# A GEOGRAPHICAL ASSESSMENT ON SUSTAINABLE WATER SUPPLY MANAGEMENT OF EASTERN YANGON DISTRICT IN YANGON CITY

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## Abstract

Water is indispensable for the survival of all living beings. Access to clean, safe and reliable water remains a challenge to many people across the world, especially in developing countries. Myanmar faces a similar challenge, despite having ample water resources and reliable rainfall. In Yangon City, only38% of the population is received by City Water Supply, majority relying on alternative sources. This study explores the challenges of current City Water Supply System in Eastern Yangon District. Additionally, the aim of research is to evaluate the sustainable water supply management system and recommend actions that can be taken to improve supply of water to the city residents. A mix methods approach was employed in the study where quantitative and qualitative data collected. Quantitative data came from a household survey and interviews. Additionally, key informants were purposively selected and interviewed to provide in depth information on water related management and policy issues in the township level Yangon City as a whole. This study investigates the existing water supply system, water supply management, water qualities by sources and the amounts of water use. The water sources of the study area are rainwater, surface water and groundwater, of which groundwater is mostly used, being unable to get sufficiently from other sources in the dry season. The spatial variation of groundwater quality and whether the water is drinkable or not is checked by WHO Standard and Myanmar National Standard. The total numbers of tube well in the district have 89561. The test results of ground water sample, the contents of chloride, iron, turbidity, alkalinity, pH and total hardness are lower than the permissible levels of WHO and Myanmar National standards. The daily per capita water consumption is about 20gallons in average, lower than that of the YCDC standard (30 gallons).

**Keywords:** Ground Water, City Water Supply System, Water Quality, Drinkable, WHO, NHL, KII

## Introduction

Water supply system is one of the basic infrastructures of urban development. Without water, human cannot survive and it is also a key to public health and environmental sanitation. Safe drinking water supply and adequate sanitation facilities are essential to public health and economic development of the nation. The availability of reliable water is becoming a problem throughout the world and is coupled with increasing population pressure. Over the next 30 year, it is expected that higher population growth rates will be in the urban areas of developing countries.

Sustainable water supply system should provide adequate water quantity and appropriate water quality for a given need, without compromising the future ability to provide this capacity and quality. Water system in the realm of sustainable development may not literally include the use of water, but include systems where the use of water has traditionally been required.

Myanmar is one of many developing countries that experience water scarcity across different urban and rural areas. Urban population in Myanmar is estimated to be approximately 30 % of total population (Census, 2014). Myanmar is endowed with rich water resources. Due to the varying topography and climate conditions, the rainfall is unevenly distributed leaving some regions of Myanmar, with an acute shortage of water. The study area is situated in the eastern part of Yangon City. This research work essentially focuses on existing water supply system,

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sustainable water supply management, the quality of supply water and the amount of water uses and future water supply and demand.

With the increasing population, the demand for water has been rising, so do the water sources. In the study area, inhabitants depend largely on surface water source and groundwater source. However, the limited availability of City Water Supply System (YCDC) water, people mostly depend on groundwater source. As the community tube well source became undependable, a greater number of households sank private tube wells and now there are 89561 tube wells within the study area of which 4449 tubewells sell water to the neighbouring households. Altogether 51 percent of the total populations of the townships depend on groundwater source.

## Aim and Objectives

The main aim of this research is to evaluate the sustainable water supply management system of the study area from the geographical point of view. The specific objectives of this research work are:(1) to examine physical environment of the study area (2) to analyze the spatial variation of water supply system and water quality (3) to investigate the available water sources and to find out the ways of safe water supply system for growing populations.

