded used to be 45.1°C and the lowest temperature recorded used to be 8.9°C (General Administration Department, 2017). The meteorological data (temperature and rainfall data) from 1987 to 2016 were collected by the Pakokku District monitoring station, Department of Meteorology and Hydrology (DMH), Myanmar. The annual average rainfall was 631.66 mm as shown in figure 4.2. The average mean temperature was 27.81°C. The highest average temperature was 35.87°C and the lowest average temperature was 19.68°C as shown in Figure 4.3 (Department of Meteorology and Hydrology, 2018).

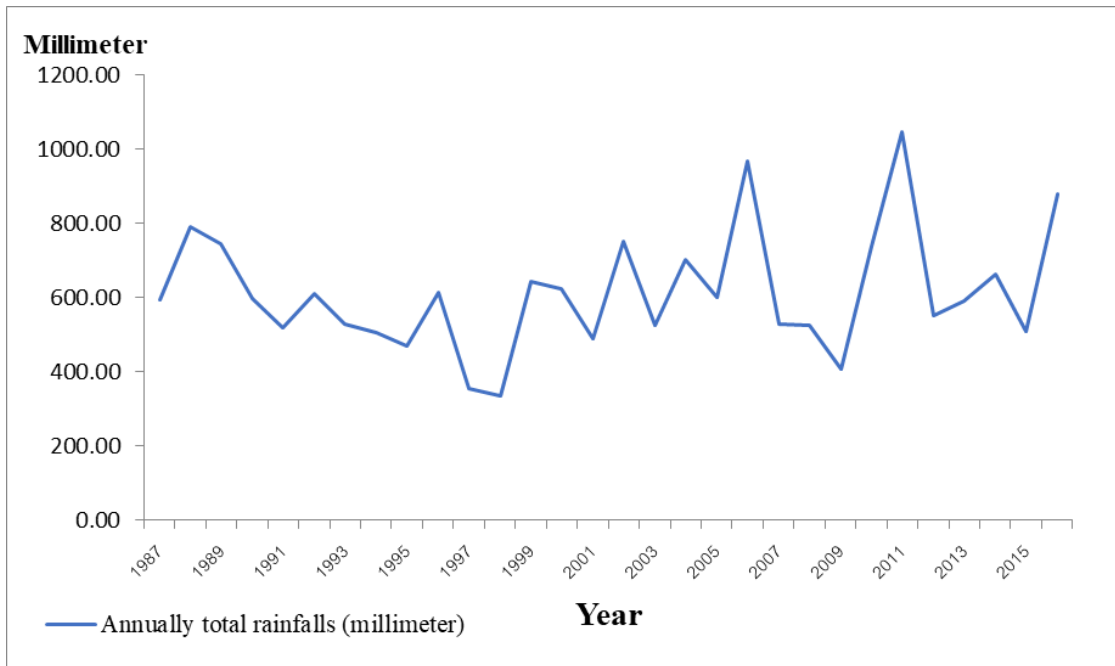


Figure 4.2 Total annual rainfall (mm) between 1987 and 2016 at the Pakokku Township, Myanmar.
 Source: Department of Meteorology and Hydrology (2018)

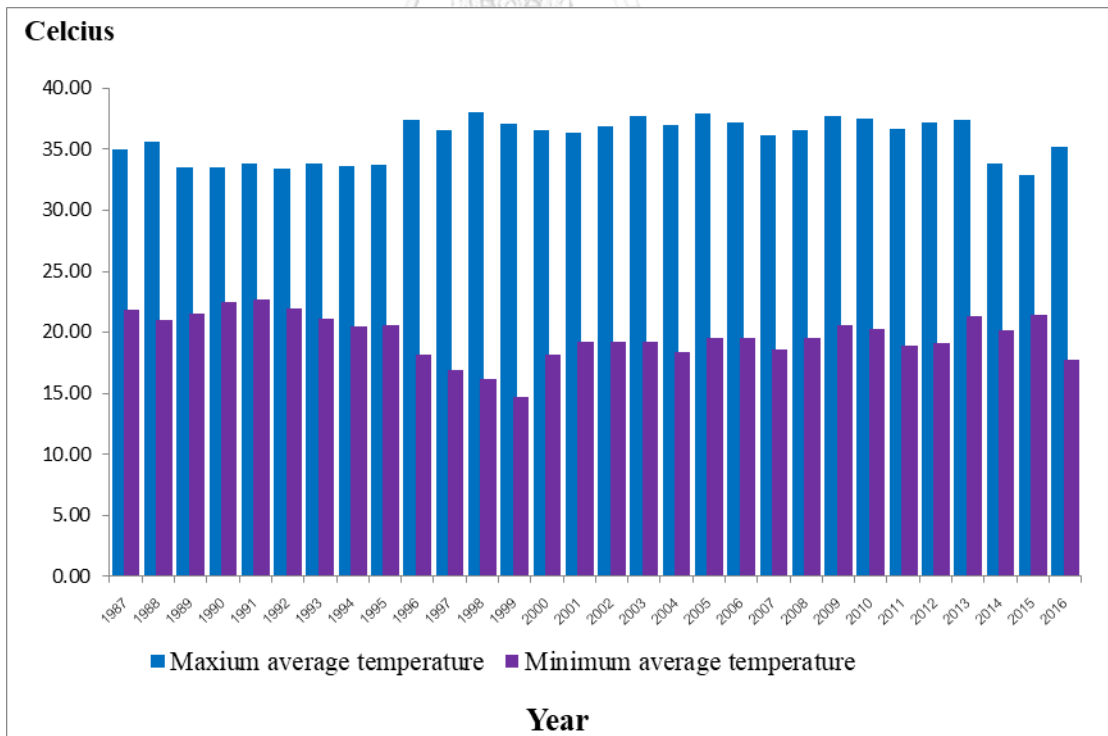


Figure 4.3 Temperature at the Pakokku Township between 1987 and 2016.
 Source: Department of Meteorology and Hydrology (2018)

According to Fee et al. (2017), the temperature in Pakokku Township is expected to rise in the coming decade. An annual average temperature would rise by 1.2-2.7°C. The total rainfall would be increased with more rain during the rainy season. In winter, the temperature in the Pakokku Township would decline in rainfall.

4.2 General information of respondents

The respondents of the study were specifically selected by the research objective, which is to study climate change adaptation on water resource management in Myanmar focusing at Pakokku Township, Magway Region, Myanmar. The respondents of the study were selected by using purposive sampling method. A purposive sampling method, also called judgment sampling, is the deliberate decision of a participant due to the qualities the participant possesses. It is a nonrandom technique that does not require fundamental theories or a set number of participants. Basically, the researcher chooses what should be known and sets out to find people who can and are willing to provide the information by the goodness of learning or experience (Bernard, 2017).

The total respondents were 61 including governmental officers, non-governmental organizations (NGOs) officers, and local peoples who are farmers, village heads, teachers, traders, employees. An in-depth interview was conducted between December 2018 and January 2019 by using a set of semi-structured questionnaire to obtain relevant information. The questionnaire was composed of three parts, namely general information of the respondents, climate change adaptation, and water resource management.

The majority of respondents were male of 92% and female of 8%. The ages of the respondents were divided into five groups. 30% of the respondents were in the age range of 51-60 years old, 26% in the range of 61 years old and above. 25% of them were in the age range of 41-50 years old and 16% of them were in the age range of 31-40 years old. Only 3% of them were in the age range of 18-30 years old.

In terms of education, 30% of the respondents graduated at the level of a secondary school, following 26% at the level of a primary school. The number of respondents who obtained a bachelor degree presented 20% and a high school 11%. 10% of them did not go to school.

The occupations of the respondents were farmers (67%), government officers (15%) and the rest were teachers, employees, livestock husbandries, traders, and non-governmental organization officers.

The study found that 51% of respondents were farmers, 12% were water committee members and the rest were local wisdom experts, officers in charge, village heads. The general information of the respondents are presented in Table 4.2 and Figure 4.4.

Table 4.2 General information of respondents

Component	Respondents (N=61)	Percentage
1. Gender	Male	92
	Female	8
2. Age (year)	18-30 years	3
	31-40 years	16
	41-50 years	25
	51-60 years	30
	61 years and above	26
3. Educational Background	None	10
	Primary school	26
	Secondary school	30
	High school	11
	Bachelor Degree	20
	Master Degree	3
4. Occupation	Farmer	67
	Teacher	5
	Government officer	15
	Employee	4
	Livestock husbandry	3
	Trader	3

	NGO officer	3
Positions of respondents	Deputy staff officer	3
	Officer in charge	8
	Staff officer	3
	Village head	7
	Local wisdom expert	8
	Head of school	5
	Water committee member	12
	Farmer	51
	NGOs officer	3



