



## **GROUNDWATER EXTRACTION IN THE CITY OF MALOLOS: A WATER SUSTAINABILITY INITIATIVE**

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*Abstract-* Today, the world experiences scarcity in water especially potable water for the mankind. In the City of Malolos, groundwater is the only and main water supply for the whole city. With this information, the people of Malolos should be aware of the status of groundwater extraction in the whole area of the city.

The groundwater extraction in the City of Malolos should always be evaluated for water is a very important need in our lives.

In this study, the researchers gathered the necessary data and conducted interviews and surveys to be able to determine and evaluate the status of groundwater extraction in the city and also forecasted the groundwater consumption for the different areas after a reasonable number of years. Also, because of lack of sufficient water conservation programs, the researchers suggested some programs and policies be implemented.

### **I. INTRODUCTION**

Water composed almost 75% of the earth. And this is one of the most important necessities of the human being. It is used for the source of living, sanitation, production of materials and goods, people's relaxation, transportation, and many more uses.

With the uses of water, the proportionality of the water demand and its use, together with the number of population and developments using, is greatly at stake. Water may be large in quantity, but as the time pass by, the population growth and

growing development are also rapidly gaining a large quantity too. As a result, sustainable water use is required. It is the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it (Gleick, et. al., 1995).

But today, with the increasing growth of human population, and increasing demand and consumption of water supply in all kind of areas, there is a possibility that water supply might be inadequate to satisfy the need. And this dilemma is called groundwater depletion, which is a serious threat to the environment. This may be caused by (1) frequent pumping of water, (2) continuous pumping of groundwater that it doesn't have enough time to recharge, (3) having a large amount of water requirement by most of the need and, (4) diminishing naturally. Also, climate change is a big factor of groundwater depletion.

In the City of Malolos, Bulacan, many things have already changed. Once, it was just a simple city, but now, the residents have increased and industrial, commercial, agricultural establishments and need also increased. And with these, the extraction and consumption of groundwater supply increased, too. There could be a possibility of a not proportional supply and consumption of groundwater and this study aims to know the sustainability of groundwater in the City of Malolos.

And by this study, the rate of groundwater extraction to supply the need for industrial,



commercial, residential and agricultural aspects will be able to identify and evaluate. This can be used as a guide on how (1) to use the water wisely and economically, (2) to economically use the energy and electricity consumed by the pumps and generators, (3) to preserve and protect the mother nature and the environment, (4) to design the correct water system for the City of Malolos, Bulacan in the future and, (5) to conserve water for the groundwater's sustainability.

Also, this study will give the difference of the rates among the four aspects, industrial, commercial, residential, and agricultural, of the community. And which of those aspects give the highest rate of consumption of the groundwater.

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### **Statement of the Problem**

The general problem of the study is "How may the groundwater extraction from, industrial, commercial, residential and agricultural areas in the City of Malolos be evaluated and consequently be used as inputs for water sustainability?"

Specifically, this study seeks answers to the following question:

1. What is the status of the groundwater extraction in the City of Malolos in terms of?
    - 1.1. Industrial
      - 1.1.1. Number of Industries;
      - 1.1.2. Number of Employees;
      - 1.1.3. Process
    - 1.2. Commercial
      - 1.2.1. Educational Institution;
      - 1.2.2. Banks and Insurance Companies;
      - 1.2.3. Restaurants and Fastfood Chains;
      - 1.2.4. Churches and Malls;
    - 1.3. Residential
      - 1.3.1. Population per Barangay
    - 1.4. Agricultural
      - 1.4.1. Agriculture; and
      - 1.4.2. Fish Ponds
  2. What policies and programs may be proposed to have sufficient water supply for the industrial, commercial, residential, and agricultural?
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## **II. RESEARCH DEVELOPMENT**

Methodology is a technique of analyzing principles or procedures of methods or rules employed by a discipline. It also includes the procedures and methods of gathering data from different organizations for the study.

### **2.1. PROJECT RESEARCH DESIGN**

This study is conducted using an evaluation method. And the success of this study is through gathering data from the previous years, related studies and literature, and taking interviews and surveys to gather the recent events. The researcher opted to use this kind of research considering the desire to acquire first-hand data from the respondents so as to formulate rational and sound conclusions and recommendations for the study.

### **2.2. PROJECT DEVELOPMENT**

Groundwater Extraction in the City of Malolos: A Water Sustainability Initiative aims to determine the groundwater availability through a long period of time and to make the people in the City of Malolos aware on how they can conserve and save water effectively and efficiently. For this study, 51 barangays were identified by the City of Malolos, Bulacan. The city of Malolos is politically subdivided into the following 51 barangays. All from those barangays will be the respondents for the study about the water supply sustainability. But these respondents will not be surveyed because these data can be gathered from the City Hall of the City of Malolos. Also, the researchers will interview the 15 managers of large institutions and industries for their consumption of water and for the policies and programs that they implement to conserve water in their establishment. The barangay captains and other government officials, together with the farmers and landowners, are targeted to interview with the same topic as the managers of the institution.