## Data and Methods

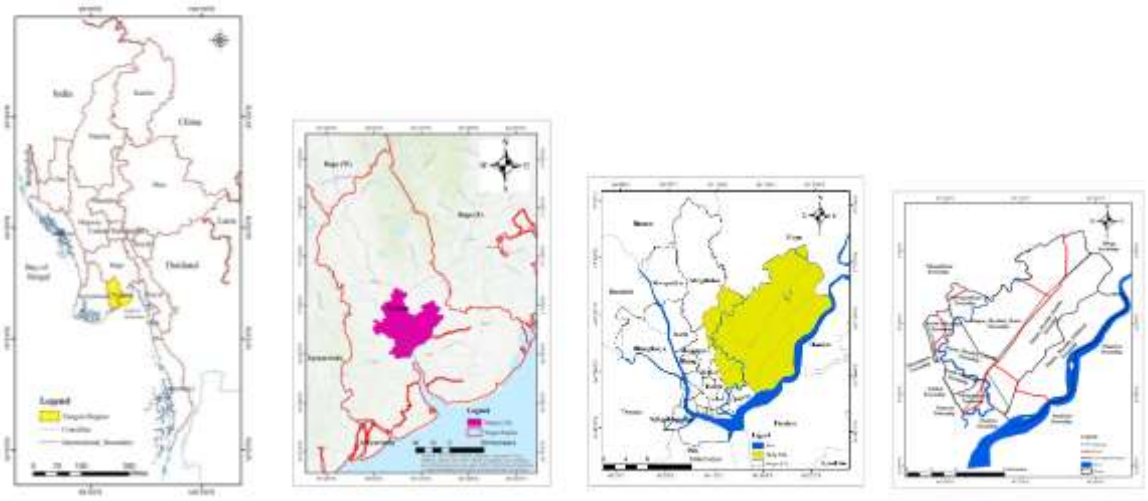
In order to have primary data, concerning water sources, water supply systems and water consumption, pilot surveys were first conducted and then questionnaire were prepared based on the information gained through pilot surveys. Table of Random Sampling Number is used in distributing the questionnaires. In addition, discussion and interviews with the inhabitants are also conducted to have in depth understanding of the problems or difficulties encountered by the residents of different townships.

Given the question that we sought to answer, a mixed method approach was found appropriate for the study, quantitative data was collected using a survey of household, randomly sampled in the District, while qualitative data was collected from relevant persons by using KII (Key informant interview's) analysis. Secondary data was also utilized in the study.

Based on the primary and secondary data available, graphs, diagrams and maps are produced using Microsoft Excel and GIS software. The sample waters are tested at National Health Laboratory, YCDC (Health Department) to identify the physical, chemical and bacteriological conditions of water. The test results are checked by WHO Guideline for Drinking Water Quality Standard (2014) and Myanmar National Standard. To assess sustainable water supply system in the study area, Multi-criteria analysis and SWOT analysis is used.

## Study area

Eastern Yangon District lies between North latitudes 16° 46′ and 17° 2′ and between East longitude 96° 9′ and 96° 22′. It has an area of 127.5 square kilometre (99.95 square miles) constituting 8 townships. According to Yangon City Development Committee (water and sanitation department), eight townships and 239 wards are including in the East Yangon District. These are Thingangyun Township, South Okkalapa Township, North Okkalapa Township, Shwepaukkan, DagonMyothit (North) Township, Dagon Myothit (South) Township, Dangon Myothit (East) Township, and Dagon (Seikan) Township.



**Source:** Map Based on 1: 63360, Map No. (94-D1)

**Figure 1** Location of East Yangon District

## Results and Findings

Water supply systems of East Yangon District are somehow related to the location, relief, drainage, climate, geology, hydrogeology and soils of the township. The main sources of water within the study area are rainwater, surface water and groundwater. The annual rainfall is about 2807 mm (110.52 inches) and thus most households use rainwater in the rainy season. As the rainfall is highly seasonal, the long dry period which lasts for about 6 months is the main source of water shortage problem. In the dry season, most of the households are using surface water and groundwater, representing 37 percent and 69 percent respectively. This indicates the heavy dependence on groundwater, particularly tubewell water in the dry season, though the quality is below the permissible level. In response to the rising temperature and longer dry period, surface water, particularly pond water begins to dry up in the late dry season. At the same time the yield of water from tubewell also decreases, resulting in insufficiency of water for the inhabitants.

The population of the study area increased gradually from 633,450 in 1990 to 1,496,620 in 2020 with an average growth rate 1.7 percent per annum. The daily per capita water consumption is about 20 gallons in average, lower than that of the YCDC standard (30 gallons). For the townships Dagon Myothit (East), Dagon Myothit (South),Dagon Myothit (Seikkan), DagonMyothit (North) Township 63percent of the inhabitants use less than 20 gallons per day per head in average while 35 percent of that of people consume more than 20 gallons each per day. In Suburban area of the district, Thingungyun township, South Okkalapa township and North Okkalapa township use more than 25 gallons per day. The difference in the daily per capita water consumption depends on the water sources, water supply systems and socio-economic status of the inhabitants.

