YANGON UNIVERSITY OF ECONOMICS
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A STUDY ON THE WATR SUPPLY SYSTEM OF MANDALAY CITY DEVELOPMENT COMMITTEE CASE STUDY: (CHANMYATHAZI TOWNSHIP)

A thesis submitted as a partial fulfillment towards the requirement for the degree of Master of Public Administration (MPA)

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ABSTRACT

The objectives of the study are to examine the water supply system of Mandalay City Development Committee in Mandalay City and to analyze the water distribution and consumption of households in Chanmyathazi Township. A survey was conducted on 205 respondents in Chanmyathazi Township with structured questionnaires about the water supply, consumption and willingness to pay to access better quality of water. This survey was carried out on the households who live in Kan Thar Yar Ward and Myot Thit 3 Ward of Chanmyathazi Township. In this study, (205) respondents were interviewed by questionnaires in order to analyze the water distribution and consumption in Chanmyathazi township. It was found that only 83 respondents can access water from MCDC water supply system, and the rest 122 respondents rely on private owned tube wells, neighboring tube wells and water sellers because the city water supply cannot cover the daily demand. The overall satisfaction on MCDC water supply system is 71.1%. The main reasons of declining satisfaction on MCDC water supply system are water pressure and water quality. But both MCDC customers and Non-MCDC customers are willing to pay more if MCDC provides better water supply services.

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LIST OF ABBREVIATIONS

ADB	- Asian Development Bank
BPS	- Booster Pumping Station
DRA	- Demand Responsive Approach
FOC	- Free of Charge
KM	- Kilometer
MCDC	- Mandalay City Development Committee
MCWSS	- Mandalay City Water Supply System
MGD	- Million Gallons per Day
NRW	- Non-Revenue Water
OPEC	- Organization of the Petroleum Exporting Countries
WTP	- Water Treatment Plant
WTP	- Willingness to Pay

CHAPTER I

INTRODUCTION

1.1 Rationale of the study

Water is accepted as a basic ingredient for food production, a moderator of economic development and an essential element of the health functioning of all the world's ecosystems. Indeed, having sufficient, safe and clean water is one of the most essential requirements for human being's healthy life. Water – essential, finite, and increasingly scare – has been 'the new oil'.

Totally, about 97% of the earth's water is saline water stored in the oceans and only less than 3% of the total water resources in the world are fresh water. In addition, approximately 69% of the freshwater is stored in glaciers and ice cap, 30% is stored as ground water and less than 1% is found as surface water in rivers and lakes, which are the easiest access to available freshwater resources in the world (Nace, 1967).

A rapidly growing urban population leads to the dramatic increase of water consumption in the world. Issues related to water sustainability become major interest both locally and globally; however, water authorities and consumers have become increasingly concerned about the condition of non-revenue water (NRW) levels, together with water losses within the utilities system. NRW seriously affects the financial viability of water utilities and significantly threatens the sustainability of water supply system. In many countries, surface water resources are being depleted; more new dams are being constructed, while ground water in some areas effectively being extracted to such an extent that problems concerning both water quantity and quality have occurred.

Satisfactory water quality is essential important issue for mankind. Access to water is also a major global problem since a major fraction of the world's population does not have access to suitable drinking water. Available water resources for human

being are limited. Limited new natural water sources and rapidly increasing population have led to innovation methods to manage a water supply system.

Mandalay, the second largest city, is located in the central area of Myanmar. Firstly, the population of Mandalay is increasing. The population of Mandalay City increases from 810,000 in 2001 to 1,208,099 in 2018. In Mandalay City, the water supply system is carried out by Mandalay City Development Committee (MCDC). The water supply system of Mandalay City is an intermittent system and consists of 127 tube wells, moat, reservoirs, pumping stations and the associated distribution network. The piped water system is distributed to 70% of population of four townships and only 7% of population can be supplied in Pyigyitagon Township (Water and Sanitation Branch, MCDC).

Increasing population, urbanization and industrialization have contributed to a decrease in water supply capacity (high losses of water) and an increase of the water supply shortage in Mandalay City. The water supply sector would be adversely affected by over extraction of surface water and groundwater with new housing developments and the progress of economic activities. If there were no improvements in the management of water supply in the study area, Mandalay City, Mandalay City will face the scarcity of water sources and poor quality of water. This study illustrates the water supply system of Mandalay City Development Committee mainly focusing on water resources, groundwater flow and existing water supply system. Moreover, this study mentions the distribution of water and household's consumption level in Chanmyathazi Township.

1.2 Objectives of the Study

The objectives of the study are to examine the water supply system of MCDC in Mandalay City and to analyze the water distribution and consumption of households in Chanmyathazi Township.

1.3 Method of Study

In this study, descriptive method is used with both primary and secondary data. For secondary data, necessary information is collected from respective government offices and from internet websites. For primary data, a survey is

conducted on households in Kan Thar Yar Ward and Myot Thit 3 Ward of Chanmyathazi Township with a well-structured questionnaire.

1.4 Scope and Limitations of the Study

The main focus is to examine only on the water supply and consumption of Kan Thar Yar Ward and Myot Thit 3 Ward of Chanmyathazi Township. The sampling unit of the study is 205 households in Chanmyathazi Township. Although Chanmyathazi Township has 16 wards, there are some wards which cannot access water sources from MCDC. Kan Thar Yar Ward and Myot Thit 3 Ward have the most convenient water sources from MCDC.

1.5 Organization of the Study

This study is organized with five chapters. Chapter one includes introduction part of this study dealing with rationale of the study, objective of the study, method of study, scope and limitations of the study an organization of the study. Chapter two describes literature review of the study including water resources, the quality of water, water supply and distribution system and review on previous studies. Chapter three presents an overview of water supply and distribution system of Mandalay City Development Committee. Chapter four focuses on survey analysis water distribution and consumption in Chanmyathazi Township. Finally chapter five is conclusion with findings and recommendations of the study.

CHAPTER II

LITERATURE REVIEW

Water, a precious natural resource, is vital for physiological processes of all organisms. Moreover, water also has a social and economic value for human beings, and on the other hand, population growth and economic development put constant pressure on the ecosystems of resources (Alcamo, et al., 2007). However, the quantity and quality of water needed to maintain ecosystems are highly variable across space and time, as a function of environmental, ecological and climatic variable, as well as of human perceptions and attitudes (Covich, 1993). Water supplies in developing countries are devoid of treatment and communities have to make use of the most convenient supply (Sobesy, 2002 & Moyo, 2004). There is a strong positive correlation between water demand and urbanization or population growth (Malmqvist & Rundle, 2002). Therefore, one of the most important things to achieve the sustainable development of urbanized cities is to have sustainable management of water supply for various water uses in these cities.

The water is necessary for the biological life, but beyond that, the resources of the water play an essential role and ubiquitous in the health and well-being of a modern economy. Water resources are essential for human development. The water for direct human consumption is a small part of the criticism of the internal system evacuation of the wastewater. The water is an essential element in many industrial production processes and commercial, as well as input as a mean of waste disposal.

The system of surface water includes the enormous of the main stem, the rivers and the Great Lakes, as well as the thousands of small neighborhood of water and ponds. Add to this countless components is person, form the factory of the ponds of the first industrial era to the large reservoirs and canals of today. Resources in salt water are also one of importance. The salt water fishing is an important source of food. The coastal water provides the transport. The major part of the water on the earth is salt.

Throughout the history , saline water has not been available for human consumption, but the recent evolution of the technology of desalination and the increase of the scarcity of freshwater have made many communities towards the ocean for the supply of freshwater. A large part of the global supply of fresh water is more or less stuck in glaciers, ice caps, and elsewhere. This means that the supply of freshwater for the man and ecosystems must come from the relatively small amount flowing as surface water, or contains in groundwater. If all the freshwater supplies were distributed evenly on the global perfectly, there would be little shortages. Some regions enjoy a plentiful supply, while others face the extreme rarity.

The shortage of water is a major problem in all parts of the world and around 1.2 billion people of the world are without drinking water. The shortage is worsening day by day with the increase population and modernization. The scarcity of water has become an important element, economic, political and social issue with world leaders and premises. In many regions of the world, rain is the main source for the water. The rain is not reliable in general, and it has become very difficult to predict with the evolution of the global climate. Therefore, the problems of water shortage are more and more serious because of the decrease in precipitation, higher need of fast-growing population, the depletion of water resources and the absence of a legal framework for the management of the water. Currently the requirement of the annual amount of water on a global scale is approximately 6,000 to 7000 km^3. The reserved of groundwater in the world is approximately 7,000,000 km^3. This amount of excess water is brought into the soil each year by the process of precipitation and filtration.

As population growth, urbanization, and current policies and water management tools are becoming essential for urban water planners to see the overview of water system. Urban water systems can be improved by reducing water demands, increasing water recycling and reuse, creating alternative water supply sources from storm water/ rain water, providing water quality to end-use needs, and implementing multi-purpose, multi-benefit infrastructure to achieve environmental goals (O' Connor, Rodrigo & Cannan, 2010).

2.1 Water Supply and Its Importance

Water is essential to life. Fresh water is a renewable resource because of the hydrological cycle, which returns the water for surface water and groundwater. At the global level, there are abundant reserves of fresh water, but the sources are not evenly distributed. Surface water is held in the lakes, streams, rivers and other bodies of water which can be amended, built and managed in such a way as to make more functional for the extraction of the water or for other human activities. The additional storage space can be in the artificial reservoirs, anything from dams and canals of lakes in the towers of water.

In volume, the earth has 40 times more of groundwater for surface water, but the quantity of groundwater varies according to the regions. Nearly 1% of all the water (including sea water) is contents under the surface of the earth in spaces in pores, cracks and fissures in the bedrock and soils. The availability depends essentially on the underground geological formations must be sufficiently porous and permeable to both retain the water and allow it to flow through the rock. The porosity is the percentage of interstitial space in the total volume of the rock. For example, the sand and gravel are very permeable.