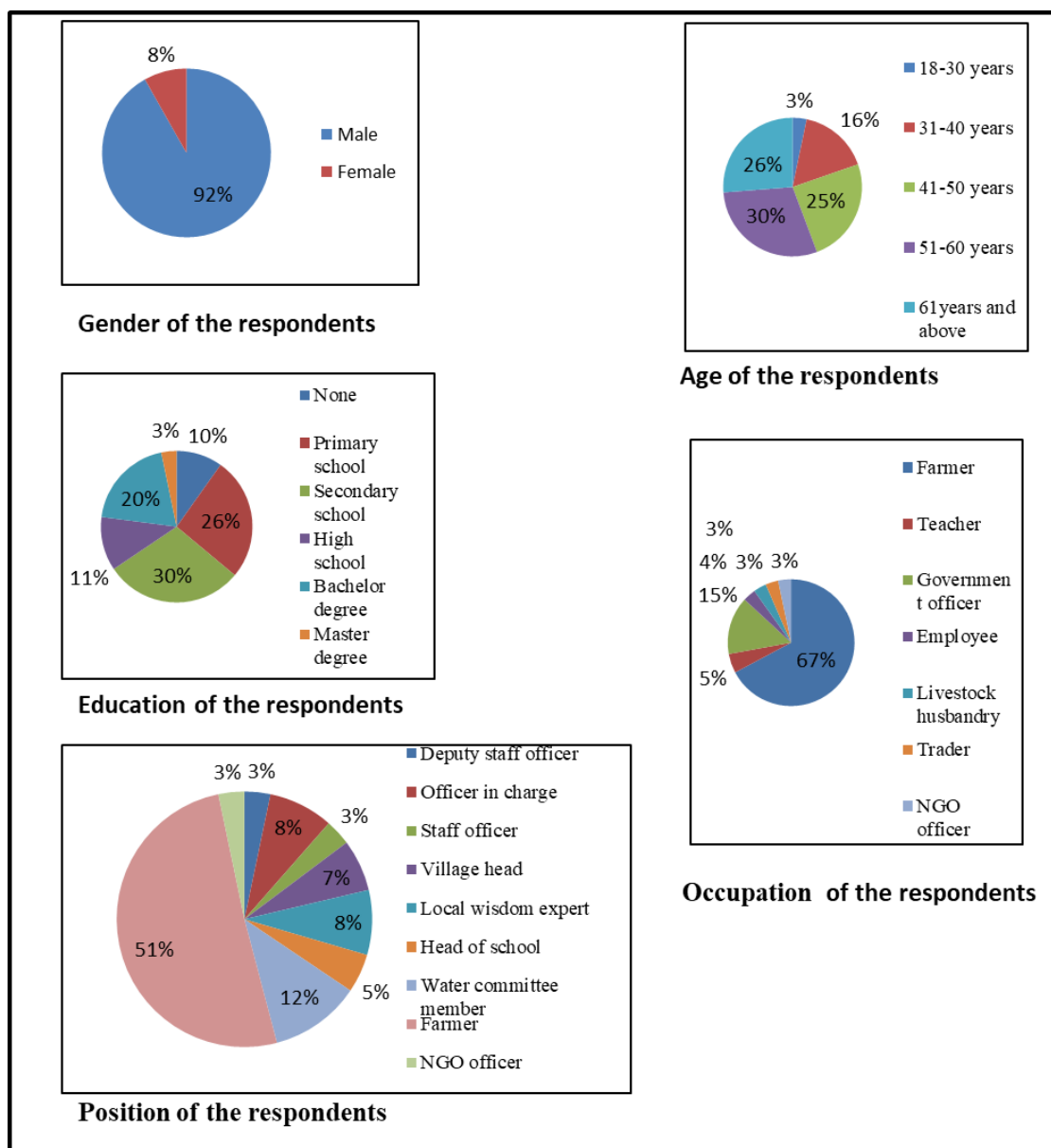


Figure 4.4 General information of respondents

4.3 Climate change adaptation

According to the IPCC (2013), the temperature of the earth globally increased in recent decades resulting in unequivocally climate change. IPCC in 2007 stated that climate change refers to a change in a state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an external period, typically decades or longer. It refers to any change in climate over time, whether due to natural or as a result of human activity.

Climate change impacts are affecting humans and natural systems. The impacts such as changing in rainfall patterns, sea level rise, heat waves, drought, frequent storms, and changing monsoon cycle, have been occurred (Horton et al., 2017). In the biological systems, there is the demise of flora and fauna in terrestrial and marine ecosystems. In human systems, climate change influences and destroy crops and food production, cause infection and passing, destruction and loss of economic livelihoods and migrations of people. Water resources are vulnerable to climate change that can have a large impact on human lives. Therefore, adaptation to climate change impacts is crucial. Climate change adaptation (CCA) was defined by the United Nations Framework Convention on Climate Change (UNFCCC) as the needed modification in response to the changes social-ecological and economic systems in relation with climate change (UNFCCC, 1992). The IPCC in 2007 defined adaptation as “the alteration in natural or human systems in response to actual or anticipated climatic stimuli or their effects”. The adaptive capacity is the capacity of a system or group to confront some changes to the impacts of climate change and especially in its extremes. Adaptive capacity is considered as an essential instrument to diminish vulnerability.

In order to know climate change, its impacts and climate change adaptation practices in the study area, the in-depth interviews were conducted with a semi-structured questionnaire in four villages in Pakokku Township, Magway region, Myanmar. The respondents who provided their views on climate change adaptation included government officers, non-governmental organizations officers, farmers, teachers, employees, livestock husbandries and traders. The total respondents were 61.

According to the collected data about climate change adaptation in the study area, the study found that 98% of the respondents knew about changing of the climate. 90% of them mentioned that temperature has increased, 80% of them noted that rainfall pattern has changed compared to the last 3 decades, and late onset and early withdrawal of monsoon have occurred in Myanmar. 77% of them found that frequent hotter days occurring.

Regarding the interviews with government officers, all of them knew about the changing of climate. 100% of them mentioned that temperature has increased, rainfall patterns have changed, late onset and early withdrawal of monsoon occurred in Myanmar, while 98% of the farmers knew about climate change. The majority of the respondents accounted for 93% mentioned that they were getting more hotter days, while 88% viewed that late onset and early withdrawal of monsoon occurred. Moreover, 85% of them mentioned that temperature has increased and rainfall patterns have also changed. 100% of respondents including teachers, employees, and non-governmental organization officers also knew about changing of climate, particularly temperature increasing and rising sea level. Additionally, 100% of the employees knew climate change in terms of changing in rainfall patterns.

In terms of the climate change impacts, 100% of respondents knew the impacts such as freshwater shortage, heat waves, crop production decreasing. 90% of them mentioned that freshwater has become a shortage. 80% of them viewed that heat waves have occurred frequently, and 74% of them mentioned that crop productions have decreased.

All government officers knew climate change impacts. The impacts that they mentioned were biodiversity losses, flash floods, crop production decreasing, impacts on human health, fresh water shortage, and impacts on infrastructures.

The farmers mentioned that heat waves, fresh water shortage, crop production decreasing, were the climate change impacts. 93% of them mentioned heat waves, while 88% mentioned freshwater shortage and 78% mentioned crop production decreasing as the climate change impacts. All of the teachers knew climate change impacts and the impacts that they mentioned were heat waves and fresh water shortage. 100% of employees mentioned that heat waves and fresh water shortage as the climate change impacts. 100% of the traders also mentioned that crop production decreasing, heat waves and freshwater shortage, were climate change impacts. 100% of non-governmental organizations officers mentioned that climate change impacts were heat waves and fresh water shortage.

The study found that 97% of the respondents have faced those impacts. To adapt to those kinds of climate change impacts, the respondents gave different answers as follows. Approximately 74% of the respondents mentioned that they were living properly in extreme weather conditions, 66% of them changed seed varieties resisting to climate change impacts, 48% of them made good tillage at their farms to maintain soil moisture content, while 46% of the respondents reduced water using, and 43% of them were changing sowing dates of crop plantation.

100% of government officers adapted to climate change impacts by staying properly in extreme weather conditions. 95% of the farmers adapted to those climate change impacts by changing the seed varieties resisting to climate change, 66% of them were practiced making good tillage at their farms to maintain the soil moisture content, and 63% of them changed sowing dates of crop plantation. 100% of the respondents including teachers, employees, and non-governmental organizations officers also adapted to climate change by living properly in extreme weather conditions and reducing water use.

Regarding the effects of climate change in the villages, the study found that heat waves, less water retained ponds in summer, rainfall variability, and dry spell occurred. About 98% of 50 respondents mentioned heat waves, 92% mentioned less water retained ponds in summer, 83% mentioned that rainfall variability. 77% of them mentioned that dry spell was climate change impacts that were affecting in their villages. In the views of farmers, the respondents accounted for 96% mentioned that the impacts that are affecting in their villages were heat waves and less water retained ponds in summer. Moreover, 88% of them mentioned rainfall variability, while 85% mentioned that dry spell affected on their villages. 100% of the rest of the respondents agreed that the major impacts that are affecting in their villages were heat waves and rainfall variation.

Regarding climate change adaptation, the study found that 87% of the respondents changed the seed varieties resisting to climate change impacts. About 79% of them have changed sowing dates of crop plantation in order to meet the rainfall. The respondents

accounted for 79% were living properly in extreme weather conditions while 72% of them were making good tillage in their farms in order to maintain soil moisture content.

Regarding the government officers point of view, 100% of the respondents mentioned types of adaptation to climate change as changing seed varieties resisting to climate change. Additionally, 89% of them mentioned that water-saving irrigation in agriculture and making good tillage in farms to maintain soil moisture content were types of adaptation to climate change.

According to the views of farmers on climate change adaptation, 90% of them mentioned that types were living properly in extreme weather conditions. 88% of them mentioned changing seed varieties resisting to climate change impacts, 80% of them mentioned making good tillage at their farms to maintain soil moisture content.

In the views of the teachers and employees, 100% of them mentioned that they were living properly in extreme weather conditions. 67% of teachers mentioned changing sowing dates, changing seed varieties resisting to climate change impacts, and harrowing and ploughing before monsoon coming, were types of adaptation to climate change. 100% of people who work in livestock husbandries, traders and NGOs officers mentioned harrowing and ploughing before monsoon coming, changing seed varieties resisting to climate change impacts, changing sowing dates of crop plantation, and staying properly in weather conditions, as the types of climate change adaptation.

According to the data collected about climate change adaptation projects in their villages, all the respondents (100%) reported that they did not have any specific project on climate change adaptation in their villages.

According to the views of the respondents, the climate change impacts that are affecting in Myanmar were temperature increasing, rainfall patterns changing, people migrations, flash floods, storm frequency increasing, droughts, rainfall variability, late onset and early withdrawal of monsoon. 95% of the respondents assumed that temperature has increased in Myanmar. The respondents accounted for 93% of them noted that rainfall

patterns have changed. Approximately 87% of the respondents claimed that people migrations were happening in Myanmar due to climate change. About 87% of the respondents mentioned that flash floods frequently occurred. The other 80% of them mentioned storm frequency increasing. 77% of the respondents mentioned about drought and rainfall variations were happening in Myanmar. Respondents accounted for 67% assumed that late onset and early withdrawal of monsoon were occurring in Myanmar.

Regarding the views of the government officers, 100% of them mentioned that flash floods, rainfall variations, and late onset and early withdrawal of monsoon, were the climate impacts that are affecting in Myanmar. Approximately, 89% of them mentioned an increase in temperature and people migrations. 67% of them mentioned rainfall variability has occurred.