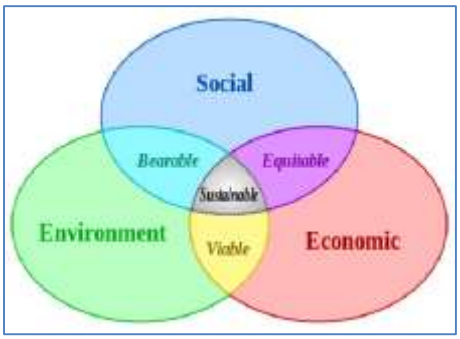
Water supply in East Yangon District is categorized into: City Water Supply System (YCDC) and non City Water Supply System. Approximately 90% of water supplied by YCDC comes from reservoirs, supplemented by tubewells. The water distribution is through pipes to the user. But non CWSS serviced areas, people have adapted to such various sources, tubewells, rain water storage, ponds, community tubewells and taps bottle water, water vendors, and also include small public water supply system. The water supply from available reservoirs can meet the needs of the existing population. However, there has been a lag between supply and demand because of many factors, including aging infrastructure, water leakages and inadequate pipelines connection in most townships. As highlighted earlier in the study, only 37% of the total households in East

Yangon District are reached by YCDC supplied water. The rest of population have relied on other sources. As relates to the infrastructure, over 60 years old age pipes are still operating especially in Thingungyun township, South Okkalapa township and North Okkalapa township. Approximately 48% of total daily supply is lost because the pipe line connections have not been rehabilitated properly. Furthermore, 87% of all connections are equipped with meter. The duration of water supply is highly variable. The availability of water depends on the distance from the water sources. The townships near the main distribution line or sources can get more in times of duration and amount. As such some households used motor to pump water from the main pipeline.

Based on calculated result, the average daily consumption of water within the study area over 33 million gallons. However, the CWSS source can deliver only about 15.19 million gallons per day and the remaining 17.81 million gallons have to be satisfied mainly by groundwater source, partly by surface water sources. Depending on localities, the depth of tube wells varies between 91.44 m (300′) and 182.88 m (600′). According to the test results of ground water sample, the contents of chloride, iron, turbidity, alkalinity, pH and total hardness are lower than the permissible levels of WHO and Myanmar National standards. The quality of YCDC water is within the maximum permissible level of WHO standards.

## Discussion

Accessing the sustainable features in water supply, that three-fold goals of economic feasibility, social responsibility and environmental integrity, is linked to the purpose of water use. Sometimes, these purposes compete when resources are limited, for example, water needed to meet the demands of an increasingly urban population and those needs of rural agriculture.




**Sources:** researchgate.net/figure Triple-bottom-line-accounting

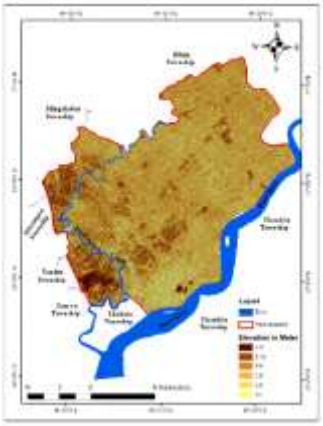
**Figure 2** Three-fold goals of Sustainable water supply management system

Sustainable water supply is a component of integrated water resource management, the practice of bringing together multiple stakeholders with various viewpoints in order to determine how water should best be managed. In order to decide if a water system is sustainable, various economical, social and ecological considerations must be considered.

Physical environment such as location, relief and drainage, geology, climate, soils and natural vegetation affect the water sources and water supply of a given area. The study area, in fact, is part of the floodplain belts of the Ngamoeyeik Creek and Bago River and thus it has no salient topographic feature, characterized by flat, low plain with a general elevation of 5.49 metres (18 feet) above sea-level, although the land imperceptibly lowers towards the Bago river and Ngamoeyeik creek. These are the major drainage system of the study area. Ngamoeyeik Creek takes its sources over mountain spur of BagoYoma, at 19.3 km (12 miles) north of Phaunggyi in Hlegu Township and meandering with a series of sharp bands along the northern, western and

southern boundaries of the study area. On the other hand, it serves as one of the main sources of drinking water for the inhabitants of Yangon City. Generally the study area is part of Greater Yangon (Yangon City). Being lowlying plain, the topmost layer which is about 15.24 metres (50 feet) in thickness is fully covered with young alluvium of recent geologic time, underlain by valley-fill deposit with a thickness ranging between 36.58 metres (120 feet ) and 91.44 metres ( 300 feet). In practice, rock units of Irrawaddy and Pegu Group are less significant for the extraction of groundwater due to their great depth. The availability of freshwater in the western part of District at depths over 152.44 metres (500 feet) is probably due to downthrown nature of the eastern side of Mingalardon-Yangon Fault, and shallow freshwater aquifers in Eastern Yangon District which may be related to the northern extension of Thingangyun-Thanlyin Anticline.