When a quantity of water available is located on the inside of a confined area, it is called an aquifer. While the aquifers can occur at various depths, those close to the surface can be used for irrigation and water supply. In an aquifer, the water has a tendency to move from recharge areas to areas of the discharge. Recharge occurs when the water between the aquifer by precipitation and the infiltration of the soil. Groundwater are usually more accessible by wells which can be dug, bored or drilled in rocks, allowing for the restoration of the groundwater to flow in an artificially created and pores in the local table of the water.

Looking at the planet of the space, if the earth was hypothetically a body, and then the water would be its soul. As the air, the sun and the power supply, without water, there would be no life on the planet. When humans change an ecosystem without thinking to maintain its natural balance, the cycle of life in the ecosystem can bias towards one side or the other and disrupt the fragile balance necessary to the maintenance of the community. Some species may die in the distance, and other can develop, but in the end the symbiotic relationships begin to break down and the

ecosystem dies. Global warming and climate change caused by pollution are on track to do so, unless that humans to work together to restore the balance of nature. Links of the water maintain all the ecosystems of the planet. The main function of the water is to propel the growth of the plants; provides a permanent housing for the species that live within it, or provides a temporary home or of reproduction for many amphibians, insects and other agencies have given birth to the water; and provides the nutrients and minerals necessary to the maintenance of the physical life. The nature as a nutrient is the most important and people need water to survive.

2.2 Water Quality

The quality of any body of surface or ground water is a function of both natural influences and human activities. Without human influences, water quality would be determined by the weathering of bedrock minerals, by the atmospheric processes of evapotranspiration and the deposition of dust and salt by wind, by the natural leaching of organic matter and nutrients from soil, by hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter they physical and chemical composition of water. As a result, water in the natural environment contains many dissolved substances and non-dissolved particulate matter. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of the organisms that rely on this ecosystem service.

Water can also contain substances that are harmful to life. These include metals such as mercury, lead and cadmium, pesticides, organic toxins and radioactive contaminants. Water from natural resources almost always contains living organisms that are integral components of the biogeochemical cycles in aquatic ecosystems. However, some of these, particularly bacteria, protests, parasitic worms, fungi, and viruses, can be harmful to human if present in water used for drinking.

The availability of water and its physical, chemical, and biological composition affect the ability of aquatic environments to sustain healthy ecosystems: as water quality and quantity are eroded, organisms suffer and ecosystem services may be lost. Moreover, an abundant supply of clean, usable water is a basic requirement for many of the fundamental uses of water on which humans depend. These include, but are not limited to:

1. water used for human consumption and public water supply;
2. water used in agriculture and aquaculture; water used in industry;
3. water used for recreation; and
4. water used for electrical power generation.

The quality of water necessary for each human use varies, as do the criteria used to access water quality. For example, the highest standards of purity are required for drinking water, whereas it is acceptable for water used in some industrial processes to be of less quality.

The quality of water required to maintain ecosystem health is largely a function of natural background conditions. Some aquatic ecosystems are able to resist large changes in water quality without any detectable effects on ecosystem composition and function, whereas other ecosystems are sensitive to small changes in the physical and chemical make-up of a body of water and this can lead to degradation of ecosystem services and loss of biological diversity. The degradation of physical and chemical water quality duce to human influences is often gradual, and subtle adaptations of aquatic ecosystems to these changes may not always be readily detected until a dramatic shift in ecosystem condition occurs.

Water quality is determined by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Drinking water quality guidelines and standards are designed enable the provision of clean and safe water for human consumption, thereby protecting human health. These are usually based on scientifically assessed acceptable levels of toxicity to either humans or aquatic organisms (United Nations Environment Programme, 2006).

2.3 Water resources

Water resources are divisible into two distinct categories: the surface water resources and ground water resources. Each of these categories is a part of the earth's water circulatory system, called the hydrological cycle, and is ultimately derived from precipitation, which is rainfall plus snow. They are interdependent and frequently the loss of one is the gain of the other. The brief description of the runoff cycle, which is a part of the hydrological cycle, will help to understand the origin and the interdependence of these two categories of water resources.

The water resource system itself consists of a vast array of interconnected components. The surface water system includes the huge-main Stem Rivers and great lakes, as well as thousands of small neighborhood streams and ponds the innumerable person-made components, from the millponds of the first industrial era to the vast reservoirs and canals of today. Then there is the vast, but unseen, system of groundwater aquifers, exceeding surface waters in terms of sheer quantity of water.

Certain resource, such as many groundwater aquifers, has replenishment rates that are so low that they are in effect nonrenewable. The use of nonrenewable resources is a problem with a strong intertemporal dimension; it involves trade-offs between the present and the future.

Rainwater is from roofs, stored in cisterns, for small individual supplies, and for larger, prepared watersheds, or catches, stored in reservoirs, for large communal supplies. Surface water is from streams, natural ponds, and lakes of sufficient size, by continuous draft, from streams with adequate flood flows, by intermittent, seasonal, or selective draft of clean flood water, and their storage in reservoirs adjacent to the weather flows but enough annual discharge, by storage of wet-weather flows in reservoirs impounded by dams thrown across stream valleys.

Groundwater is from natural springs; from wells, from infiltration galleries, basins, or cribs; from wells, galleries and, possibly, springs, with flows augmented from some other source; spread on the surface of the gathering ground, carried into charging basins or ditches, or led into diffusion galleries or wells; and from wells or galleries with flows maintained by returning to the groundwater previously withdrawn from the same aquifer for cooling or similar purposes.

2.4 Water Supply and Distribution System

Municipal water systems generally comprise; collection or intake works, purification or treatment works, transmission works, and distribution works. Collection works either tap a source continuously adequate in its flows for present and reasonable future rates of demand, or lend continuity to a source that is occasionally deficit by storing surplus waters for draft in times of drought.

Purification or treatment works render the incoming waters suitable for the purposes they are expected to serve: contaminated waters are disinfected; esthetically

displeasing waters are made attractive and palatable; iron-or manages-bearing waters are deferrized or demagnetized; corrosive waters are deactivated or stabilized; hard waters are softened; fluorine-deficient waters are fluoridated; and waters containing to much fluoride are defluoridated.

Transmission works convey the collected and treated water from the source to the community. Regional water systems may terminate at the point where they deliver water to member communities or water districts, or they may accept responsibility for the community or district distribution system as well.

2.5 Water Sustainability and Water Resource Management

Water is an important resource necessary for survival of human beings, economic development, and the functioning of the ecosystem. Organisms can live only where there is an access to adequate supplies of water. Issues of water quality and quantity have forever-troubled humans, characterized by the phenomena of floods, and droughts. While several recent efforts have made progress in defining the issues the sustainability issues of water resource management have not been clearly defined. Water resources are non-substitutable, very essential for the survival of human beings and their depletion may impose heavy economic costs and health consequences on future generations.

Misuse of water resources and poor water resource management practices have often resulted in depletion of aquifers, falling water tables, shrinking inland lakes, and stream flows diminished to ecologically unsafe levels. However, the availability of water sets the environment: less than 1% of the world’s fresh water resources are in rivers and lakes that easily available for use as fresh water on the earth. The allocation of water on earth is also set unfavorable with population.

Within the concern over the global implications of water problems, sustainability of water has been advanced as an important objective to be realized in natural resources management and water management as well. This concept is not new. It has been used in scientific literature for many centuries in fishery, forestry, groundwater, and other areas indication the rate of use of renewable natural resources to ensure the continuous supply of resources and maximum use.

Sustainability of water resources management is a set of activities that ensures that the social value of the services provided by a given water resources system will satisfy present social objectives without compromising the ability of the system to satisfy the objectives of future generations. This includes three considerations for water sustainability such as nature (river and its environment and ecosystem), current generation, and future generation needs. Thus, water resource systems must be considered as integral parts with a changing social system. The main principle for the sustainability of water resources is that the rate of extraction from both ground and surface water sources should not exceed the rate of renewal. Extraction must not jeopardize the biodiversity of the ecosystem. Equity is also important objective of sustainability. It is often expressed as the equitable distribution of the benefits, as well as the mitigation of adverse impacts on people affected by such development.

Water has no social or economic bounds, water supply management and development is the responsibility of national or city authorities in many countries. Therefore, these authorities should pay careful attention to water resource management because it can affect all sectors of society in the country. Each country, developed or developing must put together its own plan of action suitable for its hydrological conditions and needs. The plan and management for water must not only be developed in theory but also should be feasible and carried out in reality.

Water resources management includes development, control, protection, regulation, and beneficial use of surface and ground water resources. Services provided by a water sector include water supply for agricultural, industrial and municipal uses, wastewater collection and treatment, protection and enhancement of environmental resources, pollution prevention, recreation, navigation, hydroelectric power generation, storm water drainage, erosion and sedimentation control, and controlling floodwater and reducing damages due to flooding.

Water resources planning and management activities include policy formulation, national, regional and local resource assessments, institutional arrangement, legislations, and regulations, related financial management, formulation and implementation of resource management strategies, planning, design, construction, maintenance, and operation of structures and facilities, scientific and engineering research, education and training.

Sustainable management of water supply for various water uses in urbanized cities is extremely important to achieve the sustainable development of these cities. Comprehending the urban growth and clearly explaining options are two main requirements for effective decision-making about sustainable development of urban infrastructure (Grigg, 1997). Cities emerge and grow accompanied with population growth because of human resources and labor force availability and attraction to economic activities (Haughton & Hunter, 2004).

2.6 Demand Responsive Approach

The Demand Responsive Approach (DRA) has become the cornerstone of government and donor water supply policies throughout the world. Funding proposals, Country Action Plans and Implementation Manuals are full of references to DRA, and it is hard to find international non-governmental organizations (INGOs) or funding agencies that do not claim to be implementing projects based on this approach.

The shift from supply-drive water supply interventions to programmes focused on demand is easily understood. In general, supply driven water interventions have not succeeded in providing poor communities with sustainable water supplies. Communities who simply receive a water point, and who play a minor or symbolic role in project implementation understandably do not feel a sense of ownership of the project. As a result millions of dollars have been wasted as communities watch schemes, implemented on their behalf, fall into disrepair.