The views of farmers on the impacts of climate change that are affecting in Myanmar were mentioned as follows. 98% of them mentioned rainfall pattern changing, 95% mentioned temperature increasing, 90% mentioned about water scarcity. About 85% of them also mentioned about flash floods, while 83% of them mentioned about storm frequency increasing and people migration increasing. Regarding the views of the rest of respondents, 100% of them viewed that temperature increasing, rainfall pattern changing, people migration increasing, storm frequency increasing, droughts, rainfalls variations, late onset and early withdrawal of monsoon, water scarcity, were the impacts of climate change that are affecting on Myanmar. In the views of employees, 100% of them mentioned temperature increasing, rainfall pattern changing, people migrations, flash floods, storm frequency increasing, droughts, rainfall variability, late onset and early withdrawal of monsoon, and water scarcity. The respondents including 100% of people who work in livestock husbandries, traders and NGOs officers mentioned temperature increasing, rainfall patterns changing, and people migrations. 100% of the traders mentioned flash floods, late onset and early withdrawal of monsoon, and water scarcity. 100% of NGOs officers mentioned flash floods, an increase in the frequency of storms, droughts, and water scarcity.

The respondents accounted for 69% did not know governmental policy to reduce the climate change impacts. Only 13% of the respondents mentioned that the Myanmar National Adaptation Program of Action (NAPA), 2012, was the policy that the government set up to reduce climate change impacts. Regarding the views of government officers, 89% of them mentioned that the Myanmar NAPA (2012) was the policy that the government set up to reduce climate change impacts. According to the views of the villagers' group, the respondents accounted for 83% of farmers, 66% of teachers, 100% of employees, people who work in livestock husbandries, traders and NGO officers did not know governmental policy to reduce climate change impacts.

For climate change adaptation policy under their departments, the study found that 78% of 9 respondents (government officers only) stated that there was no policy about climate change under their departments. But, 56% of them mentioned that Myanmar Climate Change Alliance (MCCA), the NGO, used to conduct the project on climate change adaptation.

According to the implemented governmental policy on climate change, it would be noted that all of the respondents did not know any policy on climate change adaptation that being implemented by the government. And also all of the respondents did not answer the question about the participation in the implementation of the climate change adaptation policy in their villages because they did not know about the policy at all.

There were some recommendations from the respondents that concerned about climate change adaptation. For example,

- water metering system is the most important to reduce water leakage,
- using water efficiently is one of the good practices to adapt to climate change,
- all stakeholders need to participate in climate response actions,
- climate change awareness is needed, and
- more researches on climate change are also needed.

77% of the respondents recommended that the water metering system is the most important to reduce water leakage. The respondents including 44% of government

officers, 83% of farmers, and 100% of teachers, employees, and traders also mentioned that the water metering system is the most important to control water leakage. 100% of NGOs officers viewed the needs of researches on climate change, climate change awareness, and stakeholder participation in climate change response actions.

4.4 Water resource management

All living things require water to grow and reproduce. Water is an important source of all living things. Water resources have been impacted by factors such as climate change, economic development, population increasing, and demographic changes. It is important that people need to manage water resources due to the increase in pressure on water resources. Water resource management is the process of planning, developing and managing water resources in terms of both water quality and quantity across all water uses. It includes the institutions, infrastructures, incentives, and information systems that support and guide water management (World Bank, 2017). Moreover, water resources management is the activities of planning, developing, distributing and managing the optimum use of water resources.

To know about water resources, water resource management practices, and water resource management in the context of climate change adaptation in the study area, 50 respondents from the four villages were interviewed with in-depth interviews by using a set of a semi-structured questionnaire. They were farmers, teachers, employees, livestock husbandries, and traders in the villages. Information and data of rural water supply were obtained from the Department of Rural Development, Pakokku Township office.

The study found that 100% of the respondents used water from rainwater, pond water, deep tube well water, and river pumping project for their consumption. The Kyee river pumping project is operated by the local government under the governmental action plan. All of them knew how to manage water use by themselves. The ways to manage water resources in their villages were using water efficiently, reducing water leakage and water saving. According to the views of the farmers, 85% of them mentioned that reducing water leakage, 66% mentioned using water efficiently. The respondents

including 100% of employees and traders mentioned reducing water leakage and the water saving to manage water resources.

The study found that 100% of the respondents have faced with water resource problems, namely less water retained ponds in summer and distances to water resources. They solved such kinds of water resource problems in many ways. 96% of the respondents took water from other villages, 88% of them solved the problem by making a renovation village ponds. 84% solved by participating in government projects. 90% of farmers and 100% of traders solved the problems by making a renovation village water ponds in summer.

Regarding water resource problems in the study area, the respondents mentioned many kinds of problems, namely, water shortage, water availability, drought, management problems. 100% of the respondents mentioned water shortage, 78% mentioned drought, 30% mentioned water availability. 28% of them mentioned that they had management problems because some of the villagers did not participate in any project. 100% of the farmers mentions water shortage, 76% of them mentioned drought. The respondents including 100% traders and employees mentioned that they have confronted water shortage. 100% of traders have also confronted water availability and drought. 100% of the people working in livestock husbandries and traders have faced water shortage and drought.

Regarding the practices on water resource management implemented in the study area, the respondents mentioned their real water resources management practices, namely using piping network systems, using water metering systems, using biosand filters and digging village water ponds in summer. 100% of farmers, teachers, employees, the people work in livestock husbandries, and traders mentioned that using piping network system and water metering system, were the practices on water resource management implemented in the study area. 100% of employees, the people who work in livestock husbandries, and traders mentioned digging village water ponds in summer.

According to the information obtained about the real practices on water resource management in the study area, all of the respondents have practiced participation with village water committees. 100% of the respondents used piping network systems and water metering systems as their real practices. 76% of them have practiced participating in digging village water ponds in summer to get more storage capacity. 28% mentioned that they used bio-sand filters that were donated by the UN-Habitat.

Regarding the information obtained about water resources management practices that were used to adapt to climate change, there were many kinds of practices that the respondents were using to adapt to climate change. The practices were water saving, using water efficiently, reducing water leakage, applying water reuse for home gardens, making good tillage in their farms to maintain soil moisture content and making dykes in their farms to collect water. The study found that 92% of the respondents mentioned using water efficiently, 86% mentioned water saving, 84% mentioned reducing water leakage, 60% mentioned making good tillage in their farms to maintain the soil moisture content, and 46% mentioned making dykes in their farms to collect water.

The farmers accounted for 90% mentioned that they used water efficiently, 83% mentioned that they were applying water saving while 80% were reducing water leakage. The respondents including 100% of teachers, people who work in livestock husbandries, and traders mentioned that they practiced water saving, using water efficiently, reducing water leakage. 100% of teachers mentioned reusing water for home gardens.

76% of the respondents claimed that they have projects on water resource management in the context of climate change. Their projects were maintaining village water ponds and a project about constructing big water storage concrete tanks on water resource management in the context of climate change. The respondents including 73% of farmers, 67% of the teachers, 100% of employees and persons who work in livestock husbandries, and traders, mentioned maintaining village water ponds. 20% of the respondents mentioned that they had a project on constructing big water storage concrete tanks.

There were some projects on water resources management handled beyond the government agency in the villages. The projects were renovations of village water ponds which were funded by the UN-Habitat in three villages, namely Shin Ma Kan, Pan Tine Chone, and Kyee in the year 2013. Another project, only in Pan Tine Chone village, was a village water allocation project including a big water storage tank, a big biosand filter, a water tank tower, a pipe network to the households and it was funded by UN-Habitat in 2017. Approximately 76% of the respondents had the projects for renovations of village water ponds and 28% of them mentioned the project for water allocating to the households that were implemented only in Pan Tine Chone village and funded by the UN-Habitat.

The respondents mentioned that they got so many benefits from the projects on water resources management which were water allocation with piping network and water metering system, renovation of village water ponds and river pumping project under the climate change adaptation. The benefits that they mentioned were health benefits, getting more time for other works, increasing in livestock husbandries, more secure on accident of households fire, economic development, and getting more convenience than before. 92% of the respondents mentioned getting more time for other works and more secure on accident of households fire, while 90% of them mentioned health benefits. Approximately 86% of the respondents mentioned that they have received more economic development since they have more time to work. 84% of them mentioned a benefit increase in livestock husbandries and 58% of the respondents mentioned that they got more convenience than before.

There were some recommendations from the respondents that concerned about water resource management in the study area. For example,

- water piping network and water metering system are important for water resource management, and
- a water metering system can reduce water wasting.

According to the recommendations of the respondents, the study noted that 86% of them mentioned that the water piping network and water metering systems were

important for water resource management. 64% of them thanked the UN-Habitat for its water allocating projects and conducting the village water ponds renovation.

4.5 Policy on climate change adaptation on water resource management

4.5.1 Respondents perspectives on climate change adaptation policy

Regarding the perspective of the respondents on the policies related to climate change adaptation, the study found that the respondents accounted for 69% did not know what policy set up by the government to reduce climate change impacts. Only 13% of them mentioned that the Myanmar NAPA (2012) was the policy that the government set up to reduce climate change impacts. 89% of the government officers mentioned the Myanmar NAPA (2012) as the policy that relates to climate change. The respondents including 83% of farmers, 66% of teachers, 100% of employees, people who work in livestock husbandries, traders, and NGOs officers, mentioned that they also did not know about that policy.

Regarding the views of the government officers on the policy on climate change adaptation, 78% of noted that there was no policy about climate change adaptation undertaken in their departments.

100% of the respondents did not answer the question about the challenges to implement the climate change adaptation policy in Myanmar. All respondents mentioned that there was no policy on climate change adaptation that being implemented by the government. All of the villagers did not know about the participation in the implementation any climate change adaptation project in their village.

However, the study found that the Department of Rural Development implemented its policy by digging deep tube wells to reduce water shortage for domestic water use conducted in Shin Ma Kan and Pan Tine Chone in 2017. The Department worked together with the UN-Habitat and NGO in the Pan Tine Chone village.

4.5.2 Governmental policies on climate change adaptation and water resource management

Myanmar's National Adaptation Programme of Action, Myanmar National Water Policy, and the water-related policy of the Department of Rural Development would relate to climate change adaptation on water resource management. Myanmar Climate Change Policy (2019), Myanmar Climate Change Strategy (2018-2030), and Myanmar Climate Change Master Plan (2018-2030) have been launched in June 2109.

Myanmar's National Adaptations Programme of Action (NAPA) to climate change (2012) was the sole climate change adaptation approach of Myanmar. It served as simplified, rapid and direct channels for least developed countries to identify and communicate priority activities to tackle their urgent and immediate climate change adaptation needs. The Myanmar NAPA, therefore, specified 32 priorities for effective climate change adaptation for eight major sector, particularly agriculture, early warning systems, forest, public health, water resources, coastal zone, energy and industry, and biodiversity (NAPA, 2012). At the priority level, the water resource sector was one of the important sectors that need to be taken into account to adapt to the changing of climate.

