DECEMBER, 2019

YANGON UNIVERSITY OF ECONOMICS

MASTER OF PUBLIC ADMINISTRATION PROGRAMME

WATER SUPPLY AND DISTRIBUTION IN YANGON REGION (CASE STUDY : THAKAYTA TOWNSHIP)

THET HTAR NWE WIN

EMPA- 62 (16th BATCH)

DECEMBER, 2019

YANGON UNIVERSITY OF ECONOMIC

MASTER OF PUBLIC ADMINISTRATION PROGRAMME

WATER SUPPLY AND DISTRIBUTION IN YANGON REGION (CASE STUDY : THAKAYTA TOWNSHIP)

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

Supervised by

Dr. Tin Tin Wai
Professor
Department of Applied Economics
Yangon University of Economics

Submitted by

Thet Htar Nwe Win
Roll No. 62
EMPA 16th Batch
(2017-2019)

DECEMBER, 2019

YANGON UNIVERSITY OF ECONOMIC

MASTER OF PUBLIC ADMINISTRATION PROGRAMME

This is to certify that this thesis entitled "**Water Supply and Distribution in Yangon Region (Case Study Tharkayta Township)**" submitted as a partial fulfillment of 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. Dr. Ni Lar Myint Htoo
   Pro-Rector
   Yangon University of Economics (Examiner)
3. Dr. Phyu Phyu Ei
   Professor and Head
   Department of Applied Economics
   Yangon University of Economics (Examiner)
4. Daw Khin Chaw Myint
   Associate Professor (Retd.)
   Department of Applied Economic (Examiner)
   Yangon University of Economics
5. Dr. Khin Mar Thet
   Associate Professor
   Department of Applied Economic
   Yangon University of Economics (Examiner)

ACKNOWLEDGEMENTS

I was fortunate at first learning about an Executive Master Level in Master of Public Administration Programme at the Yangon University of Economics. I am grateful to Professor Dr. Tin Win, the Rector of Yangon University of Economics, who encouraged me to all land this course. In addition, I am also grateful to Professor Dr Ni Lar Myint Htoo, Pro-Rector of Yangon University of Economics for her Encouragement.

I wish to thank my Program Director Professor Dr. Phyu Phyu Ei, Head of Applied Economics Department and all of the teachers of MPA Programme for their perspicacious guidance and sharing knowledge and experiences during and studies.

I would to express my deepest appreciation to my supervisor Dr Tin Tin Wai, Professor, Department of Applied Economics, Yangon University of Economics, for her perspicacious guidance consistent supervision and showing valuable knowledge for completion of this study.

ABSTRACT

This thesis is highlighted to water supply system, and evaluated the functions and duties of YCDC with good, and strategies. The research paper covers the period from 2015 to 2019 and the descriptive method of study was used on available data and information. The survey was conducted on 120 respondents in Thakayta Township. The township comprises 18 wards and selected using YCDC water neighborhood 2 wards, using government tube well 1 ward and private owned tube well 1 ward. Using primary and secondary data with structured questionaries about water supply, consumption and willingness to pay access better quality of water. After the study, it is found that only 51 respondents can have access of water from YCDC water supply system and the rest 69 respondents are getting from the other water resources such as private owned tube well, government tube well, neighboring tube well and water seller. Most of households with five members use less than 3 barrel per day and the monthly expenditure for water consumption is under 1000 kyats. The YCDC supply system are using electric water pump for fetching and water meter installation is 48.3% , 64.6% of YCDC customers are willing to install water meter and 93.3% of YCDC consumers are charge with fixed rate.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

CBD	Central Business District
CSO	Central Statistical Organization
EDWS	Engineering Department (Water and Sanitation)
FOC	Free of Charge
HP	Horse Power
IUR	Inner Urban Ring
JICA	Japan International Cooperation Agency
KM	Kilometer
MG	Million Gallon
MGD	Million Gallons per day
MOAI	Ministry of Agriculture and Irrigation
NewSZ	New Suburbs Zone
NRW	Non-Revenue Water
NSZ	Northern Suburbs Zone
O & M	Operation and Maintenance
ORZ	Outer Ring Zone
OSZ	Older Suburbs Zone
SCBD	South of Central Business District
WTP	Water Treatment Plant
WTP	Willingness to Pay
YCDC	Yangon City Development Committee
YCWSS	Yangon City Water Supply System

CHAPTER I
INTRODUCTION

Water resource management is the activity of planning, developing, distribution and managing the optimum use of water resources. It is sub-set of water cycle management. Ideally, water resource management planning has regard to all the competing demands for water and seeds to allocate water on an equitable basis to satisfy all uses and demands.

Developing countries tend to have the lowest levels of waste water treatment. To improve the water consumption behavior of households, information about every mechanism dish washes, showers, washing machines, taps is wirelessly recorded. Providing innovative and integrated solutions for sustainable management of water resources to meet development needs has become the absolute necessity.

1.1 Rationale of the Study

Myanmar has an abundant water resources. Estimated runoff from rivers in a normal year is about 875 millions acre-feet. The total utilization of the nation's water resources is only about 5 percent or 45 million acre-feet. It is clear that the physical potential for further development of water resources in Myanmar is quite substantial. The government of Myanmar is fully aware of the consequences and the Ministry of Agriculture and Irrigation as responsible for overall water Management. The rapid population growth and attendant demands for more food, production and sustainable water ecosystems. Since water has direct or indirect relationship with poverty, governance, environment, climate, power, agriculture, food, education, etc., society cannot sustain life without managing water wisely and solving water problems. 100 percent of who dwelled in cities needs municipal functions for their daily life, such as water supply, electricity, transportation, markets for shopping, sanitations garbage and wastage things etc. City development committees can be said as urban development welfare organization, due to the statement, the role of YCDC can provide the development status and promote urban structure. YCDC stands critical situation for urban development and modernization. This thesis focuses on water, management systems in Yangon Region.

1.2. Objectives of the Study

The objectives of the study are to examine the current management systems of water resources in Yangon Region and to analyze the water supply and distribution in Tharkayta Township.

1.3 Method of Study

The descriptive analysis is used in the study. The data base used on both primary and secondary data. Secondary data is obtained from respective government offices, organizations and agencies and from internet website. In addition, literature studies and statistical records are collected from YCDC Book Reports. For primary data, a survey in four wards conducted of Thakayta Township with well-structured questionnaire. The sample survey was done in 2018 with the questionnaire under simple random sampling design.

1.4. Scope and Limitation of Study

The main focus is to examine only on the water Resources Management of Thakayta Township and Yangon City Development Committee (YCDC). The sampling unit of the study is 120 households in Thakayta Township. The scope of the study is from 2012-2013 to 2017-2018.

1.5 Organization of the Study

This study is organized into five chapters. The chapter 1 includes the rationale of the study, objectives of the study, scope and limitation of the study, methods of study and organization of the paper. The chapter 2 expresses literature review including water resource, water supply and Distribution system, water sustainability and water resource management, willingness to pay to access the clean water, Global water supply and importance of drinking water and previous studies. The chapter 3 illustrates water supply and distribution system of YCDC, in Yangon Division, consists of background history of water supply system in Yangon City development committee, Current water supply system in Yangon City, City water supply system and present water supply system in Thakayta Township. Chapter 4 describes the analysis and findings of water distribution and consumption in study area. Chapter 5 is conclusion with findings and recommendations.

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 eco-systems of water resources (Alcamo et al., 2007). There is a strong positive correlation between water demand and urbanization or population growth (Malmqvist & Rundle, 2002). Urban water system should provide safe water for different uses without harming the environment, and increasing demand for sustainable development will deeply affect on all urban infrastructures (Hellstrom et al., 2000). Therefore, sustainable management of water supply for various water uses in urbanized cities is extremely important to achieve the sustainable development of these cities.

As population growth, urbanization, and current policies and water management practices give stresses on water resources and urban infrastructure, urban water management tools are becoming essential for urban water planners to see the overview of their 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).

Water supply systems are mandatory for supplying water to the users. The main components of water supply systems are: (1) treatment works; (2) supply network of trunk mains and main reservoirs; (3) distribution network. The untreated raw water is conveyed to the treatment plant. The treated water is transmitted to water users through the water distribution systems.

The system water distribution is a hydraulic infrastructure consisting of various elements such as pipes, tanks, reservoirs, pumps, and valves. All of them are

crucial in delivering water of acceptable quality with specified pressure. The distribution systems can be either looped or branched. Looped systems are generally more desirable than branched system because, coupled with sufficient valving; they can provide an additional level of reliability. Moreover, in the looped system, breaking of pipe can be isolated and repaired with little impact on consumers outside the immediate area. On the other hand, in the branched system, all the consumers downstream from the break will have their water supply interrupted until the repairs are finished. Looped configuration, however, facilitates more than one path for water to reach the user, and the system capacity is greater.

2.1 Water Resource

Water is led into communities for many purposes: for drinking and culinary uses; for washing, bathing and laundering; far watering lawns and gardens; for producing hydraulic and steam power; for carrying on numerous and varied industrial process; for protecting life and property against fire and for removing offensive and possibly dangerous wastes from household and industry.

Water is the common name applied to the liquid form (state) of the hydrogen and oxygen compound H_2O. Pure water is odorless, tasteless, clear liquid. Water is one of nature's most important gifts to humankind. Essential to life, a person's survival depends on drinking water. Water is one of the most essential elements to good health -it is necessary for the digestion and absorption of food; helps maintain proper muscle tone; supplies oxygen and nutrients to the cells; rids the body of wastes; and serves as a natural air conditioning system. Health officials emphasize the importance of drinking at least eight glasses of clean water each and every day to maintain good health.

Water is a key component in determining the quality of our lives. Today, people are concerned about the quality of the water they drink. Although water covers more than 70% of the Earth, only 1% of the Earth's water is available as source of drinking. Yet, our society continues to contaminate this precious resource. Water is known as a natural solvent. Before it reaches the consumer's tap, it comes into contact with many different substances, including organic and inorganic matter, chemicals, and other contaminants.

Many public water systems treat water with chlorine to destroy disease-producing contaminants that may be present in the water. Although disinfection is an

important step in the treatment of potable water, the taste and odor of chlorine is objectionable. In addition, the disinfectants that are used to prevent disease can create byproducts, which may pose significant health risks. Consumers are taking matters into their own hands and are now determining the quality of the water they and their families will drink by installing a drinking water system that will give them clean, refreshing, and healthier water.