The annual mean temperature is 27.15 °C (80.87 F). The monthly mean temperature is highest in April with 30.4 °C (86.72 °F) and lowest in January with 24.9 °C (76.82 °F). Within the study area precipitation is high during the rainy season from May to October and low in the remaining period of the year. The average total precipitation in the period from May to October was 2696 mm of which 651.1 mm was evaporated, thus resulting in water surplus. However, the amount of precipitation received in January-April period was only 70 mm which the amount of evaporation was high with 615 mm. Thus the amount of water deficit in that period was 545 mm in the soils. The water surplus for the whole year is 1914.9 mm which occur in the period from May to October, while soil water deficit is dominant in the November to April period with 627 mm. If the surplus water can be stored by possible means, the water shortage problem in the dry season would be reduced. The meadow soil group is the most dominant characterized by high clay content. Along the both sides of the Ngamoeyeik Creek and Bago river are swampy soils (***Gleysol***) and meadow alluvial soils (***Gleysols and moderate Fluvisols***).



**Source:** Map based on 1:50000 UTM Map NO. (1696-01)

**Figure 3** Relief and Drainage map

Source: Immigration and Man Power Department

**Figure 4** Population density of East Yangon District

The social environment such as population growth, population distribution and density are also effect on sustainable water supply management in the study area. The District has 987,840 people in 2000 and population increased to 1,496,620 people or 25% of Yangon City in 2020. Annual growth rate is 1.7 percent. At this rate the population of the study area will double in the next 30 years, demanding two times of the present amount of water need. The population distribution of the district is highly uneven. More people are concentrating in suburban area such as Thingangyun township, south Okkalapa township and north Okkalapa township. Northern part of Dagon Myothit (East) township, Dagon Myothit (South), Dagon Myothit Seikkan township are sparsely populated due to low accessibility being close to the Bago river. The average population density was 11,738 persons per square kilometre (14,974 persons per square mile), much lower

than that of the inner townships of Yangon City which ranged between 100,000 and 200,000 persons per square mile. South Okkalapa township is the highest in population density with 20,211persons per square kilometre. These townships in fact, were former new town of Yangon City, settled since 1958 the establishment of the township. The township with lowest population density was Dagon (Seikkan) with 1457 persons per square kilometre.

The development of human society is somehow related to the availability of potable freshwater sources. Quality of available water, to some extent, affects the health of inhabitants of the area concerned.

## Present water supply system

### Rain water Harvesting

Rain water is the natural and fundamental sources of all water and it replenishes stream, pond and groundwater. Within the study area, rain water is received from the third week of May to the end of September, in some years to end of October. The source of rain is the moisture-being southwest monsoon wind and the average annual rainy days is 129 days. Generally rain water received during the period from June to October is sufficient for all types of use. In the study area 28.1% of household use rain water.

### Surface water

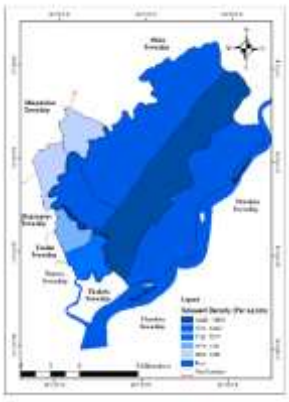
The existing surface water sources within the study area are ponds and Reservoir. There are 107dug-ponds for storing rain water in the district. The larger ponds were dug since human settled in this area as village units. Usually these ponds dry up in the later phase of dry season, resulting in water shortage problem for the households concerned which have to buy water. As highlighted earlier in the study, only 38% of the total households in Yangon City are reached by YCDC supplied water. The rest of population have relied on other sources. Approximately 90% of water supplied by YCDC comes from reservoirs, supplemented by tubewells.

### Ground water source

Groundwater accounts for greater than 50% of global freshwater; thus, it is critical for potable water (Lozan et at, 2007). Groundwater can be a sustainable water supply source if the total amount of water entering, leaving, and being stored in the system is conserved. There are three main factors which determine the source and amount of water flowing through a groundwater system: precipitation, location of streams and other surface-water body, and evapotranspiration rate; it is thus not possible to generalize a sustainable withdrawal or pumping rate for groundwater (USGS, 1999). Unsustainable groundwater use results in water-level decline, reduced streamflow, and low water quality, jeopardizing the livelihood of ground-water pumpage, increasing recharge to the ground-water system, decreasing discharge from the groundwater system, and changing the volume of groundwater in storage at different time scales (USGS,1999). A long-term vision is necessary when extracting groundwater since the effects of its development can take years before becoming apparent. It is important to integrate groundwater supply within adequate land planning and sustainable urban drainage systems. There are 89,561 private tubewell in the study area. Most of the Tubewell are located in Dagon Myothit (South) Township. Altogether 74 percent of the total populations of the District depend on groundwater source. Depending on localities, the depth of tube wells varies between 300 and 600 feet.