In Myanmar National Water Policy (2014), the article 5.2 stated that “the adaptation could also include increasing water storage in its various forms, namely, soil moisture, ponds, groundwater, small and large reservoirs, and their combination, which provides a mechanism for dealing with increased variability because of climate.” Additionally, article 5.3 of the policy mentioned that “the adaptation strategies could also include better demand management, particularly through adoption of compatible agricultural strategies and cropping patterns and improved water application methods, such as land leveling and/or drip/ sprinkler irrigation as they enhance the water use efficiency, as also, the capability for dealing with increased variability because of the climate change.” Moreover, article 4.5 of the policy stated that “community should be sensitized and encouraged to adapt first to the utilization of water as per local availability of water, before providing water through long-distance transfer. Community-based water management should be institutionalized and strengthened not

only for water utilization but also for technology transfer, for example, aggressive rainwater harvesting campaign in the dry zone, central Myanmar and across the country (National Water Resource Committee, 2014).

The policy of the Department of Rural Development could support to domestic drinking water assessment of local people. In the policy, it was clearly mentioned that the Department of Rural Development (DRD) will ensure effective water utilization plans for drinking purposes. The Department is taking 11 aspects of main development responsibilities. Among those responsibilities, the two responsibilities of the Department were closely related to rural water resource management. The first responsibility of the Department was that the Department will serve to implement the availability of rural drinking water plans which will bring about benefits to a locality. The second one was that the Department will transfer technology and give to access to knowledge in regard to the availability of purified drinking water (Department of Rural Development, 2017).

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions of the study

The objective of this research is to study climate change adaptation on water resource management in Myanmar focusing at Pakokku Township, Magway Region, Myanmar. The four villages in the Pakokku Township, namely Shin Ma Kan, Pan Tine Chone, Paung Laung Kan and Kyee were selected as the study areas because they were drought and having water shortage in the dry season. An in-depth interview using a semi-structured questionnaire was a method use to collect primary data in the study area. The purposive sampling method was used to select the relevant stakeholders. A set of questionnaire composed of general information of the respondents, climate change adaptation, and water resource management. There were 7 groups of respondents including government officers, non-governmental organizations officers, farmers, teachers, employees, livestock husbandries, and traders. The total number were 61. The data collected was analyzed using descriptive and content analysis approaches.

According to the collected data about climate change adaptation in the study area, the study found that 98% of the respondents knew about changing of the climate. 100% of government officers mentioned that temperature has increased, rainfall patterns have changed, late onset and early withdrawal of monsoon occurred in Myanmar, while 93% farmers mentioned that they were getting more hotter days. 100% of respondents including teachers, employees, and non-governmental organization officers mentioned temperature increasing and rising sea level. In terms of the climate change impacts, 100% of respondents knew the impacts such as freshwater shortage, heat waves, crop production decreasing. 100% of non-governmental organizations officers mentioned that climate change impacts were heat waves and fresh water shortage. To adapt to those kinds of climate change impacts, 100% of government officers adapted to climate by living properly in extreme weather conditions, 95% of the farmers adapted by changing the seed varieties resisting to climate change. Regarding the effects of climate change in the villages, 96% of the farmers mentioned heat waves and less water retained

ponds in summer. 100% of the rest of the respondents agreed that the major impacts that are affecting in their villages were heat waves and rainfall variation.

Regarding climate change adaptation, 100% of the government officers mentioned types of adaptation to climate change as changing seed varieties resisting to climate change, 89% of them mentioned water-saving irrigation in agriculture and making good tillage in farms to maintain soil moisture content. 90% of farmers mentioned living properly in extreme weather conditions, 88% mentioned changing seed varieties resisting to climate change impacts. 100% of people who work in livestock husbandries, traders and NGOs officers mentioned harrowing and ploughing before monsoon coming, changing seed varieties resisting to climate change impacts, changing sowing dates of crop plantation, and staying properly in weather conditions, as the types of climate change adaptation. All the respondents reported that they did not have any specific project on climate change adaptation in their villages.

In terms of climate change impacts on Myanmar, they were temperature increasing, rainfall patterns changing, people migrations, flash floods, storm frequency increasing, droughts, rainfall variability, late onset and early withdrawal of monsoon. 100% of employees, people who work in livestock husbandries, traders and NGO officers did not know governmental policy to reduce climate change impacts. 100% of NGOs officers viewed the needs of researches on climate change, climate change awareness, and stakeholder participation in climate change response actions.

The study also found that 100% of the respondents used water from rainwater, pond water, deep tube well water, and river pumping project for their consumption. The ways to manage water resources in their villages were using water efficiently, reducing water leakage and water saving. 100% of the respondents have faced with water resource problems, namely less water retained ponds in summer and distances to water resources. In order to solve water resource problems, 96% of the respondents took water from other villages. 100% of traders made a renovation village water ponds in summer.

Regarding water resource problems in the study area, 100% of the respondents mentioned water shortage, 78% mentioned drought. 100% of the farmers mentioned water shortage. For practices on water resource management implemented in the study area, 100% of farmers, teachers, employees, the people work in livestock husbandries, and traders mentioned that they use water piping network system and water metering system. Considering on water resource management practices adapting to climate change, 92% of the respondents mentioned using water efficiently, 86% mentioned applying water saving, 84% mentioned reducing water leakage. 76% of the respondents stated that they have projects on water resource management in the context of climate change. There were some projects on water resources management handled beyond the government agency in the villages such as water pond renovation.

Regarding the perspective of the respondents on the policies related to climate change adaptation, 89% of the government officers mentioned the Myanmar's NAPA (2012) as the policy related to climate change. 78% of them noted that there was no policy about climate change adaptation undertaken in their departments. All respondents mentioned that there was no policy on climate change adaptation that being implemented by the government. However, the study found that the Department of Rural Development implemented its policy by digging deep tube wells to reduce water shortage for domestic water use conducted in Shin Ma Kan and Pan Tine Chone in 2017. Myanmar's National Adaptation Programme of Action, Myanmar National Water Policy (2014), and the policy of the Department of Rural Development (2017) would relate to climate change adaptation on water resource management in the study area. Myanmar Climate Change Policy (2019), Myanmar Climate Change Strategy (2018-2030), and Myanmar Climate Change Master Plan (2018-2030) have been launched in June 2109.

5.2 Recommendations

Regarding the research results, there are some recommendations to be considered on the following issues.

- i. The local government should set up the policies related to climate change and water resource management to reduce impacts on local people.

- ii. The local government should plan to take action good practices on water resource management related to climate change adaptation to local people.
- iii. Department of Agriculture should introduce climate-smart agriculture and water saving irrigation techniques to the farmers to reduce their climate change impacts.
- iv. The local people should be trained to properly water use during the dry season.
- v. The action plans on disaster risk reduction, preparedness, relief and rehabilitation should be implemented properly to reduce impacts and to enhance the capacities of all stakeholders.
- vi. Climate and rainfall data set should be in digital forms in order to be easily accessed by relevant agencies.
- vii. Climate change information should be provided to local people that would help them to reduce climate change impacts.
- viii. Each household should have his/her own water pond under the financial support of the government.
- ix. The new theory of King Bhumibol the Great of Thailand would be introduced to farmers' practices to reduce water shortage in the dry season.

REFERENCES

- Adger, Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, 15(2), 77-86.
doi:<https://doi.org/10.1016/j.gloenvcha.2004.12.005>
- Agarwal, A., delos Angeles, M. S., Bhatia, R., Chéret, I., Davila-Poblete, S., Falkenmark, M., . . . Kindler, J. (2000). *Integrated water resources management: Global water partnership*.
- Bernard, H. R. (2017). *Research methods in anthropology: Qualitative and quantitative approaches*: Rowman & Littlefield.
- Burton, I. (1996). The growth of adaptation capacity: practice and policy. In: Adapting to Climate Change: An International Perspective [Smith, J., N. Bhatti, G. Menzhulin, R. Benioff, M.I. Budyko, M. Campos, B. Jallow, and F. Rijsberman (eds.)]. *Springer- Verlag*, 55-67.
- CBD. (2009). *Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change*. Retrieved from Secretariat of the CBD, Montreal, QC, Canada: <https://www.cbd.int/doc/publications/ahteg-brochure-en.pdf>
- Central Intelligence Agency. (2017). *World fact book: Burma (Myanmar)*. Retrieved from <https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html>.
- Denevan, W. M. (1983). Adaptation, variation, and cultural geography. *Professional Geographer*. 35, 399-407.
- Department of Meteorology and Hydrology. (2009). *Hazard profile of Myanmar*. Retrieved from http://www.themimu.info/sites/themimu.info/files/documents/Ref_Doc_Hazard_Profile_of_Myanmar_Jul2009.pdf
- Department of Meteorology and Hydrology. (2018). *Temperature and rainfall data of Pakokku Township, Department of Metereology and Hydrology, Pakokku District*.
- Department of Poppulation. (2015). *The 2014 Myanmar population and housing census*. Retrieved from themimu.info/census-data.
- Department of Population. (2017). *The 2014 Myanmar Population and Housing Census. Pakokku Township report, Pakokku District, Magway Region*. . Retrieved from https://themimu.info/sites/themimu.info/files/documents/TspProfiles_Census_Pakokku_2014_ENG.pdf.
- Department of Rural Development. (2017). *The policy of the Department of Rual Development, Myanmar* Retrieved from <http://www.drdmyanmar.org/>.
- Egashira, K., & Aye., A. T. (2006). Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. *Kyushu University Journal of the Faculty of Agriculture*, 51(373).
- Egashira, K., & Than, A. A. (2006). Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. *Journal of the Faculty of Agriculture-Kyushu University (Japan)*.
- Facon, T., & Ti, L. H. (2012). *Report on the formulation of a national water vision to action in the Union of Myanmar*. Retrieved from <http://www.fao.org/docrep/008/ae546e/ae546e04.htm>