### **2.3. EVALUATION PROCEDURE**

The collection of data, researchers considered different books, studies, and researches that are related to the study of groundwater extraction. In this study, the whole population of the City of Malolos will be considered. Surveys are brief



interviews and discussions with individuals about a specific topic, asking only a few questions. This study was a stratified random sample across the barangay that has a potential for groundwater extraction.

## 2.4. EVALUATION CRITERIA

This study is evaluated based on these factors:

- Data about the groundwater availability and consumption.
- Total number of population.
- Groundwater sustainability development.
- Ecological profile in the residential, commercial, industrial and agricultural areas in the City of Malolos, Bulacan.

## III. RESULTS AND DISCUSSIONS

This section presents the results and interpretation of all the data gathered in the conduction of the study. It includes the status of the groundwater extraction in the City of Malolos in terms of industrial, commercial, residential, and agricultural areas from the City of Malolos Water District (CMWD) and the Municipal City Hall, and the forecasted population and groundwater consumption up to the year 2040 in the City of Malolos. And the proposed policies and programs to have sufficient water supply for the residential, commercial, industrial, and agricultural areas in the City of Malolos.

### 3.1 Status of the groundwater extraction in the City of Malolos in terms of industrial, commercial, residential, and agricultural areas

Table 1

*Total Annual Volume of Groundwater Extracted the City of Malolos*

Total Annual Volume of Groundwater Extracted	
Year	Annual Volume
2013	12,489,249.00
2014	12,650,106.00
2015	12,808,667.00
2016	12,865,693.00
2017	14,089,872.00
Total:	64,903,587.00

Table 1 showed the status of extracted groundwater in the City of Malolos for the past 5 years that will be used as the basis for the forecasted volumes of the extracted groundwater in the next few years.

The data gathered in Table 1, is used for the forecasting method that will calculate the extracted groundwater for the next 23 years. Through the calculated data, the year 2040 got 21,522,799.90 cu. m. This results in an increase of water consumed with the increase in time.



Table 2

*Population data per Barangay*

Barangay	2007	2010	2015
Anilao	4,520	2,999	3,078
Atlag	5,028	5,101	5,294
Babatin	817	969	958
Bagna	5,427	5,061	5,321
Bagong Bayan	3,528	3,489	3,688
Balayong	2,532	3,059	3,338
Balite	2,425	2,579	2,813
Bangkal	8,803	11,030	12,437
Barihan	5,660	5,404	5,833
Bulihan	12,732	13,134	13,510
Bungahan	2,461	2,731	2,965
Caingin	7,874	6,867	6,899
Calero	1,131	1,214	1,281
Canalete	3,719	4,015	4,124
Caniogan	5,158	5,239	5,132
Catmon	1,828	1,988	2,382
Cofradia	4,853	3,815	3,937
Dakila	4,288	5,146	5,352
Guinhawa	3,621	3,003	4,086
Kaliligawan	342	428	302
Liang	1,575	1,564	1,661
Ligas	5,891	6,119	6,624
Longos	10,808	11,361	14,864
Look 1 <sup>st</sup>	5,922	5,614	6,808
Look 2 <sup>nd</sup>	2,485	2,610	3,108
Mabolo	6,202	6,399	6,435
Mambog	2,748	2,344	2,673
Masile	744	884	832
Matimbo	6,254	6,455	6,516
Mojon	15,541	17,261	18,239
Namayan	856	872	771
Niugan	556	572	828
Pamarawan	2,861	3,425	3,336
Panasahan	8,024	8,612	8,818
Pinagbakahan	3,816	5,653	6,087
San Agustin	2,090	2,202	2,262
San Gabriel	2,578	2,234	2,467

San Juan	3,439	4,326	4,388
San Pablo	4,954	5,035	5,240
Santiago	1,875	1,972	1,973
Stma. Trinidad	6,111	6,384	6,524
Sto. Cristo	1,714	1,929	2,025
Sto. Nino	453	532	561
Santor	6,868	8,046	8,646
Sto. Rosario	7,211	7,593	7,633
San Vicente	2,007	2,529	2,790
Sumapang Bata	2,087	2,424	2,645
Sumapang Matanda	7,696	7,258	7,554
Taal	2,101	2,118	2,231
Tikay	9,064	8,992	10,094

Table 2 showed the population count per barangay of the City of Malolos in the year 2007, 2010 and 2015 provided by the Municipal City Hall.

The population count in the 51 barangays of the City of Malolos, showed that the data's in the years 2007, 2010 and 2015 are used in the forecasting method. Results that came up to a projection of 358,156 residents on the year 2039. Time increases as population increased in the City of Malolos. With the increases, the necessity of water will do increase.

Usage of groundwater is divided into four areas: Residential, commercial, industrial and agricultural.

### 3.1.1 Residential Area

The groundwater production in the residential area covers the use of water in daily living like cleaning, washing of clothes, and such of personal hygiene. Some studies say Residential areas most likely require 7500 gal/day for only 50 households.



Real numbers are to be estimated, houses own private pumps that water districts have a restriction to know the volume of water they extract. Forecasting the comparison of the increasing number of population to the increasing need of extracted groundwater, computed to 14,049,749.75 cu. m. for the expected volume on the year 2040. Forecasted population increases to 42.08% and the forecasted groundwater volume increased to 52.06% in the year 2040.