**Source:** Water and Sanitation Department (YCDC)

**Figure 5** Pipe Water Supply System



**Source:** Water and Sanitation Department (YCDC)

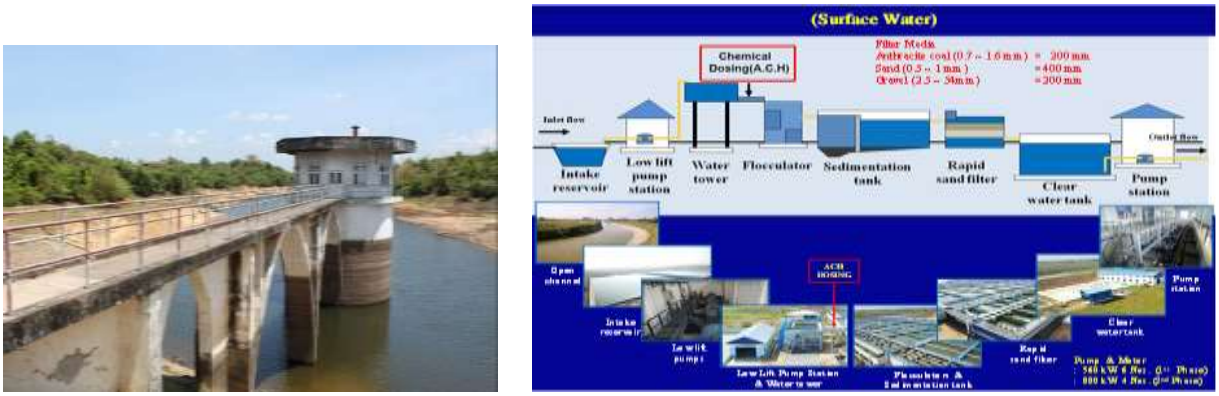
**Figure 6** Tubewell density of East Yangon District

## Assessment of sustainable water supply management in the study area

A water supply system with be sustainable only if it promotes officiencies in both supply and demand side. Collection water from precipitation is one of the most sustainable sources of water supply since it has inherent barriers to the risk of over-exploitation found in surface and groundwater sources, and directly provides drinking water quality. However rain water harvesting systems must be properly designed and maintained in order to collect water efficiently, prevent contamination and use sustainable treatment system in case the water is contaminated. A number of drinking water treatments exist at point-of-use, each with advantages and disadvantages. These include solar treatment, boiling, using filters, chlorination, combined methods such as filtration and chlorination, flocculation and chlorination. Although technically given the Earth's surface and precipitation, rainwater harvesting can meet global water demand, the solution can most practically be a supplement to sustainable water supply system given a level of uncertainty (especially with climate change), and competing land-use applications.

The water supply from available reservoirs can meet the needs of the existing population. However, there has been a lag between supply and demand because of many factors, including aging infrastructure, water leakages and inadequate pipelines connection in most townships. Among the 239 wards of 8 township only 112 wards receive piped water from Gyobyu reservoir, Hlawga reservoir, Ngamoeyeik reservoir. In the study area, sustainable water supply system from reservoir has operated by eight stage/ phase as open channel from creek, intake reservoir, low lift pumps station, water tower, flocculation and sedimentation tank, rapid sand filter, clear water tank, pump station to pipe connection figure(2). The daily amount of water delivered to the district is about 15.19 million gallons per day. Of the total 332,307households, only 121591 households (37 %) have now access to the piped water source.

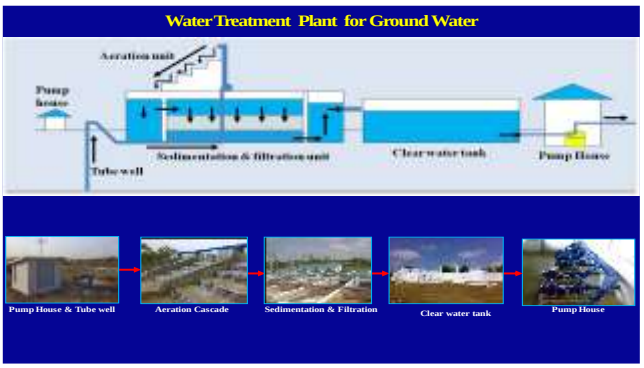
Ngamoe Yeik Creek → Ngamoe Yeik (water intake) reservoir → Pre-sedimentation tank → Addition of Aluminium Chlorohydrate [Al2Cl (OH) 5] in the water tank → Flocculation unit → Sedimentation tank → Rapid Sand Filtration → Clear well → Pump station → Distribution Network




**Sources:** Water and Sanitation Department (YCDC)

**Figure 7** Sustainable water supply management system of Ngamoeyeik reservoir

To provide sufficient clean and safe water for household uses, industrial and construction uses, the Township Development Committee together with YCDC arranged access to central water supply system, delivering water to 128 wards of the township, covering 21 % of the District population. Local water supply system is based on the community tube wells and it can provide water to only 36 % of the total population. The wards that have the access to central water supply system depend largely on groundwater acquired through tube wells. The amount of clean and safe water that can be delivered depends on the means of sustainable water supply system and the materials used in the system. Water supplied by pipeline system from YCDC tubewell water that operate aeration cascade, sedimentation or filtration, use clear water tank, pump house and connect to pipeline shown in figure(3). It reaches directly to the residence attached with meter for measuring the volume of water uses by each household. There are 128 tubewell and 118 concrete tanks support by Yangon City Development Committee. The District now (2020) has 89561 private tube wells. Those cannot afford to sink a tube well have to buy water from the nearby houses that have tube well. Private water supply system support water to 46.91 percent of the population. The majority of the inhabitants buy purified water for drinking. Only a small proportion of the households can store rainwater and drink it all year round.




**Sources:** Water and Sanitation Department (YCDC)

**Figure 8** Sustainable water supply management system of YCDC tubewell

## Water Quality

Water quality is most important for the health of consumers. Within the study area rain water, surface water and groundwater are the existing water sources. As rain water is formed by condensation of moisture in the atmosphere, it is generally clear and less contaminated by impurities.This pure rainwater has a pH of about 5.6. To identify the quality of water in the study area water samples are taken from Dagon Myothit (North) township. According to laboratory test result the pH values are 7.4 compared with WHO standard (6.5-8.5) and National Standard (7 to 8.5).

## Quality of Surface Water

Surface water of the study area includes pond water and water from Reservoir water, distributed by Central Water Supply System of Yangon City. There are 107 ponds within the study area of which ponds in Dago Myothit (North)Township and Dagon (East) township are taken. Both sample waters are slightly yellowish in physical appearance. Turbidity values are fairly high with 17 NTU in ward 51 and 30 NTU in Sitpintaung ward, higher than permissible level of WHO Standard (5NTU). The pH values are 6.9 and 6.6 respectively and thus they are within maximum permissible level both by WHO Standard and Myanmar National Standard.

Central water supply system of YCDC shares water to112 wards of the District, of which water samples from Ngamoeyeik reservoir water and Gyobyu reservoir water are taken for laboratory test. The physical appearance of sample water is clear and the turbidity value of Gyophu is 20 NTU, while that of Ngamoeyeik reservoir water has 7 NTU, including within the maximum permissible level by WHO standard. Water delivered through pipelines from Ngamoeyeik reservoir has no colour and odour, as it has been filtered by a series of filtering tanks and filtering machine before being sent into the pipelines. The sample waters include 9 mg/l of chloride respectively which are within maximum permissible level (250 mg/l) of Myanmar National standard. The pH values of the sample waters from 7.4 in Ngamoeyeik reservoir and Gyophu reservoir is 7.9 which is within the highest desirable level by WHO. The iron content is 0.85 mg/l in Ngamoeyeik reservoir water and 0.8 mg/l in Gyophu water lower than WHO Standard (1 mg/l). The pipe water contains no sodium nitrate, and the contents of nitrate, fluoride and chlorine are lower than WHO Standard and thus it is suitable for drinking.

## Quality of Groundwater

The majority of inhabitants in the District rely on groundwater. Groundwater is bacteriologically free and safe, but more minerals usually dissolve in it. Water samples from 8 tubewells were collected for laboratory test. Quality analysis includes physical appearance, chemicals dissolved in the water, and bacteria included. Generally the wards located in the western part and eastern part are close to the Ngamoeyeik Creek and Bago river thus the groundwater is affected by the salty water. The aquifer lies at great depth and the water quality is relatively low with high content of undesirable chemical. The tubewell water is much affected by the stream water increasing the values of pH, Turbidity, Chloride, Alkalinity and Sodium Nitrite, much higher than WHO Standard. The water withdrawn from this area is favourable only for domestic uses. The eastern part of the township is fairly distant from the Ngamoeyeik Creek and the underlying acquifer is thick with yellow sand layer and therefore the water withdrawn from the tubewells of the eastern part is fairly good in quality.