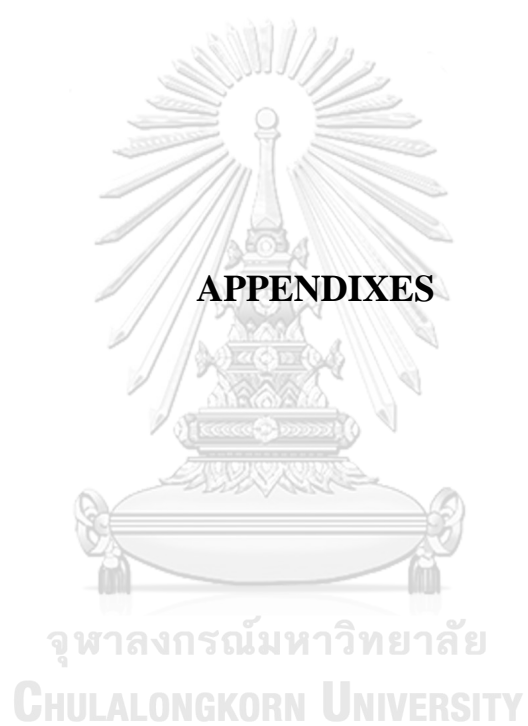
- Fankhuser, S. (1996). The potential costs of climate change adaptation. In: Adapting to Climate Change: An International Perspective [Smith, J., N. Bhatti, G. Menzhulin, R. Benioff, M.I. Budyko, M. Campos, B. Jallow, and F. Rijsberman (eds.)]. Springer-Verlag.
- FAO. (2000). *New dimensions in water Security-water, society and ecosystem services in the 21st century*. Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome.
- Fee, L., Gibert, M., Bartlett, R., Capizzi, P., Horton, R., & Lesk, C. (2017). *Scenarios for building resilience in Pakokku township: Climate Change Vulnerability Assessment (2016-2050)*. Retrieved from UN-Habitat: <http://myanmarcalliance.org/en/mcca-partners/documents/>
- Füssel, H.-M., & Klein, R. (2006). *Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking* (Vol. 75).
- General Administration Department. (2017). *Township profile of Pakokku, Pakokku District, Magway Region, Myanmar*. Retrieved from http://www.themimu.info/sites/themimu.info/files/documents/TspProfiles_GAD_Pakokku_2017_MMR.pdf.
- Gerald, C. N. e. (2009). Climate change, impact on agriculture and costs of adaptation. doi:10.2499/0896295354
- Gleick, P. (2000). *The changing water paradigm, a look at twenty-first century water resources development*. Water International 25 (1), 127–138.
- GWP. (1996). *Dublin-Rio Principles*. Retrieved from <https://www.gwp.org/contentassets/05190d0c938f47d1b254d6606ec6bb04/dublin-rio-principles.pdf>
- GWP. (2000). *Integrated Water Resources Management. TAC Background Paper no. 4. Global Water Partnership. Stockholm* Retrieved from http://www.unep.org/civil_society/GCSF8/pdfs/IWRM_water_efficiency_eng.pdf.
- Hadden, R. L. (2008). *The geology of Burma (Myanmar): an annotated bibliography of Burma's geology and earth science*. Topographical Engineering Center, US Army Corps of Engineers, Virginia.
- Hardsety, D. L. (1983). Rethinking cultural adaptation. *Professional Geographer*. 35, 399-406.
- Hoekstra, A. Y., & Savenije, H. H. (2009). *Water Resources Management*
- Horton, R., Mel, M. D., Peters, D., Lesk, C., Bartlett, R., Helsing, H., . . . Rosenzweig, C. (2017). *Assessing climate risk in Myanmar: Technical Report*. Retrieved from New York, NY, USA: Center for Climate Systems Research at Columbia University, WWF-US, WWF-Myanmar:
- IPCC. (2001). *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]*. Retrieved from Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, :
- IPCC. (2007a). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P.*

- Palutikof, P.J. van der Linden and C.E. Hanson, Eds.* Retrieved from Cambridge University Press, Cambridge, UK:
- IPCC. (2007b). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* [Core Writing Team, Pachauri, R.K. and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 104 pp.
- IPCC. (2013). *Summary for Policymakers. In Climate Change 2013: The physical science basis.* Retrieved from Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
- IPCC. (2014). *Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 1-32.
- Karim, Z. (1996). Agricultural vulnerability and poverty alleviation in Bangladesh. In *Climate Change and World Food Security*, T.E. Downing (Ed.), NATO ASI Series, 137. . Springer-Verlag, 307-346.
- Kirmani, S. S., & Guy, J.-M. (1997). *Fostering riparian cooperation in international river basins: The World Bank at its best in development diplomacy* (Vol. 335): World Bank Publications.
- Klein, R. J. T., & Tol, R. S. J. (1997). *Adaptation to Climate Change: Options and Technologies, An Overview Paper.* Technical Paper FCCC/TP/1997/3, United Nations Framework Convention on Climate Change Secretariat, Bonn, Germany.
- Kovats, S., & Akhtar, R. (2008). Climate, climate change and human health in Asian cities. *Environment and Urbanization* 20:165-175. *Environment and Urbanization*, 20, 165-175.
- Kreft, S., Eckstein, D., Dorsch, L., & Fischer, L. (2016). *Global Climate Risk Index 2016: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014.* Retrieved from www.germanwatch.org/en/cris
- Kreft, S., Eckstein, D., Junghans, L., Kerestan, C., & Hagen, U. (2015). *Global Climate Risk Index 2015: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2013 and 1994 to 2013.* Germanwatch e.V., Office Bonn. Retrieved from www.germanwatch.org/en/cris
- Lateef, F. (2009). Cyclone Nargis and Myanmar: a wakeup call. *Trauma and Shock. Journal of Emergencies*, 2(106-113).
- Lavell, A., Oppenheimer, M., Diop, C., Hess, J., Lempert, R., Li, J., . . . Myeong, S. (2012). Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC).

- Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 25-64.
- Lawrence, E. (1995). *Henderson's Dictionary of Biological Terms*. Longman Scientific and Technical, Harlow, United Kingdom, 693 pp. .
- Leimgruber, P., Kelly, K. S., Steininger, M. K., Brunner, J., Müller, T., & Songer, M. (2005). Forest cover change patterns in Myanmar (Burma) 1990–2000. *Environmental Conservation*, 32(4), 356-364.
- Lian, K. K., & Bhullar, L. (2010). Adaptation to climate change in the ASEAN region.
- Maung, U. H. (2009). Global warming and world climate change (Myanmar version).
- Meel, P. v., Leewis, M., Tonneijck, M., Leushuis, M., Groot, K. d., Jongh, I. d., . . . Nauta, T. (2014). Myanmar integrated water resources management strategic study. Retrieved from <https://docplayer.net/13558357-Myanmar-integrated-water-resources-management-strategic-study.html>
- MNPED, & MOH. (2011). *Myanmar multiple indicator cluster survey 2009-2010 Final Report*. Nay Pyi Taw, Myanmar: Ministry of National Planning and Economic Development; and Ministry of Health Retrieved from http://www.childinfo.org/les/MICS3_Myanmar_FinalReport.pdf
- MOECA. (1994). The National Environment Policy. Retrieved from <https://businesshumanrightsburma.files.wordpress.com/.../national-environmental-poli...>
- MOECA. (2012). *Myanmar initial national communication under the United Nation Framework Convention on Climate Change (UNFCCC)*. Retrieved from unfccc.int/resource/docs/natc/mmrnc1.pdf
- MOECA. (2015). *Myanmar's Intended Nationally Determined Contribution-INDC*. Retrieved from www4.unfccc.int/ndcregistry/.../Myanmar%20First/Myanmar%27s%20INDC.pdf
- MOFA. (2015). *Water in Myanmar*. Paper presented at the Global Myanmar Water Conferenc. <https://www.rvo.nl/sites/default/files/2016/03/Factsheet%20water%20Myanmar.pdf>
- MOIP. (2015). *The 2014 Myanmar population and housing census*. Retrieved from data.unhcr.org/thailand/download.php?id=421
- Muller, M., Schreiner, B., Smith, L., Koppen, B. v., Sally, H., Aliber, M., & Pietersen, K. (2009). *Water security in South Africa*. Development Planning Division. Working Paper Series No.12, DBSA. Midrand.
- Myanmar. (2015). *The 2014 Myanmar population and housing census*. Retrieved from themimu.info/census-data
- Myanmar Information Management Unit (2018). [Magway Region Map, Myanmar].
- NAPA. (2012). *Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change*. Retrieved from <https://unfccc.int/resource/docs/napa/mmr01.pdf>
- National Water Resource Committee. (2014). *Myanmar National Water Policy*. Retrieved from National Water Resource Committee, Myanmar: <https://www.myanmarwaterportal.com/pages/24-nwrc/459-blog.html>
- NCEA. (2010). *National report on the UNCCD implementation*. Retrieved from Yangon: National Commission for Environmental Affairs:

- Nesheim, I., Wathne, B. M., Ni, B., & Tun, Z. L. (2016). *Myanmar: Pilot introducing the National Water Framework Directive*.
- Netherlands, & Myanmar. (2014). *Myanmar Integrated Water Resources Management Strategic Study, Executive report*. Retrieved from <https://www.royalhaskoningdhv.com>
- Oki, T., & Kanae, S. (2006). Global hydrological cycles and world water resources. *science*, 313(5790), 1068-1072.
- OneWorld. (2010). *Burma climate change; A OneWorld briefing*. Retrieved from <http://uk.oneworld.net/guides/burma/climate-change>
- Oo, H. L. (2015). *Case study: Integrated Water Resources Management in Myanmar*. Retrieved from http://www.un.org/waterforlifedecade/waterandsustainabledevelopment2015/pdf/Htun_Lwin_oo_MyanmarGDG.pdf
- Pattanapanchai, M., Shah, F., & Annandale, G. (2002). *Sediment management in flood control dams*. Paper presented at the American Agricultural Economics Association Annual Meeting.
- Rosenzweig, C., Casassa, G., Karoly, D. J., Imeson, A., Liu, C., Menzel, A., . . . Tryjanowski, P. (2007). Assessment of observed changes and responses in natural and managed systems. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 79-131.
- Servat, E., & Ferrari, E. (2010). *Global change: Facing risks and threats to water resources*. Wallingford, Oxfordshire: IAHS Press.
- Slagle, J. T. (2014). *Climate Change in Myanmar: Impacts and adaptation*. (Master), Naval Postgraduate School, Monterey, California, Retrieved from <http://hdl.handle.net/10945/44672>
- Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R. J. T., & Yohe, G. (2001). Adaptation to climate change in the context of sustainable development and equity. In: *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 877-912.
- Smith, K. (1996). *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge, London, United Kingdom, 389 pp.
- Swatuk, L. (2005). *Political challenges to implementing IWRM in southern Africa*. *Physics and Chemistry of the Earth*, 30, 872–880.
- Tun, T. (2006). Biodiversity: Status of forest biodiversity in Myanmar. Paper presented at the 5th Annual Meeting of the Academy of Forestry Science.
- UNEP. (2009). *Towards Myanmar's National Strategy for Adaptation to Climate Change, Participatory rural appraisal synthesis report. Preparation of National Adaptation Programmes of Action (NAPA Project)*. Retrieved from <https://www.thegef.org/project/preparation-national-adaptation-programme-action-napa-0>

