YANGON UNIVERSITY OF ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

A STUDY ON IMPROVING WATER ACCESS IN CENTRAL DRY ZONE, MYANMAR

(Case study: Three Villages in Bagan-Nyaung U Township)

HLAING PHYU MIN
EMPA - 9 (16th BATCH)

NOVEMBER, 2019

YANGON UNIVERSITY OF ECONOMICS

MASTER OF PUBLIC ADMINISTRATION PROGRAMME

A STUDY ON IMPROVING WATER ACCESS IN CENTRAL DRY ZONE, MYANMAR

(Case Study: three villages in Bagan-Nyaung U Township)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Public Administration (MPA)

Supervised by

Daw Aye Aye Moe
Lecturer
Department of Applied Economics
Yangon University of Economics

Submitted by

Hlaing Phyu Min
Roll No - 9
EMPA – 16th Batch
(2017-2019)

NOVEMBER, 2019

YANGON UNIVERSITY OF ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

This is to certify that this thesis entitled **"A Study on Improving Water Access in Central Dry Zone, Myanmar" (Case Study: three villages in Bagan- Nyaung U Township)** submitted as a partial fulfilment towards the requirements for the degree of Master of Public Administration has been accepted by the Board of Examiners.

BOARD OF EXAMINERS

1. Professor Dr. Tin Win
   Rector
   Yangon University of Economics (Chief Examiner)

2. Professor Dr. Ni Lar Myint Htoo
   Pro-Rector
   Yangon University of Economics (Examiner)

3. Professor Dr. Kyaw Min Htun Pro-
   Rector (Retired)
   Yangon University of Economics (Examiner)

4. Professor Dr. Phyu Phyu Ei
   Programme Director and Head of Department
   Department of Applied Economics
   Yangon University of Economics (Examiner)

5. Dr. Khin Mar Thet
   Associate Professor
   Department of Applied Economics
   Yangon University of Economics (Examiner)

NOVEMBER, 2019

ABSTRACT

Access to water supply, sanitation and hygiene (WASH) is important role for the socio-economic development. The purposes of this study are to identify the status of WASH, to examine the advantage of access to water and to analyze the socio-economic development of households at three villages: Te Ma, Zee O and TaungShey in Bagan-Nyaung U Township, Dry Zone of Myanmar. To achieve these objectives, a quantitative, descriptive method was used. The semi-structured questionnaires are used to gather data from 288 respondents those who are from the selected three villages and key informant interviews are conducted to Executive Engineer (EE) from DRD/ Nyaung U, BAJ staff and local private drillers. The survey found that every village has access to water and only 8% of population are still lack of enough water. The residents reduce the burden of fetching water due to transportation distance. According to the survey, 74% of respondents are satisfied to pay water cost as they accept about the electricity fees to operate the tubewells. Additionally, 95% of survey respondents states that their family incomes are improved because of direct and/or indirect effective of having more water points in their villages. About 94% of respondents state that their social conditions become improved after received water resources in their villages, about 96% of the survey respondents are agreed that their health situation was improved after received the water resources in their villages.

ACKNOWLEDGEMNETS

First and foremost, I would like to express my deep acknowledgement to Professor Dr. Tin Win, Rector, Yangon University of Economics for his kind permission and for giving me an opportunity to undertake this thesis. I am also grateful to Professor Dr. Ni Lar Myint Htoo, Pro-Rector, Yangon University of Economics and Professor Dr. Kyaw Min Htun, Pro-Rector (Retd.), Yangon University of Economics for his invaluable constructive advice and guidance for writing this thesis.

I wish to express my deepest appreciation to Professor Dr. Phyu Phyu Ei, Director of MPA Programme and Head of the Department of Applied Economics, Yangon University of Economics, who provided all necessary support throughout the entire MPA course.

Again, I wish my special thanks to my supervisor, Daw Aye Aye Moe who supervised the preparation of this thesis, who is also my teacher for Health Economics subject which is one of MPA's curriculum.

I would like to acknowledge my thankfulness to Dr. Khin Mar Thet, Associate Professor, Yangon University of Economics for the precious suggestions for polishing this thesis.

I owed my special gratitude to all board of examiners, teachers for giving their precious time, energy and efforts in sharing invaluable knowledge throughout the MPA course. I would like to great a special thanks to BAJ staffs, local drillers and DRD/Nyaung U for providing the necessary data for this study. Additionally, I express my sincerely thanks to everybody for their willingness to participate in this study. I also wish to acknowledge the kind understanding of my colleagues from Danish Refugee Council and extend my deepest gratitude to them.

Last, but not least, my sincere thanks to my family who support me throughout attending the MPA program and participating the household survey in the selected three villages as well.

TABLE OF CONTENTS

			Page
ABSTRACT			i
ACKNOWLEDGEMENTS			ii
TABLE OF CONTENTS			iii
LIST OF TABLES			v
LIST OF FIGURES			vi
LIST OF ABBREVIATIONS			vii
CHAPTER	**1**	**INTRODUCTION**	
	1.1	Rationale of the Study	1
	1.2	Objectives of the Study	4
	1.3	Method of Study	4
	1.4	Scope and Limitations of the Study	4
	1.5	Organization of the Study	4
CHAPTER	**2**	**LITERATIRE REVIEW**	
	2.1	Water Scarcity and Water Use	6
	2.2	Global situation of WASH and Importance of Access to WASH	9
	2.3	Linkages between poverty and WASH	16
	2.4	Relationship between Water, Education and Health	17
	2.5	Review on Previous Studies	19
CHAPTER	**3**	**IMPROVING WATER ACCESS IN CENTRAL DRY ZONE, MYANMAR**	
	3.1	Overview on Improving Access to Water	21
	3.2	Monitoring of SDG Goal (6) Indicator	25
	3.3	Myanmar Sustainable Development Plan (2018-2030)	27
	3.4	Regional Geology and Hydrogeology of Dry Zone	28
	3.5	Access to Water in the Study Area	30

CHAPTER 4 SURVEY ANALYSIS

4.1 Survey Profile 32

4.2 Survey Design 34

4.3 Survey Results 35

CHAPTER 5 CONCLUSION

5.1 Findings 47

5.2 Recommendations 49

REFRENCES

APPENDIX

LIST OF TABLES

Table	Title	Page
2.1	Definition of improved and unimproved drinking water sources	9
2.2	Ladder for global monitoring of drinking water	10
2.3	Ladder for global monitoring of sanitation	11
2.4	Ladder for global monitoring of hygiene	12
2.5	Global basic service indicators for WASH	14
2.6	Definition of improved water supply and sanitation	16
2.7	Poverty and WASH	17
3.1	Percentage of population in households with access to improved water in dry and rainy seasons	23
3.2	Percentage of population with access to improved water on premise in dry season	24
3.3	SDG Goal (6) Indicator Baseline Report for Myanmar	25
3.4	Summary of the major aquifer units in the Dry Zone	29
4.1	Data Summary for Demographic Characteristics	35
4.2	Water in Challenges	36
4.3	Sources for Drinking Water in past 20 years	37
4.4	Sources for Drinking Water in year 2019	37
4.5	Sources for Domestic Water in past 20 years	38
4.6	Sources for Domestic Water in year 2019	38
4.7	Willingness to Pay on Water Fees	40
4.8	Improving Water Access and its Benefits in Family Income	41
4.9	Improving Water Access and its Benefits in Social Development	43
4.10	Improving Water Access and its Benefits in Health	44
4.11	Improving Water Access and its Benefits in Education	45

LIST OF FIGURES

Figure	Title	Page
4.1	Groundwater situation of Te Ma, Zee O and Taung Shey villages	33
4.2	Willingness to pay for water fees	40

LIST OF ABBREVIATIONS

BAJ	Bridge Asia Japan
CSO	Central Statistical Organization
DDA	Department of Development Affairs
DRD	Department of Rural Development
EE	Executive Engineer
FAO	Food and Agriculture Organization of the United Nations
IWMI	International Water Management Institute
INGO	International Non-Governmental Organization
IWRM	Integrated Water Resources Managerment
JMP	Joint Monitoring Programme
LMICs	Lower Middle-Income Countries
MDG	Millennium Development Goals
MOHS	Ministry of Health and Sports
WASH	Water, Sanitation and Hygiene
WB	World Bank
WRUD	Water Resources Utilization Department
WFP	World Food Programme
WHO	World Health Organization
SDG	Sustainable Development Goal
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Program
UNICEF	The United Nations Children's Fund

CHAPTER 1
INTRODUCTION

1.1 Rationale of the Study

The Dry Zone of Myanmar lies within Myanmar's central plains, bounded by mountains to the east and west. The Dry Zone, the most water scarcity region, has the second highest population density in Myanmar and which remains one of the least developed in the country. (Myanmar IWRM Strategic Study, 2014)

The people in the Dry Zone could not break the poor circle because of this water scarcity problem. About 70% of households have access to safe water for domestic purposes, which is close to the national average, but seasonal water scarcity is very common. (MNPED and MOH, 2011). According to WFP, a quarter of all households reported having insufficient water especially in the dry summer season. About a third of people in Dry Zone collect their drinking water from protected wells, and another third from tube wells and more than one-third of the population does not have access to sanitation facilities. (IWMI, 2013)

According to IWMI's community-level survey, the villagers from Dry Zone are using water (except irrigation), about 15-20% for drinking purposes, about 50% for other domestic purposes and 30-40% for livestock watering. The relative proportions allocated between different uses did not significantly change between seasons, during droughts or for the different types of identified farm households. (IWMI, 2013). Access to water is not the same between one village to another. The villagers collect water for various purposes from different sources such as rivers and streams, large and small reservoirs, village ponds and groundwater. Even within a single village, access to agricultural and domestic water can vary very greatly. (IWMI, 2013)

The agricultural systems of Dry Zone are complex. Farmers cultivate paddy and non-rice crops such as pulses, oilseeds, cotton, tobacco, vegetables as well as raising large and small livestock. Land in Myanmar is described traditionally, which suitability for different types of cultivation mainly different between "Le"(paddy) and "Ya" (dryland) lands. The Dry Zone is vital to Myanmar's agriculture sector by producing

sesame, groundnuts and pulses which are one of the major export earners for the Country, and 22% of its rice.(IWMI, 2013)

The challenges of Farmers in Dry Zone are being compounded by less than usual rainfall. The mean annual rainfall in the Dry Zone ranges 500mm - 1,000 mm which is less compared to the other area of the country ranges 2,000m-5,000 mm. The common temperatures reach to 40 °C in the dry season. The Dry Zone is the only in the semi-arid area of Southeast Asia and the annual rates of evaporation are more than double those of its rainfall. The wet season, coinciding with the south west monsoon, always fall from the month of May to October. The dry season is separated into winter and summer. The winter season falls for the period between November and February and summer between March to April. (IWMI, 2013)

Water scarcity is affected not only for agriculture but also for domestic use, was identified as a major constraint to livelihoods and wellbeing for the people in the Dry Zone. Access to water and water supply security is paramount to improving food security, incomes and livelihoods of rural people toward socio-economy development.

The key determinants of poverty, social and economic development for the people in the Dry Zone are access and availability of water resources. The major constraints to access the surface water from rivers or storage reservoirs are sparse infrastructure and the high costs of pumping. As the groundwater is the main water resource for Dry Zone, the utilization of groundwater needs to be planned and developed systematically in order to be sustainable for the future.

IWMI, 2013 report indicates that small- scale water management technologies can bring many benefits and that would improve livelihoods and food security of the local communities.

In Bagan-Nyaung U, most of the villagers mainly depended on their rain water harvesting ponds near to their villages. When the rain water ponds are dried up, they have to go and fetch water from the tubewells which are located in the several kilometers away.

There are about 3,009 population in three chosen villages: Te Ma, Zee O and Taung Shey villages in Bagan-Nyaung U township, who faced the water scarcity problem in last 20-years and they did not have enough water at that time. Almost every family member woke up so early in severely in the morning to collect water. Poor families carry the water with buckets, while those who can afford it use bullock carts with tanks/drum.