## Water Supply and Demand in the Study Area

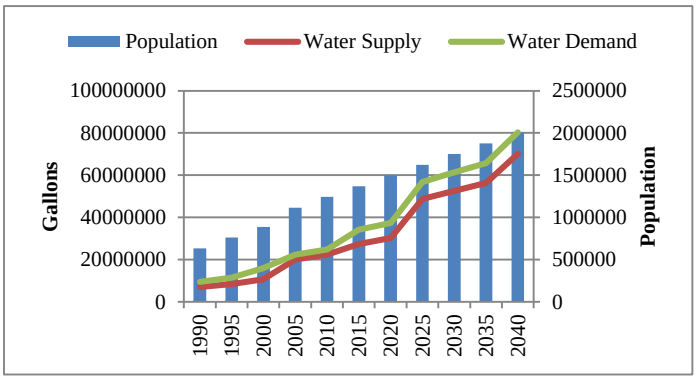
The basic requirements for water supply system are availability of ample water sources, maintainance of the system and means of delivery to the consumers. Initatives to meet demand for water supply will be sustainable if they prioritize measure to avoid water waste. Avoiding wastage will contribute to reducing water consumption and consequently, to delaying the need for new resources.

The Central Water Supply System of YCDC delivers 205 gallons of water daily of which 14 million gallons come from Hlawga Reservoir, 27 million gallons from Gyobyu Reservoir, 54 million gallons from Phugyi Reservoir,90 million gallons from Ngamoeyeik Reservoir and 20 million gallons from YCDC Tubewell. For the study area water is directly delivered through pipelines from Hlawga Reservoir, Gyobyu Reservoir, Ngamoeyeik Reservoir and YCDC Tubewell. The water is received by 121,591 households in 8 Township and the daily amount of water released for the District is 15.19 million gallons. The remaining households have to rely mainly on groundwater source which is generally low in quality. The future water demand and supply conditions are presented in Table(1) based on the current amounts of demand and supply, as well as in the previous time. The existing CWSS and LWSS cannot satisfy the need. On the other hand, the number of population has been growing rapidly. Unless necessary water supply projects are laid out and implemented, based on the number of population in next 10 years or 20 years, water shortage problem would be a great concern for the greater proportion of the inhabitants of the study area. It is learnt that a new water supply project is being implemented. The project is Lagumpyin Reservoir water treatment Plant from which 30 million gallons of water is to be delivered daily to the four townships of Dagon Myothit (North), Dagon Myothit (East), Dagon Myothit (South), Dagon Myothit (Seikkan) and Thilawa SEZ. Ngamoreyeik reservoir will promote for clean and safe drinking water and domestic water use by the ADB aid.

**Table 1 Past and Future Water Supply and Demand of East Yangon District (1990-2040)**

| Year | Population | Water Supply | Water Demand |
|---|---|---|---|
| 1990 | 633450 | 6967950 | 9501750 |
| 1995 | 760625 | 8367095 | 11409675 |
| 2000 | 887840 | 10654080 | 15981120 |
| 2005 | 1113035 | 20070630 | 22300700 |
| 2010 | 1242230 | 22360140 | 24844600 |
| 2015 | 1369425 | 27388500 | 34235625 |
| 2020 | 1496620 | 30231478 | 37415500 |
| 2025 | 1623815 | 48714450 | 56833525 |
| 2030 | 1751010 | 52530300 | 61285350 |
| 2035 | 1878212 | 56346360 | 65737420 |
| 2040 | 2005400 | 70189000 | 80216000 |

**Source:** Immigration and Man Power Department and field observation




**Source:** Based on table (1)

**Figure 9** Past and Future Water Supply and Demand of East Yangon District (1990-2040)

The assessment of sustainable water supply management of East Yangon District is used SWOT analysis. The sustainability evaluation frameworks based on the multi criteria analysis as social, environmental, economic, risk-base and functional criteria.