- UNESCAP. (2011). Food Security and Natural Disasters: Country Status Paper.
- UNFCCC. (1992). United Nations Framework Convention on Climate Change. Geneva: United Nations. Retrieved from <https://unfccc.int/resource/docs/convkp/conveng.pdf>
- UNFCCC. (2007). Climate change: Impacts, vulnerabilities and adaptation in developing countries. Retrieved from unfccc.int/resource/docs/publications/impacts.pdf
- USAID. (2008). *Ecosystem approach and Integrated Water Resources Management - Interrelated approaches*. Retrieved from https://www.iucn.org/sites/dev/files/.../ecosystem_approach_and_iwrm_fact_sheet_0.pdf
- USGS. (2009). Water resources. Retrieved from https://www.wsfcs.k12.nc.us/cms/lib/NC01001395/Centricity/ModuleInstance/17064/Water_Resources.pdf
- Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., . . . Heuer, S. (2009). Regional vulnerability of climate change impacts on Asian rice Production and scope for adaptation. *Advances in Agronomy*, 102, 91-133.
- WFP. (2011). *Food security assessment in the Dry Zone Myanmar*. Rome, Italy: World Food Programme (WFP). Retrieved from <http://home.wfp.org/stellent/groups/public/documents/ena/wfp234780.pdf>
- World Bank. (2017, Sep 20, 2017). Water resources management. Retrieved from <http://www.worldbank.org/en/topic/waterresourcesmanagement#2>
- World Vision. (2008). *Disaster monitor, Myanmar*. Retrieved from https://luetz.com/docs/dmfs5_myanmar.pdf
- Yohe, G., & Tol, R. S. J. (2002). Indicators for social and economic coping capacity: moving toward a working definition of adaptive capacity. *Global Environmental Change*, 12, 25-40.



APPENDIXES

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

APPENDIX 1



No.....

Questionnaire of research

on

Climate Change Adaptation on Water Resource Management:
A Case Study of Pakokku Township, Magway Region, Myanmar

Explanation:

1. This questionnaire is subjected to a thesis research of Mr. Khin Maung Soe, a master student in the Environment, Development and Sustainability Program, Graduate School of Chulalongkorn University, Bangkok, Thailand.
2. The purpose of this questionnaire is to collect data related to the research titled “Climate Change Adaptation on Water Resource Management: A case study of Pakokku Township, Magway Region, Myanmar.”
3. The questionnaire consists of 3 sections as follows;
Section 1 General information of respondent 5 questions,
Section 2 Climate Change Adaptation 14 questions, and
Section 3 Water Resource Management 9 questions.

To conduct this research, I would kindly request you to taking notes and recording during the interview. All data will be confidentially handled for the research purpose only.

Your cooperation in this research is greatly appreciated.

Yours sincerely,
Mr. Khin Maung Soe

Section 1: General information of the respondents

Objective:

To collect general information of respondents in the study area

Explanation: Please mark the choice selected

1. Gender

- () Male
() Female

2. Age

- () 18-30 years
() 31-40 years
() 41-50 years
() 51-60 years
() over 61 years

3. Education

- () None
() Primary school
() Secondary school
() High school
() Diploma
() Bachelor degree
() Master degree
() Doctoral degree
() Other (please specify).....
.....



จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

4. Occupation

- () Employee
- () Own business
- () Teacher
- () Farmer
- () Government officer
- () Other (please specify).....
-

5. Position

- () Head of school
- () Village head
- () Director/ Manager of government office
- () Non-government organization
- () Monk
- () Local wisdom expert
- () Other (please specify).....
-

Section 2: Climate change adaptation

Objective:

To collect information on climate change adaptation pthat use to be being implemented in the study area.

1. Do you know climate change? How?

() Yes (please specify)

.....
.....
.....
.....
.....

() No

2. Do you know climate change impacts? What type of such impacts?

() Yes (please specify)

.....
.....
.....
.....

() No

3. Have you faced with climate change impacts? How do you adapt to those impacts?

.....
.....
.....
.....

4. What kinds of climate change impacts are affecting in your community?

(a) Drought

.....
.....
.....

(b) Flood

.....
.....
.....

(c) Other (please specify)

.....
.....
.....

5. Do you know types of adaptation to climate change?

() Yes (please specify)

.....
.....
.....
.....
.....

() No



6. Do you have any project about adaptation in your community?

() Yes (please specify)

.....
.....
.....
.....
.....

() No

7. What are the climate change impacts that are affecting in Myanmar?

.....
.....
.....
.....
.....

8. What policy has the government set up to reduce climate change impacts?

.....
.....
.....
.....
.....

9. Is there any policy on climate change adaptation under your Department?

() Yes (please specify)

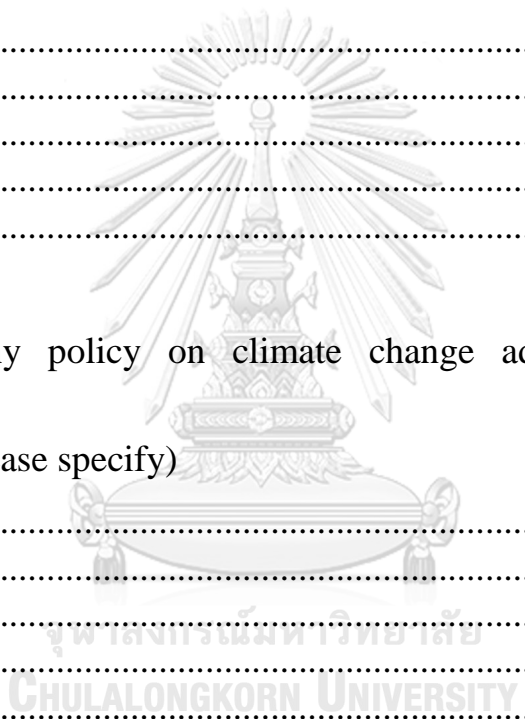
.....
.....
.....
.....
.....

() No

10. Is there any project on climate change adaptation handled beyond the government agency (e.g., NGO)?

() Yes (please specify)

.....
.....
.....
.....
.....



() No

11. What are the challenges to implement the climate change adaptation policy in Myanmar?

.....
.....
.....
.....
.....

12. Is there any policy on climate change adaptation that being implemented by government? How does it work?

.....
.....
.....
.....
.....

13. In which role are you involving in the implementation of climate change adaptation policy in your community?

.....
.....
.....
.....
.....

14. What recommendation that you would have?

.....
.....
.....
.....
.....



Section 3: Water resource management

Objective:

To know good and successful water resource management practices on climate change adaptation in the study area

1. What kinds of water resources are there in your community? Do you know how to manage water resources in your community?

() Yes (please specify)

.....
.....
.....
.....
.....

() No

2. Have you faced with water resource problems? How do you solve such problems?

.....
.....
.....
.....
.....

3. What kinds of water resource problems have occurred in your community? How long?

(a) Drought

.....
.....
.....

(b) Flood

.....
.....
.....

(c) Water pollution

.....
.....
.....

(d) Other (please specify)

.....
.....
.....

4. What is/are the real practice(s) on water resource management implemented in your community?

.....
.....
.....
.....
.....

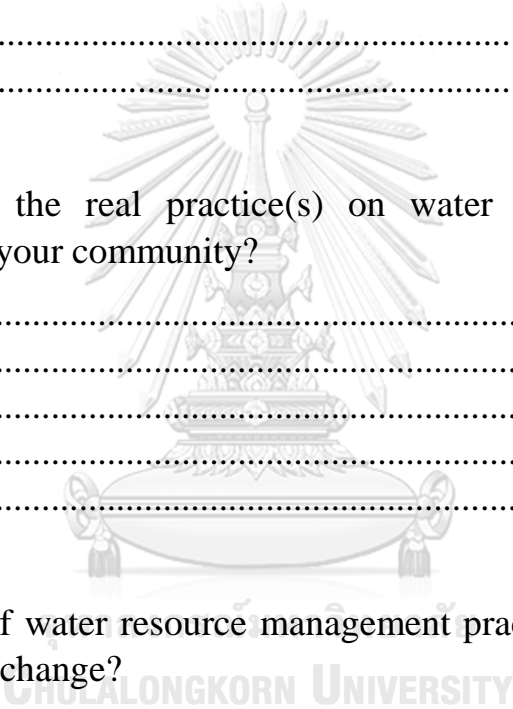
5. What kinds of water resource management practices are you using to adapt to climate change?

.....
.....
.....
.....
.....

6. Does your community have a project on water resource management in the context of climate change adaptation?

() Yes (please specify)

.....
.....



.....
.....
.....

() No

7. Is there any project on water resource management handled beyond the government agency (e.g., NGO)?

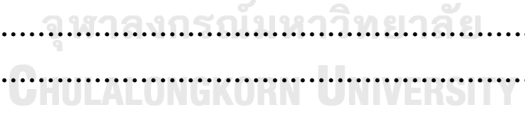
() Yes (please specify)

.....
.....
.....
.....

() No

8. What benefits have you got from the project on water resource management under climate change adaptation policy?

.....
.....
.....
.....



9. What recommendation that you would have?

.....
.....
.....
.....



နံပါတ်.....