In response to solve these problems, the international water sector is increasingly trying to implement with different approach programmes. Instead of villagers drilling rigs in their community, DRA-based policies suggest that they must take the lead in water supply interventions. Communities have to demand improved services, play the lead role in the project, choose which facilities they and how they want to manage. They have to make meaningful contributions to their project in the form of cash, labor or in-kind contributions. Moreover, in the long term, the communities must take responsibility for sustaining their systems.

The principles of DRA are that: water is an economic and social good, management should be focused at the grassroots appropriate level, i.e. community or

water point users group. Women are critical players and not just water collectors, they generally respond to technical problems at water issue, and have more capacity. This capacity needs to be acknowledged and integrated into water supply services. Water resources should be managed in a holistic manner.

The basic aim is to enhance the chance for water supply service sustainability in the field. As such, DRA inspired policies are being promoted by many donors in the belief that they will effectively achieve sustainable water supplies (Water Aid, 2003). DRA influences as water should be seen as an economic good as well as a social good, water supply as a market- 'market test' – are users WTP at least much as the economic cost of providing these service.

Demand assessment is a broad discussion part about why and how donors and governments should consult with households and other stakeholders that are affected by projects and policy interventions. These potential beneficiaries, especially for poor households, have knowledge of and hold attitudes about the direct and indirect consequences of infrastructure.

2.7 Willingness to Pay to access the clean water

Willingness to Pay (WTP) is the maximum amount of money the consumer would give up in order to enjoy an improvement in quality (Haq, et.al 2007). The level of payment for water is directly proportional to financing of urban water supply infrastructure development (Wittington, et al., 1987, 1991). WTP could be over-estimated by private sector and under-estimated by government agency (Rogerson, 1996). However, WTP at household level can be affected by access to the other alternative water source which are reliable than the public water utility system (Littlefair, 1998). Adepoju and Omonona (2009) showed that the demand for improved water services is significantly related to the income of the household members.

Finding the correct value for non-revenue water in any system is often difficult, since in many instances considerable volumes of un-metered water are used, which have to be estimated. Where domestic water is not metered, much more of the volume of water actually consumed has to be estimated. For the control purpose, good quality data needs to be interpreted accurately and a clear understanding of supply

boundaries gained. The components of non-revenue water are determined by a field study with investigation of all properties in the study area and all the components of water distribution network such as reservoir, pumps, valves, pipes, etc. (Tabesh and Asadiani, 2005).

2.8 Reviews on Previous Studies

Literature reviews on previous MPA thesis papers guided how to approach the illustration of thesis topic and clarification with clear points.

Phyo Aung Hein (EMPA 11th Batch, 2018) had made a study on water supply system of Yangon City Development Committee (Case Study: Water Distribution and Consumption of Botahtaung Township). In this study, there was shortage of water and inadequacy of distribution of water in the study area because of population growth and increasing water demand in Yangon City, aging facilities in distribution network and higher percentage of non-revenue water. Both YCDC customers and Non-YCDC customers are willing to pay more for getting clean water from YCDC Water Supply System.

Then, Tun Myaing Win (EMPA 10th Batch, 2014) had made a study on accessibility of safe drinking water in Dala Township, Southern Yangon District. In this study, it was found safe drinking water management system is not really sufficient because low monthly income, regularly drinking water shortage in summer season and public awareness concerning the concept of dependency mindset on both government and drinking water donation association.

CHAPTER III

WATER SUPPLY AND DISTRIBUTION SYSTEM OF MCDC

3.1 Water resources in Myanmar

Total Natural Renewable Water Resources (NRWR) of Myanmar amount is annually is around 1,100 cubic kilometers. Water endowment (i.e., the total sustainable of water per inhabitant) is about 24,000 cubic meters per year, which are a relative high amount compared to other countries in the region (400 cubic meters) and the rest of the world.

Total water withdrawal is less than 5% of the renewable resource available; around 89% of this is for agriculture, 10% is for municipalities and 1% is for industries. Approximately 91% of the total withdrawal comes from surface water and 9% from groundwater. Groundwater is mostly used for domestic purpose (Asian Development Bank, 2013).

Myanmar has abundant surface water resources due to four main river systems and tributaries, the Ayewarwaddy, Thanlwin, Chindwin and Sittoung River. Catchment area covers almost 90% of the country. The levels rainfall in Myanmar, vary quite a lot according the geographical location. The driest areas receive less than 1,000 mm of rain annually, while the wettest parts may receive well over 5,000 mm. most rain falls during the south-west monsoon, originating from the Bay of Bengal. The valleys and river plains areas relatively dry as most rain passes over and only comes down in the hilly and mountains. Groundwater resources have been estimated at 156 cubic kilometers per year. Groundwater availability varies across the country according to hydrogeological conditions.

3.2 Background History of the Water Supply System in Mandalay Region

Mandalay city is located in the central region of Myanmar to at 21° 58' N 96° 04' E. It is also the second largest city and the last capital of the faithful of Myanmar. It is located to 445 miles north of Yangon and bordered by the Ayeyarwaddy River to the west. Population in 2016 is about 1.46 million. Mandalay's location in the central/ northern part of Myanmar makes it an important hub for transport of people and goods. Also in the religious context it is important, as it seen as the pilgrimage for the Buddhist. In the municipal area of Mandalay City, six cantons include, Aungmyaetharsan, Chanayetharsan, Chanmyathazi, Maharaungmyae, Pyigyitagon and Amarapura.

The main facilities supplying water to Mandalay City were constructed form 1983 until 1992 under Mandalay Water Supply Project co-financed by ADB, OPEC fund and Myanmar Economic Bank. Mandalay City Development Committee (MCDC) has been improving and expanding the water supply system subsequent to the ADB Project. At that time, the water is distributed to approximately 50% or 0.4 million of the population, and covers 60% or 65 km^2 of the City area.

The water source for the existing water supply system is groundwater, and the quantity of groundwater drawn is approximately 104,500 m^3/d according to a brochure published by MCDC in July 2000. Groundwater is drawn by tube well pumping stations (Tube well). The most of water drawn is conveyed to a reservoir at No.1 Booster Pumping Station (BPS1) for distribution to the consumers by pumps of BPS1 through a network of pipes.

Service area of this water supply system does not cover the eastern area from 60^{th} street and southern area. Residents of these areas have to rely on 24 spot water supply systems (MCDC well) constructed by MCDC and the similar 30 spot water supply systems (KOICA well) constructed by KOICA (Korea International Cooperation Agency), or the private wells as well. There are approximately 14,000 private wells in Mandalay City.

Before the completion of the ADB project, the moat water supply system and 13-production well system had been operated as the public water supply system. Although 13-production well system has not been used since completion of the ADB project, the moat water has been still used for fire-fighting and partly for domestic use

of mainly residents living in the area west of the Palace, but not counted as a public water supply system. The existing water supply system consists of tube wells, two booster pumping stations (BPS), distribution reservoirs, and distribution pipelines.

According to a report (Water Supply and Sanitation Sector review, UNDP), 12 million imperial gallons per day of water replenishes the Palace moat and comes from Sedawgyi dam, situated 46 km north east of the Palace.

Tube wells No. 1 to 19 were constructed from1983 to 1992 by ADB loan project and other tube-wells no 20 and the rest of the tube-wells are constructed by MCDC own budget. At the time, there are 127 MCDC tube wells. The numbers of booster pumping stations (BPS) also increase. There are 16 BPS in Mandalay city. No.16 BPS is not operating but the rest BPSs are operating well to distribute water to pipe network.

By combing with international organizations, MCDC has planned many water projects which aim to improve water supply system in the future. The following projects are currently being implemented in Mandalay City.

1. Amarapura Water Supply and Sanitation Project (AFD Grant Project)

2. Mandalay Urban Services Improvement Project (MUSIP) which covering water supply, wastewater, drainage, solid-waste, transportation, institutional strengthening and capacity building (both ADB and AFD Financed Projects)

3. Pyigyidagon 30% Water Supply Project (JICA Grant Project which was recently completed.

4. Pyigyidagon 70% Water Supply Project (the Netherlands Government Financed (50% Grant + 50% Loan Project) which is ongoing project.

5. Water Worx Project to improve the performance of the autonomously operating water company; MCDC in Mandalay (Vitens Evides International; the Netherlands)