The people in those three villages were mainly depending on their village ponds which can be stored rain water only about 7 months annually and therefore they had been facing water scarcity about 5 months in the summer seasons (February–June) in every year. Therefore, they need to find and fetch water from another water sources from their neighbor villages' tubewell and/or water pipe line which are far from their villages and it consumes a lot of time about 4 -12 hours for one trip by bull cart. Additionally, there were limitation of their water fetching time because which depending on the water distribution time.

According to the geological structure of the study area, the groundwater could be available around 800 ft and it was not possible to drill by private drilling machines. Only the limited drilling rigs owned by the government from WRUD/DDA could effort to drill those type of deep tubewells. In addition to that, there were very high cost to drill deep tubewells by using these government's drilling rigs not only the spare parts (drill pipes, carry horse pipe, mud pump) of the rig which needed to be imported but also drilling accessories such as bits, bentonite, etc. Moreover, the drilling Experts were also very limited especially for solving the problems while drilling new tubewell such as lost circulation, drill pipe cutting. Because of those challenges; cost, materials and technology, there were long time period of water scarcity problem for the study area.

Starting from year 2000, there were different water supply projects by different donors with the implementation of the government counterparts in order to solve those water scarcity problems.

Bridge Asia Japan (BAJ), INGO implements its water supply project in the Dry Zone and constructed more than 100 new tubewells in Bagan Nyaung U and Kyaukpadaung area during year 2000-2013. BAJ provided its assistance to the selected three villages by drilling the deep tubwells in year 2001, 2005, 2012 respectively.

During the study period, every village has access to water and only 8% of population are still lack of enough water. The new tubewell construction and existing tubewell rehabilitation activities are still needed to fulfill the water demand of local people.

This study presents improvement in water assess and how it affects in socio-economic development of the three villages after they had own tubewell(s) in their villages.

1.2 Objectives of the Study

The main objective of the study is to analyze the improvement of water access. And other objectives are to identify the status of WASH and to examine the socio-economic development of households.

1.3 Method of Study

The study is descriptive method base on both primary and secondary data and using quantitative approache to meet with the objectives successfully. Primary and Secondary data were gathered from the Department of Rural Development (DRD) in Nyaung U, Bridge Asia Japan and other internet websites. The primary data was collected from the household of the study area with the age over 40 were interviewed, key informant interview was made with EE from township Rural Development, staff from Bridge Asia Japan and private drillers. Simple random sampling method is used to select the required number of respondents from the total households at the selected three villages Te Ma, Zee O and Taung Shey in Bagan Nyaung U.

1.4 Scope and Limitations of the Study

This study focuses only on the advantages of access to water at three villages called Te Ma, Zee O and Taung Shey, in Bagan Nyaung U township, Mandalay Region of Myanmar, after having the water point in their respective villages. The three villages are selected based on the location which are far from the Ayeyarwaddy river and the villagers were facing the severest water scarcity in the region in last 20-year ago. This study is limited to analyze the water quality scientifically.

1.5 Organization of the Study

This thesis consists of five chapters. This Chapter 1 is introductory chapter including rationale, objectives, scope and limitations of study, Chapter 2 gives Literature Review including water scarcity and water use, global situation of WASH and importance of access to WASH, the linkages between poverty and WASH, relationship between water, education and health, and review on previous studies, Chapter 3 then focuses on improving water access in the context of central Dry Zone in Myanmar. Chapter 4 presents Survey Analysis containing survey profile and design,

analysis of survey findings on the benefits of access to water and the socio-economic development of households by using descriptive method. This thesis concludes with Chapter 5 where summary of findings and recommendations are given.

CHAPTER 2
LITERATIRE REVIEW

In this chapter, various literature related to the subject of the study are reviewed. Area covered are water scarcity and water use, global situation of water, sanitation and hygiene (WASH) and importance of access to WASH, linkages between poverty and WASH, connection between water, education and health and review on previous studies of WASH.

2.1 Water Scarcity and Water Use

There are different definitions about water scarcity and FAO is hereby defined as a gap between available water supply and expressed demand of freshwater in a specified domain, under prevailing institutional arrangements and infrastructural conditions.

Scarcity is signaled by unsatisfied demand, tensions between users, over-extraction of groundwater, competition for water, and insufficient flows to the natural environment (FAO, 2012).

Water scarcity includes water shortage, water stress and water crisis, where water crisis is a situation of the available potable water, unpolluted water within a region is less than the demand of that region (Wikipedia, 2019).

Water scarcity results from an imbalance between water use and available water resources. Water scarcity causes deterioration of fresh water resources in terms of quality (eutrophication, organic matter pollution, saline intrusion, etc.) and quantity (aquifer over-exploitation, dry rivers, etc.). Based on expert judgment and experience, the value of this criticality ratio indicates high water stress. (World Water Council, 2017).

In the water scarcity, there are two type of mechanisms as physical (absolute) water scarcity and economic water scarcity, whereas physical water scarcity is a result of inadequate natural water resources to supply demand of a region, and economic

water scarcity is a result of poor management of the sufficient water resources (Wikipedia, 2019).

Water scarcity have a great impact especially for the human health, socio-economic development, and the environment.

Water scarcity have a direct impact on cultivating crops and livestock, which can lead to food shortages and eventually starvation, and therefore obvious lack of drinking water and hunger is one the most serious effect of water scarcity apart from dehydration. Because of the water shortages, people cannot shower regularly, wash their clothes or clean their homes properly and which create lack of sanitation and personal hygiene.

Water scarcity generates sanitation problems because people need to drink unsecured water. Due to water is scarce, people are storing the water at home which creates breeding grounds for mosquitoes, and it brings dengue and malaria. Additionally, lack of water creates other diseases such as trachoma (an eye infection that can cause blindness), plague and typhus.

Due to having access to water is one of a popular global economic issue and the main top causes of international tension as well, local conflicts, sometimes resulting in warfare, are triggered over scarce water resources. With the increasing of global population and growing needs, these tensions could multiply in the future.

Water scarcity creates negative impacts on rivers, lakes, and other freshwater resources and therefore it harms the environment in several ways such as nutrient pollution, increased salinity and the loss of floodplains and wetlands. Ecosystems and biodiversity are also threatened by the scarcity of water resources.

Because of changing in lifestyle and increasing of population as well, the amount of water use for human is increasing, which fixed with spatial and temporal variations in water availability. This means that the water to produce not only food consumption for human, but also industrial processes and other uses is becoming scarce.

Increasing of water uses by humans creates reducing the amount of water available for industrial and agricultural development. Moreover, it has a profound effect on aquatic ecosystems and their dependent species. Environmental balances are disturbed, and which cannot play their regulating role.

There are ways to save water and prevent water scarcity such as sustainable water management, reclaimed water, pollution control and better sewage treatment, awareness & Education.

Due to water conservation and efficiency are key components of sustainable water management, improving water infrastructure must be a priority. Smart irrigation systems and solar desalination are excellent examples of clean technology for water efficiency and control, which obviously applies even more to the agriculture and farming sector- the largest consumer of water.

Harvesting of rainwater and recycled waste water can reduce scarcity and ease pressures on groundwater and other natural water bodies. Ground water recharge process prevents water scarcity by moving water from surface water to groundwater.

Without proper sanitation, the water becomes full of diseases and unsafe to drink and therefore it is mandatory to address pollution, measuring and monitoring water quality. Besides, improving the sewage systems in specific areas is also one of the way to prevent water scarcity form becoming any worse.

In order to cope with future water scarcity, education is critical. Moreover, it is necessary to reform all forms of consumption, from individual use until the supply chains of large companies.

Based on socio-economic development, population growth and changing consumption patterns, water use has been increasing worldwide about one percent per year since 1980s. Global water demand is also expected to continue to increase with similar rate until year 2050, mainly because of rising demand in the industrial and domestic sectors. (UN-Water., 2019)

In globally, more than two billion people are living in countries which have the high level of water stress, and about four billion people suffering the water scarcity for at least one month of the year. The level of water stress will continue to increase because demand for water grows and the effects of climate change intensify. (UN-Water., 2019)

According to the WHO, about 50 liters of water per person per day are needed to ensure to meet the most basic needs while keeping public health risks at a low level. (WHO/UNICEF, 2017)

2.2 Global situation of WASH and importance of access to WASH

Water is the basic human need which equally important as air and is connected to every form of life on earth. Water is also direct or indirect connected to every aspect of human day-to-day activities. (Dinka, 2018)

The human rights to water and sanitation entitle everyone, without discrimination, to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use including water for drinking, personal sanitation, clothes washing, food preparation, and personal hygiene. (UNESCO, 2019)

2.2.1 Drinking Water

Access to drinking water means that the source of drinking water is less than a kilometer away from its place of use and at least 20 litres can be obtained per household member per day (Evans and others, 2013).

Table 2.1 Definition of improved and unimproved drinking water

Improved drinking water	**Unimproved drinking water**
Use of: • Piped water into dwelling, yard of plot • Public tap or standpipe • Tubewell or borehole • Protected spring • Protected dug well • Rainwater collection	Use of: • Unprotected dug well • Unprotected spring • Cart with small tank or drum • Tanker truck • Surface water (river, dam, lake, pond, stream, canal, irrigation channel) • Bottled water (considered to be improved only when the household uses drinking water from an improved source for cooking and personal hygiene)

Source from web site: https://www.researchgate.net/publication/283422043

Improved drinking water sources includes the sources that, by nature of their construction or through active intervention, are protected from outside contamination, these include piped water in a dwelling, plot or yard, and other improved sources such a public taps or standpipes, tube wells or boreholes, protected dug wells, rainwater collection and protected springs.

Unimproved drinking water sources are unprotected dug well, unprotected spring, cart with small tank/drum, tanker truck, bottled water and surface water (river, dam, lake, pond, stream, canal, irrigation channels).

WHO/UNICEF JMP updates its ladder for global monitoring of drinking water.

Table 2.2 ladder for global monitoring of drinking water

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved water source that is located on premises, available when needed and free from faecal and priority chemical contamination
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Source: WHO/UNICEF, 2017

Improved sources include piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, and packaged or delivered water (UNWater, 2018).

The population using improved water sources will be subdivided into three classes during the SDG time frame, based on the level of service provided. To meet the criteria for a safely managed drinking water service, people must use an improved water source that meets three criteria; accessible on premises, available when needed, and the water supplied should be free from contamination. It will be classified as a basic drinking water service, if the improved source does not meet any one of these criteria, but a round trip to collect water takes 30 minutes or less. If water collection from an improved source takes more than 30 minutes, it will be categorized as a limited service. (WHO/UNICEF, 2017)

By 2015, about 71% of global population used safely managed drinking water services, 17% used basic services, 4% used limited services, 6% used unimproved services and 2% used surface water services. (UNWater, 2018)

2.2.2 Sanitation

Sanitation is also important for human rights and has an important gender element, as toilets should ensure privacy and safety which are the needs of women and girls. (UNWater, 2018). JMP updates its ladder for global monitoring of sanitation.

Table 2.3 ladder for global monitoring of sanitation

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite
BASIC	Use of improved facilities that are not shared with other households
LIMITED	Use of improved facilities shared between two or more households
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
OPEN DEFECATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces or with solid waste

Source: WHO/UNICEF, 2017

Improved facilities include pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs. (UNWater, 2018)

Progress was also achieved in sanitation coverage during the implementing of the MDGs, but it still lags compared to the progress in drinking water supply. The proportion of the global population practicing open defecation dropped from 20% to 12% between year 2000 to 2015. By 2015, about 39% of global population used safely managed sanitation water services, 29% used basic services, 8% used limited services, 12% used unimproved services and 12% used open defecation. (UNWater, 2018)

2.2.3 Hygiene

The SDG target 6.2 calls for countries to end open defecation practice and to ensure that everyone has access to a basic latrine or toilet. In addition, to set up systems to handle the excreta generated safety. It highlights the importance of hygiene, previously neglected in national and global goals and calls for special attention to be given to women's and girls needs. JMP updates its ladder for global monitoring of hygiene.

Table 2.4 Ladder for global monitoring of hygiene

SERVICE LEVEL	DEFINITION
BASIC	Availability of a handwashing facility on premises with soap and water
LIMITED	Availability of a handwashing facility on premises without soap and water
NO FACILITY	No handwashing facility on premises

Source: WHO/UNICEF, 2017

Handwashing facilities can be fixed or mobile, including a sink with tap water, buckets with taps, tippy-taps, and jugs or basins designated for handwashing. Soap includes bar soap, liquid soap, liquid soap, powder detergent, and soapy water but does not include ash, soil, sand or other hand washers. (UNWater, 2018)

Households with a soap and water washing facility on premises must meet the criteria for a basic hygiene facility and households with a facility but without water or soap will be classified as having a limited facility.