The increment of population counts and groundwater extraction demands more need for water for several years to pass.

### 3.1.2 Commercial Area

The groundwater extraction in the commercial area covers the use of water in establishment operation like in cleaning, washing dishes, and toiletries found in schools, restaurants, banking institutions, etc. Studies that have been researched that schools with 100 units need 2000 gal/day, restaurants take 8 gal/patron, and hospitals demand 25 gal/day per bed.

Types of the commercial establishment are scattered in the City of Malolos, it maybe hospitals, schools, hotels, markets, restaurants and many more. Private usage of groundwater from their own source. Increasing establishments results in a mark of more groundwater to be extracted. 43.08% only, are the establishments connected to the CMWD. Concessionaires increased in the growing City of Malolos, as the popping of new commercial establishments in the future. A 27.08% increased of establishment in 2040 and 121.15% increase in number concessionaires also in 2040. It only shows that the increase of concessionaires and establishments increases the need for a 222.01% groundwater extracted on the commercial area. Forecasting serves as an estimated computed number for a basis of a study.

### 3.1.3 Industrial Area

The groundwater consumption in the industrial area covers the use of water in factories and industries operation like the production of metal works, foods, beverages, pharmaceutical products, and etc. An industrial water usage rate most likely acquires 752 km<sup>3</sup>/year.

Industrial areas use a large amount of water. Containing large facilities, equipment, and machineries they use. Number of people working for the industry. Industries that contain many types, that uses water depending on their line of business. Years of counting an additional industrial facility will be rising in the future. Accuracy is limited due to confidentiality rule of the industries and manufacturers. Annual volumes of groundwater extracted are estimated depending on the type of business, the industry is performing for the research purpose.

Forecasted calculation of industrial industries in the City of Malolos is increasing to 80% on the year 2040. While 165.29% increase on the year 2040 for the groundwater extracted. Percentage increase results in a bigger usage of groundwater extraction in the next following years.

### 3.1.4 Agricultural Area

Studies, agricultural areas convey 1570 number of employees, which water demand coefficients are ratios of water to employees, and each represents the amount of water demand per employee to produce products or supply services.

The primary source of water supply in the agricultural areas in the City of Malolos is fresh surface water from the creek and stream connected to the river outside the City of Malolos. Saltwater and surface water are used in the breeding of fishes.



The computed calculation is not offered, due to a number of the agricultural area does not use groundwater and will just be forced to use groundwater extracted, if they are lacking stock of the water they commonly used.

### **3.2. Proposed policies and programs for Groundwater Extraction Conservation in the City of Malolos**

Usage of groundwater is increasing. The primary resource in this study is experiencing scarcity because of the climate change, the non-proportionality of the demand for water and the supply of water, and the negligence of the users.

With the results of the forecasted data, policies and programs are needed to be implemented to conserve water for a sustainable source until the future.

#### **3.2.1 NPA-NRP (No Program Attended, No Renewal of Permit)**

This policy focuses on the commercial and industrial areas in the city. The owner of the establishments and the manufacturers should require their employees to attend seminars and programs concerning the topic, Conservation and Sustainability of Water. And the certificates of the seminars and programs attended will be one of the major requirement in renewing their permit. This policy also opens the eyes of the employees about the status of the quantity of water supply in the city. These programs and seminars will be conducted and organized by the responsible agency and government officials.

#### **3.2.2 Change of Source**

Each barangay near the creeks and streams connected to a larger body of water should have a small to average water treatment plant that will cleanse the water from the surface water. This treated water should play as the primary source of water supply in the barangay and be the groundwater the secondary option to the households in the barangay

#### **3.2.3 Strong Implementation of City Ordinance 28-2017 entitled “City of Malolos Rainwater Conservation and Flood Prevention”**

This ordinance tells us that the use of groundwater causes soil erosion and the ground level of the city is continually dropping that’s why, in addition to this, there should be a strong implementation of this ordinance. The city officials should be strict and shall not allow any suspicious internal arrangements. Any official caught should also be penalized by the authority.

The Municipal Office should also regularly check (monthly or every three months) if rainwater storage facilities are being used by the establishments and businesses in their operation to help reduce the extraction of groundwater, thus, helping the city reduce flood and soil erosion.

## **IV. CONCLUSIONS**

Based on the findings of the study, the following conclusions are drawn;

1. The researchers conclude that the City of Malolos Water District (CMWD) might not sustain all the concessionaires for the next few years based on the forecasted annual volume in all areas in the city.
2. The researchers conclude that as time increases, the population increases and the volume of groundwater consumed also increases. The more that the city or place is overcrowded with people, the more people’s necessity will become. Yet, the need for each stays the same.
3. The researchers conclude that the primary source of water in agricultural areas in the in the City of Malolos is fresh water from creek and stream connected to the river.
4. The researcher then concludes that conducting and organizing of policies and programs will is the most effective solution to sustain and to lessen the shortage of water in the city of Malolos.





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