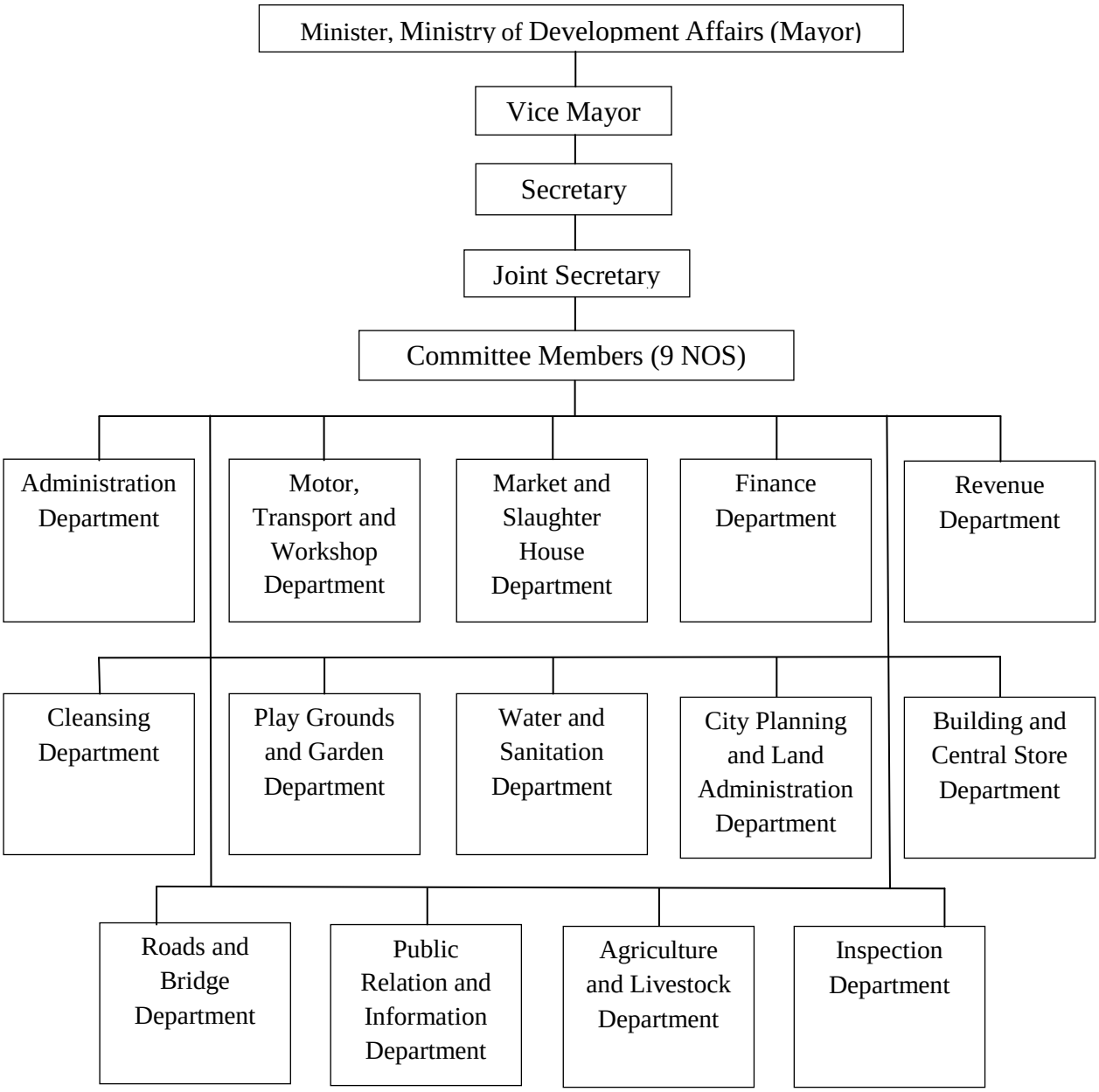
3.3 Mandalay City Development Committee (MCDC)

Firstly, MCDC was established by the State Law and Order Restoration Council's 1992 City of Mandalay Development Law. In 2002, the said law was repealed by State Peace and Development Council and replaced with the 2002 City of Mandalay Development Law. Mandalay Region Hluttaw enacted the new MCDC Law in 2014 December.

According to the provisions of Mandalay City Development Law, MCDC bestowed wide powers and authority, for instance, MCDC was authorized to implement its own project by using its own funding resources. However, at present, MCDC needs to apply permission of projects to the national government and the funding sources of MCDC are incorporated into the national budget by the new policy. MCDC set up as a ministerial level and comprises with 14 departments and one committee office, to create a modern city with the features and characteristics of city while preserving its greenery and the intrinsic beauty for its citizens by the guidance of the national government. MCDC is directly responsible for the development and maintenance of Mandalay in all aspects.

MCDC was formed by the Mandalay Regional Government, and legally comprises 13 to 15 members; the Chairman (Mayor), Vice-Chairman (Vice-Mayor), Secretary, Joint-Secretary, and the other are Committee Members. Mayor of Mandalay City is responsible not only the Chairman of MCDC but also the minister of MCDC is showing in Figure (3.1).

Figure 3.1 Organization Chart of Mandalay City Development Committee



Source: MCDC

3.3.1 Water and Sanitation Department

The water and sanitation department of MCDC was formed in 1992 to be responsible for the water supply of Mandalay, a city with a population of about 670,000 people. Water and sanitation department is one of the 14 departments under MCDC, which is responsible to supply clean and potable water to the citizens of Mandalay City and to serve sewerage and sanitation facilities of the city. The main tasks of water and sanitation department are:

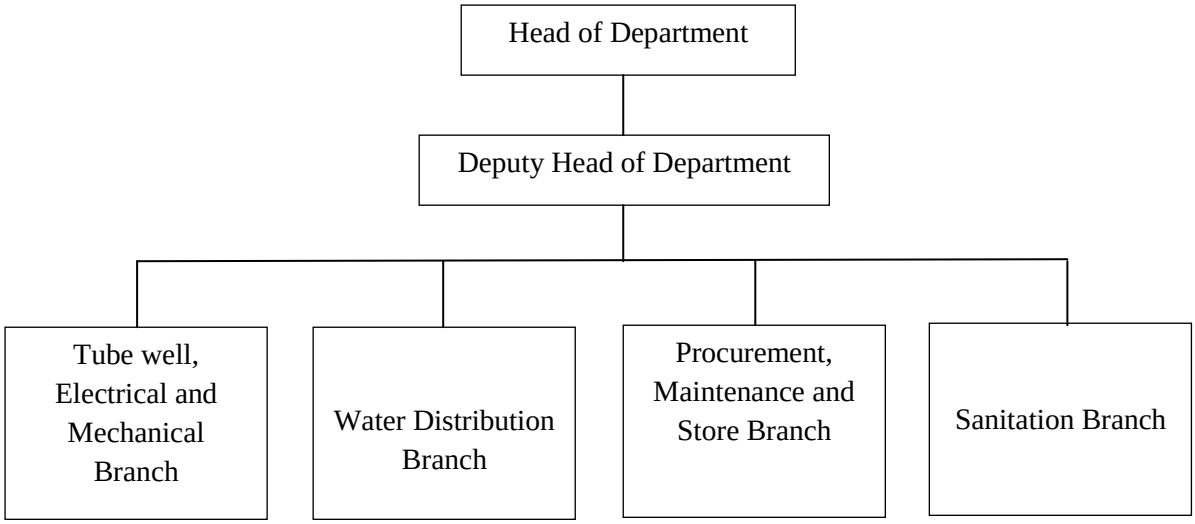
1. Formulation of water supply policies in Mandalay City
2. Preparation, allocation and control of budget for water supply and wastewater treatment & disposal.
3. Supply of enough clean water to meet the demand of city dwellers.
4. Controlling the water quality.
5. Billing the water charges for water supply system.
6. Operating and maintaining for the existing water supply system and wastewater treatment and disposal system.
7. Formulation and execution of plans for improvement including extension of the existing water supply system and facilities.
8. Procurement of pumps, pipes and equipment and materials related to water supply system and wastewater discharging system.
9. Formulation of wastewater treatment management & disposal in Mandalay City.
10. Control prevention of flood in low land area during the raining season.

There are 4 branches under water and sanitation department:

1. Tube well, electrical and mechanical branch
2. Water distribution branch
3. Procurement, maintenance and store branch
4. Sanitation branch

The total number of staff members the whole department was 415 in 2018. The below Figure illustrates the organization chart of Water and Sanitation Department.

Figure 3.2 Organization Chart of Water and Sanitation Department



Source: MCDC

3.4 Present Water Supply System

The existing water supply in Mandalay City has two main categories, namely MCDC owned facilities and private owned facilities. MCDC owned facilities included MCDC owned in-house connection, communal tanks, standpipe and other arrangement facilities. There are four levels in MCDC facilities. MCDC supply services level means the level of accessibility of water, which can be defined as individual level, Level I, Level II, and Level III.

Individual : there is a water source without pipeline network supply, only house owners can access the water source facility

Level I : there is a water source without pipeline network supply, beneficiaries' access to the water source facility

Level II : there is/are water sources(s) with pipeline network supply; however beneficiaries access the water from communal/ public faucets

Level III : there is/are water source(s) with pipeline network supply; beneficiaries can utilize the water from the in-house faucet (house connection).

3.4.1 Existing Main Source of Water

The sources of water for city water supply system are surface water and groundwater. Groundwater is the main source for city water system. The production amount of water per day from the water supply of MCDC is 40.42 MGD which contains 78.85% of groundwater and 21.15% of surface water. MCDC tube well, groundwater, produces 31.87 MGD. Ayeyarwaddy River and Sedawgyi Dam, surface water, produce 8.55 MGD.

(a) Surface Water Resources

The current water supply amount of Mandalay City Water Supply System (MCWSS) is 40.42 MGD, including the amount of water generated from Ayeyarwaddy River, i.e. 1.7 MGD and Sedawgyi Dam, i.e. 6.85 MGD. 25 numbers of tube-wells among 32 numbers along Ayeyerwaddy river bank are pumped out to the reservoir in BPS 1. Pumping out water amount to BPS 1 is 1.5 MGD.

Mandalay Hill Reservoir: Hill Reservoir is situated in halfway up on Mandalay Hill and was built in 1991 by the ADB project. The reservoir is a concrete structure having a capacity of 2.5 Million Gallons. BPS 8 boosts water from Ayeyarwaddy River to this reservoir. Gravity flow method is used when water is distributed to the pipe network.

Elevated Reservoirs: There are two (2) elevated tanks namely elevated reservoir No.1 and elevated reservoir No.2 in the distribution network. They were completed in 1991 by the ADB Project. Each reservoir is a steel structure with a capacity of 500m^3. High water level of elevated reservoir No.1 and elevated reservoir No.2 is 104 m and 93 m, respectively. Both of the capacity of elevated reservoirs is 1 Million Gallons and store water especially from MCDC tube wells.

(b) Groundwater Resources

MCDC is using ground water source from tube wells and pumped into ground water tank, then BPS boosts water to the supply network. At the present, there are 127 MCDC-owned tube wells with total maximum yield amount of 31.87 MGD, however actual yield amount is less that maximum amount is depending on the operation hours of the tube wells. People who cannot get MCWSS services are using private tube wells as a water source.

(c) Rain Water

Traditionally, rainwater is collected by private owned facilities such as drums, small tanks, containers, etc. rainwater is used for their individual purpose in many places.

3.4.2 Water Supply Facilities

There are two Water Treatment Plants (WTP) in the existing MCWSS. One treatment plant is used for the water from Ayeyarwaddy river and treated by slow sand method. The rest treatment plant is used for the water from Sedawgyi Dam and treated by rapid sand method. Only surface water is treated. The quality of ground water in Mandalay City is good. In MCWSS, there are 15 ground water tanks and 15 main pumping stations to transport water and to supply water with pressure.