သုတေသန မေးခွန်းလွှာ

ပခုက္ကူမြို့နယ်၊ မကွေးတိုင်းဒေသကြီး၊ မြန်မာနိုင်ငံတွင် ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ခြင်းအား ရေအရင်းအမြစ်စီမံခန့်ခွဲမှုအပေါ်လေ့လာခြင်း

ရှင်းလင်းချက်။

- ၁။ ဤမေးခွန်းလွှာသည် ထိုင်းနိုင်ငံ၊ ဘန်ကောက်မြို့ရှိ ချူလာလောင်ကွန်း တက္ကသိုလ်၊ ဘွဲ့လွန်သင်တန်း၊ ပတ်ဝန်းကျင်ရေးရှည်စဉ်ဆက်မပြတ်ဖွံ့ဖြိုးရေး အစီအစဉ်တွင်မဟာဘွဲ့သင်တက်ရောက်သင်ယူလျက်ရှိသော ဦးခင်မောင်စိုး ၏ သုတေသန စာတမ်းအတွက် ရည်ရွယ်ပါသည်။
- ၂။ ဤမေးခွန်းလွှာ၏ ရည်ရွယ်ချက်မှာ “ပခုက္ကူမြို့နယ်၊ မကွေးတိုင်းဒေသကြီး၊ မြန်မာနိုင်ငံတွင် ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ခြင်း အား ရေအရင်းအမြစ်စီမံခန့်ခွဲမှုအပေါ်လေ့လာခြင်း” ခေါင်းစဉ်ဖြင့် ပြုလုပ် သော သုတေသနအတွက် လိုအပ်သောကိန်းဂဏန်း အချက်အလက်များနှင့် သတင်းအချက် အလက်များ ကောက်ယူရန် ရည်ရွယ်ပါသည်။
- ၃။ ဤမေးခွန်းလွှာတွင် အောက်ပါအတိုင်း အပိုင်း (၃) ပိုင်းပါဝင်ပါသည်။
 အပိုင်း(က)တွင် ဖြေဆိုသူများ၏ အထွေထွေအချက်အလက်များအတွက် မေးခွန်း (၅) ခု၊
 အပိုင်း(ခ)တွင် ရာသီဥတုပြောင်းလဲမှုအား လိုက်လျောညီထွေနေထိုင်ခြင်း အတွက် မေးခွန်း (၁၄)ခုနှင့်
 အပိုင်း(ဂ) တွင် ရေအရင်းအမြစ် စီမံခန့်ခွဲမှုအတွက်မေးခွန်း (၉)ခုတို့ပါဝင်ကြ ပါသည်။

ဤသုတေသနမေးခွန်းများ မေးနေစဉ်အချိန်အတွင်း မှတ်စုစာအုပ်တွင် မှတ်သားခြင်း၊ အသံဖိုင်မှတ်တမ်းတင်ခြင်းများကို ဆောင်ရွက်ခွင့်ပြုပါရန် လေးစားစွာ တောင်းဆိုအပ်ပါသည်။ မိမိအနေဖြင့် ရရှိလာသော သတင်းအချက်အလက်များအား လျှို့ဝှက်စွာကိုင်တွယ်မည်ဖြစ်ပြီး သုတေသနပြုလုပ်ရန် အတွက်သာ အသုံးပြုသွားမည်ဖြစ်ကြောင်း လေးစားစွာ အသိပေးအပ်ပါသည်။

ဤသုတေသနလုပ်ငန်းစဉ်တွင် သင်၏ပူးပေါင်းဆောင်ရွက်ပေးမှုအား အထူးပင် ကျေးဇူးတင်ရှိပါသည်။

လေးစားစွာဖြင့်
ဦးခင်မောင်စိုး

အပိုင်း(က)။ ဖြေဆိုသူများ၏ အထွေထွေအချက်အလက်များ

ရည်ရွယ်ချက်။

သုတေသန လေ့လာမှုဧရိယာအတွင်းရှိ ဖြေဆိုသူများ၏ အထွေထွေ အချက်အလက်များကို မေးမြန်းကောက်ယူရန် ဖြစ်ပါသည်။

ရှင်းလင်းချက်။ ကျေးဇူးပြု၍ သင်ရွေးချယ်သောအချက်အလက်များကို အမှန်ခြစ် ရေးခြစ် ပေးပါ။

မေးခွန်း (၁)။ ကျား/ မ

() ကျား

() မ

မေးခွန်း (၂)။ အသက်

() ၁၈ နှစ် မှ ၃၀ နှစ်

() ၃၁ နှစ် မှ ၄၀ နှစ်

() ၄၁ နှစ် မှ ၅၀ နှစ်

() ၅၁ နှစ် မှ ၆၀ နှစ်

() ၆၁ နှစ် နှင့် အထက်

မေးခွန်း (၃)။ ပညာရေး



จุฬาลงกรณ์มหาวิทยาลัย
JANGHALONGKORN UNIVERSITY

- () ကျောင်းမနေခဲ့ပါ
- () မူလတန်းအဆင့်
- () အလယ်တန်းအဆင့်
- () အထက်တန်းအဆင့်
- () ဒီပလိုမာလက်မှတ်ရ
- () တက္ကသိုလ်ဘွဲ့
- () မာစတာဘွဲ့
- () ပါရဂူဘွဲ့
- () အခြား (ကျေးဇူးပြုပြီးဖော်ပြပေးပါ).....

မေးခွန်း (၄)။ အလုပ်အကိုင်

- () လုပ်သား
- () ကိုယ်ပိုင်လုပ်ငန်းလုပ်ကိုင်သူ
- () ဆရာ/ဆရာမ
- () လယ်သမား(သို့) တောင်သူ
- () အစိုးရဝန်ထမ်း
- () အခြား (ကျေးဇူးပြုပြီးဖော်ပြပေးပါ).....



မေးခွန်း (၅)။ ရာထူးအဆင့်

- () ကျောင်းအုပ်
- () ကျေးရွာ အုပ်ချုပ်ရေးမှူး
- () တာဝန်ခံအရာရှိ/ ညွှန်ကြားရေးမှူး(အစိုးရရုံး)
- () ဝန်ထမ်း (အစိုးရမဟုတ်သောအဖွဲ့အစည်း)
- () ဘုန်းတော်ကြီး
- () ကျေးရွာအကြောင်း ကောင်းစွာသိရှိသူ/နဲ့စပ်သူ
- () အခြား (ကျေးဇူးပြု၍ ဖော်ပြပေးပါ).....



အပိုင်း (ခ)။ ရာသီဥတုပြောင်းလဲမှုအား လိုက်လျောညီထွေနေထိုင်ခြင်း

ရည်ရွယ်ချက်။

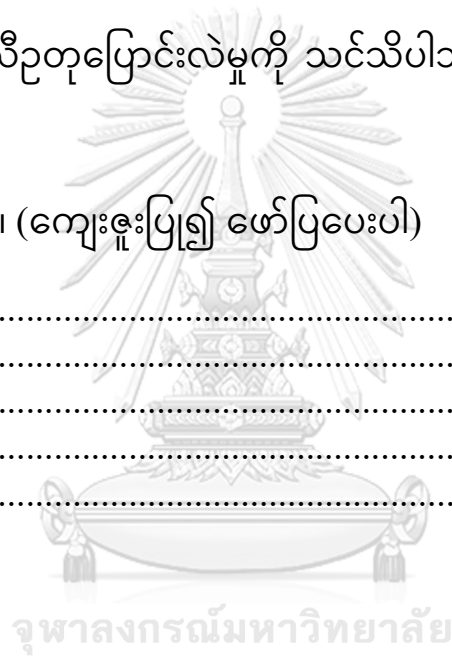
လေ့လာမှုဧရိယာအတွင်း အကောင်အထည်ဖော် ဆောင်ရွက်ခဲ့ခြင်း(သို့) ဆောင်ရွက်လျက်ရှိသော ရာသီဥတုပြောင်းလဲမှုအား လိုက်လျောညီထွေ နေထိုင်ခြင်းအပေါ် သတင်းအချက်အလက်များအား ကောက်ယူရန် ဖြစ်ပါ သည်။

မေးခွန်း (၁)။ ရာသီဥတုပြောင်းလဲမှုကို သင်သိပါသလား။ သင်ဘယ်လို သိပါသလဲ။

() သိပါသည်။ (ကျေးဇူးပြု၍ ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မသိပါ။



မေးခွန်း (၂)။ ရာသီဥတုပြောင်းလဲမှုကြောင့်ဖြစ်ပေါ်သော ထိခိုက်သက်ရောက်မှု(impact) များကို သင်သိပါသလား။ ဘယ်လို အမျိုးအစားသက်ရောက်မှုများကို သင်သိရှိပါသလဲ။

() သိရှိပါသည်။ (ကျေးဇူးပြု၍ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မသိရှိပါ။

မေးခွန်း (၃)။ ရာသီဥတုပြောင်းလဲမှုကြောင့် ဖြစ်ပေါ်သော ထိခိုက်သက်ရောက်မှု (impact) များကို သင်ကြိုတွေ့ဖူးပါသလား။ ထိုကဲ့သို့သော ထိခိုက်သက်ရောက်မှု (impact) များကို သင်မည်ကဲ့သို့ လိုက်လျောညီထွေနေထိုင်ပါသလဲ။

.....
.....
.....
.....
.....

မေးခွန်း (၄)။ ရာသီဥတုပြောင်းလဲမှုကြောင့်ဖြစ်ပေါ်သော မည်သည့်ထိခိုက်သက်ရောက်မှု (impact) များက သင်တို့၏အသိုင်းအဝိုင်းအဖွဲ့အစည်း (community) ကို သက်ရောက်လျက်ရှိ နေပါသလဲ။

(က) မိုးခေါင်ခြင်း

.....
.....
.....
.....

(ခ) ရေကြီးခြင်း

.....
.....
.....
.....

(ဂ) အခြား (ကျေးဇူးပြု၍ ဖော်ပြပေးပါ)

.....
.....
.....
.....

မေးခွန်း (၅)။ ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ခြင်း အမျိုးအစားများကို သင်သိပါသလား။

() သိပါသည်။

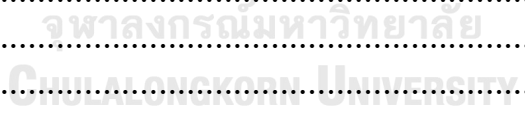
.....
.....
.....
.....
.....

() မသိပါ။

မေးခွန်း (၆) သင်တို့၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း (community) တွင် ရာသီဥတု ပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ရေး ဆောင်ရွက်နေသော စီမံကိန်းတစ်ခုခု ရှိပါသလား။

() ရှိပါသည်။ (ကျေးဇူးပြုပြီးဖော်ပြပေးပါ)

.....
.....
.....
.....
.....