**Table 2 SWOT analysis on sustainable water supply management in East Yangon District**

| Criteria/ components | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| Social | -Fair user acceptance and willingness,<br>- easy in user awareness and involvement | -Some people less public participation and contribution<br>-less demand & supply management options<br>-lack of support from institutions | - number of jobs it creates,<br>- favourable for recreational values (ponds& reservoir)<br>- more water uses knowledge and involvement | - Increase in population,<br>- large amount of water uses,<br>- human health and hygiene |
| Environmental | -abundant rainfall,<br>-many ponds, reservoirs water,<br>-easily to collect water<br>-favourable condition for pipe connection (low relief) | -part of the floodplain,<br>-less conservation on existing water resources<br>- | - possible to store in surplus water(may-Oct),<br>- effective conservation in existing ponds, tanks, reservoir, tubewell | -climate change (decrease in rainfall)<br>-insufficient water in dry season,<br>-waste product deposit on ground, creek and stream)<br>-flooding |
| Economic | -Fair cost of YCDC water<br>-acceptance of water bill | -high cost for dug Tubewell,<br>-expensive cost buy water | - having many commercial activities & industries,<br>- possible to low cost water supply system and distribution | -heavy cost of capital, maintenance, and operational of water supply options, including water distribution and storage |
| Risk-base | - less probability of supply shortfalls<br>-fair maintenance and operational of water supply options | -Low lying flood plain,<br>-salt water instruction in GW near River,<br>-low in water quality, - GW contaminate near sewage and solid waste | -more ability to perform satisfactorily under a range of system changes(eg.climate)<br>- less magnitude of failure duration | - climate change,<br>- pond water dry up in late dry season,<br>- over exploitation<br>- decrease in aquifer & low water quality |
| Functional | -fair technical feasibility,<br>-ability to use already available water infrastructure and monitoring water quality | -insufficient amount of YCDC water supply<br>-less access supply water distance main pipeline<br>-technical knowledge needed | - new water harvesting area,<br>- upgrading distribution pipe line networks<br>- new water supply project by YCDC | - growth urban infrastructure,<br>- challenges with water supply management of site<br>- aging infrastructure, water leakages and inadequate pipelines connection |

**Source:** Field Observation

## Suggestions and Conclusion

Although the inhabitants have adequate water in the rainy season, the majority have to rely on the City Water Supply System and groundwater. Therefore, strong concrete ponds should be constructed to store more rainwater to be able to offer quality water sufficiently in the dry season. The existing CWSS pipeline cannot deliver water effectively and thus each booster should be installed in each Township to enhance the flow of water. The quality of water delivered by the housing projects is unfavourably low and thus it should be treated before delivering. As such the authority concerned of the projects should build sustainable large concrete tank to store water and supply sufficiently. As the existing pipes have been laid out for a long time, lots of deposits are stuck in the inner walls of these pipes, decreasing the flow of water and also contaminating the water. Both tubewell water and pond water are high in turbidity. Such water is kept one or two

nights to get fairly clear water. Therefore, CWSS system should be extended to the wards that have no access to it. The solid wastes as well as liquid wastes are disposed indiscriminately around the ponds, beyond the house compound and beside the creek bank which enhance water pollution. Depending on different acquifers and the distance from the Ngamoeyeik Creek, the groundwaters withdrawn from tubewells are more or less high in iron, chloride, pH, alkalinity, sodium nitrite and hardness, higher than permissive level of WHO Standard and thus such water should be somehow treated or boiled before drinking. The Industrial Zone is located close to the bank of Ngamoeyeik Creek and most industrial wastes are released into the creek, contaminating the stream water and groundwater. The YCDC and the responsible persons of the Industrial Zone should find out the best means of disposing industrial wastes. The flooding of highly contaminated water in rainy season and inavailability of clean and safe water in the dry season increase the incidence of diarrhoea, bowel disorder, dysentery jaundice, typhoid and polio. To reduce such ill-health, the inhabitants cautiously treat the available water which is more or less contaminated with undesirable chemicals and pollutants. The existing concrete tanks in the housing projects are close to sewer tanks, decreasing the quality of water. The YCDC has instructed to chlorinate the water to somewhat improve the water quality. Consuming chlorinate water for long period may cause ill-health to the consumers. Therefore, the concrete tanks for storing water should be built away from the sewer tanks. Some households use very shallow sewer pit and thus the dirty matters degrade the environmental quality and surface water. Occasional educative talk should be launched to increase the awareness of hygienic and healthy lifestyle. With the increasing population, the number of tubewell has been increasing which can exhaust the existing aquifers in the long run. Therefore, the responsible persons should undertake effective arrangements to be able to provide clan, potable water to the inhabitants of the study area. The general trend is that population of the study area is likely to increase at the present rate (1.7%) and the majority would have to depend more on groundwater which is fairly low in quality, unless the YCDC shows concern over the water related problem in the study area and extend the existing CWSS pipeline system covering all the wards of the study area. Indeed, the real problem, for the time being, is not shortage of water, but inavailability of clean, safe and potable water in sufficient amount at low expense.

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