3.4.3 Water Supply Pipe

In MCWSS, some transmission pipelines are more than 30 year old and choked by scaling. Also, the distribution network have been expanded year by year due to population growth in the city and development activities, thus, new and old pipe are mixed. The total length of transmission, distribution and internal network pipe line is 375.13 km. The total length of transmission pipe line is 11.2 km, the total length of distribution pipe line is 111.67 km and the total length of internal network pipeline is 252.26 km. The types of pipe which are used by MCDC are Ductile Iron Pipe, High Density Polyethylene Pipe and Polyvinyl Chloride Pipe (China).

3.4.5 Demand sites and coverage

The main objective of the whole system is to supply the adequate safe water for the city. According to the data of Water and Sanitation Department, the daily water consumption amount for a person in Mandalay City is 30 imperial gallons or 36 US liquid gallons. In 2018, the total daily water demand was 67 MGD but could provide only 40 MGD.

The water demand coverage of the MCWSS is about 70% of people who live in the northern part of the city, especially Aungmyaetharsan Township, Chanayetharsan Township, Chanmyathazi Township and Maharaungmyae Township.

3.4.5 Water Uses

In MCWSS, there were 99,6777 connections in July 2018, and out of these domestic meter connections are 90.16%, 2.5% is commercial meter connections and the rest 7.24% is departmental connections and free charge (FOC) connections.

3.4.6 Water Supply Service Condition

(a) Service Hours

In MCWSS, service hours vary depending on areas. Average supply duration is estimated as 4 hours per day. Details are shown in Table 3.1.

Table 3.1 Service Hours of Mandalay Water Supply System

Service Hours	Location
7:00 am -11:00 am	Northern part of 35th street
14:30 pm-17:30 pm	Aung Myae Tharsan Township, Chan Aye Tharsan Township, Chan Mya Thazi Township and Mahar Aung Myae Township.
22:00 pm-1:00 am	Southern part of 35th street

Source: MCDC, 2018

(b) Water Pressure

Average water pressure of MCWSS is about 0.75 bars. Hydraulically favorable areas get high pressure, while hydraulically unfavorable areas get low pressure.

(c) Water Tariff and Connection Fees

Water tariff and connection fees are paid by consumers from households and enterprises. The current water tariff has 5 categories, namely, Domestic, Commercial, Domestic Industry, Foreign Industry and Using Moat water. Using moat water is taxed by the size of pipe and the rest categories are taxed by unit. Water meter is read every two months and the bills are issued every. MCDC has the policy to collect water charges from all types of customers except some limitations such as government offices, monasteries, religious areas and residences of high officials.

At present, there are two main collecting systems, indicated billing system, and water meter billing system. Un-metered domestic customers are charged in flat

rate with integrated bill including other charges and taxes. Metered consumers are charged according to the meter reading. It is now the policy of MCDC that it practices universal metering for all domestic and commercial consumers.

Based on the user types, charges are different. Domestic use is 200 Kyats per unit, commercial use is 260 Kyats per unit, domestic industry use is 660 Kyats per unit and foreign industry use is 1100 Kyats per unit. For moat water, charges are determined by the sizes of pipes which users connect.

CHAPTER IV

SURVEY ANALYSIS

4.1 Survey Profile

Chanmyatharzi is located 21° 56' 0" North Latitude to 96° 5' 0" East Longitude and area is 2.58 Km^2. The township is located in south-central area of Mandalay. Chanmyatharzi is bounded by the Ayeyarwaddy River in the west, Maharaungmye Township in the north, Pyigyitagon Township in the south. Total population is 283,781 numbers, 16 numbers of wards, and 53,047 numbers of household. Entire population lives in urban areas. The population density of Chanmyatharzi Township is 11,002 persons per square kilometer. Chanmyathazi Township is one of the townships which can access water supply from MCDC. Therefore, Chanmyathazi Township is selected to conduct a survey. The survey questionnaire data were collected in Kan Thar Yar Ward and Myot Thit 3 Ward of Chanmyathazi Township.

4.2 Survey Design

The study is undertaken to analyze the water distribution and consumption of Chanmyathazi Township by quantitative research method for this survey. This study relies upon both primary and secondary data. The questionnaires are divided into three parts. The first portion the questionnaire is asked for obtaining the background information about the respondents of Chanmyathazi Township. The second portion of the questionnaire is about sources of water and water use. The last part of the questionnaire is about the MCDC water supply system. For this study, a sample of 205 households of selected wards was randomly chosen.

4.3 Survey Findings

The questionnaires related to water are regarding about water resources, access to water, water consumption and evaluation of existing service level in the study area. Survey findings are:

1. Source of water
2. Distribution of water
3. Time taken for fetching water
4. Household water consumption
5. Drinking water use practice
6. Using electric/fuel pump for getting water
7. Water meter installation and satisfaction of water pressure
8. Billing system
9. Sufficiency of water, satisfaction of water quality from existing water supply
10. Waterborne diseases and
11. Service level and satisfaction of overall water supply system from MCDC

4.3.1 Demographic Characteristics of Respondents

205 respondents of selected residents in Chanmyathazi Township are involved. The demographic characteristics of the respondents which include gender, age, occupation, marital status, religion, native place, educational level, total family member and average family income per month shown in Table (4.1).

Table (4.1) Demographic Characteristics of Respondents

Demographic Characteristics	Number of Respondents	Percentage
Gender		
Male	77	37.6
Female	128	62.4
Age		
22-34 years	42	20.5
35-44 years	44	21.5
45-54 years	60	29.3
55-64 years	29	14.1
More than 64 years	30	14.6
Occupation		
Government employee	4	2
Company employee	1	0.5
Own business	96	46.8
Casual Labor	19	9.2
Dependents	85	41.5
Marital status		
Married	156	76.1
Single	29	14.2
Divorced	13	6.3
Widowed	7	3.4
Religion		
Buddhist	191	93.2
Christian	1	0.5
Islamic	13	6.3

Table (4.1) Demographic Characteristics of Respondents (Cont'd)

Demographic Characteristics	Number of Respondents	Percentage
Native place		
Kachin	5	2.4
Kayin	2	1
Mon	3	1.5
Shan	5	2.4
Bago	2	1
Magway	46	22.4
Yangon	3	1.5
Mandalay	106	51.7
Sagaing	33	16.1
Educational level		
Illiterate	6	3
Monastery education	20	9.9
Primary	54	26.3
Middle	45	21.9
High	49	23.8
Degree and above	31	15.1
Total family member		
1 to 5 members	113	55.1
6 to 10 members	75	36.6
11 to 15 members	11	5.5
16 to 20 members	5	2.4
21 to 25 members	1	0.5
Average family income per month		
Under 100000 Kyats	4	2
100001 to 300000 Kyats	62	30.2
300001 to 500000	85	41.5
More than 500000 Kyats	54	26.3

Source: Survey Data, 2019

Among the respondents, male respondents are 37.6% and the remaining 62.4% are female. The age of respondents range from minimum 22 years to maximum 67 years, the age of 22 years to 34 years is 20.5%, 35 years to 44 years is 21.5%, 45 years to 54 years is 29.3%, 55 years to 64 years is 14.1% and more than 64 years is 14.6%. Maximum age group of respondent is 45 years to 54 years and the minimum age group of respondent is 55 years to 64 years.

As regard the occupation, 46.8% of high proportion respondents are ownership (own business). Moreover, dependents are 41.5%, government employee is 2%, and company employee is 0.5% while 9.2% of the respondents are casual labor.

Regarding marital status, most of the respondents (76.1%) are married among total 205 of respondents, while 14.2% are single, 6.3% are divorced and 3.4% are widowed. Most of the respondents (93.2%) are Buddhist, Islamic is 6.3% and Christian is 0.5%.

When the respondents were asked about native places, it is found that only 51.7% of total respondents are Mandalay origin whereas 48.3% are from the other states and regions. It shows the migration from other part of the country has come into existence in Mandalay City. At present, not only rural to urban migration is seen but also urban to urban migration is evident in Mandalay City. This is one problem that Mandalay City is facing and is trying to solve the consequences of this migration which has led to overcrowded houses and highly demand of water requirement and its consumption.

Educational level of the respondents is ranked by six levels. Among 205 respondents, the illiteracy are 3%, monastery education are 9.9%, low educational level (primary school) are 26.3%, middle educational level (middle school) are 21.9%, high educational level (high school) are 23.8% and advanced educational level (university and graduated) are 15.1%. Therefore, the highest proportion in educational level is low educational level (primary school).

Most of respondents (55.1%) have one to five family members. 36.6% of respondents (36.6%) have six to ten family members, respondents (15.4%) have eleven to fifteen family members and respondents (2.4%) have sixteen to twenty family members. Only 0.5% of respondents has more than twenty family members.

Among then, respondents' families (2%) have under 100000 kyats, respondents (30.2%) have between 100001 kyats and 300000 kyats, respondents (41.5%) have between 300001 kyats and 500000 kyats and respondents (26.3%) have up to 500000 kyats. Therefore, most of the families among the study population have a middle average family income because they do own businesses.

4.3.2 Sources of water and water use

Water is needed by all household, many social and economic amenities, government offices, educational institutions, religious establishments, hospitals and a large number of industries. Water is needed by all these players both as a basic commodity in itself and important raw material in the production process. There are four different types of sources in the study area which are as follows:

1. MCDC Central Water Supply System
2. Private Owned Tube well
3. Neighboring Tube well
4. Water seller

Table 4.2 Sources of Water

Sources of Water	Number of Respondents	Percentage
MCDC Central Water Supply System	83	40.5
Private Owned Tube well, Borehole or pump	78	38
Neighboring Tube well, Borehole or pump	5	2.5
Water Seller	39	19
Total	**205**	**100**

Source: Survey Data, 2019

As per survey data in Table 4.2, 40.5% out of total respondents are from MCDC Central Water Supply System users and 38% out of total respondents get water from private owned tube wells. 19% out of total respondents purchase from water seller and 2.5% of respondents mentioned that they get water from their neighbors' tube wells.