2.2.4 Importance of Access to WASH

Because of water underpins economic development and social wellbeing, access to safe water supply and adequate sanitation services are important for maintaining a healthy and productive workforce in both at home and at the work. (UN Water, 2016)

At a basic level, everyone needs access to safe water in adequate quantities for multiple purposes, including drinking, cooking, personal hygiene and sanitation facilities that do not harm for their health or dignity. Therefore, access to safe and protected (clean and fresh) water is the fundamental right of humans. The UN and other countries have announced that access to clean and healthy drinking water is a basic

human right, and a crucial step towards raising living standards throughout the worl. (Dinka, 2018). Water access was also one of the key objectives of UN-MDGs and UN-SDGs as well. (Dinka, 2018).

Access to acceptable and affordable drinking water is a persisting problem for millions of individuals, including women and girls in vulnerable situation. Similarly, access to sanitation services is another major challenge, mostly in LMICs and for the people living in poverty and disadvantaged situations. (UNESCO, 2019)

More than two-thirds of the earth's surface are covering by water, but mostly salty and unable to drink, the freshwater supply is available only 2.7% of the available water on earth and only 1% of the available freshwater (in reservoirs, rivers and groundwater) is usable. In addition, the available freshwater resources are inaccessible because they are in the hidden part of the hydrological cycles, which is in the deep aquifers and in glaciers (frozen in the polar ice), which means that safe drinking water on earth has very small proportion (about 3%) in the freshwater resources. It is also possible to obtain fresh water from the seawater by desalinizing. There is not enough fresh water available in some countries and it is call physical scarcity, and there is plenty of fresh water available in some countries, but it is costly to use, called economic scarcity. (Dinka, 2018)

International cost–benefit analyses have shown that water, sanitation and hygiene (WASH) systems have good social and economic returns relative to their costs as an average global benefit–cost ratio of 2.0 for improved drinking water and 5.5 for improved sanitation. The benefits of improved WASH services for vulnerable groups are likely to change the balance of any cost–benefit analysis that accounts for improvements in the self-perceived social status and dignity of these groups. (UN-Water., 2019)

WHO/UNICEF indicates that the below five global basic service indicators (Water, Sanitation, Hygiene, Waste Management and Environmental Cleaning) provide a valuable starting point for global monitoring of WASH services.

Table 2.5 Global Basic Service Indicators for WASH

Basic Indicator	Additional indicators
1. Service element: Water	
Availability: functionality	Availability: sufficient quantities of water for different uses, continuity, seasonality, water storage, location and number of water points, ratio of water points to patients or beds.
Accessibility: on premises	Accessibility: accessibility of drinking water to those with disabilities. Acceptability: taste and appearance of drinking water
Quality: improved water Source	Quality: E. coli, Legionella, residual, chlorine, chemicals, etc. and on-site water treatment Others: piped supply, multiple sources, provision of water for different uses including drinking and different standards for different types of facilities
2. Service element: Sanitation	
Availability: usability, for men and women, for staff	Availability: location and number of toilets, ratio of toilets to patients or beds
Accessibility: to those with limited mobility	Accessibility: distance to toilets from Consultation areas
Acceptability: affording privacy and menstrual hygiene	Acceptability: cultural appropriateness
Quality: improved toilets or latrines	Quality: cleanliness, connection to sewer, faucal sludge management Others: evidence of open defecation on facility Grounds, drainage, and run off management, vector control measures in toilets

3. Service element: Hygiene	
Availability: functionality of hand hygiene facilities at points of care, functionality of Handwashing facilities at toilets	Availability: location and number of handwashing stations, ratio of handwashing stations to patients or beds Others: hand hygiene compliance, visibility of hygiene promotion materials, hygiene promotion activities, training on hygiene and infection control
4. Service element: Waste Management	
	Availability: location and number of waste bins and receptacles, ratio of waste bins to patients or beds, functionality of incinerators, availability of fuel/power for incinerators, disposal of chemical and radioactive waste Accessibility: bins out of reach from children
Quality: segregation of health care waste, treatment and disposal	Quality: fenced waste storage area Others: fenced waste storage area
5. Service element: Environmental Cleaning	
Availability: protocols in place Quality: staff trained	Availability: location and number of cleaning stations, presence of cleaning supplies, including disinfectant Quality: cleaning frequency, observed cleanliness, cleaning methods used

Source: WHO/UNICEF, Global Baseline Report, 2019

Improved and unimproved water supply and sanitation services are also classified by WHO.

Table 2.6 Definition of improved water supply and sanitation

Intervention	Improved	Unimproved
Water Supply	• House connection • Standpost/pipe • Borehole • Protected spring or well • Collected rain water • Water disinfected at the point-of-use	• Unprotected well • Unprotected spring • Vendor-provided water • Bottled water • Water provided by tanker truck
Sanitation	• Sewer connection • Septic tank • Pour-flush • Simple pit latrine • Ventilated Improved Pit latrine	• Service or bucket latrines • Public latrines • Latrines with an open pit

Source: Global Water Supply and Sanitation Report, 2000

The services can be defined as unimproved not only if they are unsafe, but also if they are unnecessarily costly, such as bottled water or water provided by tanker truck. (WHO, 2004)

2.3 Linkage between poverty and WASH

Water has a vital role to play in responding to the socio-economic. Success in economic development efforts is needed to ensure a sustainable flow of funds for the development of water resources. It is evident that there is mutual dependency on water and socio-economic development. These can be nodes in a vicious cycle that also positions communities in a deteriorating spiral of poor economic growth and inadequate access to safe and adequate supply of water and sanitation. Additionally, they can be nodes in a virtuous cycle, reinforcing one another in an autocatalytic manner, and contributing to an upward spiral in which improved socio-economic development generates resources needed for improved development of water resources, which in turn promotes and encourages more socio-economic development. (UN-Water/Africa (Agency), 2009)

Table 2.7 Poverty and WASH

		Poverty dimensions	Key effects
Lack of water sanitation and hygiene		Health and nutrition	□ Water and sanitation related illnesses □ Stunting and wasting from diarrhea caused malnutrition □ Reduced life expectancy
		Education	□ Reduced school attendance by children (especially girls) due to ill health, lack of available sanitation, or water collection duties
	□	Gender and social Inclusion	□ Burdens borne disproportionately by women, limiting their entry into the cash economy
		Income/ Consumption	□ High amount of budget used on water □ Reduced income-earning because of poor health, time spent collecting water, or lack of opportunity for businesses requiring water inputs □ High consumption risk because of

Source: https://www.researchgate.net/publication/230557463

Insufficient water and sanitation services increase people's cost of living, reduce their earning potential, harm their well-being, and make life more risky. (Bosch, Hommann, Rubio, Sadoff and Travers, 2000).

2.4 Relationship between Water, Education and Health

Education and health are basic objectives of social development, whereas health is central to well-being and education is essential for a satisfactory and rewarding life. At the same time, education plays a key role in the ability of a developing country to absorb modern technology and to create the capacity for self-sustaining growth and development. (Thet Htar Hsu, 2018)

(a) Water and Education

Water and sanitation facilities in schools are fundamental for promoting good hygienic behavior which reflects children's health and well-being. Lack of latrines, safe water for drinking and hygiene and inappropriate and inadequate sanitary facilities, create to absenteeism and high drop-out rates, especially for the girls.

By 2016, about 58 out of the 92 countries surveyed had over 75% coverage of drinking water in schools. About half of schools in Sub-Saharan Africa, and over a third of schools in Small Island Developing States, where there had no drinking water services. Furthermore, 67 out of 101 countries had over 75% coverage of improved single-sex sanitation facilities classified as providing a basic sanitation service. An estimated 23% of schools did not have sanitation service and more than 620 million children around the world did not have a basic sanitation service at their school (WHO/UNICEF, 2018).

(b) ater and Health

There are increased health benefits by increasing availability of water, however there is not a direct linear relationship with water quantity used. According to WHO standard, people need about 20 liter per day, which they consider to be basic access to water and there can be serious concerns about health and well-being if there is less of this level. Beyond this amount communities need to be focus on water source protection with establishing good hygiene and sanitation as well as household treatment. People who need travel more than 1 km to fetch water do not use much for bathing or laundering which is very sensitive to service levels. (Mellor, 2009)

Carrying water appears to have direct detrimental impacts on the mental and physical health of the carrier, and his or her ability to participate in domestic, formal and informal work. In addition, water fetching can create to psychosocial and emotional distress, which can influence perceptions of general health, disability related to musculoskeletal disorders as well as work performance and satisfaction (Diouf et al., 2014). Incidents and fear of physical and sexual violence is widely reported by children and women in relation to fetching water. (Sorenson, 2011).

(c) Water related diseases

There are five different routes of infection for water-related diseases: water-borne diseases (e.g. cholera, typhoid), water-washed diseases (e.g. trachoma), water-based diseases (e.g. schistosomiasis), water-related vector-borne diseases (e.g. malaria, filariasis and dengue), and water-dispersed infections (e.g. legionellosis).

Water-borne and water-washed diseases consist of infectious diarrhoea which includes cholera, shigellosis, salmonellosis, amoebiasis, and other protozoal and viral intestinal infections. These are transmitted by water, person to person contact, animal to human contact, and food borne, droplet and aerosol routes. As infectious diarrhoea causes reulted from poor access to water and sanitation (Guy Hutton and Laurence Haller, 2004).

According to global estimates of cause-specific disability-adjusted life years 9 (DALYs), the number of DALYs per 100,000 population dropped from 45,000 in year 2000 to 36,300 in year 2015. There was a drop in DALYs related to nearly all communicable diseases and nutritional deficiencies, including diarrhoeal diseases, which fell over 50% as 2,530 to 1,160 DALYs per 100,000 population. The rate of the decline in diarrhoeal diseases DALYs was similar across all income groups. Waterborne diseases, however, remain a significant burden among disadvantaged and vulnerable groups in worldwide, especially among low-income economies where 4% of the population suffered from diarrhoea in 2015, among them 60% of which were children under five-year old age. (WHO, 2016).

2.5 Review on Previous Studies

There are many scholars and researchers conducted the study on water, sanitation and hygiene, with different points of view.

Zin Mar Lwin (2005), studied the water supply status in Bagan-Nyaung U township. This studied found that among 218 villages in Bagan-Nyaung U area, 45 villages were luck of access to water supply, 68 villages are not sufficient water. Only 105 villages could enjoy their water supply facilities in her studied period.

Ei Thwe Tun (2011), conducted a thesis on the title of “The utilization of land and water resources in Myanmar agriculture”. This study highlights that Myanmar uses only a few portion of its land and water resources for agriculture and it is necessary to undertake a plan to utilize the remaining resources in order to be sustainable. Public

awareness and public participation are also important to enhance for successful implementation of sustainable use of land and water resources for agricultural development.

Myint Zaw (2015), conducted a thesis on the title of "A study on status of Water, Sanitation and Hygiene (WASH) in the Pantanaw township, Ayeyarwaddy region". This study showed that access to improved water is indicated that 83% (urban 93% and rural 78%) and to sanitation as 76 % (urban 83% and rural 73%). Among sources of information about water, sanitation and hygiene, health talk is the highest effective source in the rural communication. Second effective source is TV and video click, which is highest channel to reach urban community. The role of family members is at the third level to getting awareness of WASH for both communities. The printed media (book, newspaper, journal, poarwe, etc) is likely to be the forth one of awareness raising in urban community. Likewise, radio programme is a reliable media for the rural community.

Thet Htar Su (2018), studies the socio-economic conditions in Tharrawaddy Township of Bago Region. This study found that education and health services which includes safe water resource and number of latrines are the main factors for the socio-economic development.

Megersa Olumana Dinka (2018), studies "Safe Drinking Water: Concepts, Benefits, Principles and Standards". This study shows that water regulations are importance for the provision of drinking water that is to be sufficient in quantity, safe, accessible, acceptable, affordable and reliable. Drinking water regulations include controlling of the water supply systems which are water source, water treatment, water distribution and use, wastewater and gray water.(Dinka, 2018)

CHAPTER 3
IMPROVING WATER ACCESS IN CENTRAL DRY ZONE, MYANMAR

3.1 Overview on Improving Access to Water

Historically in Myanmar, there has been a proliferation of government authorities responsible for village water supply, whereas, Ministry of Social Welfare established Rural Water Supply and Sanitation Board (RWSSB) in 1952, then Rural Sanitation and Water Supply Board (RSWSB) in 1953.

Ministry of Agriculture received the handover and implementing the water supply activities by forming Agriculture and Rural Development Corporation in 1959 and Rural Water Supply Division (RWSD) in 1972.

In 1985, UNICEF started working with Rural Water Supply Division (RWSD), Agricultural Mechanization Department, under Ministry of Agricultural and Forest and constructed deep tubewells in Central Dry Zone of Myanmar.

In 2005, Water Resources Utilization Department (WRUD), the successor of RWSD under Ministry of Agriculture and Irrigation becomes focal department for rural water supply. Under Ministry of Border Areas, National Races and Development Affairs, Department of Development Affairs (DDA) was established in 1994 and handled rural water supply activities. In 2012, the DDA has been dissolved and recreated as the Department of Rural Development (DRD), which moved to a new ministry, the Ministry of Livestock, Fisheries and Rural Development in 2013. However, the DDA at State/ Region level did not dissolve, which has been divided into the DDA and the DRD, with the DDA reporting to General Administration Department, the Ministry of Home Affairs.

During the Drinking Water Decade (1981-1990), with the collaboration of Rural Water Supply Department (RWSD,), UNICEF-WASH Section had provided water supply facilities including construction of deep tube wells installed with Mono pumps, shallow tube wells attached with handpumps and gravity flow systems in rural areas of Myanmar.

UNICEF-WASH section, with the collaboration of Department of Rural Development (DRD), has been providing water supply facilities in rural areas across the country including construction of water supply facilities, water quality testing, Water Safety Plan and capacity building of DRD engineers and technicians.

Assessment of data collection on access to water supply system for rural areas was conducted by Department of Development Affairs (DDA) in 1999-2000. At the same time, DDA also set up a 10-year Rural Water Supply Project (RWSP) from year 2000-2010 to increase access to water supply in 27,052 villages throughout Myanmar. After 10 years RWSP, some remaining villages still faced water scarcity. Therefore, DDA developed an additional 5- year RWSP from 2011-2016 to extend the water supply coverage to these remaining villages. In the meanwhile, DRD also set up the 20-year Rural Water Supply Plan for the period for year 2011-2031 to contribute to one of the five tasks of Rural Development in the National Comprehensive Development Plan (NCDP).

With the aim for aligning with MDG goal and the vision of the framework, DRD developed "Strategic Framework for Rural Development" jointly with World Bank in March 2014 in order to improve socioeconomic life of rural populace and narrow down of urban-rural divides".

Current Rural Water Supply plan (2017-2030) to contribute to improve socio-economic life of all the rural populace through provision of equitable, effective, efficient and affordable services for water supply and sanitation and safe hygiene behavior by 2030.

Table 3. 1 Percentage of population in households with access to improved water in dry and rainy seasons

State/Region	Dry	Rainy	Union Dry	Union Rainy
Rakhine	42	45	74	80
Kayin	72	74	74	80
Tanintharyi	80	80	74	80
Chin	78	84	74	80
Magway	82	84	74	80
Ayeyarwaddy	53	85	74	80
Shan	85	87	74	80
Bago	76	89	74	80
Saging	91	92	74	80
Kayah	87	92	74	80
Mandalay	92	92	74	80
Mon	92	94	74	80
Kachin	95	95	74	80
Yangon	86	95	74	80
Nay Pyi Taw	95	96	74	80

Source: CSO, UNDP and WB, 2018

According to Myanmar Living Condition Survey conducted in year 2017, across the country, the lowest improved water access can be found in Rakhine, where only 40 percent of the population has access to improved water in both the dry and rainy seasons. This is about half the national average during both seasons. Similarly, limited access is reported in Ayeyarwady during the dry season, where just over half of people (53 percent) have access to an improved water source. Rakhine and Ayeyarwady differ markedly however in their access over the dry and rainy season: in Rakhine, access remains low in both the dry and rainy season, while in Ayeyarwady access to an improved water source rises to 85 percent of the population in rainy season. (CSO, UNDP and WB, 2018)

Transportation of water is predominantly an issue especially in the rural areas of Myanmar. The average round-trip to collect water is 10 minutes in the rainy season, 12 in the dry season and the vast majority of round-trip are under 30 minutes. The averages vary across states and regions, estimate in Nay Pyi Taw (7 minutes) and longer

in Mandalay, Magway and Kayah (greater than 14 minutes on average). As overall in Myanmar, it is slightly under half of those who must transport water face short roundtrips of 1 to 5 minutes. (CSO, UNDP and WB, 2018)

Table 3. 2 Percentage of population with access to improved water on premise in dry season, by State and Region

State/Region	Improved safely managed (inside the dwelling or compound)	Improved basic (within 30 minutes round trip collecting)	Unimproved	Surface water
Rakhine	18	24	7	51
Ayeyarwaddy	34	19	3	44
Magway	47	34	9	9
Bago	50	26	10	14
Tanintharyi	55	24	16	4
Chin	58	19	0	22
Kayin	58	14	23	5
Shan	61	24	6	8
Saging	62	28	2	8
Mandalay	63	27	0	8
Nay Pyi Taw	64	31	1	4
Kayah	67	20	5	8
Mon	78	14	5	3
Yangon	79	7	0	14
Kachin	81	14	1	4

Source: CSO, UNDP and WB, 2018

Given the substantial rainfall and groundwater potential of both Rakhine and Ayeyarwady, the low rates of onsite water access signal low investments in localized water capture. Unimproved water includes unprotected wells or springs and other sources of water. The data label is only shown in those states or regions where unimproved water accounts for more than 3 percent of drinking water sources. (CSO, UNDP and WB, 2018)

3.2 Monitoring of SDG Goal (6) Indicator

At the international summit on the SDGs, Myanmar's delegation stated that "Myanmar will redouble its effort to achieve sustainable development by mainstreaming the SDGs in its national development agenda".

Since the National Statistics Offices around the world have to handle the role of Monitoring and Evaluation (M&E) on the progress of the SDG implementation, the Central Statistical Organization (CSO) of the Ministry of Planning and Finance in Myanmar and UNDP jointly examined in May 2016 the readiness and availability of Myanmar's data to measure the SDG indicators.

The table (3.3) shows the measurement of the Goal 6 which focuses on drinking water, sanitation and hygiene, and also the quality and sustainability of water resources**.**

Table 3. 3 SDG Goal (6) Indicator Baseline Report for Myanmar

Goal 6	Indicator	Year	Myanmar	South-East Asia	World
6.1.1	Percentage of population using improved drinking water sources *	2015	80.6%	90.3%	91.1%
6.2.1	Proportion of population using improved sanitation facilities*	2915	79.5%	72.2%	67.7%
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	1998-2002	2.85%	7.7%(1)	8.8%(1)
6.5.1	Degree of IWRM Implementation (0-100)	2011	1.8	-	-
6.a.1	Amount of water- and sanitation -related official development assistance that is part of a government-coordinated spending plan	2014	14.58 million constant 2014 USD	-	10.0 billion constant 2014 USD (2)

Source: CSO and UNDP, Aug 2017

* Indicator rephrased compared to the SDG Indicator.

(1) Around 2012.

(2) Total for all developing countries.

Access to safe and affordable drinking water, as well as access to adequate and equitable sanitation is monitored through Indicators 6.1.1 and 6.2.1. The percentage of population using improved drinking water sources in Myanmar remained below the Regional and World averages in 2015, at 80.6%. However, the proportion of population using improved sanitation facilities was higher in Myanmar than at the regional and global level, reaching almost 80%.

Goal 6 also foresees to monitor water-use efficiency in order to ensure sustainable withdrawals and supply of freshwater to avoid water scarcity. The level of water stress (Indicator 6.4.2), which is the proportion of available freshwater resources that is withdrawn, was very low in Myanmar over the period 1998-2002, with only 2.85% of available freshwater being withdrawn according to the relevant data source. Water resource management, including through trans-boundary cooperation, is another aspect included in Goal 6. Indicator 6.5.1 reflects the extent to which integrated water resources management (IWRM) is implemented on a scale from 0 to 100. It measures to which extent policies, institutions, management tools and financing integrate water resources management. With a score of 1.8 in the year 2011, implementation of IWRM was at an early stage of development in Myanmar in that year.

Indicator 6.a.1 measures the ODA provided towards water and sanitation related activities, including infrastructure development, policies and capacity development.16 It shows that international donors allocated almost 15 million USD (based on 2014 constant USD) for this sector in Myanmar in 2014. At global level, the total ODA provided to all developing countries for water supply and sanitation amounted to 10.0 billion USD (based on 2014 constant USD). (UNDP, Central Statistical Organization, August, 2017)

WHO/UNICEF (JMP), 2014 indicates that Myanmar has met the MDG targets for both water supply and sanitation. Access to improved water supply is reported as 86% nationwide, while for sanitation is 77% nationwide, with open defecation at removed villages just 5%. However, under new Sustainable Development Goal (SDG) classifications, the 2017 JMP report indicates that population using basic drinking water service reported as 66% nationwide, while population using basic sanitation services is 65% nationwide, with open defecation at removed villages at just 5%.

3.3 Myanmar Sustainable Development Plan (2018-2030)

The Myanmar Sustainable Development Plan (2018-2030) is structured around 3 Pillars, 5 Goals, 28 Strategies and 251 Action Plans. The goal no. 5 is Natural Resources and The Environment for Posterity of the Nation. The strategy no. 5.3 stated that "Enable safe and equitable access to water and sanitation in ways that ensure environmental sustainability". (Ministry of Planning and Finance, 2018)

In parallel, there is a national Strategy for Rural WASH and WASH in Schools and Health Facilities, where all organisations working in or supporting the WASH Sector – Government, Development Partners, International NGOs, national and local NGOs, and private sector, will be involved to carry out the way to meet the needs of the rural populations for improving domestic water supply services, access to and use of improved sanitation with elimination of open defecation, and improved hygiene behaviour by the Year 2030. (Department of Rural Developement, 2016).

With this national strategy, the water supply target for rural community supply to access to potable water supplies and improved water for other domestic is targeted 70% in year 2020, 85% in year 2025 and 100% in year 2030. Similarly, the target for school water supply is 40%, 65% and 100% at year 2020, 2025 and 2030 respectively. The target for rural health center water supply is 50%, 75% and 100% at year 2020, 2025 and 2030 respectively as well.

The sanitation for the rural community including open defecation free (declared ODF), solid waste management, access to safe sanitation (own or shared), hand washing facilities are also targeted to meet 100% in the year 2030.

The school sanitations such as latrines adequate for boys and girls separately, urinals for boy at schools, private space for girls for menstrual hygiene, hand washing facilities, special facilities for children with disabilities and appropriate solid waste disposal are also targeted to meet 100% in the year 2030.

Targets at the rural health center including latrines, handwashing activities, waste water treatment system and clinical and hazardous waste disposal are also plan to meet 100% in the year 2030.

As Hygiene targets, Hygiene behaviours, Use of improved toilet, Washing hands with soap at critical times, Safe disposal of infants' faeces and Safe water handling in the home are also targeted to meet 80 – 100 % in the year 2030. (Department of Rural Developement, 2016)

With continuous water supply programme, Dry Zone people are now in the position to enjoy having with safe drinking water and sufficient domestic water supply. Previously, the Dry Zone people were with water scarcity problems and they need water supply assistance and their voice was "WE WANT WATER, NOT GOLD"

Improved access to water is widely acknowledged for livelihood enhancement and the general well-being of around 10 million people in the Dry Zone of central Myanmar, and most of these people depend on agriculture for their livelihoods.

3.4 Regional Geology and Hydrogeology of Dry Zone in Myanmar

The Dry Zone is one of the region which have the most poor natural resource and climate sensitive region in Myanmar. The Dry Zone covers about 54,390 square kilometers and represents about 10% of total land area of the country. There are 85 townships comprising of 15,802 villages in this Zone of three divisions; Mandalay, Magwe and Sagaing. The population in the Dry Zone is estimated at 18 million people in 2016 which constitutes 34% of the country's total population of about 53 million. The population density is 123 people per square kilometer, that is the third most densely populated region in Myanmar. Overall across the Dry Zone, water is scarce, soil is degraded, and vegetation cover is thin due to severe erosion. The Dry Zone have limited rainfall ranges between 500mm-1,000mm and the average mean temperature is about 27° C and the temperature often rises to about 43° C in the summer period. This dry environment with its other natural limiting factors has led to conditions of growing food insecurity and severe environmental degradation. (MSR, UNDP, 2016)

The major economic activities in the Dry Zone are subsistence farming such as cash crops items (paddy, sesame and groundnut) and small-scale livestock rearing. Agricultural productivity is low, and the farmers are heavily dependent on products from the natural forest especially fuel wood, pole, post and fodder to support their living and livestock. Most of landless people are working as labours of seasonal farm, then migrate to urban regions during non-planting time to find temporary employment.

Dry Zone is situated almost exclusively within the lowland region bounded by north-south-oriented faults along its boundaries, including the largest and most active Sagaing Fault (Stokes 1988; Pramumijoyo et al. 2010). Dry Zone emerged as a result of the uplifting of the neighboring regions during the late Cretaceous and early Tertiary periods, with the central trough subsiding and progressively filled with sediments which

may attain a thickness of 20 km or more (Thein 1973). The lowland portion of Dry Zone is characterized by upper terrestrial deposits and marine deposits at depth. Tectonic activity in the late Tertiary period resulted in folding and thrusting, including the formation of the Pegu Yoma hills. Nowadays, the lowland region may be considered as a large basin divided into two unequal halves; the larger Irrawaddy Valley and the smaller Sittang Valley, separated by the complex folded range of the Pegu Yoma which is structurally connected to a line of extinct volcanoes with small crater lakes and eroded cones, including the highest dormant volcano, Mount Popa (1,518 m). The generalized geology that illustrates the distribution of the major aquifer groups in Dry Zone is presented in below table.

Table 3. 4 Summary of the major aquifer units in the Dry Zone

Aquifer units	Lithology	Occurrence	Quality
Alluvial	Sands, silts and gravels	Near major river courses and tributaries	Usually fresh
Irrawaddy	Mainly sands and sandstones, with gravels, grits and sandstones	Common throughout most of DZ	Usually fresh with high iron content
Pegu	Marine sandstones, shales and siltstones	Western and central parts of DZ	Mostly brackish or saline
Mainly along the foothills of the Unknown western mountains (Eocene)	Sandstones, shales and clays	Mainly along the foothills of the western mountains	Unknown

Source*:* Adapted from MOAI, 2003

There are four major aquifer groups across the Dry Zone; Irrawaddy and Alluvial groups constitute the most important aquifers, supplying groundwater that is of sufficient quality for both domestic and irrigation use. Suitable resources are less common in areas underlain by Pegu and Eocene aquifers. (Drury, 1986)

3.5 Water Access in the Study Area

Across Dry Zone, the Eocene sandstones, shales and clays outcrop mainly along the foothills of the western mountains (7% of Dry Zone). Pegu strata outcrop over large parts of Dry Zone (20%) and are characterized by their oil-bearing properties. The Pegu group consists of well stratified sandstones and blue or grey clays/shales, of which the former is often calcareous and well cemented. (Drury, 1986).

The Irrawaddy group strata outcrop most widely over Dry Zone (38%). The unit is comprised of massive, loosely cemented sand and sandstone beds. Irrawaddy deposits, which are mainly clastically-derived and loosely cemented, contain many highly permeable zones. Irrawaddy group aquifers are usually comprised of poorly consolidated sand and gravel layers and are semi-confined to confined in nature. (Drury, 1986).

Alluvial deposits overlie the Irrawaddy and Pegu outcrops and extend across 29% of Dry Zone. In some areas, these are alluvial plateau gravels which pass laterally into red earth beds (clayey sands) representing old laterite soils. These lateritic deposits are usually found at high elevations some distance from present river courses. The older alluvium occurs mainly in basins formed along old river courses, whereas the younger alluvium is found in significant amounts in the valleys of the main rivers, such as the Irrawaddy, Chindwin and Mu. The Alluvial deposits comprise gravels, sands, silts and clays. They generally make good quifers, except where they are very fine-grained. The major distinguishing feature between the overlying Alluvial group and the Irrawaddy group is a distinctive change in color from yellowish brown downwards to bluish grey which is widespread in the sediments. Many shallow dug wells used for domestic supplies draw upon the alluvial aquifers.

Groundwater occurs throughout Dry Zone. However, groundwater of a suitable quality and that which is accessible at a reasonable cost cannot be found everywhere, e.g., in areas underlain by aquifers of the Pegu group rocks. The Irrawaddy and Alluvial groups are the most important aquifers due to their ability to provide good yields and water of a high quality. Groundwater is the earth's major reservoir of potable water. There is more water stored beneath the ground than that collectively in streams, lakes, dams and the atmosphere. The ratio of groundwater to surface water is likely to be considerably higher in the Dry Zone which does not support large areas of surface water or permanent snow. Slow moving groundwater is generally free of pollution and

contamination and is relatively unaffected by droughts. However, groundwater systems need to be thoroughly understood and extraction needs to be effectively managed so that significant water level declines and deleterious chemical changes do not occur. Groundwater flow direction can be assessed by plotting water levels from several tubewells to determine hydraulic gradients, hence groundwater direction and velocity.

Before constructing deep tubewells, it is very important to examine carefully on underground aquifer layer because the structure of underground layer and nature of the soil are complex in the dry zone area.

Among the studied three villages, Te Ma and Zee O villages are located in the Irrawaddy aquifer zone and Taung Shey is in the Alluvial aquifer zone and therefore the fresh water can only be available by drilling the deep tubewells.

Through this study, it was approved that the tubewells are the main reliable water sources especially for the dry and wet seasons. The drop in the use of deep-tube wells during the wet season is the consequence of the availability of rain water collection which is the second source of drinking water available during the wet season.

CHAPTER 4
SURVEY ANALYSIS

4.1 Survey Profile

Bagan-Nyaung U area is the most picturesque earchitectural complex in Myanmar. It is situated between 94°45'00" E to 95°00' 00" E and 21°00' 00" to 21°15' 00" N. It is located on both sides of the Ayeyarwaddy River bank and approximately 145 km southwest of Mandalay and 187 km from Yangon. (Tun Naing Zaw ,Swun Wunna Htet& Min Thura Mon, 2018). To accomplish the objective of analysis, current accessibility of water points are key influencing factors on the improvement of socio-economic in three villages: Te Ma, Zee O and Taung Shey in Nyaung U township, Dry Zone of Myanmar.

The three villages are selected as the target survey area because the villagers were suffering the water shortages problem in the previous years and those villages have been provided the deep tubewells with the assistance of the government and individual donors during recent years.

Te Ma village is located about 13 miles in the east of Nyaung U with Latitute 21.1408 and Longitude 95.0897. Its population was 980 in 20-year ago and it became 1,186 in year 2019. The village pond is 0.5 mile far from the village, that could store water only for three months. The protected river water is available, but it is no enough for the villagers because it could provide only one time per week. The first tubewell is constructed with depth of 925ft by Bridge Asia Japan (BAJ), INGO funded by JICA in year 2001. The second tubewell is constructed with the depth of 945 ft by DRD, funded by National Community Driver Development Project (NCDDP) in year 2018.Thus, it could say that access to water supply service in Te Ma village is reaching to the demand.

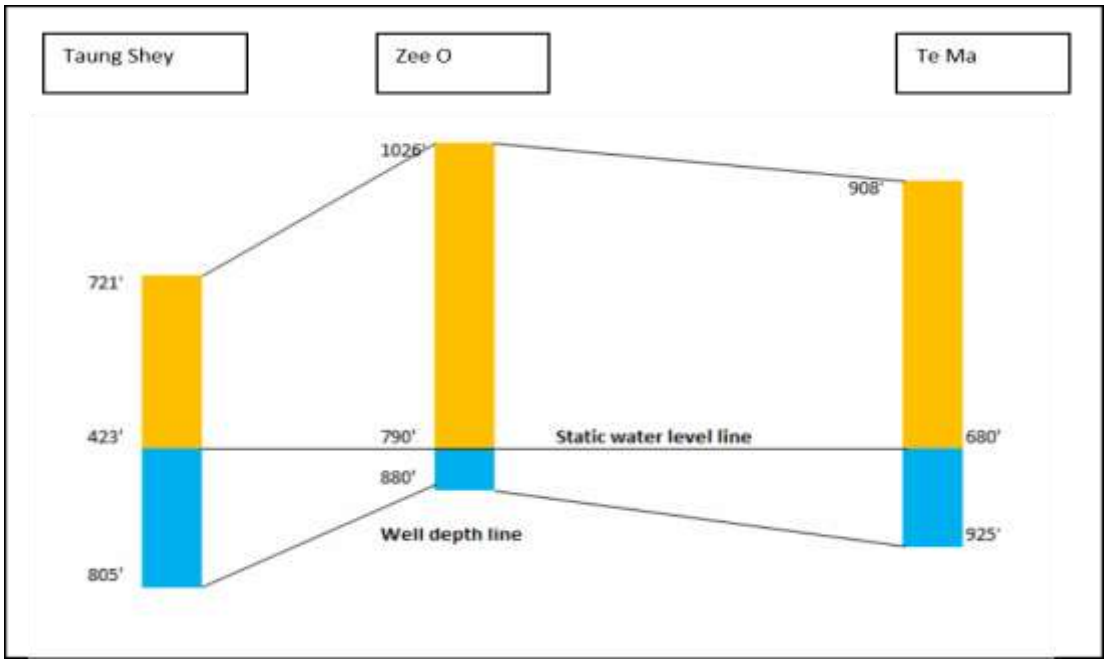
Zee O village is located about 16 miles in the Southeast of Nyaung U with Latitute 21.1098 and Longitube 95.036. Its population was 1,000 in 20-year ago and it became 1,051 in year 2019. The village pond is about one mile far from the village. that could store water only for 7 months. The protected river water is available, but it is not enough for the villagers because it could provide only one time per five days. The first

tubewell is constructed with the depth of 880ft by BAJ, funded by JICA in year 2005. The second tubewell is constructed with the depth 980ft by local driller, funded by private local donor in year 2018 and the third tubewell is constructed with the depth of 935 ft by local driller, funded by private Vietnamese monk in year 2018. Thus, it could say that access to water supply service in Zee O village is reaching to the demand.

Taung Shey village is located about 6 miles in the Southeast of Nyaung U with Latitute 21.1049 and Longitube 94.975. Its population was 665 in 20-year ago and it became 772 in year 2019. The village pond is about one mile far from the village, that could store water only for four months. The protected river water is available, but it is not enough for the villagers because it could provide only one time per five days. The first tubewell is with the depth of 804ft by BAJ, funded by WATABE in year 2008. The second tubewell is constructed with the depth of 802ft by local driller, funded by NCDDP in year 2019. Thus, it could say that access to water supply service in Te Ma village is reaching to the demand.

According to the ground water situation, Te Ma and Zee O villages are located in the Irrawaddy aquifer zone and Taung Shey is in the Alluvial aquifer zone. And therefore, the fresh water can be available by drilling the deep tubewells

Figure 4. 1 Ground water situation of Te Ma, Zee O and Taung Shey villages



The figure 4.1 shows the static water level and estimated depth to drill tubewells for getting potable water at the three villages: Te Ma, Zee O and Taung Shey.

In the study area, 288 respondents were selected for the interview. Household data were collected by using face to face interviewing method. Based on the sample calculation, the studied sample size was 288. Survey group consisted of thesis applicant of present study who acted as a team leader and five members who are well experienced in data collection. Moreover, they were trained to conduct data collection in accordance with survey procedure. Then the answers were analyzed by using Excel software. Findings from the data results were shown in respective tabular form and interpreted accordingly. This study has been done using descriptive method.

4.2 Survey Design

Key Informant Interview was conducted with Township staff officer from Department of Rural Development- Nyaung U District, staff of Bridge Asia Japan, and the individual local drillers. In order to meet the objective of this study, a survey was conducted with 288 respondents by using semi structured question.

The selected three villages have total population as 3009. The formula developed by Wallstreetmojo that provides a simplified formula to calculate the sample size as below.

$$n = N * \frac{\frac{Z^2 * p * (1-p)}{e^2}}{[N - 1 + \frac{Z^2 * P * (1-p)}{e2}]}$$

Where,

n = sample size

p = proportion having the measured characteristic (expected prevalence) = 50%

Z = Critical value of 95% corresponding to confidence level

N = Population size

e = Margin of error

To obtain comprehensive sample, "p" is defined as 50%, the biggest sample size and "e" margin of error is 5.5% (eg. 0.055 = $\pm$ 5.5). As this is household-based survey, N is 3,009 (total population in three villages). Then n is 287. But in reality, 288 households are assessed. (Wallstreetmojo, n.d.)

The respondents were selected over the age of 40 in total of 288 (96 samples x 3villages). The English version of the questionnaire was translated into Myanmar. Questionnaire consists of nineteen sections; personal and enterprise demographic data,

current and past 20-year situation on access to water, effective of changing different water sources in term of socio-economics including earning money/incomes, social, health and education. The questionnaires used in this study is presented in Appendix. The survey employed quantitative technique collecting questionnaires information.

4.3 Survey Result

The survey results of the study are based on the structured questionnaire and proceed with the analysis of the questions.

4.3.1 Demographic Characteristics of the Respondents

In this study, total of 288 respondents are included to give some findings regarding the effect of improving water points in their villages. The specific characteristics of these respondents are presented in the presentations and discussions that follow.

Table 4.1 Data Summary for Demographic Characteristics

Particulars	Number	Percent (%)
Gender		
Male	128	44
Female	160	56
	288	100
Age		
40-50	113	39
>50	175	61
	288	100
Level of Education		
Illiterate	24	8
Can read and write	57	20
Primary	73	25
Middle	61	21
High	39	14
Graduate/Postgraduate	34	12
	288	100

Source: Survey data, 2019

In the study, the gender ratio of the respondents is made up of 56 % male and 44 % female. Majority of age group of respondents is 40-50 years old and then follows over 50 years old according to the requirement of the study objective.

4.3.2 Water in Challenges

Before 20 years ago, the water fetching is the most challenges for the people in those three villages especially in the summer season about 5 months per every single year. Because of their main water resource, own village ponds are dried up and they need to go and fetch water from their neighboring's available water sources (tubewells, government river pipe line water) and it is big investment for them in term of human, cattle and time as shown in below table (4.2). It is clearly that they cannot dream to grow any plants because can't effort for watering.

For the poor people who don't have the cart were having big burden to buy the water and therefore they borrow the cart from the cart owner, fetch water and then they settle their manpower to the cart owner's business such as farming, palm producing process, etc.

Table 4.2 Water in Challenges in past 20-year

Village	Sources	Distance (mile)	Time	Availability
Tema	Wet Lu village tubewell	1	1 to 1.5 hours by cart including waiting time at the distribution points	Once per two day
	Kannigyi village tubewell	1.5	1.5 to 2 hours by cart including waiting time at the distribution points	Once per two day
Zee O	Government managed river water pipe line located at Pyun	7.5	12-13 hours by cart including waiting time at the distribution points	Day time
Taung Shey	Ku Ywar village tubewell	2	About 3 hours by cart including waiting time at the distribution points	Once per two day

Source: Survey data, 2019

The transportation distance to collect water is the serious challenges in all three villages before year 2000. The villagers were reduced the usages of water including bathing, handwashing, clothes washing and it negatively effects to the sanitation, hygiene behavior and socio-economics including health and education.

Time for fetching water in the selected villages is saved and the residents reduce the burden of fetching water due to transportation distance.

4.3.3 Access to Water in the Household

The availability of water in the village households is not only for the water for domestic use but also for the enough potable water.

Table 4.3 Sources for Drinking Water in past 20 years

Particulars	Respondents			
	Te Ma	**Zee O**	**Taung Shey**	**Percent (%)**
Village pond water	40	19	10	24
River pipe line water(protected)	35	50	66	52
Rain water	21	27	20	24
Tubewell water	0	0	0	0
Total	**96**	**96**	**96**	**100**

Source: Survey Data, 2019

Table 4.4 Sources for Drinking Water in year 2019

Descriptions	Respondents			
	Te Ma	**Zee O**	**Taung Shey**	**Percent (%)**
Village pond water	0	0	0	0
River pipe line water(protected)	65	26	35	44
Rain water	25	29	24	27
Tubewell water	6	41	37	29
Total	**96**	**96**	**96**	**100**

Source: Survey Data, 2019

The survey findings showed that people in three villages are mainly use protected river water for their drinking purpose. In 20 years ago, 24% of the respondents were using unsafe pond water for their drinking purpose. After year 2000, based the available of better water resources and their higher knowledge, in habitants in three villages are no longer to use the unsafe pond water for drinking purpose. The selected villages have better quality of water due to construction of tubewell.

Table 4.5 Sources for Domestic Water in past 20 years

Particular	Respondents			
	Te Ma	**Zee O**	**Taung Shey**	**Percent (%)**
Village pond water	60	55	62	61
River pipe line water (protected)	9	30	21	21
Rain water	27	11	13	18
Tubewell water	0	0	0	0
Total	**96**	**96**	**96**	**100**

Source: Survey Data, 2019

Table 4.6 Sources for Domestic Water in year 2019

Particular	Respondents			
	Te Ma	**Zee O**	**Taung Shey**	**Percent (%)**
Village pond water	27	23	20	24
River pipe line water (protected)	6	5	3	5
Rain water	3	4	5	4
Tubewell water	60	64	68	67
Total	**96**	**96**	**96**	**100**

Source: Survey Data, 2019

The survey finding show that, 61% of respondents were using the pond water for their domestic purposes while they don't have tubewell in the past 20-year ago. After their village have own tubewells, the tubewell water is available at individual household by connecting the pipe lines, therefore, they are happy to use the tubewell water several purposes, although they need to pay water fees, although they need to pay the fee, they are convenient to use.

The pond water is available with free of charge, but it is not available for the whole year, its dried up especially in the summer time. The selected villages are also needed to go and fetch the pond water. Because of these limitations, only 24 % of respondents are using village pond water for domestic purpose.

According to the survey, it was found that the respondents have their own tubewells in respective villages, the respondents have sufficient water for domestic purposes. The respondents broke their water scarcity problem because water from the tubewell reaching to fulfill their requirement. All respondents are very satisfied because it is significantly improved their living style. The water pipes lines have been connected to every household and they do not require to consider time for water fetching for the domestic purposes however some villagers still need to fetch drinking water due to the fact that they prefer to drink protected river water which has been also connected to the village by pipe line system.

The respondents have extra time for other occupation. The villagers from selected villages have similar life style with town dwellers. The villagers can grow plants and other crops by using water from tubewells, they access enough water to clean, wash and take a bat. So, water accessing from tubewells contribute to improve their socio-economic status.

4.3.4 Cost for the Water

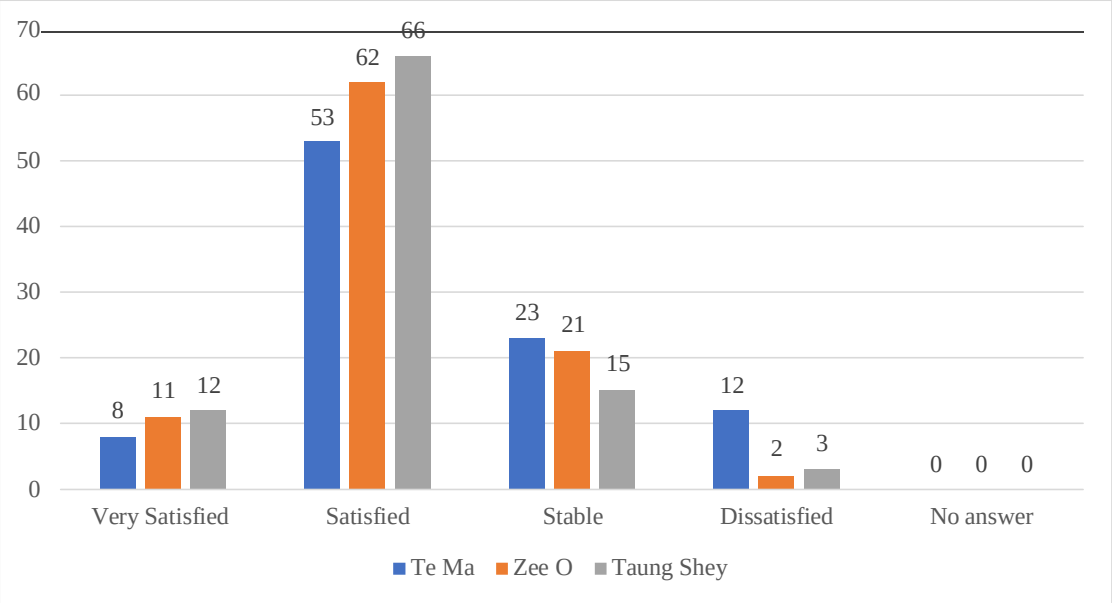
Currently, the water pipe lines have been installed from the village water storage tank to all individual household in all three studied villages. The charge for water fee is about 125-175 kyat per barrel (50gallons) of water, which is reasonable for the villagers. The respondents were asked about their willing to pay for water fees by comparing different water sources. Since the respondents can give more than one answers, the answers mentioned by the respondents can be seen in the following table 4.7.

Table 4.7 Willingness to Pay on Water Fees

Particular	Te Ma	Zee O	Taung Shey	Total	Percent (%)
Very Satisfied	8	11	12	31	11
Satisfied	53	62	66	181	63
Stable	23	21	15	59	20
Dissatisfied	12	2	3	17	6
No answer	0	0	0	0	0
Total	96	96	96	288	100

Source: Survey data, 2019

Figure 4.2 Willingness to pay for water fees



Source: Survey Data, 2019

The survey findings show that only 6% of respondents are not willingness to pay for the water fees. It is because of the reason that their family members are using water more than requirement because it is very easy to get the access and it crates big cost. Other 74% of respondents are satisfied as they accept about the electricity fees to operate the tubewells.

4.3.5 Water Reflects Income Benefits

The survey shows that the better access to water creates tremendous opportunity for the poor and is a progressive strategy for their family income growth. The respondents have more chance for other income generating occupation and saved time from fetching water.

Table 4. 8 Improving Water Access and its Benefits in Family Income

Improving water access reflects more earnings	**Number of Respondents**			**Total**	**Percent (%)**
	Te Ma	**Zee O**	**Taung Shey**		
Significant improved	65	59	57	181	63
Little improved	26	33	32	91	32
No improve	5	4	7	16	5
No Response	0	0	0	0	0
Total	**96**	**96**	**96**	**288**	**100**
Area of Developments (Multiple Responses)					
Can use the cattle in cultivation instead of using in fetching water	53	48	47	148	52
Because of less fetching time, more time for business and getting more earnings	38	38	37	113	39
Less expense for medial fees	5	10	12	27	9
	96	**96**	**96**	**288**	**100**

Source: Survey Data, 2019

According to the survey result, 95% of survey respondents states that their family incomes are improved because of direct and/or indirect effective of having more water points in their villages. It is because of that they can use their cattle in the business on cultivating the crops, they can save the water fetching time and get more chance to emphasize in their crop cultivation. Additionally, they can reduce the medical expenses

as their family member can improve their hygienic and away from the water related diseases.

Through this survey, all three village formed the village water committee and they can save the money by selling tubewell waters. By following the government's National Community Driven Development Project (NCDDP), all three studied villages can contribute to implement other village development infrastructure such as village to village connection road, set at the electricity which reflect and added to be more developed for the villages.

Consequence of this village development, the individual household have owned motor bikes and some villager owned the vehicles. This infrastructure development opens the eyes and ears of the villagers and getting more knowledge about business and therefore the villagers can sell their crops to the better market with reasonable prices.

4.3.6 Water Reflects Social Benefits

The three studied villages save the capital money through selling of tubewell water. Due to the good management of the Village Water Committee, this capital money bigger and bigger by promoting village loan system. In addition, the capital money contribute other village development activities and maintain the village infrastructure such as renovation on primary school, monastery, pagoda, pipeline connection for the needed place, purchasing new engine for the tubewell, etc.

Table 4.9 Improving Water Access and its Benefits in Social Development

Improving water access reflects the benefit of social development	Respondents			Total	Percent (%)
	Te Ma	Zee O	Taung Shey		
Significant improved	31	42	54	127	44
Little improved	57	49	39	145	50
No improvement	8	5	3	16	6
No Response	0	0	0	0	0
Total	**96**	**96**	**96**	**288**	**100**
Area of Developments (Multiple Responses)					
More community development activities	19	16	17	52	18
Creating the green environment in the village	12	12	11	35	12
Creating the clean environment in the village	11	12	12	35	12
Higher living standards	23	20	22	65	23
Happy because of healthy	7	17	15	39	14
Creating more family life	24	19	19	62	21
Total	**96**	**96**	**96**	**288**	**100**

Source: Survey data, 2019

According to the survey result, 94% of respondents state that their social conditions become improved after received water resources in their villages. The young leader groups can enjoy and more participate in village social activities, the villagers can spend more leisure time, religious affairs and social welfare. The green and clean environment creates their better living standard. Instead of water fetching time, they can gain more family life and it brings social benefits for the family and the village as well. In addition to that the psychological impacts such as reduction of stress and

worries for fetching water, getting sound sleep in night time, refreshment form daily bath, can not be measured in monetary terms. (Zin Mar Lwin, 2005)

4.3.7 Water Reflects Health Benefits

Access to water and sanitation are key determinants of public health and are core inputs into health indicators such as infant and child mortality, malnutrition, maternal and family well-being.

Health care facilities are classified as having basic water services if they use water from an improved source located on the premises, and from which water is available at the time of the assessment. Health care facilities with an improved water source not located on the premises (but still within 500 metres) or that don't have water available at the time of the assessment are classified as having limited water services. Health care facilities with no water source, or that take water from an unimproved water source, or use an improved water source more than 500 metres away are classified as having no water service.

Table 4. 10 Improving Water Access and its Benefits in Health

Improving water access reflect health development	**Number of Respondents**			**Total**	**Percent (%)**
	Tema	**Zee O**	**TaungShey**		
Significant improved	38	60	57	155	54
Little improved	47	34	39	120	42
No improvement	11	2	0	13	4
No Response	0	0	0	0	0
Total	**96**	**96**	**96**	**288**	**100**
Area of Developments (Multiple Responses)					
Improving toilet facilities	31	28	28	87	30
Decrease water related diseases	8	11	10	29	10
Decrease visits for treatment	4	6	6	16	6
Improving personal hygiene	25	25	25	75	26
Improving health knowledge through higher education	28	26	27	81	28
Total	**96**	**96**	**96**	**288**	**100**

Source: Survey data, 2019

According to the survey result, 96% of the survey respondents are agreed that their health situation was improved after received the water resources in their villages. Before the tubewells were constructed, the villagers responded that there was no sufficient water for personal hygiene, and therefore all three villages expended habit of open defecation. 30% of respondents mention that they are using proved toilets which are better facilities than the situation in past 20-year ago. According to the survey, there are no open defecation in the three surveyed villages.

The survey findings show that the villagers are having health knowledge and improving their personal hygiene. Moreover, the respondents replied that the outbreak of water related diseases are prevented from improving assessment of water.

4.3.8 Water and Education

Access to clean water improves education in many ways. The number of hours able to spend in school is inversely proportional to the number of hours needed to fetch water for essential daily needs.

Table 4. 11 Improving Water Access and its Benefits in Education

Improving water access reflects the improvement of Education	**Responses**			**Total**	**Percent (%)**
	Te Ma	**Zee O**	**Taung Shey**		
Significant improved	75	79	87	241	84
Little improved	21	17	9	47	16
No improve	0	0	0	0	0
No Response	0	0	0	0	0
	96	96	96	288	100
Area of Developments (Multiple Responses)					
Improving school attendance	51	53	50	154	54
Students are getting more study time	45	43	46	134	46
Total	**96**	**96**	**96**	**288**	**100**

Source: Survey data, 2019

The survey findings showed that all respondents agree that the school attendance was improved after getting water resources in their village. It is increased

because the student does not need to pay attention for fetching water. And they can study more in their school lecture. It creates more educated, knowledge and finally develop to the whole community.

The survey found that there are significantly higher school attendance percent for the middle and high school students. It is the fact that the age of 10-16 year who are the middle and high school students, they are free to fetching water and participate their family's business. Instead, they can attend school regularly and give more attention to study the school lecture.

.

CHAPTER 5
CONCLUSION

5.1 Findings

In the Dry Zone of Myanmar, there were thousands of drilled wells constructed in the past that have become dysfunctional because access to materials, technology, high cost and other resources were constrained. Since those earlier projects did not include technology transfer and most importantly, there was no training of local engineers to address these issues.

There was no potential to drill a deep tubewell by the local drilling machine especially for the studied area and always relies on the Government/ INGO assistance because of the main constraints on the drilling rig, drilling equipment such as drilling bit, drill pipe, mud pump, bentonite and pump which were needed to be imported mostly from Japan and Australia, costs and technical skills as well.

Some positive signs are emerging. A number of INGOs and international aid agencies including JICA, Bridge Asia Japan (BAJ), ADRA, Proximity, ActionAid with the cooperation of government counterparts such as WRUD, DDA, DRD have been implementing Water Supply Projects.

BAJ, JICA and DDA/DRD bring valuable supports not only providing the tubewells but also providing technical trainings (Geophysical survey, pumping test, logging, drilling method, maintenance and rehabilitation technic, etc) to the local drillers, DRD engineers and technicians. By using these technics, skills and knowledge, there were qualified local drillers, geophysical surveyors, who could effort perform tubewell construction process professionally for the Dry Zone area. This is very big achievement not only job opportunity for those local people but also for the people in Dry Zone because they could break their water scarcity problem.

With the calculation of the geophysical surveyors, the drillers can estimate the tubewell depth, water level, and water quality as well.

On the other hand, the different type of drilling equipment such as drill bit, pump (mono, submersible, compressor), pipe, engine, solar system is introduced in the

Myanmar market with reasonable prices and quality. This market makes encourage the local driller in order to continue to perform their drilling activities.

The survey found that the villagers from the selected villages can save the time and reduce the burden of fetching water because there is no transportation distance. In fact, individual household has access to their village's own tubewell water by connecting pipe line system. In this survey period, all respondents have sufficient potable water for both drinking and domestic purposes. And only 6% of respondents are not willingness to pay for the water fees, because of the reason that the easy access to water make their family members to using water more than requirement, and it crates cost for water fees. Another 74% of respondents are satisfied to pay water fees because they could understand about the electricity fees to operate the tubewells and feel that the water selling price is quite reasonable.

About 95% of survey respondents states that their family incomes are improved through direct or indirect effective of having more water points in their villages. They express that instead of time consuming in water fetching, not only the people also their cattle can emphasize in their occupation sector especially in cultivating the crops. Additionally, they can reduce the medical expenses as their family member can improve their hygienic habits and away from the water related diseases. And about 94% of respondents state that their social conditions become improved after received water resources in their villages. The young leader groups can enjoy and more participate in village social activities. The green and clean environment creates their better living style.

Moreover, the survey found that the poor communities could benefit directly from improved access to basic water and sanitation services through improved health, averted health care costs and time saved. Good management of water resources brings more certainty and efficiency in productivity across economic sectors and contributes to the health of the ecosystem.

5.2 Recommendations:

As tubewells are the main water sources for this study area, Dry Zone of Myanmar, the maintenance and rehabilitation of tubewell are key factor in order to sustain for the long-term use of those existing tubewells.

Due to decline of pump capacity or clogging of the old screen pipes of the tube wells, the amount of water discharge can be reducing after about 10 years of life. These wells should recover by rehabilitation of the tubewell and repair or replacement of pumps or its spare parts. From the viewpoint of effective use of these existing wells, a set of tubewell repair equipment with specified tools and accessories should be made available in the easy market. As a preventing measure, the villagers need to save the money by selling the water of the existing tubewell and keeping the spare parts (engine), water management fund for tubewell maintenance (developing, cleaning, replacing spare parts of the pump) in order to be sure to handle to solve any unexpected damage of the existing tubewells.

Although information on groundwater is sparse, the Dry Zone has moderate levels of the resource, with annual local recharge estimated at 4,777 Mm^3y^{-1}. This is equivalent to about half of the current surface water storage and less than 2% of total surface water resources. While groundwater is extremely important for the Dry Zone, its utilization must be planned and developed carefully to ensure it is used sustainably over the long term.

A major hindrance to the current (and previous) studies has been the lack of easily accessible data. Many data are dispersed across government departments and often held at division and district level. Some information is only available at individual scheme level and some simply cannot be obtained. Much monitoring, particularly of groundwater, has been limited and opportunistic, rather than strategic and inclusive.

There is an urgent need to establish an effective water-related data management system, comprising contemporary monitoring networks underpinned by appropriate data collection protocols and modern easily accessible databases and analyses tools. The development of such a system, encompassing both surface water and groundwater, must be a government owned process and should be a nation-wide endeavour. (IWMI, 2013)

Investment in rainwater harvesting and storage structures is needed to enable supplementary irrigation during the earliest stages of the crop cycle. Rooftop rainwater

harvesting is unlikely to be sufficient for more than domestic use, but the construction of small reservoirs that harvest water from a small catchment, while generally not sufficient for full dry season irrigation, could provide enough water for supplementary irrigation in the wet season (i.e. bridging dry spells) and at the start of the summer dry season. Such reservoirs could make a substantial contribution to safeguarding wet season yields. The Irrigation Department is well placed to provide technical assistance in the placement and construction of reservoirs. Currently, a local NGO, Proximity, is promoting the construction and rehabilitation of earth embankments in the Dry Zone. However, the primary focus is supply of domestic and livestock water, not irrigation. Past attempts at small reservoirs and tanks have had limited success due to problems of siltation and collapse of the embankments. The large number of reservoirs requiring rehabilitation in the Dry Zone is testament to the significant erosion problems. Consequently, greater consideration needs to be given to sustainability and upstream watershed management (i.e. measures that reduce flood runoff and sediment transport), in conjunction with the construction/rehabilitation of embankments, is essential.

REFERENCES

Brambert, Kiniorska. (2018). Changes in the Standard of Living in Rural Population of Poland in the Period of the EU Memembership, *Sciendo*, Volume 10: Issue 2.

Bosch, Hommann, Rubio, Sadoff and Travers. (2000). Water, Sanitation and Poverty. Retrieved from https://www.researchgate.net/publication/230557463

Central Statistical Organization (CSO), UNDP and WB. (2018). "Myanmar Living Conditions Survey 2017: Key Indicators Report"

Central Statistical Organization/UNDP. (2017). Measuring Myanmar's starting point for the Sustainable Development Goals, SDG Indicator Baseline Report.

Department of Rural Developement. (2016). National Strategy for Rural Water Supply, Sanitation and Hygiene (WASH) and WASH in Schools.

Dinka, M. O. (2018). Intechopen. Retrieved from https://www.intechopen.com/books/water-challenges-of-an-urbanizing-world/safe-drinking-water-concepts-benefits-principles-and-standards

Drury, A. R. (2017). Hydrogeology of the Dry Zone- Central Myanmar. Australian Water Partnership.

Dufour, M. S., WHO (2003). Assessing Microbial Safety of Drinking Water; improving approaches and methods.

Evans, Bartram, Hunter, Williams, Geere, Majuru, Bates, Fisher, Overbo, Schmidt. (2013). Research Gate. Retrieved from: https://www.researchgate.net/publication/283422043

FAO. (2012). Coping with water scarcity, An action framework for agriculture.

Government of the Republic of the Union of Myanmar. (2016). National Strategy for Rural Water Supply, Sanitation and Hygiene (WASH), WASH in Schools and WASH in Health Facilities (2016-2030).

Hutton, Haller. WHO (2004). Evaluation of the Costs and Benefits of Water and Sanitation Improvemetns at Glabal Level.

IWMI. (2013). Improving Water Management in Myanmar's Dry Zone for Food Security, Livelihoods and Health.

JMP. (2019). WASH in Health Care Facilities, Global Baseline Report.

Livelihoods and Food Security Thrust Fund, IWMI, NEPS. (2013, January). Water Resorurce Acessment of the Dry Zone of Myanmar. Retrieved from https://www.researchgate.net/publication/266261203

Mellor, J. E. (2009). Water and Sanitation Accessibility and the Health of Rural Ugandans. Ministry of Planning and Finance. (2018). Myanmar Sustainable Developement Plan (2018-2030).

MSR, UNDP. (2016). Impact Assessmen t Addressing Climate Change Risks on Water Resources and Food Security in the Dry Zone of Myanmar, Baseline Reprot .

Myint Zaw (2015). A Study on Status of Water, Sanitation and Hygiene (WASH), Pantanaw Township, Ayeyarwady Region. Unpublished MPA thesis, Yangon University of Economics

Myanmar IWRM Strategic Study (2014). Research and Analysis, Strategies and Measures

Department of Rural Development.(2016). National Strategy for Rural WASH and WASH in Schools and Health Facilities

Simon, R. (2015). Retrieved from https://www.slideshare.net/richisimon/concept-and-meaning-of-social-development.

Sorenson, S. B. (2011). Retrieved from http://repository.upenn.edu/spp_papers/166

Thet Htar Hsu. (2018). A Study on the Socio-Economic Conditions of Tharrawaddy Township, Unpublished MPA thesis, Yangon University of Economics.

Tun Naing Zaw ,Swun Wunna Htet& Min Thura Mon. (2018). Geohazards and Preliminary Studies on Environmental Degradatin in Bagan-Nyaung Oo Area, Mandalay Region. Journal of the *Myanmar Academy of Arts and Scienc.*

UN Water. (2016). The United Nations World Water Development Report.

United Nations. (2018). The Sustainable Development Goals Report.

United Nations., African Union., & African Development Bank. (2009). The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development.

UNWater. (2018). Sustainable Development Goal 6, Synthesis Report on Water and Sanitation.

UN-Water, WHO. (2017). Financing Universal Water, Sanitation and Hygiene under the sustainable development goals.

UN-Water., p. b. (2019). The United Nations World Water Development Report.

WHO. (2004). Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level.

WHO. (2017). Food Safety. Retrieved from WHO: https://www.who.int/news-room/fact-sheets/detail/food-safety

WHO/UNICEF. (2017). Progress on Drinking Water, Sanitation and Hygiene.

Wikipedia.(2019). Water Scarcity. Sciencedaily, Retrieved from https://www.sciencedaily.com/ terms/water_scarcity.htm.

World Water Council. (2017). Retrieved from https://www.worldwatercouncil.org/ en/water-crisis

Zin Mar Lwin. (2005). An Evaluation on Rural Water Supply Project with Special Reference to Water Supply Status in Bagan Nyaung Oo Township, Mandalay Division, Unpublished MPA thesis, Yangon University of Economics.

APPENDICES

Appendix (I)

Survey Questionnaire

Q1. Responder's Basic Information

Name	:	
Age	:	
Female/Male	:	
Role in the family	:	Household leader Husband Wife Son Daughter Other
Address	:	

Q2. In your family, who is taking responsibility of water fetching?

Q3 to Q8 are needed to answer for current situation.

Q3. In your family, water is using for which purpose?

- Drinking Domestic use Family garden
- Irrigation for business income

Q4. The average water usage of your one family member is …….

Gallon/ day.

Q5. How much water your family need for one day?

Q6. Currently, the drinking water for your family is

(a) collecting from which source?

- Tubewell Village pond River pipeline
- Rainwater storage tank others

(b) How far the water source from your house?

- Water point reaching to the house about 0.25miles about 0.5 miles
- about 1 mile about 2 miles about 3 miles

(c) How long the time is needed to get one drum (50 gals) of water?

□ 0 min □30 min □60 min □120 min □180 min □Other

(d) How much the water fees for one drum of water?

(e) How to collect this water?

□ Constructing pipe line water □by bull cart □by handcart □by motorbike

□ Buying from others □Other

Q7. Currently, the water using for domestic or irrigation purpose for your family is

(a) collecting from which source?

□ Tubewell □Village pond □River pipeline

□ Rainwater storage tank □others

(b) How far the water source from your house?

□ Water point reaching to the house □about 0.25miles □about 0.5 miles

□ about 1 mile □about 2 miles □about 3 miles

(c) How long the time is needed to get one drum (50 gals) of water?

□ 0 min □30 min □60 min □120 min □180 min □Other

(d) How much the water fees for one drum of water?

(e) How to collect this water?

□ Constructing pipe line water □by bull cart □by handcart □by motorbike

□ Buying from others □Other

Q8. Is there water shortage period? If any, how many month(s) per year?

□ No □Not more than one month □More than one month □about two month If any, how did you solve this water shortages problem?

Q9 to Q14 are needed to answer for the situation in last 20 years

Q9. In your family, water is using for which purpose?

□ Drinking □Domestic use □Family garden

□ Irrigation for business income

Q10. The average water usage of your one family member is …….
Gallon/ day.

Q11. How much water your family need for one day?

Q12. In last 20-years ago, the drinking water for your family is

(a) collecting from which source?

 Tubewell Village pond River pipeline
 Rainwater storage tank others

(b) How far the water source from your house?

 Water point reaching to the house about 0.25miles about 0.5 miles

 about 1 mile about 2 miles about 3 miles

(c) How long the time is needed to get one drum (50 gals) of water?

 0 min 30 min 60 min 120 min 180 min Other

(d) How much the water fees for one drum of water?

(e) How to collect this water?

 Constructing pipe line water by bull cart by handcart by motorbike
 Buying from others Other

Q13. In last 20-years ago, the water using for domestic or irrigation purpose for your family is

(a) collecting from which source?

 Tubewell Village pond River pipeline
 Rainwater storage tank others

(b) How far the water source from your house?

 Water point reaching to the house about 0.25miles about 0.5 miles
 about 1 mile about 2 miles about 3 miles

(c) How long the time is needed to get one drum (50 gals) of water?

 0 min 30 min 60 min 120 min 180 min Other

(d) How much the water fees for one drum of water?

(e) How to collect this water?

 Constructing pipe line water by bull cart by handcart
 by motorbike Buying from others Other

Q14. Is there water shortage period? If any, how many month(s) per year?

 No Not more than one month More than one month about two month If any, how did you solve this water shortages problem?

Q15. How effect to your family by changing the different water resources?

(a) Earning money (incomes) Improvement

 No change little improved significantly improved No answer
If any improvement, which are the followings: Choose one (or) more relevant

 Can use the cows, bulls in the irrigation instead of using in fetching water
 Save the time because of less fetching time
 Getting a chance to do another earning job
 Other, if any

(b)**Social Improvement**

 No change little improved significantly improved No answer If any improvement, which are the followings: Choose one (or) more relevant

 Can implement more community development activities
 Improving village dignify
 Creating the green environment in the village
 Creating the green environment in the village
 Higher living standards
 Creating more family life
 Creating happy and healthy family
 Other, if any

(c)**Health Improvement**

 No change little improved significantly improved No answer
If any improvement, which are the followings: Choose one (or) more relevant

 Improving toilet facilities

 Decreasing water related diseases
 Decreasing visits to the clinic for treatment
 Improving personal hygiene
 Improving health knowledge through higher education
 Other, if any

(d)Education Improvement

 No change little improved significantly improved No answer

If any improvement, which are the followings: Choose one (or) more relevant

 Improving school attendance
 Students are getting more study time
 Other, if any

Q16. Is there any effect/benefit upon reducing of water fetching time Yes No If it is yes, which of the following are utilized:

 The students in the family are getter more study time
 More willing to participate village development activities
 More earning money because of getting more time for business
 The children are actively participating in the exercise
 More pay attention to the family issues
 Other, if any

Q17. Frequency of water related diseases in your family?

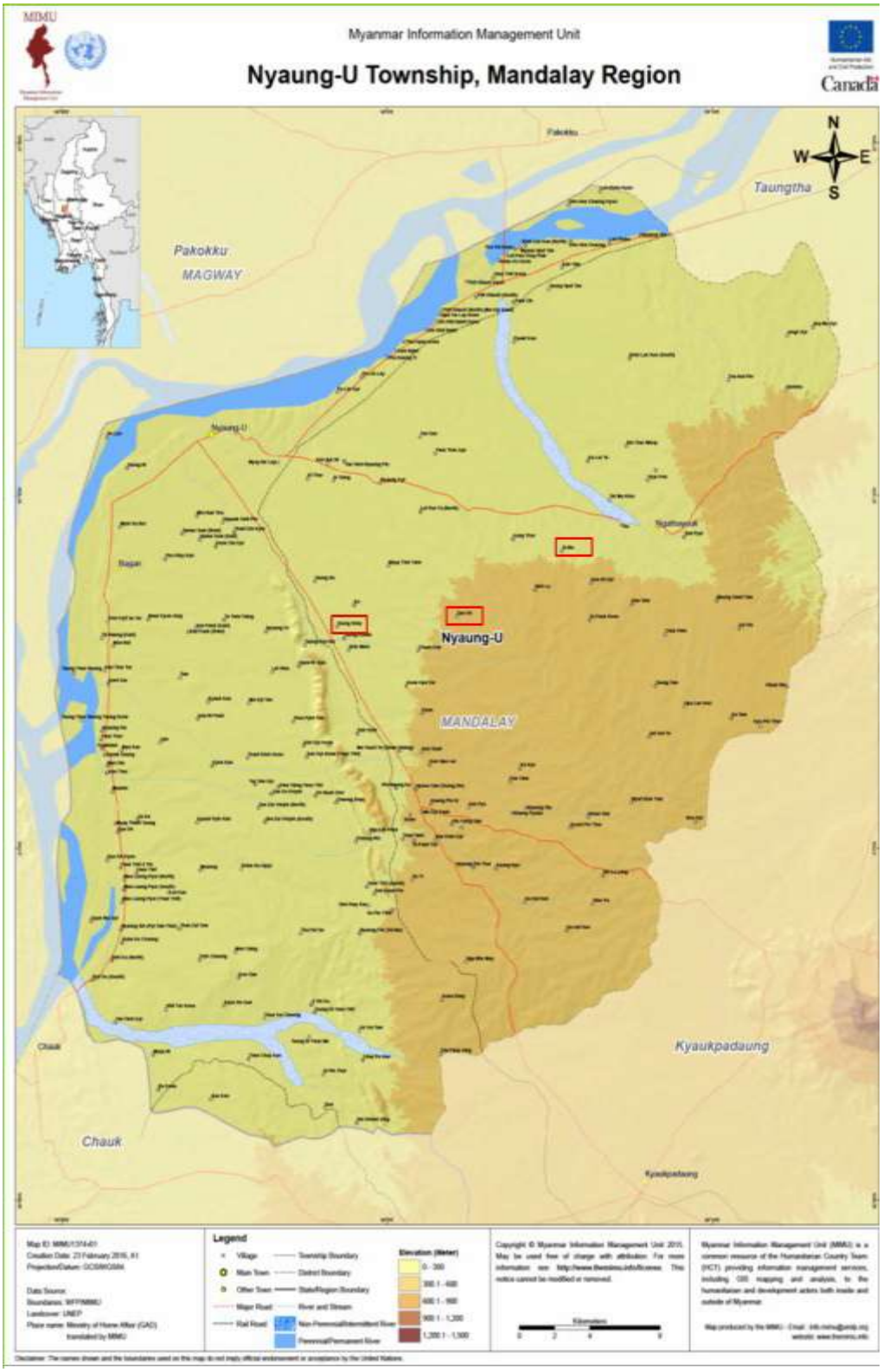
 Past 20-year ago/ …….. times Past 10-year ago/ …… times
 Past 5-year ago/ ……. times This year /…… times
 Other, if any

Q18. Please state other improvement in your family because of different water resources.

Q19. Please state other improvement in your village because of different water resources

---

Appendix (II)



Source: MIMU, 2019