Although the draft of water from distribution is commonly referred to as water consumption or consumed, most of it is discharged as spent or wastewater. Use of water is a more exact term. True consumptive use refers to the volume of water evaporated or transpired in the course of use-principally in sprinkling lawns and gardens, in raising and condensing steam, and in bottling, canning, and other industrial operations. Service pipes introduce water into dwellings, mercantile and commercial properties, industrial complexes, and public buildings. The water delivered is classified accordingly and there are wide variations in water consumption because of differences in climate, standards of living, extent of sewerage, type of mercantile, commercial and industrial activity, water pricing, resort to private supplies, water quality for domestic and industrial purposes, distribution system pressure, completeness of meterage and systems management.

Water for poor quality may drive consumers to resort to uncontrolled, sometimes dangerous, sources, but the public supply remains the preferred source when the product water is clean, palatable, and of unquestioned safety; soft for wash; ag and cool for drinking; and generally useful to industry. The availability of groundwater and nearby surface sources may persuade large industries and commercial enterprises to develop their own process and cooking waters.

Water resources are divisible into two distinct categories: the surface water resources and the ground water resources. Each of these categories is a part of the earth's water circulatory system, called the hydrologic 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 run-off cycle, which is a part of the hydrologic cycle, will help us to understand the origin and the interdependence of these two categories of water resources.

Water is biologically necessary for life, but beyond this, water resources play a vital and pervasive role in the health and welfare of a modern economy. Water for direct human consumption is a small but critical part of the domestic system, which

also includes water used in food preparation, cleaning and sewerage disposal. Water is an essential element in many industrial and commercial production processes, again both as an input and as a medium of waste disposal.

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.

Water is essential for daily life of a human being, so the pollution of water prevention for and effective water supply and consumption is required to sustain the environment. The nature of the water source commonly determines the planning, design, and operation of the collection, purification, transmission, and distribution works. Common sources of freshwater and their development are:

Rainwater is from roofs, stored in cisterns, for small individual supplies, and from 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 waters, and their storage in reservoirs adjacent to the streams or otherwise readily reached from them; and from streams with low dry 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 ground water previously withdrawn from the same aquifer for cooling or similar purposes.

Municipal supplies may be derived from more than one source, the yields of multiple sources ordinarily being combined before distribution. A high-grade supply for

general municipal uses supported by a low-grade supply for certain industrial purposes or for firefighting. Unless the low-grade, usually no potable supply is rigorously disinfected, health authorities rightfully frown upon its employment because it may be cross-connected, wittingly or unwittingly, and possibly disastrously, with the high-grade (potable) supply. Non Revenue Water (NRW) in a water supply system is a concept has been recently introduced by the International Water Association instead of Unaccounted for Water (UfW) (Farley and Trow, 2003),

Non-Revenue Water (NRW) can be defined as the difference between the amount of water put into the distribution system and the amount of water billed to consumers in authorized meter and un-metered water consumption. NRW is comprised of apparent losses and real losses. Apparent losses include human management and metering errors and lead to consumption of water without charging. Real losses are some amount of water, which is wasted from the network, are categorized to water losses from reported and unreported bursts, background losses, reservoir leakage, and overflow, leakage from valves and pumps.

Non-Revenue Water management is important for urban water supply systems in all countries. A high NRW level is the result of a poorly run water utility that lacks the governance, the autonomy, the accountability, the technical and managerial skill necessary to provide reliable service to their people. The most dramatic evidence of water supply management inefficiency is the high ratio of non-revenue water or water that is not accounted for due to illegal connections, leakages, and other weaknesses in water supply system management. For instance, NRW is only 7% in Singapore (one of the lowest worldwide) and about 38% in Bangkok, which is about the average among developing countries.

2.2 Global Water Supply and Importance of Drinking Water

Water supply is the provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes. In 2010, about 84% of the global population had access to piped water supply through house connections or to an improved water source through other means than house, including standpipe, protected springs, and protected wells. However, about 14% did not have access to an improved water source and had to use unprotected wells or springs, canals, lakes or rivers for their water needs. A clean water supply, especially so with regard to sewage, is the single most important

determinant of public health. Destruction of water supply and sewage disposal infrastructure after major catastrophes poses the immediate threat of severe epidemics of waterborne diseases. (http://en.wikipedia.org/org/wiki/Gaseases)

Water supply systems get water from a variety of locations, including groundwater, surface water, conservation, and the sea through desalination. The water is purified and disinfected through chlorination and sometimes fluoridated. Treated water then either flows by gravity or is pumped to reservoirs, which can be elevated such as water towers or on the ground. Once water is used, wastewater is typically discharged in a sewer system and treated in a wastewater treatment plant before being discharged into a river, lake or the sea or reused for landscaping, irrigation, or industrial use.

Water supply service providers, which are often utilities, differ from each other in terms of their geographical coverage relative to administrative boundaries; their sectorial coverage; their ownership structure; and their governance arrangements. Many water utilities pal vide services in a single city, town, or municipality. However, in many countries municipalities have associated in regional, inter-municipal, or multi-jurisdictional utilities to benefit from economies of scale. In the United States, these can take the form of special-purpose districts, which may have independent taxing authority. Water supply providers can be either public, private, mixed or cooperative. Most urban water supply services around the world are provided by public entities. An estimated 10 percent of urban water supply is provided by private or mixed public-private companies, usually under concessions, leases or management contracts.

90% of urban water supply and sanitation services are currently in the public sector. They are owned by the state or local authorities, or also by collectives or cooperatives. They run without an aim for profit but are based on the ethos of providing a common good considered to be of public interest. In most middle and low-income countries, these publicly owned and managed water providers can be inefficient as a result of political interference, leading to over-staffing and low labour productivity. Ironically, the main losers from this institutional arrangement are the urban poor in these countries. Because they are not connected to the network, they end up paying far more than the implicit subsidies that they receive from loss-making utilities.

The Earth seems to be unique among the other known celestial bodies. It has water, which covers three-fourth of its surface and constitutes 60-70 weight percentage of the living world. Water regenerates and is redistributed through evaporation, making it seem endlessly renewable. Actually, only 1% of the world's water is usable, 97% is salty seawater, and 2% is frozen in glaciers and polar ice caps. Thus, that 1% of the world's water supply is a precious commodity necessary for survival. Dehydration (lack of water) will kill human beings faster than starvation (lack of food). Since the plants and animals human beings eat also depend on water, lack of it could cause both dehydration and starvation. Water that looks drinkable can contain harmful elements, which could cause illness and death if ingested.

2.3 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 deficient 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 manganese-bearing waters are deferrized or demagnetized; corrosive waters are deactivated or stabilized; hard waters are softened; fluorine-deficient waters are fluoridated; and waters containing too 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.

Distribution works dispense the collected, treated, and transmitted water to consumers in wanted volume at adequate pressure through systems of pipes and reservoirs that provide water for firefighting as well as for normal uses. Meters may be installed to make an equable charge for the water used. Some communities meter all services; others restrict meterage to the services of large water users; a few install meters only for the purpose of monitoring or governing overall operation of the system.

2.4 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 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 in which we live: 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 unfavorably with our 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 indicating the rate of use of renewable natural resources to ensure the continuous supply of resources and their 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 societal 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 their environment and ecosystem), current generation, and future generation needs. Thus, water resource systems must be considered integral parts with a changing societal system. One way we could show that 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 an 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 their own plan of action suitable for their hydrological conditions and need. The plan and management for water must not only be developed in theory but 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 re-sources and labour force availability and their attraction to economic activities. (Haughton & Hunter, 2004)

2.5 Willingness to Pay to access the clean water

Willingness to Pay (WTP) is the maximum amount of money that 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 (Whittington, et al., 1987, 1988). 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 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.

The correct value for NRW 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 NRW 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). NRW consist of unbilled authorized consumption and water losses as these are the component for which the utility does not receive revenue.

2.6 Review on Previous Studies

Aung Kyaw Soe (2012) submitted a study on YCDC water supply system and YCDC water supply connection in four districts. In this study, it was found that 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 Unaccounted for Water.

As stated by Kyaw Lwin Oo (2011) a study on problem and prospects of water supply system in Dala Township. In this study, it was also found that the problem mainly concerned with high content of salt in the ground water and lack of access to Yangon City water supply system. According to water distribution system and water management practices, the measures to take fresh water are also presented in this paper.

Kyaw San Kyaw (2011) states a study on water supply and consumption of Dagon Myothit (North). In this study, it can be seen that Central Water Supply System facilities should be extended and modified the pipeline system. Some wards located near the main pipeline of Central Water Supply System need to be installed with water supply facilities to access potable water 62% of households in High Income Wards, 56% of households in Middle Income Wards and 20% of households in Low Income Wards have access to water from only private tube-wells.

CHAPTER III
WATER SUPPLY AND DISTRIBUTION SYSTEM OF YCDC

Yangon City is growing with increasing population, reinforced by the continuous migration of rural people to the city and the creation of new satellite towns (Yangon Region Government, YCDC & JICA, 2013). Moreover, due to the current national changes and development plans, Yangon City is forecasted to become a mega city with 10 million populations in 2040 (Yangon Region Government, YCDC & JICA, 2013). In Yangon Region, 33 townships are belonged to in Yangon City and are administrated by the Yangon City Development Committee (YCDC). The 33 townships of Yangon City can be differentiated into seven zones: the Central Business District (CBD), the Inner Urban Ring (IUR), the Outer Ring Zone (ORZ), the South of Central Business District (SCBD), the Northern Suburbs Zone (NSZ), the Older Suburbs Zone (OSZ), and the New Suburbs Zone (NewSZ).

3.1 Background History of the Water Supply System in Yangon City

Water supply in Yangon City has a long history that started since 1842 with 30 wells near the center of the City. In 1842, King Tharrawady gave instruction to construct 30 open wells in Yangon City to start the water supply facility of the city.

In 1879, the first water supply system with pipeline was initiated in Yangon City by using water from Kandawgyi Lake to Baotahtaung and Pazundaung townships via 10 inches diameter east iron pipes. In 1384, this water supply system was augmented by the construction of Inya Lake, water from which was diverted to Kandawgyi lake by 30 inches diameter pipelines and distributed to the city through 27 inches diameter pipelines.

In 1894, the water supply system in Yangon City was developed with pumping station and service water tank by the construction of Phoesein pumping station and Shwedagon service water tank (1 MG storage capacity). The water delivered from Kandawgyi Lake to Phoesein pumping station was pumped to the

Shwedagon service tank via 27 inches diameter pipeline and distributed water to the western part of the city from that tank.

In 1904, Hlawga Reservoir (14 MGD supply capacity), situated about 17 miles (27km) north of Yangon City, was introduced in Yangon City water supply system, continuously, the water supply from Kandawgyi Lake and Inya Lake has ceased due to the deterioration of water quality from these lakes resulted by rapid urbanization. Water from Hlawga reservoir was pumped through 42" inches diameter CI pipeline to Yegu pumping station by booster pumping station of Hlawga reservoir. In 1906, the construction of Yegu pumping station was completed, and water was pumped to Shwedagon reservoir via 42 inches diameter, from which water was distributed to the whole city. Since that time, the use of Phoesein pumping station was terminated. In 1925, Kokkine service water tank (20 MG storage capacity) was constructed and added to the existing water supply system to expand the served area.

In 1941, the construction of Gyobyu reservoir (27 MGD supply capacity), situated about 40miles (64km) north of the city, was completed, and water was supplied with 56" diameter mild steel pipes through Yegu pumping station to Kokkine service water tank.

In 1989, Phugyi reservoir (54 MOD supply capacity), situated about 32 miles (51 km) of the city, *was* added to the water supply system by connecting with Hlawga reservoir through a 60" diameter pre-stressed concrete pipe. In 1992, 66 inches diameter pre-stressed concrete pipe laying project from Hlawga reservoir to Yegu pumping station was completed and water has been distributed to Yangon City. At that time, the daily water supply amount of the whole system was 85 MGD, including water amount (10 MGD) from YCDC owned tube wells.

In 2000, Yangon Pauk ground Water Treatment Project (WTP) was implemented to supply 1MGD water amount to Dala Township, southern part of the city on the other bank of Yangon River. In 2005, Ngamoeyeik Water Treatment Project (WTP)(Phase 1 with 45 MGD supply capacity), using water source from Ngamoeyeik reservoir, which was constructed and managed by Ministry of Agriculture and Irrigation, was operated tosupply water to the eastern part of the city, especially, new suburb townships of the city.

In 2009, South Dagon ground Water Treatment Project (WTP)(No.1 and No.2 with total 2 MGD supply capacity) and Thaephyu ground water treatment project (1MG supply capacity) was implemented at the eastern and western extended part of

the city to supply water to the suburb regions which are far from the main water supply system. The second phase of Ngamoeyeik WTP was accomplished in early 2014, and it started its function to reinforce the water supply system of the city with daily supply capacity 45 MG. The history of reservoir development in City water supply system is shown in Table 3.1.

Table (3.1) Water Reservoirs Development in Yangon City Water Supply System

Year	Name of Reservoir	Remarks
1879	Kandawgyi Lake	Water supply had stopped in 1906
1884	Inya Lake	Water supply had stopped in 1906
1904	Hlawga Reservoir	27km away from the City (currently use)
1940	Gyobyu Reservoir	64km away from the City (currently use)
1989	Phugyi Reservoir	70km away from the City (currently use)
1995	Ngamoyeik Reservoir	48km away from the City (currently partial use)

Source, YCDC, Administration Department, 2019

Generally, Myanmar is blessed with abundant water, but this resource is poorly distributed both in space and in time. Yangon City has also an abundance of natural resources of water from the Hlaing River, Panhlaing River, Yangon River, Bago River and Punzundaung Creek. However, most of the water sources near the City are not utilized for water supply due to water quality with saline intrusion. There is a natural tidal effect in each river near the southern part of Yangon City where is the mouth of Adman Sea and Bay of Bengal. Most of the water sources for City water supply are from the northern part of the City (see APPENDIX III). It is far from the City center. Most of the dams for supplying water to the City were constructed in the northern part of Yangon City. This is quite far from the city area, so generally, conducted pipe length for water supply is from 16 miles to 40 miles (25.75 km to 64.37 km).

In addition, many social and economic amenities, government ministries, educational institutions, religious establishments, hospitals and a large number of

industries are also found in the City. Water is needed by all these players both as a basic commodity in itself and an important raw material in the production process.

This section is to provide a description of the status of water supply for the current city population, and then identify the issues, which are related to non-revenue water and water sustainability, on the existing water supply system management.

3.2 Yangon City Development Committee (YCDC)

YCDC was initially established as a city municipal organization since Myanmar was under the British to carry out municipal works, and its name was changed in history as Rangoon City Municipal Corporation in 1922, as Rangoon City.

Municipal Committee in 1972, as Rangoon City Development Board in 1977, as Rangoon City Development Committee in 1985 (YCDC, 2014).

According to the provisions of Yangon City Development Law (14 May 1990), YCDC bestowed wide powers and authority, for instance, YCDC was authorized to implement its own project by using its own funding resources. However, at present, YCDC needs to apply permissions of projects to the national government, and the funding sources of YCDC are incorporated into the national budget by the new policy. YCDC set up as a ministerial level and comprises with 20 departments and seven committee office, to create a modern city with the features and characteristics of city while preserving its greenery and the natural beauty for its citizens by the guidance of the national government. YCDC is directly responsible for the development and maintenance of Yangon City in all aspects.

According to Yangon City Development Law, YCDC must organize with minimum seven members to maximum 15 members; the Mayor, Vice-Chairman (Vice-Mayor), Secretary, Joint-Secretary, and the other are Committee Members. Mayor of Yangon City is responsible not only the Chairman of YCDC but also the minister of Development Affairs of Yangon Region. The current organizational chart of YCDC is shown in Figure 3.1. (See Appendix IV)

3.2.1 Engineering Department (Water & Sanitation)

Engineering Department (Water & Sanitation) (EDWS) is one of the 20 departments under YCDC, which is responsible to supply of clean and potable water to the citizens of Yangon City and to serve sewerage and sanitation facilities of the city.

The main objectives of Engineering Department Water and Sanitation (EDWS) are:

1. To distribute the adequate, safe and wholesome water for city dwellers
2. To collect the water tariff completely
3. To prevent water leakage and control the reduction of non-revenue water
4. To manage for systematic sewage disposal
5. To upgrade water distribution facilities and sewerage system

Engineering Department Water and Sanitation (EDWS) is organized with six divisions, and they are:

1. Reservoirs division
2. Water Supply division
3. Sanitation division
4. Revenue and administration division
5. Electrical and mechanical division
6. Pipe plant division

There are (4) supporting branches for EDWS:

1. Research section
2. Store section
3. Computer section
4. Water quality monitoring section.

The head of department of Deputy Director General Engineer (DDGE), who is supported by two Directors of Engineer (DE), five Deputy Director Engineers (DYDE) and twenty two Assistance Director Engineers (ADE), head of each division. The total number of staff members in the whole department was 18st in 2019. The below figure (3.2) illustrates the organization charts of Engineering Department of Water and Sanitation (EDWS). (See Appendix V)

3.3 Current Water Supply System

The existing water supply in Yangon City has two main categories, namely YCDC owned facilities and private owned facilities. YCDC owned facilities included YCDC owned in-house connection, communal tanks, standpipe and other arrangement facilities such as boat, tanker. There are four levels in YCDC owned

facilities. YCDC 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 source(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).

YCDC and its previous have initiated a system of water supply to poor communities via communal tank facilities. In this case, a brick tank was built and connected to the YCDC supply network. The capacity of existing tanks size is from 400 gallons to 20,000 gallons. The customers collect water through taps fixed on the tank.

Standpipes have also been provided for the use of pedestrians in the past. The Myanmar General Consultants (1993) reported that 2,500 standpipes existed in 1980, but that these had later declined to 825 in 1993. The current policy appears to be to get rid of them gradually. Though data on the number and location of standpipes are not currently available, in-depth discussions with township staff revealed that there are 245 standpipes in four townships. Beneficiaries from standpipes do not pay any charge for water. Similar to communal tanks, these facilities are proper for low-income communities.

Furthermore, there is still a practice of water delivery via a tanker. Water is collected from YCDC 's own boreholes. It was carried by boat to the township across the river and delivered via a tanker. This township is a water deficit area in Yangon City, especially in dry season.

3.3.1 Main Source of Water System in Yangon City

The sources of water system in Yangon city are surface water, ground water and rain water. Surface water is the main source of Yangon city water system. In

Yangon city the main surface water resources are Hlawga Reservoir, Gyobyu Reservoir, Phugyi Reservoir and Ngamoyeik Reservoir.

Table 3.2 shows a list of current water sources of Yangon City together with their daily water supply capacity. About 90% of the water source of the system is surface water from reservoirs, and the rest is ground water from tube wells as the supplement of water supply system.

Table (3.2) Current Water Sources of Yangon City Water Supply System (YCWSS)

Water Sources	Daily Capacity	Water Source	Start-up Year
Hlawga Reservoir	14 MGD	Surface Water	1904
Gyobyu Reservoir	27 MGD	Surface Water	1940
Phugyi Reservoir	54 MGD	Surface Water	1992
Ngamoyeik WTP (Phase 1)	45 MGD	Surface Water	2005
Ngamoyeik WTP (Phase 2)	45 MGD	Surface Water	2014
Yangon Pauk	1 MGD	Ground Water	2000
South Dagon	2 MGD	Ground Water	2009
Thaephyu	1 MGD	Ground Water	2009
YCDC tube wells	16 MGD	Ground Water	1842
Total	**205 MGD**	**90% Surface Water + 10% Ground Water**	

Source: YCDC, Administration Department, 2019

(a) Surface Water Resources

The current water supply amount of Yangon City Water Supply System (YCWSS) is 205 MGD, including the amount of water generated from the second phase of Ngamoeyeik Water Treatment Plant (WTP), i.e. 45MGD. The total water supply amount was 160 MGD until the end of financial year 2013-2014.

Hlawga Reservoir: This is situated at about 17 miles north of Yangon City and was built in 1904. The catchments area of Hlawga Reservoir is 10.5 sq-mi and water surface area is 4.4 sq-mi in full water level. Maximum storage volume approximately 12,000 million gallons (MG). It has dependable yield of 16.5 million gallon per day (MGD). The crest level of reservoir is +62 ft above mean sea level. Water is withdrawn from the intake tower and it has three ports to cope with watt level fluctuation.

Gyobyu Reservoir: This was built in 1,940. Gyobyu Reservoir has a total catchment area 12.9 sq-mi and water surface area is 2.8 sq-mi at full water level. Gyobyu Reservoir is a homogeneous, rolled earth fill structure. It is approximately 700 ft; and located above mean sea level of +215 ft. This reservoir area is heavily forester and is non-populated. Total capacity is approximately 16,600 million gallons (MG) Gyobyu has dependable yield of 27 MGD. Water is withdrawn from the intake tower and it has three intake ports to cope with water level fluctuation.

Phugyi Reservoir: Construction work on Phugyi Reservoir was launched in 1973 and completed in 1988. The extent of the whole watershed area is 27.27 sq-mi and water surface area is 6.8 sq-mi at full water level. Maximum storage volume is approximately 23,000 mg. The crest level of the spill way is 115 ft above mean sea level. Phugyi Reservoir has dependable yield of 54 MOD. It is 32 miles from Yangon City. Water is withdrawn from the intake tower and it has two intake ports.

Ngamoyeik Reservoir: Ministry of Agriculture and Irrigation (MoAI) has constructed and managed Ngamoeyeik reservoir for multi-purposes, such as water supply for agriculture, saltwater intrusion prevention, flood control etc. , and one of the these purposes is to supply 90 MGD raw water for Yangon City. YCDC constructed Ngamoeyeik WTP for the treatment of raw water obtained from Ngamoyeik reservoir. First phase of WTP has been operated in 2005 and second phase in 2014 (March), and each phase has capacity of 45 MGD.

Table (3.3) Current Surface Water Sources of YCWSS

Items	Hlawga Reservoir	Gyobyu Reservoir	Phugyi Reservoir	Ngamoeyeik Reservoir
Constructed years	1900-1904	1937-1940	1973-1984	1992-1995
Location (from city)	17 mi North	40 mi North	32 mi North	38 mi North
Catchment area (sq-mi)	10.5	12.9	27.27	160
Water Surface are (sq-mi)	4.4	2.8	6.8	17.19
Total capacity (MG)	12000	16600	23000	52000
Effective capacity	10000	8240	20000	48840
Maximum Water Level	62	215	120.86	1.17
Top of spillway (ft)	62	215	115.5	107
1st intake level (ft)	57.2	201	90	90
2nd intake level (ft)	49.2	180	74	72
3rd intake level (ft)	42.2	138	-	-
Water supply capacity (MGD)	14	27	54	45+45
Start-up year	**1904**	**1940**	**1992**	**2005 (Phase 1) 2014 (Phase 2)**

Source: YCDC, Administration Department, 2019

(b) Ground Water Resources

Yangon City Development Committee (YCDC) is using ground water source from tube wells and directly injected into the distribution pipeline network to reinforce the surface water from reservoirs. At present, there are 645 YCDC-owned tube wells with total maximum yield amount of 20 MGD, however actual yield amount is less that maximum amount is depending on the operation hours of the tube wells. Water produced from these tube wells are directly injected into nearby YCDC pipelines or service reservoirs, being mixed with surface water from reservoirs. Moreover, about 3 million populations in Yangon City, who cannot get YCWSS services, are using private tube wells as a water source. The total withdrawal amount from both YCDC and private tube wells is estimated about 79MGD. If additional groundwater would be used in future to meet the increasing water demand, this extraction amount can exceed the total groundwater potential, i.e. 83 MGD (estimated).

(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. Being an area across the river, without any reliable water source, rainwater is the only main source of water for the people especially in Dala and Seikkyikanoung to Township. But, up to now a systematic method of collecting rainwater or improved techniques that have proven to be more efficient in collecting water in other Asian countries has yet to be introduced to this area.

3.3.2 Water Supply Facilities

There are six Water Treatment Plants (WTP) in the existing YCWSS. Two treatment plants are for the surface water treatment and treated by flocculation, sedimentation, and filtration processes. The other four are ground water treatment plants by cascade aeration and filtration processes. In YCWSS, there are six main pumping stations to transport water and to supply water with pressure, however, most of the pumping stations require proper equipment for operation, such as pressure gauges, flow meters etc. YCWSS has two service water tanks to regulate the water supply.

3.3.3 Water Supply Pipeline

In YCWSS, some transmission pipelines are more than 100 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 and distribution pipes in YCWSS is about 1,455 km and the detail data of aged pipes are listed in Table 3.4.

Table (3.4) Age Transmission Main Pipes in YCWSS

Start-up year	Pipe material	Diameter	Length	Age
1904	Cast iron	1,060 mm	22.85 km	115
1914	Mild steel	1,060 mm	8.05 km	105
1940	Mild Steel	1,400 mm	69.2 km	79
1989	Pre-stressed concrete	1,520 mm	25.75 km	30
1992	Pre-stressed concrete	1,650 mm	16.74 km	27

Source: YCDC, Engineering Department, 2019

3.3.4 Water Coverage Supply in Yangon City

The main objective of the whole system is to supply the adequate safe water for the city, so the main demand site in this system is Yangon City, with population 7.4 million in 2015. According to the data of EDWS, the daily water consumption amount for a person in Yangon City is about 30 gallons per day. In 2019, the total daily water demand was 222 MGD by using the consumption rate 30gpcd (gallons per capita day).

The water demand coverage of the YCWSS is about 30 % and people with no water supply service obtain water from other water sources like wells, tube wells, ponds, and rain (Yangon Region Government, YCDC & JICA, 2013; Khaing, 2006). Generally, Yangon City Water Supply System can supply water only one-third of city dwellers.

There were 1,582,994 households in Yangon City, however, the number of water connections, households connected with city water supply system, was only 624,379on the May, 2015. Based on the number connection, the water demand coverage of Yangon City was about 39 %.

In 2015, the actual daily water supply amount in Yangon City was 54.52 MGD that was calculated by using the actual income from 2015-May water meter bills. The total daily water demand was 222 MGD calculated by using water consumption rate 30 gpcd for 7.4 million populations in 2015. The following Table 3.5 shows the calculations of demand coverage of the system in Yangon City based on connections and volume derived from actual household.

Table (3.5) Demand Coverage of the YCWSS in 2019

Demand site		**Yangon City**
Daily Demand	222 MGD	7.4 million population with 30 gpcd consumption
Demand Coverage (connection based)	39 %	The ratio of the number of actual supply connection, i.e. 624,379, and the number of households, i.e. 1,582,994

Source: YCDC, Engineering Department, 2019

3.3.5 Water Uses

In YCWSS, there were 624,379 connections in May 2015, and out of these connection, 90% is domestic connections, 8% is commercial connections, 1% is departmental connections and the rest 1% is free of charge (FOC) connections for religious buildings, such as pagodas, temples, monasteries, churches, mosques etc. 78% of total connections are metered and the others are unmetered. The detail number of connections of different types of water uses was shown in Table 3.6.

Table (3.6) Demand Coverage of the YCWSS in 2019

Category	Domestic	Commerce	Department	FOC	Total
Metered	453,968	41,222	4,275	-	499,465
Unmetered	107,974	8,728	1,969	6,243	124,914
Total	**561,942**	**49,950**	**6,244**	**6,243**	**624,379**

Source: YCDC, Engineering Department, 2019

3.3.6 Water Supply Service Condition

(a) Service Hours

In YCWSS, service hours vary widely between 6 hours and 24 hours per day depending on areas. Areas located near to water source and main pipes, low areas, etc., can get water continuously, however, hydraulically unfavorable areas i.e. areas located far away from water source and main pipes, hilly areas, can get water only when there is surplus water or in night time. Average supply duration is estimated as 9.1 hours per day.

(b) Water pressure

Water pressure of YCWSS also has the same situation as service hours' case and varies widely from < 0.3 bar to >1.5 bars, and average pressure is about 0.75 bars. Hydraulically favourable areas get high pressure, while hydraulically unfavourable areas get low pressure.

(c) Non-Revenue Water Rate

Previously revenue water quantity was estimated at 54.52 MGD while supplied quantity was estimated as 160 MGD. Non-revenue water is calculated as 105,48MGD or 66 % and the detailed water balancing analysis for non-revenue water amount is shown in Table 3.8. Non-revenue water amount in YCWSS is high because of leakage in old pipes, free water supply to religious buildings, water meters malfunction and illegal connections.

Table (3.7) Non-Revenue Water Consumption of YCWSS

<table>
<tr><td rowspan="4">Total Water supply volume 160 MGD (100%)</td><td rowspan="2">Authorized water consumption</td><td>Billed authorized consumption</td><td>54.52 MGD (45.24%) Revenue water</td></tr>
<tr><td>Unbilled authorized consumption</td><td rowspan="3">87.61MGD (54.76%) Non-revenue</td></tr>
<tr><td rowspan="2">Water losses</td><td>Commercial Losses Unauthorized consumption Master inaccuracies Data handling errors</td></tr>
<tr><td>Physical losses (50% estimated) Leakage in water facilities Leakage in pipeline Leakage in meters & connection</td></tr>
</table>

Source: YCDC, Administration Department , 2019

(d) Water Tariff and Connection Fees

Water Tariff and connection fees are paid by consumers from households and enterprises. The current water tariff has 3 categories, namely, Domestic, Department, Commercial and Industry. The bills are issued with meter-boxes. Water meter is read every month and the bills are issued every month. There are still some un-metered distribution to government departments and staff quarters. YCDC has the policy to collect water charges from all types of customers except some limitations such as government offices, 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 YCDC that it practice universal metering for all domestic and commercial consumers.

(e) Water Billing system

In YCWSS, metered connections are charged by fixed rate per unit billing system in every month, and unmetered connections are charged by flat rate billing system in every quarter of the year, i.e. every three months. Even though customers

can be categorized in to four types: domestic, commerce, department, and FOC, there are only two charged rates, i.e. 110 Kyats per m3 for commercial connections and 88 Kyats per m3 for other connections except FOC connections.

3.4 City Water Supply System

The residents of Yangon have several sources of water supply. The most popular sources among residents are YCDC supply water and private owned tube well. The findings of current Yangon City Water Supply System will be summarized as below:

1. Water Sources and Facilities
2. Water Supply Pipelines and Maintenance
3. Authorize Consumption and Water Meters
4. Problems of YCWSS

3.4.1 Water Sources and Facilities

The residents of Yangon have several sources of water supply. The most popular sources among residents are YCDC water supply and private owned tube well. The present YCDC water supply network service is not sufficient for all residents. Only 37% of the total population is served by YCDC supply water pipes. Even within this low service area, the city water supply network data is out of date and incomplete, operational information is irregularly collected and analyzed, only few records are kept and recorded data are fragmented. The water pressures are very low and most of the residents need to use water pump to fetch water from YCWSS. Out of 33 townships in Yangon, only 6 townships can get 24 hours of continuous water from supply pipe line and many townships only have a couple of hours for water in their available water pipe network. In YCWSS, service hours vary widely between 6 hours and 24 hours per day depending on areas. Areas located near to water source and main pipes, low areas, etc., can get water continuously, however, hydraulically unfavorable areas i.e. areas located far away from water source and main pipes, hilly areas, can get water only when there is surplus water or in night time.

There are six WTPs in the existing YCWSS. Two treatment plants are for the surface water treatment and treated by flocculation, sedimentation, and filtration

processes. The other four are ground water treatment plants by cascade aeration and filtration processes. In YCWSS, there are six main pumping stations to transport water and to supply water with pressure, however, most of the pumping stations require proper equipment for operation, such as pressure gauges, flow meters etc. YCWSS has two service water tanks to regulate the water supply. The current water supply amount of YCWSS is 205 MGD, including the amount of water generated from the second phase of Ngamoeyeik WTP, i.e. 45MGD.

3.4.2 Water Supply Pipelines and Maintenance

The network pipes are aging. Over 50% of the network has pipes more than 50 years old, 80% of the network is cast iron and most of the joints are leak prone from lead caulked joints. Network data is out of date and incomplete so even the schematic diagrams do not accurately indicate the situation of the network in the ground. There is a lack of operational maintenance resources and lot of leakage on service pipes due to long service pipe lines and customer is responsible for the repair of their service line directed from the YCDC main distribution pipe.

3.4.3 Authorized Consumption and Water Meters

There are billed authorized consumption and unbilled authorized consumption. Billed authorized consumption includes billed metered consumption and billed un-metered consumption. Unbilled authorized consumption includes unbilled metered consumption and unbilled un-metered consumption.

Metering in the whole system are required throughout the distribution network to establish the amount of water harvested, treated, imported, exported, stored, and consumed. To accurately measure, water use in a distribution system, meters must be installed by level of water distribution such as source or raw water meters, bulk flow, production or purchase meters, district meters, industrial, commercial and non-domestic meters, and domestic/residential meters. To ensure accuracy, meter selection, installation, systematic and cost effective replacement schemes, and appropriate and systematic schedules to ensure efficient information flow must be taken. These step lead to correct revenue collection. Meter calibration needs to be undertaken periodically to assess drift in accuracy. A systematic metered testing, repair, and replacement program must be established. Lack of progress towards

comprehensive metering must be challenged at the policy making and operational level. Even metered customers have to maintain their meters properly.

3.4.4 Problems of YCWSS

Increasing water demand due to the higher population growth and developing industrial zone, YCWSS is encountering various problems relating with technology, organization, institution, and finance & management are listed in below:

(1) **Technical Problems**: consist low demand coverage, high non-revenue water amount, poor water quality, aging water facilities & main pipelines, inappropriate layout of facilities and insufficient operation & maintenance (O&M) of facilities.

(2) **Organizational Problems**: consist lack of planning section, lack of monitoring section, lack of O&M and management according to performance indicators, poor awareness of customer services, poor water quality testing system and poor human resources development in the

(3) **Institutional problems**: consist of standards for installation of service conditions, standards for water meter, standards for installation of individual storage tank, standards for installation of individual pumping facilities and inspection of installation works for service pipe.

(4) **Financial Management Problems**: consist of cheap water price, water pricing system, need for introducing corporate accounting system, and computerization in limited services.

In order to improve the YCWSS, YCDC should strengthen the following points:

(1) O & M of water treatment process and water quality monitoring

(2) Water Network Management/ Water distribution control

(3) Introducing the new sustainable water resources for ceasing the underground water consumption

(4) Computerization, field data acquisition and analysis, Customer data management, etc.

(5) Modern design organization with engineering standardization

(6) Labor safety management

3.5 Present Water Supply System in Thakayta Township

The existing water supply in Thakayta Township has YCDC supply system. YCDC owned in house connection, communal tanks, Standpipe and other arrangement facilities such as tank, tube wells, pump station and fire hydro.

The main sources of water for township was supply system are Hlawga Reservoir, Phugyi Reservoir and Ngamoyiek Reservoir.

The following Table (3.8) shows list of current water sources of Thakayta Township together with daily water supply capacity.

Table (3.8) List of Current Water Sources

Water Sources	Daily Capacity	Start-up Year
Hlawga Reservoir	14 MGD	1904
Gyobyu Reservoir	27 MGD	1940
Ngamoeyeik (Phase 1)	45 MGD	2005
Ngamoeyeik (Phase 1)	45 MGD	2014
Total	141 MGD	

Source: Engineering Department (Water & Sanitation) Thakayta Township.

Current water sources of Thakayta Township water systems one Ngamoeyeik, Hlawga, Gyobyu, Reservoir and tables wells. Engineering department (water and sanitation) is under YCDC and distribution the water supply to Thakayta Township.

Water Uses in Thakayta Township

The following Table (3.9) shows Thakayta Township households using water resources consumption.

Table (3.9) Households Using Water Resources Consumption

Sr. No.	Consumption	Household	Population	Percentage
1	YCDC	6993	23428	15.2%
2	YCDC Tube Well	1824	8804	4%
3	YCDC + Tube Well	5016	23811	10.9%
4	Own Tube Well	13975	77217	30.3%
5	Ground Tank	591	2861	1.3%
6	Others	17653	86352	38.3%

Source: Engineering Department (Water & Sanitation) Thakayta Township. 2019

Water Resources Data from Thakayta Township

In Thakayta Township water supply from 35 tube wells, 10 water pumps stations, 12 ground tanks and 16 fire hydrants.

The following Table (3.10) shows 35 tube wells locations and using water pump stations.

Table (3.10) Water Resources data from Thakayta Township

Sr.No.	Tube Well Name	Location	Water Pump Capacity	Daily Loading Gallons	Time Consumption Hour
1	Tha/1	Yamonna Street Yanpyae	7.5 KW(2)	-	-
2	Tha/2	Thumana Street 3-Yanpyae	5.5KW	37500	15
3	Tha/3	Zawthanyone Street 2-south	3.7KW	8000	10
4	Tha/5	Manpye Street 3-manpye	5.5KW(1)	13500	3
5	Tha/6	Aungmitha Street, 4-south	3.7KW	21600	6
6	Tha/7	Theingi street, E0-ward 15 quarter	3.7KW	2400	2
7	Tha/8	Min thaw Tha Street, 6-west	7.5KW	-	-
8	Tha/12	Viewpoint 110 south	5.5KW	36000	12
9	Tha/13	Thalanadi street 10-south	7.5KW	-	-
10	Tha/15	Ayarwon Street, 7-east	7.5KW(2)	24000	4
11	Tha/19	Htoopayone 15 street, 1-HPY	5.5KW	21600	18
12	Tha/20	Thanlyin Housing	5.5KW	44000	11
13	Tha/21	Ayarwon Street, 7-east	5.5KW(2)	44000	11
14	Tha/26	Ayarwon Street, 7-east	3.75KW(2)	-	-
15	Aung Thuka	Aungthuka Street,6-east	3.75KW	20000	20

Table (3.10) Cont'd

Sr.No.	Tube Well Name	Location	Water Pump Capacity	Daily Loading Gallons	Time Consumption Hour
16	Thadayone	Thadawone Street, 7-east	5.5KW	36000	12
17	Aung Thapye	Aungthapye Street, 7-east	5.5K5.5K WW	6400	8
18	View Point	View point Street, 9-ward	5.5KW	-	-
19		Htoopayone 21 street, 2-north	2HP	1500	-
20		7 Zaylame, 7-east	2HP	1500	-
21		Middle Village 10-north	2HP	1500	-
22	Ayarmon	Ayarwon Street 1/Htoopayone	7.5KW	8000	8
23	Zin Ma Tube	Zinma Street 5-ward	3.7KW	6000	10
24	Khine Shwe Wha	Between Khinshwewha and Aungthapye, 7-east	4KW	27000	9
25	Shwe Ingyin	Waizanwartha and Thathuma Street	7.5KW(4)	288000	24

Source: Engineering Department (Water & Sanitation) Thakayta Township.2019

Note: Good Tube Well = 28

Bad Tube Well = 7

Total Tube Well = 35

Source: YCDC, Thakayta, 2017

CHAPTER IV
SURVEY ANALYSIS

4.1 Survey Profile

Thakayta Township Water Resources, Access to Water, Water Consumption

In Thakayta Township there are four water resources such as name of Ngamoeyeik, Hlawga and 35 tubes-wells. The use of later resources is 41575 number of peoples and distributed by 18 wards. And then there is 10 water pump stations, 12 underground tanks and 16 fire hydrants. Engineering department (water and sanitation) is one of the department from YCDC, which is to the citizen of Thakayta township and to serve sewerages and sanitation facilitates of the township.

4.2 Survey Design

The data collection method chosen for the study was through a self-structure questionnaire. The survey was conducted on 120 households from the Thakayta Township. The township comprises 19 wards and selected using YCDC water neighborhood 2 wards, using Government Tube Well 1 ward and private owned tube well 1 ward.

The questionnaire was divided into three parts: (1) characteristics of the respondents (2) sources of water and water uses, (3) source of water and water use in Thakayta Township. The questionnaire had multiple choice questions in which the researcher provided a choice and respondents were asked to select one or more of the alternatives and dichotomous questions that had only two response alternatives Yes or No.

Collected data were tabulated, analyzed and interpreted in the light of objective of the study by applying descriptive statistics.

4.3 Survey Finding

The survey findings are presented by three parts: (1) characteristics of respondents, (2) source of water and water use in Thakayta Township. (3) YCDC water supply System.

4.3.1 Characteristics of Respondents

The characteristics of respondents include gender, age, material status, race, religion, and education level, household size, income level, occupation.

Table (4.1) Distribution of Respondents by Gender

No.	Particular	Number of respondents	Percentage (%)
1.	**Gender**		
	Male	74	61.7
	Female	46	38.3
	Total	**120**	**100.0**
2.	**Age Level (Years)**		
	Under 35	28	23.3
	35-45	34	28.3
	45-55	45	37.5
	Above 55	13	10.8
	Total	120	100.0
3.	**Marital Status**		
	Single	91	75.8
	Married	21	17.5
	Divorced	4	3.3
	Widow	4	3.3
	Total	**120**	**100.0**

No.	Particular	Number of respondents	Percentage (%)
4.	**Race**		
	Kachin	1	.8
	Kayin	6	5.0
	Burman	98	81.7
	Mon	1	.8
	Rakhine	2	1.7
	Other	12	10.0
	Total	**120**	**100.0**
5.	**Religion**		
	Buddha	98	81.7
	Christain	6	5.0
	Islamic	16	13.3
	Total	**120**	**100.0**
6.	**Education Level**		
	Middle	35	29.2
	High	52	43.3
	Passed High	15	12.5
	Graduate	17	14.2
	Master	1	.8
	Total	**120**	**100.0**
7.	**Household size**		
	1-5	82	68.3
	6-10	35	29.2
	11-15	3	2.5
	Total	**120**	**100.0**

No.	Particular	Number of respondents	Percentage (%)
8.	**Income Level**		
	Under 100000	16	13.3
	1000000-200000	36	30.0
	200001-300000	40	33.3
	300001-400000	18	15.0
	400001-500000	8	6.7
	Above 500000	2	1.7
	Total	**120**	**100.0**
9.	**Occupation**		
	Student	2	1.7
	Government Staff	15	12.5
	Company Staff	20	16.7
	Business Man	15	12.5
0	Retired	13	10.8
	Self-employee	36	30.0
	Housewife	19	15.8
	Total	**120**	**100.0**

Source: Survey Data, 2019

According to Table (4.1), 120 respondents in the survey, selected from (4) wards of Thakayta Township in Yangon region are shown. It is found that 74 (61.7%) out of respondents are male and only 46 (38.3%) out of total respondents are females.

Age level classified by four categories. They are under 35 years, 35 years to under 45 years, 45 years to under 55 years above and 55 years and above. Most of the respondents are between 45 years and under 55 years is 45 (37.5%), 35 years and under 45 years is 34 (28.3%), under 35 years is 28 (23.3%) and 55 years

and above is 13 (10.8%). Majority of respondents in the marital status (75.8%) were single, (17.5%) were marriage and (30.3%) were divorced and widow.

The most of respondnets 98 respondents (81.7%) were Burman race and others 12 (10%) were the second largest. It can be seen that the majority of study area is Burma and others races such as Kayin, Rakhine, Kachin, Mon are also living together in this area is 8.3%.

Regarding 120 respondents of religions, 98 (81.7%) were Buddhists, 16 (13.3%) were Islam and 6 (5%) were Christian in the study area.

As indicated that the education qualification of respondents, (43.3%) of the total respondents were high school level, (29.2%) were middle level, (14.2%) is graduate level, (12.5%) were passed high school level and the last (0.8%) were master level.

Winthin the 120 respondents, member are classified by three categories such as, family members 1 to 5, family members 6 to 10 and family members and family member 11 to 15.68.3% of respondents have family member of one to five, 21.2% of respondent have family member of six to ten, and 2.5% of respondent have family member of eleven to fifteen.. (33.3%) of the respondents earned between kyat 200,001 to Kyat 300,000 (30%) respondents earned between kyat 300,001 to kyats 400.00 (13.3%) respondents earned between kyat under 100,00 (6.7%) respndents earned between kyat 100,001 to kyat 500,000 and (1.17%) earned the minimum income group above kyat 500,000. As indicated that 120 respondents (30%) were self-employee (16.7%) were company staff (15.8%) were housewife (12.5%) were government staff and business man (10.8%) retired person and (1.7%) were students.

4.3.2 Source of Water and Water Use in Thakayta Township

Water is basic need for all households and basic commodity and important raw materials in the life. And then source of water are also important for social economic standard. In this section source of water in Thakayta township and consumption barrel per day, monthly expenditure for using YCDC water and Non-YCDC water, others treatment drinking water and their water storage.

Table (4.2) Source of Water

Sources of water	Number of respondents	Percentage (%)
YCDC water supply system	51	42.5
Private owned tube well	43	35.8
Government tube well	6	5.0
Neighboring tube well	10	8.3
Water seller	8	6.7
Other	2	1.7
Total	120	100.0

Source : Survey Data, 2019

Table (4.2) shows in Thakayta Township there are classified by six types of water sources in this area and 42.5% out of total respondents are from YCDC central water supply system users and 35.8% out of total respondents got water private owned tube wells. 8.3% out of total respondents mentioned that they connected to their neighboring tube wells with their own pipe and pay money for their water on a monthly basis.

Table (4.3) Household Water Consumption

Household water consumption (Barrel per day)	Number of respondents	Percentage (%)
Less than 3	70	58.3
3-5	39	32.5
5-7	10	8.3
7 and above	1	.8
Total	120	100.0

Source : Survey Data, 2019

Table (4.3) Water in a day, 58.3% out of the total respondents show that the households needed to use less than 3 barrel per days (approximately 150 gallons) of water for then daily use, 32.5% of respondents used 3 to 5 barrels per days (approximately 250 gallons) and followed by 8.3% of respondents consumed 5 to 7

barrels of water. The rest 0.8% of respondents need to use 7 and above barrels of water in a day.

.

Table (4.4) Monthly Expenditure for using YCDC Water

Monthly total expenditure of water for YCDC	Number of respondents	Percentage (%)
Under 500K	23	19.2
500K - 1000K	37	30.8
1000K - 1500K	19	15.8
1500K - 2000K	8	6.7
2000K - 2500K	10	8.3
2500K - 3000K	9	7.5
3000K - 5000K	3	2.5
5000K and above	11	9.2
Total	120	100.0

Source : Survey Data, 2019

Table (4.4) show, (30.8%) were the most respondents monthly total expanditure of water for YCDC between kyat 500 to 1000 kyat, (19.2%) were the second largest respondents monthly total expenditure of water for YCDC less than kyat 500, (15.8%) were the third largest respondents monthly total expenditure of water for YCDC between kyat 1001 to kyat 1500 and (9.2%) were the fourth largest respondents monthly total expenditure of water for YCDC kyat 5000 and above.

Table (4.5) Monthly Total Expendure of Water non-YCDC customs

Monthly total expenditure of water for No-YCDC	Number of respondents	Percentage (%)
Under 500K	9	7.5
500K - 1000K	7	5.8
1000K - 1500K	23	19.2
1500K - 2000K	17	14.2
2000K - 2500K	15	12.5
2500K - 3000K	21	17.5
3000K - 5000K	14	11.7
5000K and above	14	11.7
Total	120	100.0

Source : Survey Data, 2019

Table (4.5) shows, 37 (30.8%) respondents between kyat 1001 to kyat 1500, 21 (17.5%) respondents between kyat 2501 to kyat 3000, 17 (14.2%) respondents between kyat 1501 to kyat 2000 and 14 (11.7%) respondents between kyat 3001 to 5000 kyat and kyat 5000 and above.

Table (4.6) Treatment of Drinking purpose

Treatment drinking water	Number of respondents	Percentage (%)
Purified drinking water (Bottled)	108	90.0
Boiled water	7	5.8
Natural water	5	4.2
Total	120	100.0

Source : Survey Data, 2019

Above the Table (4.6) shows, 108 (90%) respondents for purified drinking water (Bottle), 7 (5.8%) respondents for boiled water and 5 (4.2%) respondents natural water.

Table (4.7) Water Storage in Thakayta Township

Water storage tank and capacity	Number of respondents	Percentage (%)
Ground tank	14	11.7
Overhead tank	38	31.7
Drum	58	48.3
Other (pots, plastic, containers)	3	2.5
No storage tank	7	5.8
Total	120	100.0

Source : Survey Data, 2019

Table (4.7) Shows, 13 (94.2%) respondents to stored water, 7(5.8%) respondents are not stored water. 58 (48.3%) respondents stored water in drum (barrels), 38 (31.7%) of respondents stored water in overhead tanks and followed by 14 (11.7%) of respondents storing water in ground tanks and 3 (2.5%) respondents stored water in plastic containers. They are ground tank, overhead tank, drum, other (pots, plastic, containers), and no storage tank. Some the households are need to be store water for their daily used. 94.2% out of the total respondents needed to store water, but 5.8% respondents used water directly from source. 48.3% of total respondents water in drum (barrels) 31.7% of respondents stored water in overhead tanks and followed by 11.7% of respondents storming water in ground tanks and 2.5% respondents stored water in plastic containers.

The nature of overhead tank capacity is mostly 100 gallons to 400 gallons with plastic epoxy paint. Ground tank is usually concrete tanks with capacity of 100 gallons to 500 gallons. Some respondents use barrels, which approximately 50 gallons, and each household uses 2 to 4 barrels.

4.2.3 YCDC Water Supply System

In this section, YCDC water supply system are using electric water pump for fetching, water meter installation or not and different of actual unit consumption in billing system, water borne disease from YCDC water.

Table (4.8) Using Electric Water Pump for Fetching YCDC water

YCDC water supply per day	Number of respondents	Percentage (%)
1 hour to 2 hours	58	48.3
3 hours to 4 hours	35	29.2
5 hours to 6 hours	15	12.5
24 hours	12	10.0
Total	120	100.0

Source : Survey Data, 2019

Table (4.8) Shows, Among 58 out of 200 respondents that are 48.3% of total respondents used YCDC water supply 1-2 hours per day. Followed by 29.2% of YCDC customers are able to access 3-4 hours per days and the rest 22.5% can access water from YCDC pipe lines 24 hours without interruption.

Table (4.9) Willing to Install Water Meter by un-metered YCDC Customers

Type of Customer		Water meter installation		Total
		Yes	No	
Using electric water pump for fetching YCDC	Yes	53	21	74
	No	8	38	46
Total		61	59	120

Source : Survey Data, 2019

Table (4.9) shows, installing water meter and un-metered using YCDC water in Thakayta Township. Total respondents 120, among 53 YCDC customers, using electric water pump for fetching and water meter installation and 38 YCDC

customers, not using electric water pump and not meter installation. People using water pumps with different capacities such as 0.5 HP, 0.75 HP, 1.0 Hp and 1.5 HP.

Out of 59 (49%) using YCDC water customers are not installation water meter and 61(51%) using YCDC water customers are installation water meter.

Table (4.10) Un-Meter Customers Opinion

Type of customers	Willing to Install		Do not want to Install		Total	
	Qty	Percentage (%)	Qty	Percentage (%)	Qty	Percentage (%)
Un-metered customers	38	64.6	21	35.6	59	100

Source : Survey Data, 2019

The respondents 120 given un-metered customers (59) are classified willing to install meter and do not want to install meter are given table (4.10) and 38 (64.6%) customers are willing to install water meter and 21 (35.6%) are not want to install water meter.

Table (4.11) Different Actual Water Consumption and Unit Quantity Bill

Count	Some as actual consumption	Different from actual consumption	Total
Frequency	77	43	120
Percentage (%)	64.2	35.8	100

Source : Survey Data, 2019

Water consumption are charged by fixed rate per unit billing systems every month. 64.2% of YCDC customers answered that the quantity of water in billing system is equal as actual consumption. The rest 35.8% mentioned that the quantity of water in billing system is different from actual consumption.

Table (4.12) Water borne disease by YCDC water

Water borne diseases	Number of respondents	Percentage (%)
Not infected	79	65.8
Infected	41	34.2
Total	120	100.0

Sources : Survey Data, 2019

Water Bone Diseases means Diarrhea, Dysentery and cholera etc. The respondents are asked if there are such cases consuming YCDC water according to the table (4.11) shows, 65.8% of the total respondents answered as not infected, but 34.2% answered as infected. The storage of water is not systematic and water may be stored in unclean containers.

Table (4.13) Water Pay for Water Supply by Respondents

Amount of Willingness to pay	Number of respondents	Percentage (%)
Under 500K	16	13.3
500K less than 1000K	29	24.2
100K less than 1500K	26	21.7
1500K less than 2000K	14	11.7
2000K less than 2500K	9	7.5
2500K less than 3000K	16	13.3
3000K and above	10	8.3
Total	120	100.0

Source : Survey Data, 2019

In table shows, water pay for water supply by respondents accepted by cleaning water or not. According to table (4.13), 24.2% of total number of respondents willingness to pay 500 kyats less than 1000 kyats 24 hours clean water supply by YCDC customers, 21.% of total number of respondents willingness to pay 1000 kyats less than 1500 kyats for 24 hours clean water supply by YCDC customers. The least of 8.3% respondents that above 3000 kyats.

Table (4.14) Type of Billing System

Type of billing system	Number of respondents	Percentage (%)
Fix rate	112	93.3
Flat rate	8	6.7
Total	120	100.0

Sources: Survey Data, 2019

Table (4.14) shows, there are two types of billing system. According to the survey data, meter connections are charge at fixed rate for every month, 93.3% of YCDC consumers are charge with fixed rate and 6.7% of respondents with unmetered connections are charge by flat rate billing system in every quarter of the year.

CHAPTER V
CONCLUSION

The Yangon City Development Committee (YCDC) is playing a very important role in the socio-economic development of Yangon region. In 2020, Yangon City Development Committee Planned to achieve its goals by using 'Yangon Strategic Development plan, 2020" to implement the target plan, take a leading role in role rural welfare activities, and to take fulfillment in current activities such as to work together and link with sector, social development of city and water supply.

Fresh water is one of the most important factors for human life and there are many sources of fresh water in Yangon region. There for fresh water management is important role all over the counties and environmental conservation is an important factor of the world. At present, YCDC is just to care on supplying water, but to care control in process.

5.1 Findings

A survey was conducted on the satisfaction of respondents on Thakayta water management in Thakayta Township regarding about water source, distribution system, access to water consumption and evaluation of existing service level. Total respondent of gender shows 61.7% of male and 38.3% females with the largest group in age is between 35 years to 45 years. The race and religion of the respondent shows 81.7% of the total respondent are Myanmar, Kayin is 5% and other 10% 81.7% of the total respondents are with 13.3%. It is found that 43.3% of the total respondents are high level education level and 0.8% of the total respondents masters level most of the households members of 120 respondents the majority is 1 to 5 members with 68.3% of the respondents. Most of the hour holds earned income less than 300000 kyats is 76.6% and the rest more than 300000 kyats is 23.4%.

A survey of 120 respondents, only 51 respondents of 42.5% YCDC water supply system. The rest of respondent are getting water from private owned tube well, government tube well, neighboring tube well, water seller and other sources (ponds,

rain water etc.) Most of the household are consumption less than 3 barrels per day with the average size of 1 to 5 families 90% of total respondents said that they are getting drinking water by buying purified bottles and 5.8% of total respondents treated water by boiling and filtering the drinking.

Among 120 respondents, 48.3% of respondents drum to stone water for their daily use, and 31.7% is storing overhead tank and 11.7% is storing in the ground tank. It is seen that the household who use private tube wells need grounded water tank or overhead tank.

Total respondents 120, 44.17% (53) customers who can access water meter installation and using electric water pump for fetching YCDC. 64.2% of YCDC customer said there was no difference between water consumption in actual and unit quality shown in water bill the rest 35.5% mentioned the difference in quality between actual consumption and water billed.

Improved water supply system is also one of the criteria to increase the living standard of Thakayta Township to extend the momentum of industrial and commercial development of urban infrastructure and to prevent water borne disease. From the survey data, 65.8% of Thakayta YCD Customers stated as not infected water borne disease using YCDC water. By mean improving water supply system, other water-related business such as food production, industrial and commercial product can be developed.

Most of the households are willing to pay more for the improvement of the water supply service. From the survey data, YCDC water supply system, they satisfied with water supply sufficiency, water pressure, water quality, the accuracy of unit in water bill and actual consumption and water billing system from YCDC water supply system of Thakayta Township.

5.2 Recommendations

Due to this statement, YCDC and EDWS must undertaken the following factorsare :

Rehabilitations of the obsolete distribution pipeline, the new pipe laying as well as replacement of old aged pipes in Thakayta township. Reduce the high rate of unaccented for under to get the public participation, education of reduce the customer wastage should be broadcasted by television, radio, sounds and magazines. Formulation of an integrated water management plan to guide coordination of

development activities to install the new booster pumps with high efficiency in low pressure area.

The complete installation of water metering system should be enforced for all production and consumption. It is need to find the new water resources for water supply and distribution of adequate and safe drinking water to fulfill the increasing water demand of Thakayta Township. Pipe leakages should be repaired and monitoring and regular maintaining system is done by Engineering Department Water and Sanitation

REFERENCES

Alcamo, J., Florke, M., & Marker, M. (2007).Future long-term changes in global water resources driven by socio-economic and climatic changes. Hydrological Sciences Journal, 52(2), 247-275.

Aung Kyaw Soe (MPA 8th Batch).'A Study on YCDC Water Supply Connections in (4) Districts".Unplished (MPA) Thesis, Yangon Institute of Economics, Myanmar.

Doll, P., & Fiedler, K. (2007).Global-scale modeling of groundwater recharge. Hydrology and Earth System Sciences Discussions, 4(6), 4069-4124.

JICA & YCDC (2013).*The Preparatory Study for on Improvement of Water Supply, Sewerage and Drainage System in Yangon City.* Yangon City: JICA & YCDC.

JICA & YCDC (2014).*The Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City.* Yangon City: JICA & YCDC.

Khin Kay Khaing (2006).Water Supply in Yangon City. *In Megacity Yangon: Transformation Processes and Morden Developments, Second German-Myanmar Workshop in Yangon/Myanmar 2005* (Vol. 7, p.237) LIT Verlag Munster.

Kyaw Lwin Oo (MPA 10th Batch). '*A Study on Problem and Prospects of Water Supply System in DallaTownship*".Unpublished (MPA) Thesis, Yangon Institute of Economics, Myanmar.

Morely, I. (2013). Rangoon. *Cities, 31,* 601-614.

O'Corner, T. P., Rodrigo, D., & Cannan, A. (2010).*Total water management : The new paradigm for urban water resources planning*. Water Resources, 457, 2149.

Taylor, R. G., Scanlon, B., Doll, P., Rodell, M., Van Beek, R., Wada, Y. &Treidel, H. (2013).*Ground water and climate change. Nature Climate Change,* 3(4), 322-329.

Yangon City Development Committee, *Yangon Strategic Development Plan 2020,* Union of Myanmar, March 2007.

Yangon Region Government YCDC & JICA (2013). *The Strategic Urban Development Plan of the Greater Yangon.* Retrieved June 1, 2014, from the (Website: http://www.ycdc.gov.mm/uploas-pdf/20130518-YGN-MP-ENG-final1.pdf)

YCDC. (2014a). *Yangon City Development Committee.* Retrieved, June 1, 2014, from (http://www.ycdc.gov.mm/uploas-pdf/20130518-YGN-MP-ENG-final1.pdf)

YCDC. (2014b). *Yangon City Development Committee*. History of Yangon. Retrieved June 1, 2014, from the (http://www.ycdc.gov.mm/pages.php?pagrname=Hsistory)

Haq, et al., 2007

Whellington, et al., 1987, 1988

Rogensor, 1996

Littlefair, 1998

Tabech and Asadianie, 2005

APPENDICES

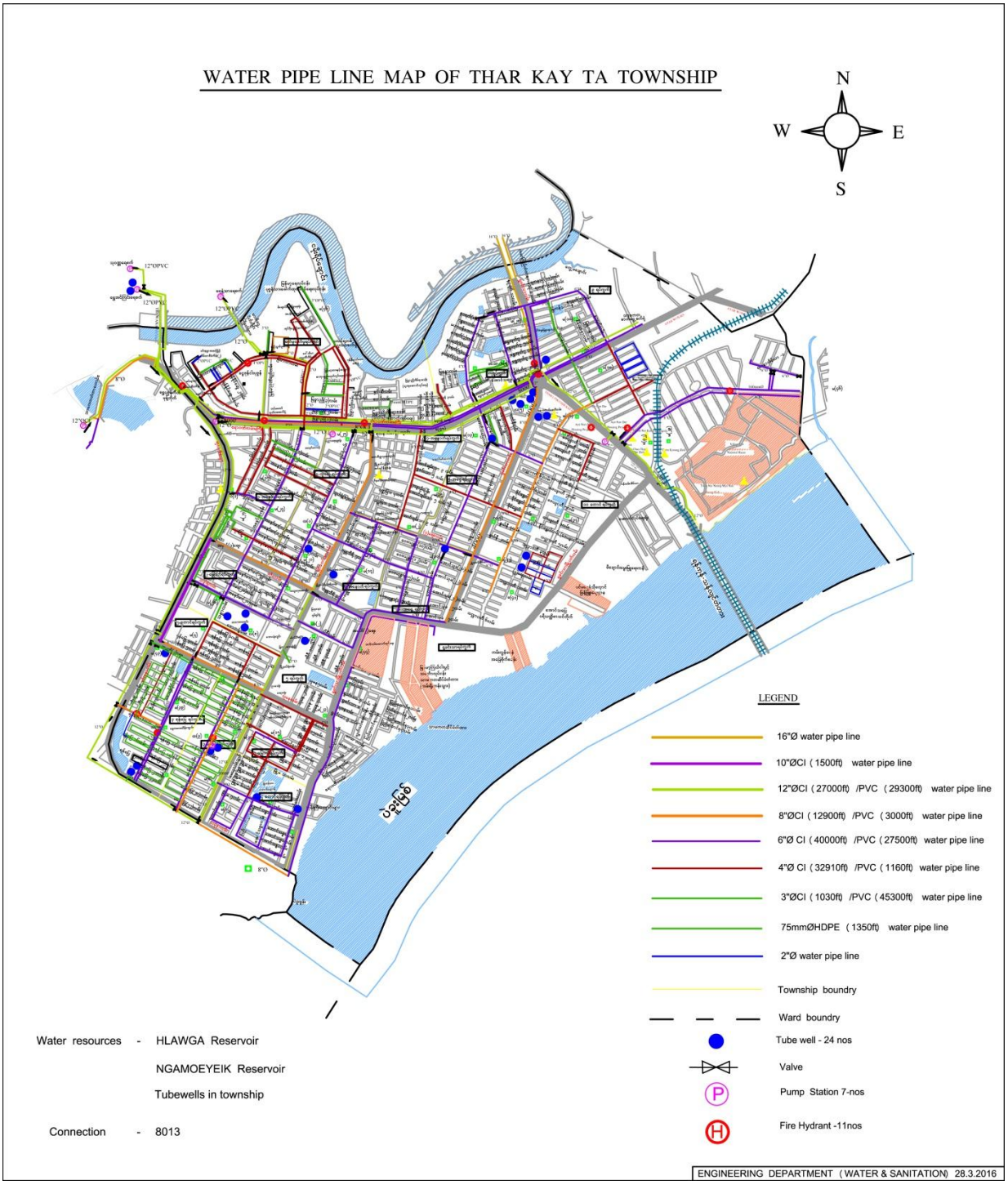
APPENDIX I

Tube Well Water Resources Data from Thakayta Township

APPENDIX II

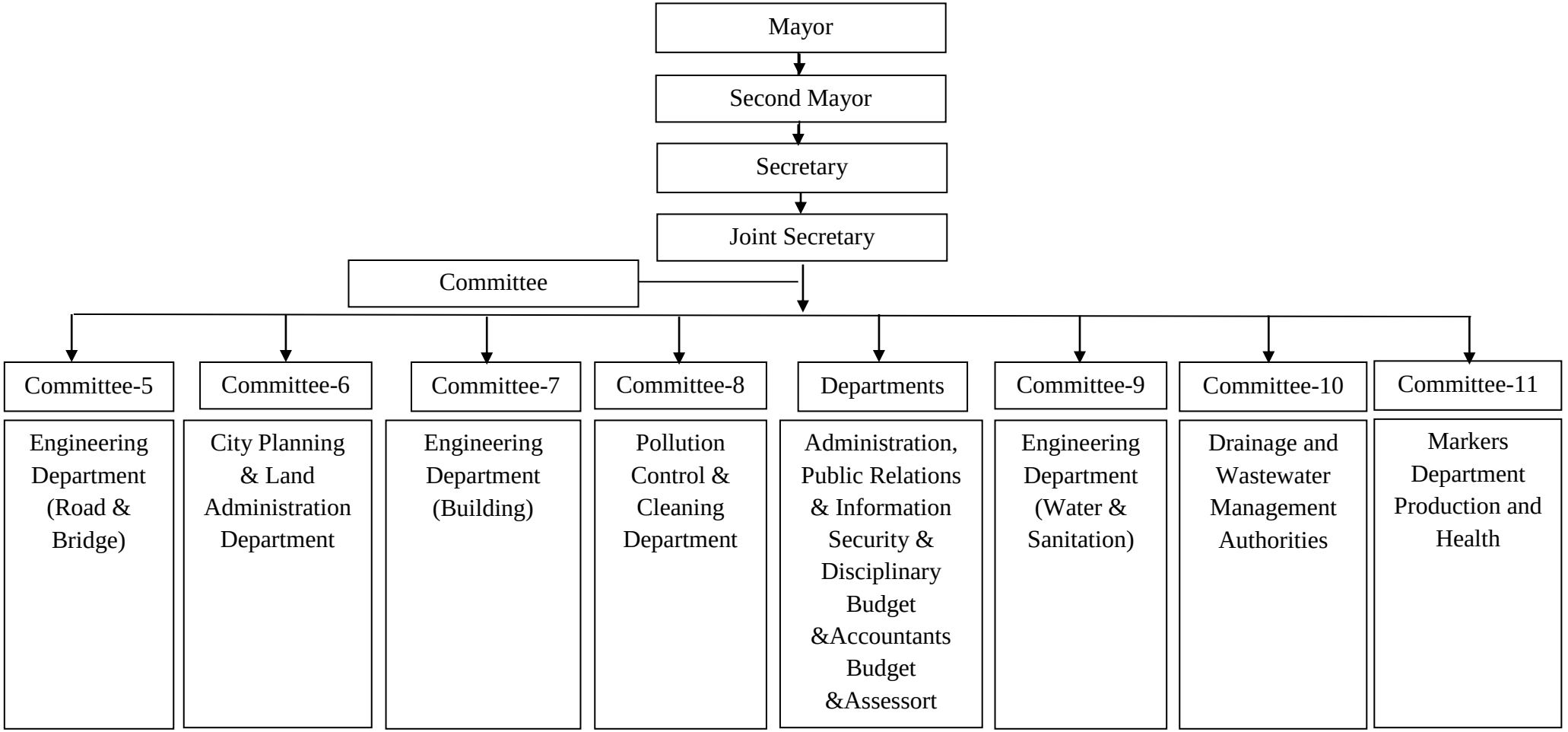
သာကေတမြို့နယ်အတွင်းရှိအဝီစိတွင်းပြပုံ

APPENDIX III



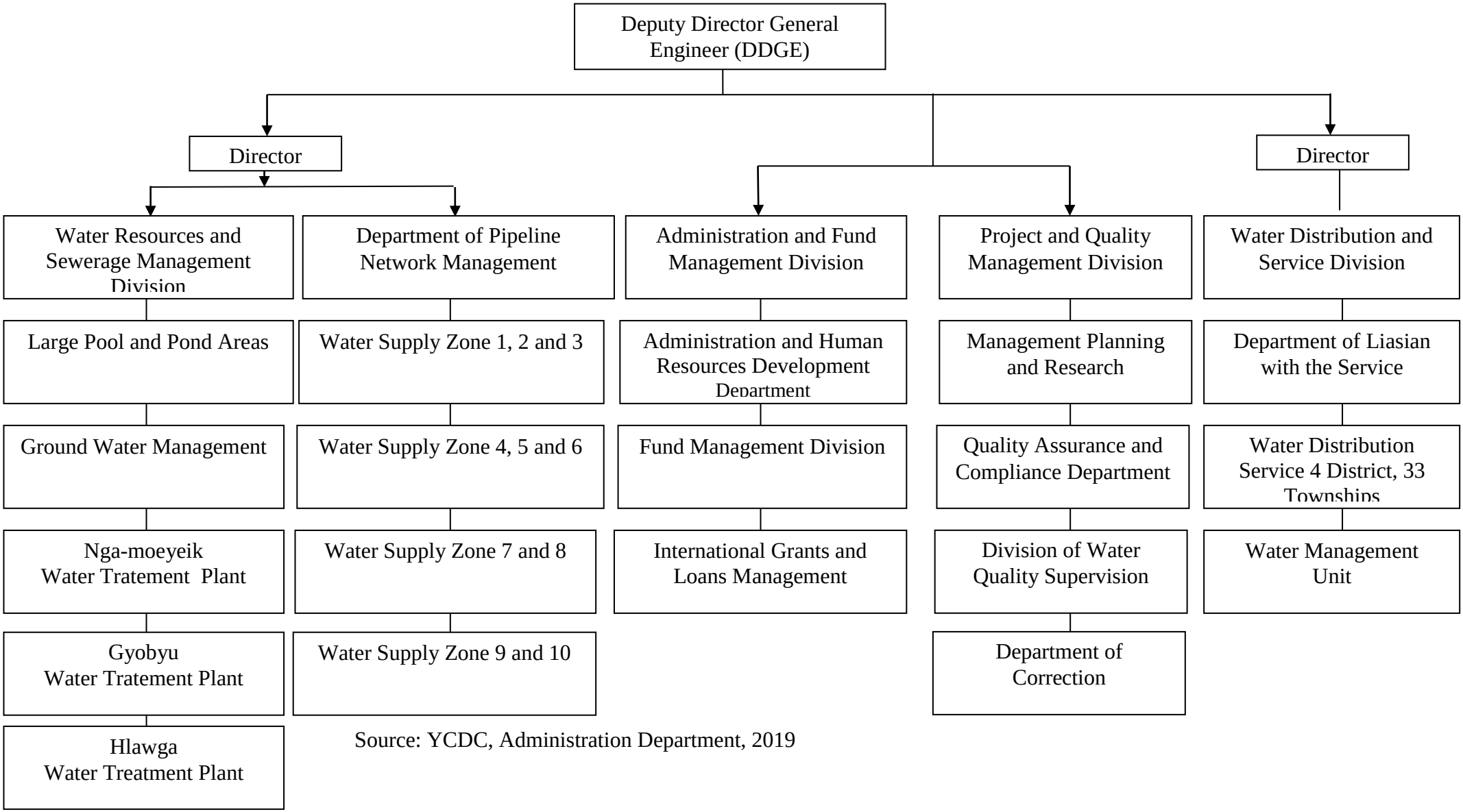
APPENDIX IV

Oragnization chart of Yangon City Development Committee



APPENDIX V

Organization Chart of Engineering Department Water &Sanitation (EDWS)



Source: YCDC, Administration Department, 2019