Table 4.3 Household's Water Consumption

Water Consumption (Barrel per day)	Number of Respondents	Percentage
1-2	98	47.8
3-4	68	33.1
5-6	28	13.7
7-8	7	3.4
9-10	4	2
Total	**205**	**100**

Source: Survey Data, 2019

According to 4.3, 47.8% out of total respondents show that their households needed to use 1-2 barrels (approximately 100 gallons) of water for daily use, 33.1% of respondents used 3-4 barrels and followed by 13.7% of respondents consumed 5-6 barrels of water, and 3.4% of respondents use 7-8 barrels of water. The rest 2% of respondents need to use 9-10 barrels of water in a day.

Table 4.4 Monthly Total Expenditure of water for MCDC Respondents

Amount (Kyat/month)	Number of Respondents	Percentage
1-1,500	9	10.8
1,501-3,000	16	19.3
3,001-4,500	20	24.1
4,501-6,000	19	22.9
6,001-7,500	5	6.0
7,501-9,000	2	2.4
9,001-10,500	3	3.6
10,501-12,000	3	3.6
12,001-13,500	1	1.2
13,501-15,000	3	3.6
Above 15,000	2	2.4
Total	**83**	**100**

Source: Survey Data, 2019

Table 4.4 shows that monthly total expenditure of water for MCDC respondents. MCDC respondents paid a minimum of under 1,500 Kyats per month and the maximum amount is up to 15,000 Kyats per month. Expenditure depends on the usage of water. The total expenditure includes paying bill from MCDC but does not include the purchase of purified drinking water for everyday use. The different expenditures of each respondent are based on the size of the family member and the amount of water usage.

Table 4.5 Monthly Total Expenditure of water for Non-MCDC Respondents

Amount (Kyat/month)	Number of Respondents	Percentage
0	5	4.1
1-1,500	8	6.6
1,501-3,000	15	12.3
3,001-4,500	15	12.3
4,501-6,000	22	18.0
6,001-7,500	7	5.7
7,501-9,000	3	2.5
9,001-10,500	8	6.6
10,501-12,000	3	2.5
12,001-13,500	0	0
13,501-15,000	26	21.3
Above 15,000	10	8.2
Total	**122**	**100**

Source: Survey Data, 2019

According to survey data, Table 4.5 shows that monthly total expenditure water from Non-MCDC respondents. Non-MCDC respondents paid minimum 0 Kyat per month and maximum amount is up to 15,000 Kyats per month depend of the usage of water. The total expenditure includes paying for water from different sources but does not include purchase of purified drinking water for everyday use. Some of respondents highlighted that they live together with all relatives in same compound and it causes more expenditures for the usage of water for every month. Some households can use water from their neighbors' tube wells without paying any cost.

Table 4.6 Suitable drinking water from all sources

Suitability of drinking water	Number of Respondents	Percentage
Yes	125	61
No	80	39
Total	**205**	**100**

Source: Survey Data, 2019

Table 4.7 Accessing of Drinking water

Accessing of Drinking water	Number of Respondents	Percentage
Purified drinking water (bottled)	145	70.7
Boiled	3	1.5
Natural water	56	27.3
Using purifier filter	1	0.5
Total	**205**	**100**

Source: Survey Data, 2019

As per Table 4.6, 61% out of total respondents mentioned that the water from all sources is suitable as drinking water and the rest 39% respondents stated that water is not suitable for drinking because water sometimes involve bad smell, chlorine and little snail. In Table 4.7, 70.7% of total respondents purchased bottled/purified drinking water, followed by 27.3% of respondents drink natural water and 1.5% of respondents boil water for drinking. The rest 0.5% of respondent set up water purifier to get drinking water.

Table 4.8 Sufficient water supply

Sufficiency of water supply	Number of Respondents	Percentage
Yes	188	91.7
No	17	8.3
Total	**205**	**100**

Source: Survey Data, 2019

According to Table 4.8, 91.7% of total respondents are able to access sufficient water supply for the whole year-round. The rest 8.3% of respondents said they do not have sufficient water supply in dry season.

Table 4.9 Type and Capacity of Water Storage Tank

Type of Storage Containers	Frequency of Storage Capacity															Total	Percentage (%)
	25 gal	50 gal	100 gal	150 gal	200 gal	250 gal	300 gal	400 gal	500 gal	600 gal	700 gal	800 gal	1000 gal	1500 gal	3000 gal		
Ground water tank	-	1	12	-	36	1	3	25	4	7	-	3	2	1	1	96	46.8
Overhead tank	-	1	-	-	6	-	-	7	-	-	1	1	-	-	-	16	7.8
Drum	-	5	5	1	11	-	5	11	1	1	-	-	-	-	-	40	19.5
Others (pots, plastic containers, etc.)	6	34	8	-	4	-	-	-	-	-	-	-	-	-	-	52	25.4
No storage tank	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.5
Total																**205**	**100**

Source: Survey Data, 2019

Most of the respondents needed to store water for their daily use. 204 (99.5%) out of total respondents needed to store water, only 1 (0.5%) respondent used water directly from pumping. 46.8% of total respondents stored water in ground water tank, 25.4% of respondents stored water in pots and plastic container, and followed 19.5% of respondents stored water in drum and the rest 7.8% of respondents stored water in overhead tanks.

4.3.3 MCDC Water supply System

Actually, average duration of MCDC water supply is four hours per day. As per survey data 83, out of 205 respondents that are 40.5% of total respondents used water from MCDC water supply system. According to table 4.10, 25.3% of MCDC respondents are able to access 2-4 hours per day from MCDC supply pipes. Followed by 20.5% of MCDC respondents are able to access 5-7 hours per day, 14.5% of MCDC respondents are able to access 8-10 hours per day, 3.6% of MCDC respondents are able to access 20-22 hours per day, 1.2% of MCDC respondents are able to access 11-13 hours per day. The rest 34.9% of MCDC respondents can access water from MCDC pipelines 24 hours without interruption.

Table 4.10 Total duration of MCDC Water Supply per day

Hours per day	Number of Respondents	Percentage
2-4	21	25.3
5-7	17	20.5
8-10	12	14.5
11-13	1	1.2
14-16	0	0
17-19	0	0
20-22	3	3.6
24 Hours	29	34.9
Total	**83**	**100**

Source: Survey Data, 2019

Table 4.11 Ratio of Using Electric Pump for Fetching MCDC Water

Using Electric Water Pump for Fetching MCDC Water by MCDC Respondents	Number of Respondents	Percentage
Yes	76	91.6
No	7	8.4
Total	**83**	**100**

Source: Survey Data, 2019

Among 83 MCDC respondents, 91.6% of total respondents used electric water pump to get water from MCDC water supply pipes because the water pressure is very low. Only 8.4% do not use water pumps for getting water from MCDC supply pipes. Customers who do not need to use electric pump connect with new pipe line system, therefore the water pressure is high.

Table 4.12 Satisfaction on MCDC water quality (bathing, washing, cleaning)

Satisfaction on MCDC water quality (bathing, washing, cleaning)	Number of Respondents	Percentage
Yes	82	98.8
No	1	1.2
Total	**83**	**100**

Source: Survey Data, 2019

According to Table 4.12, 98.8% of total MCDC respondents expressed that they are satisfied with MCDC water quality for bathing, washing and cleaning. The rest 1.2% of respondents said they are not satisfied with the quality of water from MCDC for indoor uses because the color of water is sometimes dark.

Table 4.13 Satisfaction on MCDC water quality for cooking

Satisfied with MCDC water quality for cooking	Number of Respondents	Percentage
Yes	71	85.5
No	13	14.5
Total	**83**	**100**

Source: Survey Data, 2019

According to Table 4.13, 85.5% of total MCDC respondents expressed that they are satisfied with MCDC water quality for cooking. The rest 14.5% of respondents said they are not satisfied the quality of water from MCDC for cooking because water contains bad smell, chlorine smell and turgidity.

Table 4.14 Water Meter Installation

Water Meter Installation	Number of Respondents	Percentage
Metered	83	100
Un-metered	0	0
Total	**83**	**100**

Source: Survey Data, 2019

According to Table 4.14, all of MCDC respondents installed water meters. Some are well functioning. Some are not well functioning because they have been set up since 1992 and there is no regular maintenance by respective staffs.

Table 4.15 Respondent's Perception on Water Pressure from MCDC water supply

Particular	Number of Respondents	Percentage
Sometimes high/ sometimes low pressure	2	2.4
Low pressure	5	6.0
Always low pressure	68	81.9
High pressure	2	2.4
Always high pressure	6	7.2
Total	**83**	**100**

Source: Survey Data, 2019

Respondent's perception on MCDC water supply pressure (Table 4.15) shows that 81.9% of respondents said "always low pressure", 7.2% of respondents said "always high pressure", 6% of respondents said "low pressure", 2.4% of respondents said "high pressure" and the rest 2.4% of respondents said "sometimes high/ sometimes low pressure". Respondents who said "high pressure and always high pressure" connected pipes with new distribution pipe lines from MCDC water supply system and they do not need to use electric water pump to fetch water.

Table 4.16 Satisfaction on MCDC water supply pressure by Respondents

Satisfaction on MCDC water supply pressure	Number of Respondents	Percentage
Satisfied	33	39.8
Not Satisfied	50	60.2
Total	**83**	**100**

Source: Survey data, 2019

60.2% of MCDC respondents answered that they are not satisfied with current water supply pressure because they have to use electric water pump to get a steady supply of water from MCDC water supply line and they have to pay additional charges for using electric. 39.8% of respondents are satisfied on MCDC water pressure because they do not want to use private owned tube wells. The water pressure depends on whether the respondent's house is located the main distribution pipe and pumping station.

Table 4.17 Difference between water consumption in actual and unit quantity in water bill

Particular	Number of Respondents	Percentage
Bill meter quantity same as actual consumption	59	71.7
Bill meter quantity different from actual consumption	24	28.9
Total	**83**	**100**

Source: Survey Data, 2019

Metered connections are charged by fixed rate per unit billing system every two months per once. 71.1% of MCDC respondents answered that the quantity of water in billing system is equal as actual consumption. The rest 28.9% mentioned that the quantity of water in billing system is different from actual consumption. Some respondents who have not well functioning water meters pay water bill at a rate which is regarded by a team of township staff. With regard to metered rates, water meters are read by a team of staff in every two-month pre-once. The task of these teams is to visit each household where the water meter is fixed, read the meter, and prepare to issue bill to customer. Customers pay according to the meter use.

Table 4.18 Types of billing system

Types of billing system	Number of Respondents	Percentage
Fix rate	76	91.6
Flat rate	7	8.4
Total	**83**	**100**

Source: Survey Data, 2019

According to Survey data, well metered connections are charged at fix rate for two months per time, 91.6% of MCDC consumers are charged at fixed rate and 8.4% of respondents with not well metered connections are charged by flat rate. Fix rate is 200 Kyats per unit. Flat rate is decided by the team of township staff who go to read the meter, therefore it is not easy to guess the flat rate.

Table 4.19 Quality of the water supply by MCDC

Quality of water	Number of Respondents	Percentage
Very Good	5	6
Good	37	44.6
Fair	40	48.2
Bad	1	1.2
Total	**83**	**100**

Source: Survey Data, 2019

As per Table 4.19, 48.2% of respondents answered that the quality of the water form MCDC is “Fair” and 44.6% of respondents answered “Good” and 6% of respondents answered “Very Good” and the rest 1.2% answered “Bad”. Therefore, it could be seen that the majority are satisfied with the quality of water from MCDC.

Table 4.20 Causes of water borne diseases by MCDC water

Water borne diseases (Diarrhea/Dysentery/Cholera etc.)	Number of Respondents	Percentage
Not infected	81	97.6
Infected	2	2.4
Total	**83**	**100**

Source: Survey Data, 2019

As unpurified water or contaminated water can cause diseases such as diarrhea, dysentery etc. the respondents are asked if there are such cases consuming MCDC water, 97.6% of the total respondents stated as not infected, however, the rest 2.4% stated as infected.

Table 4.21 Willingness to Pay for 24 hours clean Water Supply by MCDC Respondents

Amount of Willingness to Pay (Kyat/month)	Number of Respondents	Percentage
1-2,500	8	9.6
2,501-5,000	31	37.3
5,001-7,500	13	15.7
75,01-10,000	14	16.9
10,001-12,500	4	4.8
12,501-15,000	6	7.2
15,001-17,500	0	0
17,501-20,000	4	4.8
Above 20,000	3	3.6
Total	**83**	**100**

Source: Survey Data, 2019

According to Table 4.21, all of MCDC respondents are willing to pay (WTP) more for 24 hours clean water from MCDC water supply services and they suggested to have better services from MCDC. Above the Table 4.21 shows the minimum amount 1-2,500 Kyats per month the respondents were willing to pay for improvement of water supply services and maximum amount the respondents were willing to pay was above 20,000 Kyats per month.

Table 4.22 Willingness to Pay for Clean Water Supply by Non-MCDC Respondents

Amount of Willingness to pay (Kyat/month)	Number of Respondents	Percentage (%)
No	5	4.1
1-1,500	5	4.1
1,501-3,000	17	13.9
3,001-4,500	8	6.6
4,501-6,000	43	35.2
6,001-7,500	9	7.7
7,501-9,000	2	1.6
9,001-10,500	17	13.9
10,501-12,000	1	0.8
Above 12,000	15	12.3
Total	**122**	**100**

Source: Survey Data, 2019

According to Table 4.22, 4.1% of total Non-MCDC respondents mentioned that they were not willing to pay (WTP) anymore for getting clean water supply from MCDC because they have private own tube wells and they do not want to connect MCDC water supply pipe. The rest 95.9% of respondents mentioned that they were willing to pay more for getting MCDC clean water supply. The minimum amount they were willing to pay was 1-1,500 Kyats per month and the amount of maximum willing to pay was above 12,000 Kyats per month to get water from MCDC supply system.

Table 4.23 Overall satisfaction by consuming MCDC water supply

Overall Satisfaction	Number of Respondents	Percentage (%)
Satisfied	59	71.1
Unsatisfied	24	28.9
Total	**83**	**100**

Source: Survey Data, 2019

The overall satisfaction of MCDC customer's on water supply sufficiency, water pressure and duration of getting water from MCDC water supply line, water quality, and water billing system shows that the majority of the respondents (71.1%) are satisfied with MCDC water but still there is 28.9% not satisfied with this.

CHAPTER V

CONCLUSION

5.1 Findings

This study aims to examine the water supply system of MCDC in Mandalay City and to analyze the water distribution and consumption of households in Chanmyathazi Township. In order to analyze the water distribution and consumption of holseholds issue in Mandalay region, Chanmyathazi Township was selected to conduct the survey and the sample size was 205 households from Kan Thar Yar Ward and Myot Thit 3 Ward.

The survey questionnaire included demographic characteristics; gender, age, occupation, marital status, religion, native place, educational level, total family member and average family income per month. In this study, the questions concerning sources of water and water use were asked based on sources of water, household's water consumption, monthly total expenditure for water, suitable drinking water from all sources, accessing of drinking water and type and capacity of water storage tank. This study also examined the water supply system of MCDC such as total duration of MCDC water supply per day, using electric pump for fetching MCDC water, water meter installation, perception on water pressure from MCDC water supply, satisfaction on MCDC water supply pressure, billing system, quality of the water supply by MCDC, water borne diseases and willingness to pay for clean water.

It was found that 51.7% of respondents are Mandalay origin whereas the rest are from other states and regions. But there is no migration from Chin, Rakhkhine, Ayeyarwaddy and Taninthayi. Especially, most of people who moved from Magaway region lost their farm land because of Ayeyarwaddy bank erosion. Rural to urban migration is a problem that the vast majority of these people will be living in overcrowded slums with inadequate, water and sanitation services. Among 205 respondents, 85 (41.5%) respondents earn income between 300,001 and 500,000

Kyats per month by doing own business. According to survey data, 46.8% of respondents are business owner.

In Mandalay City, MCDC water supply is one of the sources to get water for domestic use. According to survey data, only 83 (40.5%) respondents can access water from MCDC water supply system. This is because MCDC water supply cannot provide sufficient water supply for increasing population in Mandalay City. Moreover, 122 respondents (59.5%) access water from tube wells. 98 respondents (47.8%) use average one to two barrels (50 gallons to 100 gallons) per day. The reason of low level for water consumption is due to the cold season but water consumption in the hot season is relatively high.

Minimum monthly total expenditure of water for MCDC respondents is under 1,500 Kyats per month and maximum amount is up to 15,000 Kyats per month. Minimum monthly total expenditure of water for Non-MCDC respondents is 0 kyat and maximum amount is up to 15,000 Kyats per month. It can be seen that both MCDC respondents and Non-MCDC respondents pay the same amount of expenditure for getting water.

In order to secure public health and improve the living environment, distributed water must be disinfected properly and appropriate treatment is indispensable to allow the existing water to be used as a source of drinking water. Among 205 respondents, 80 respondents answered that water from tube wells and MCDC water supply system can be used as drinking water. The main water source of MCDC water supply system is from ground water. The quality of ground water in Mandalay City is rather good. 125 respondents buy purified drinking water (bottled) because they are sensitive about the quality of water. 4.16, 91.7% of total respondents are able to access sufficient water supply from both MCDC water supply system and tube wells for the whole year. The rest 8.3% said insufficient water supply in dry season.

Average duration of MCDC water supply system is four hours per day. 34.9% of MCDC respondents can access water from MCDC pipelines 24 hours without interruption. Because of illegal pipe connections from distribution pipe line, total duration hours vary. Only 25.3% of MCDC respondents could answer the correct average duration of MCDC water supply system.

91.6% of MCDC respondents have to use the electric water pump for to fetch water from MCDC water supply pipes because the water pressure is very low. When the perceptions on water pressure from MCDC water supply system were asked, 81.9% of MCDC respondents mentioned that the water pressure is always low and have to use the electric water pump. It costs more electric charges. Therefore, 60.2% of MCDC respondents are not satisfied with the water pressure.

Based on the study, the rest 14.5% of respondents are not satisfied the quality of water from MCDC for cooking. The reason is because water contains bad smell, chlorine smell and turgidity. But an overall satisfaction on the quality of water from MCDC water supply system is relatively high. Only 1.2% of MCDC customer is not satisfied with the quality of water from MCDC. The overall satisfaction of MCDC customer's on the whole MCDC water supply system is 71.1% based on the services of MCDC.

5.2 Recommendations

With rapid urbanization in country, exiting water supply services have been unable to cope with the increased demand for water arising from growing population and rapid economic growth. Some of the MCDC's problems are the increasing population growth, extension of new townships, industrial and commercial development, increasing water demand, customer complaints for water pressure & water quality, aging facilities in pipe network, insufficient operation and maintenance facilities. In order to decrease the MCDC's problems especially on the water supply system, it is important to make reviews on the whole water supply system. Therefore, MCDC should also take an analysis on its water supply system in order to provide the best services for users.

MCDC distributes the good quality of water. Chlorine smell should be checked before the water is distributed into the distribution pipes because some MCDC respondents get water which contains chlorine smell and it causes to decrease the quality of water from MCDC water supply system. Staffs from water distribution branch should follow up the regular monitoring to the pipe lines to reduce pipe leakages and should take pipe maintenance activities as soon as possible because pipe leakages decline the quality of water from MCDC. That is one of the facts declining

the quality of water. Moreover, aging pipe network should be replaced to rise up the quality of water. MCDC uses ground water as the main source for the city water supply system but it should be more environmental friendly. To handle this issue, surface water, Ayeyarwaddy River is treated enough to use for the water supply system.

Finally, MCDC should do awareness campaigns concerned with its water supply services to the users for willingness to pay more and should expand pipe network area to cover the daily demand. When people do not get sufficient water supply for MCDC water supply system, tube wells are used as the source of water supply. Extracting water from ground should also be controlled by MCDC to retain the water source for the city.

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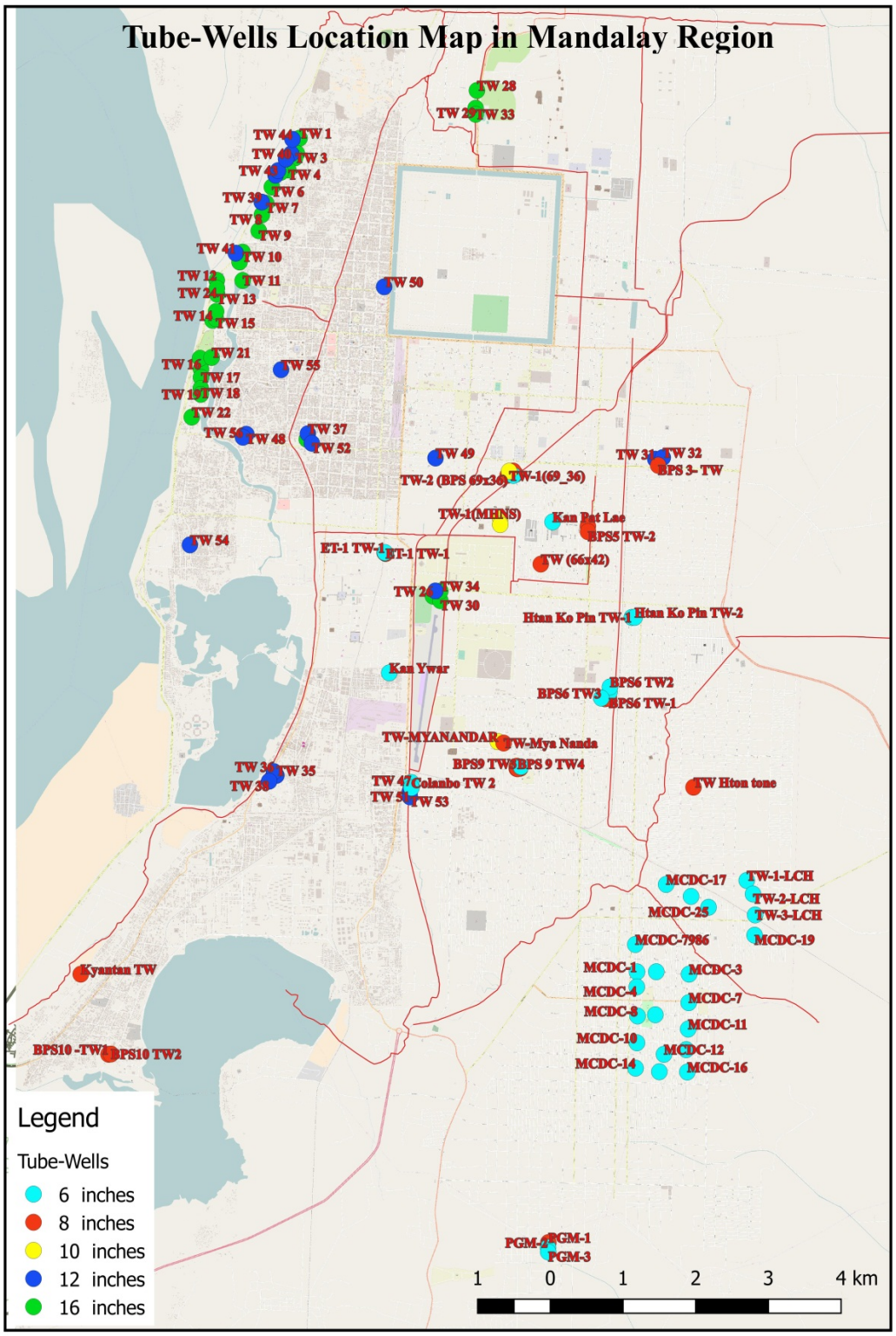
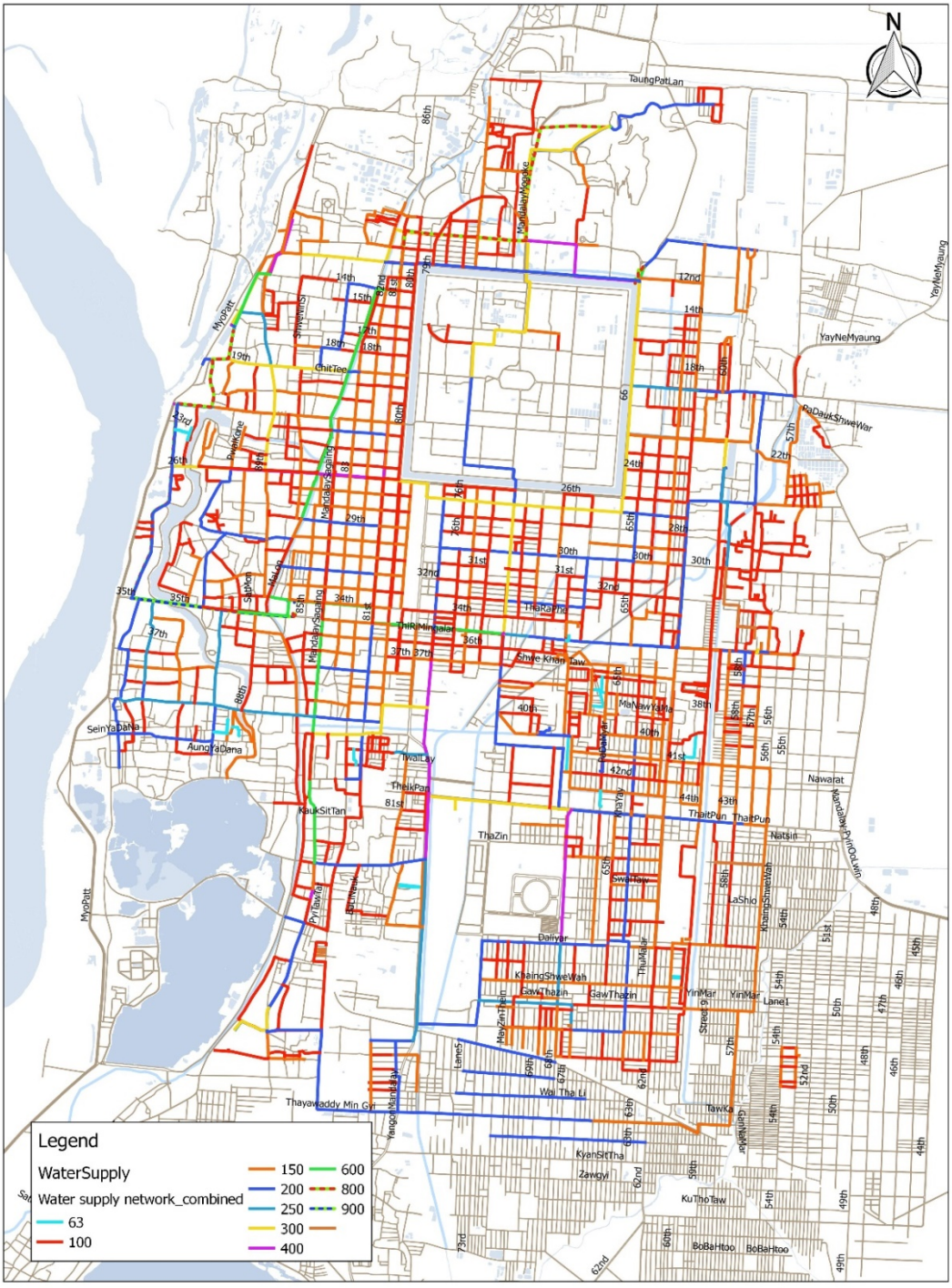
APPENDIX A



Source: MCDC

Mandalay Water Supply Map



Source: MCDC

APPENDIX B

Questionnaires

Socio demographic

Sr no.	Questions	Response
1.	Gender	
2.	Age	
3.	Occupation	
4.	Marital Status	
5.	Religion	
6.	Native Place	
7.	Educational level	
8.	Total Family Member	
9.	Average Family Income per month (Kyats)	

Sources of water and water use

10. What is your main source for getting water?

MCDC Central Water Supply System	
Private owned Tube Well, Borehole or Pump	
Neighboring Tube Well, Borehole or Pump	
Water Seller	
Other (Specify)	

11. How many barrels per day does your family consume?

……

12.How much monthly cost of consuming water do you pay? (MCDC Customer)

……..

13. How much monthly cost of consuming water do you pay? (Non-MCDC Customer)

…….

14. Is the water you obtain suitable to use as drinking water?

……..

15. Which way do you use to get drinking water?

Buying purified drinking water (bottled)	
Boiling	
Natural water	
Other (Specify)	

16. Do you have sufficient water to use the whole year?

……

17. What kind of storage do you use to store water? (Please mention the capacity)

……

Water supply system of Mandalay City Development Committee

18. How many hours is the total duration per day?

……

19. Do you use electric motor to fetch water from MCDC water supply?

……

20. For bathing, washing and cleaning, are you satisfied the water quality?

……

21. For cooking, are you satisfied the water quality?

…….

22. Do you install water meter?

…….

23. How is the water pressure?

Sometimes high/ sometimes low	
Low	
Always low	
High	
Always high	

24. Are you satisfied with the water pressure?

……..

25. Does the quantity of water you consume match with the unit the meter shows?

……..

26. How is the billing system?

Fix rate	
Flat rate	

27. How is the quality of water distributed by MCDC?

Very good	
Good	
Fair	
Bad	

28. Are there water borne diseases when you use water from MCDC water supply?

……..

29. For 24 hours access to clean water supply system, how much do you want to pay each month? (MCDC respondents)

…….

30. For 24 hours access to clean water supply system, how much do you want to pay each month? (Non-MCDC respondents)

…….

31. Are you satisfied with the water supply system of MCDC?

……