() မရှိပါ။

မေးခွန်း (၇)။ မြန်မာနိုင်ငံတွင် သက်ရောက်လျက်ရှိသော ရာသီဥတုပြောင်းလဲမှုကြောင့် ဖြစ်ပေါ်လာသည့် ထိခိုက်သက်ရောက်မှု(impact) များက မည်သည့်အရာများ ဖြစ်ကြပါသလဲ။

.....
.....

.....
.....
.....

မေးခွန်း (၈)။ အစိုးရအနေဖြင့် ရာသီဥတုပြောင်းလဲမှုကြောင့်ဖြစ်ပေါ်သော ထိခိုက် သက်ရောက်မှု(impact)များကိုလျော့ချရန် မည်သည့်မူဝါဒများကို ချမှတ်ပြီးဖြစ်ပါ သလဲ။

.....
.....
.....
.....

မေးခွန်း (၉)။ သင်ရဲဌာနအောက်မှာ ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီ ထွေမှု ရှိစေရေးအတွက် မူဝါဒချမှတ်ထားခြင်းရှိပါသလား။

() ရှိပါသည်။ (ကျေးဇူးပြု၍ ဖော်ပြပါ)

.....
.....
.....
.....

() မရှိပါ။

မေးခွန်း (၁၀)။ အစိုးရမဟုတ်သော အခြားအဖွဲ့အစည်းများမှ ဆောင်ရွက် လျက်ရှိသော ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ရေးအတွက် စီမံကိန်းတစ်ခုခု ရှိပါသလား။ (ဥပမာ-အစိုးရမဟုတ်သော အဖွဲ့အစည်း တစ်ခုခု)

() ရှိပါသည်။ (ကျေးဇူးပြု၍ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မရှိပါ။

မေးခွန်း (၁၁)။ မြန်မာနိုင်ငံတွင် ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေ
နေထိုင်ခြင်းမူဝါဒအား အကောင်အထည်ဖော်ဆောင်ရွက်ရန် မည်သည့် အရာ
များက စိန်ခေါ်မှုများ (အခက်အခဲ၊ အဟန့်အတားများ) ဖြစ်ကြသလဲ။

.....
.....
.....
.....
.....

မေးခွန်း (၁၂)။ အစိုးရမှ အကောင်အထည်ဖော်နေသော ရာသီဥတုပြောင်းလဲမှုကို
လိုက်လျောညီထွေနေထိုင်ခြင်းမူဝါဒ တစ်ခုခုရှိပါသလား။ ၎င်းမူဝါဒကို
အကောင်အထည်ဖော်ဆောင်ရွက်နေမှုအခြေအနေ ဘယ်လိုရှိပါသလဲ(၎င်းက
ဘယ်လိုလုပ်ဆောင်သလဲ)။

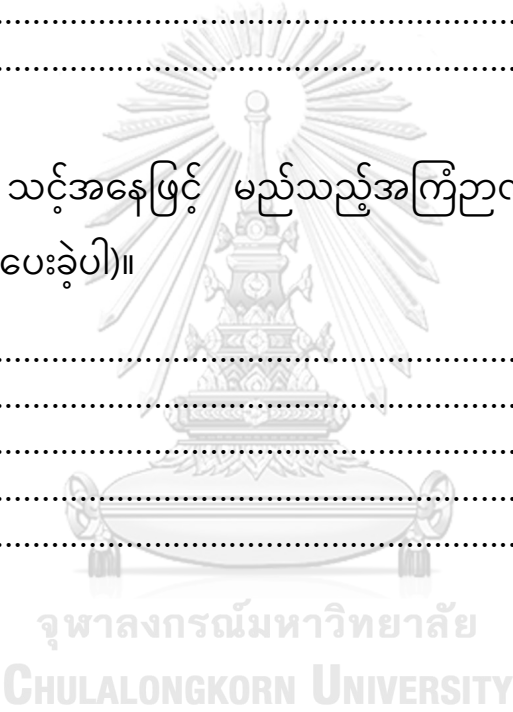
.....
.....
.....
.....
.....

မေးခွန်း (၁၃)။ သင်တို့၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း(community)တွင် ရာသီဥတု ပြောင်းလဲမှုကို လိုက်လျောညီထွေနေထိုင်ခြင်းမူဝါဒ အကောင်အထည်ဖော် ဆောင်ရွက်ရာတွင် သင့်အနေဖြင့် မည်သည့်အခန်းကဏ္ဍမှ ပါဝင်သလဲ။

.....
.....
.....
.....
.....

မေးခွန်း (၁၄)။ သင့်အနေဖြင့် မည်သည့်အကြံဉာဏ်များ ပေးချင်ပါသလဲ(အကြံဉာဏ် များ ပေးခဲ့ပါ)။

.....
.....
.....
.....



အပိုင်း (ဂ)။ ရေအရင်းအမြစ် စီမံခန့်ခွဲမှု

ရည်ရွယ်ချက်။

လေ့လာမှုဧရိယာအတွင်း ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေ နေထိုင်ခြင်းတွင် ကောင်းမွန်ပြီး အောင်မြင်သော ရေအရင်းအမြစ်စီမံခန့်ခွဲမှု အလေ့အကျင့်ကောင်းများကို သိရှိစေရန်။

မေးခွန်း (၁)။ သင်တို့၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း(community)တွင် မည်သည့် ရေအရင်းအမြစ် အမျိုးအစားများရှိပါသလဲ။ သင်၏ အသိုင်း အဝိုင်းအဖွဲ့အစည်း (community) အတွင်းရှိ ရေအရင်းအမြစ်များအား မည်ကဲ့သို့စီမံခန့်ခွဲရမည်ကို သင်သိ ပါသလား။

() ရှိပါသည်။ (ကျေးဇူးပြု၍ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မရှိပါ။

မေးခွန်း (၂)။ သင့်အနေဖြင့် ရေအရင်းအမြစ်ဆိုင်ရာ ပြဿနာများကို ကြုံတွေ့ ဖူးပါသလား။ ထိုကဲ့သို့သော ရေအရင်းအမြစ်ဆိုင်ရာပြဿနာများကို သင်မည် ကဲ့သို့ ဖြေရှင်းပါသလဲ။

.....
.....
.....

.....
.....
မေးခွန်း (၃)။ သင်၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း(community)တွင် မည်သည့် ရေအရင်း အမြစ်ဆိုင်ရာ ပြဿနာအမျိုးအစားများ ကြုံတွေ့နေရပါသလဲ။ ကြုံတွေ့နေရတာ ဘယ်လောက် ကြာကြာ ရှိပြီလဲ။

(က) မိုးခေါင်ခြင်း

.....
.....
.....

(ခ) ရေကြီးခြင်း

.....
.....
.....

(ဂ) ရေထုညစ်ညမ်းခြင်း

.....
.....
.....

(ဃ) အခြား (ကျေးဇူးပြု၍ ဖော်ပြပေးပါ)

.....
.....
.....

မေးခွန်း (၄)။ သင်တို့၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း(community) အတွင်းမှာ အကောင် အထည်ဖော် ဆောင်ရွက်လျက်ရှိသော ရေအရင်းအမြစ်စီမံခန့်ခွဲမှု အတွက် အမှန်တကယ် ကျင့်သုံးနေသော အလေ့အကျင့်(တွေ)က ဘာတွေလဲ။

.....
.....
.....
.....
.....

မေးခွန်း (၅) ။ သင့်အနေဖြင့် ရာသီဥတုပြောင်းလဲမှုကို လိုက်လျောညီထွေရှိစေရန် မည်သည့် ရေအရင်းအမြစ်စီမံခန့်ခွဲမှု အလေ့အကျင့်များကို ကျင့်သုံးလျက်ရှိပါသလဲ။

.....
.....
.....
.....
.....

မေးခွန်း (၆)။ သင်၏ အသိုင်းအဝိုင်းအဖွဲ့အစည်း(community)မှာ ရာသီဥတုပြောင်းလဲမှုအား လိုက်လျောညီထွေနေထိုင်နိုင်ရန်အတွက် ရေအရင်းအမြစ်စီမံခန့်ခွဲခြင်းဆိုင်ရာစီမံကိန်း တစ်ခုခုရှိပါသလား။

() ရှိပါသည်(ကျေးဇူးပြု၍ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မရှိပါ။

မေးခွန်း (၇)။ အစိုးရဌာနမဟုတ်သော အခြားအဖွဲ့အစည်းများမှ ဆောင်ရွက်
နေသော ရေအရင်းအမြစ်စီမံခန့်ခွဲခြင်းဆိုင်ရာစီမံကိန်း တစ်ခုခု ရှိပါသလား။
(ဥပမာ-အစိုးရမဟုတ် သော အဖွဲ့အစည်းတစ်ခုခု)

() ရှိပါသည်။ (ကျေးဇူးပြု၍ ဖော်ပြပေးပါ)

.....
.....
.....
.....
.....

() မရှိပါ။

မေးခွန်း (၈)။ သင့်အနေဖြင့် ရာသီဥတုပြောင်းလဲမှုအား လိုက်လျောညီ
ထွေနေထိုင်ခြင်း မူဝါဒအောက်ရှိ ရေအရင်းအမြစ်စီမံခန့်ခွဲမှု စီမံကိန်းမှ မည်
သည့်အကျိုးကျေးဇူးများ ရရှိပါ သလဲ။

.....
.....
.....
.....
.....






မေးခွန်း (၉)။ သင့်အနေဖြင့် မည်သည့်အကြံဉာဏ်များ ပေးချင်ပါသလဲ(အကြံ
ဉာဏ်ပေး ခဲ့ပါ)။

.....
.....
.....
.....
.....

APPENDIX 2

Photos from field collection at the study area

	
<p>Interviewed with a respondent from Paung Laung Kan village</p>	<p>A water tower tank in Shin Ma Kan village</p>
	
<p>Shin Ma Kan village water pond</p>	<p>Kye River Pumping Project</p>
	
<p>Shin Ma Kan village wter pond</p>	<p>Interviewed with people from Shin Ma Kan village</p>
	
<p>A water tower tank in Pan Tine Chone village</p>	<p>Kye village water pond</p>

VITA

NAME	Khin Maung Soe
DATE OF BIRTH	12 March 1989
PLACE OF BIRTH	Kanbalu, Sagaing Region, Myanmar
HOME ADDRESS	No.34, Koe Myo village, Kanbalu Township, Sagaing Region, Myanmar.
AWARD RECEIVED	Scholarship from TICA



จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY