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Groundwater Level Depletion Assessment of Dhaka City Using MODFLOW

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Abstract The primary source of drinking water for the approximately 21 million residents of the Dhaka metropolitan area is groundwater. Rapid development and overuse of groundwater resources from the subsurface aquifer are to blame for the alarming rate of groundwater level depletion in the Dhaka metropolitan area. A quick assessment is needed to predict the spatiotemporal distribution of groundwater levels in the future in order to manage this limited resource sustainably. Using the numerical model code MODFLOW, this work makes an attempt to simulate groundwater flow in subsurface aquifer systems. The Dhaka Water Supply and Sewerage Authority's bore log data was used to map the groundwater aquifer networks of the city of Dhaka (DWASA). The data gathered from the Bangladesh Water Development Board was used to assign the model boundary and hydrogeological parameters. All grid cells inside the model recharge boundary are considered to have the same recharge distribution. The model's results show that excessive groundwater extraction from aquifer systems, rather than a decline in recharge rates throughout the corresponding years, is the primary cause of the downward trend in groundwater level inside the city region. If the rate of pumping continues the same as it was in 2020, the depletion of groundwater level may get worse in the following years as a result of the city of Dhaka's growing population and development.

Keywords: *Dhaka metropolitan area, groundwater level depletion, MODFLOW, aquifer, population*

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1. Introduction

The use of aquifers is enhancing as a source of water supply throughout the world as the groundwater availability and quality is good enough [1]. Few years before groundwater was treated as a safe water source. But in recent years, the condition of water apprises that groundwater is vigorously vulnerable to inanition in many countries in the world, especially in developing countries [2].

In the heart of Bangladesh, Dhaka City has noticed a threatening decline in groundwater last two decades. The main reasons lie in overconsumption and lack of recharge due to urbanization. Almost 68% of the supply of water in Dhaka City is dependent on groundwater [3]. To fulfill this huge demand for water, the groundwater level is declining by 2-3 meters each year [4]. Considering the existing depletion rate, the study predicts that the groundwater table will go down to about 110 to 115 meters by 2050 if any preventive measures are not taken [5]. The Groundwater Hydrology (GWH) department of the Bangladesh Water Development Board (BWDB) has placed 1250 piezometers throughout the country to monitor the depth of the groundwater level [6,7]. All the piezometers placed in Dhaka City show the declining trend of the water table [8]. Previously, the subsurface void in Dhaka was refilled by flowing water from the northern subsoil of the Gazipur district along its neighboring areas [5]. But now these areas also suffer from a severe depletion of groundwater levels. For such reasons, the present study has been taken as of great importance to show the trend in groundwater decline in Dhaka City.

[9] have tried to assess the change in groundwater flow patterns and flow paths in response to the pumping effect. The study has been conducted regionally in the Bengal Basin of India and Bangladesh. The study has numerically and graphically conceptualized the adverse effects that shallow wells will face because of the fact that the Bengal Basin has a greater horizontal gradient than a vertical gradient. Even though this region has minimal gradient due to topographic reasons, it has a large-scale flow of groundwater when dug up to 80-100 m. But the flow paths in the shallow well are most likely to perish due to the

extreme amount of abstraction. One of the major issues in Bangladesh apart from the depletion of groundwater regarding groundwater is Arsenic contamination. [10] tried to find the origin and anthropogenic influences on the Arsenic concentration in groundwater through the help of Carbon. Nowadays, organic Carbon is considered to be the driving factor for the transformation of the geochemical process that eradicates Arsenic from the sediment particles. To quantify the impact of organic Carbon, research was conducted in a place in Munshiganj, Bangladesh where there were around 25 irrigation wells and the only source of groundwater recharge was through ponds or rice fields. The results stated that the concentration of Arsenic was less in the groundwater which originated from the rice fields than in the groundwater that originated from the ponds. [11] studied Groundwater modeling by using Visual MODFLOW 3.1. Their research work has been conducted to predict the future response of groundwater level after 20 years (from 2008) for increasing abstraction and assessment of the usability of the artificial recharge of aquifers of Dhaka City using the Groundwater modeling technique. The model predicts that the Groundwater level will decline to about -120m in the central part of Dhaka City after 20 years if the abstraction increases with an increasing number of wells with time. [12] studied the groundwater model of Dhaka. The objective of his study work was to improve the groundwater model and explore its application in a scenario study. From model analysis, he found that the highest total abstractions will be in the southern area and the lowest in the western area of Dhaka. The result of the scenario analysis indicates that the artificial recharge can recover groundwater up to 18 meters. [13] studied groundwater contamination due to the influence of septic tank effluent by using MODFLOW. From the study, they observed that chloride concentration is increasing with time for the influence of septic tank effluent. [14] found the groundwater contamination issue due to improper disposal of domestic waste in the area of Alandur in Chennai. They used Visual MODFLOW to find out the contaminant flow direction and MT3D for the simulation of pollutant transport. From the survey they notice, domestic wastewater is directly discharged into groundwater, so this condition pollutes groundwater resources. From model analysis, they observed that nitrate concentration in the groundwater in the Alandur area was 60 ppm reported on groundwater development in Bangladesh. They found about 75% of cultivated land is irrigated by groundwater and the remaining 25% by surface water. They suggest a way to protect these resources from pollution. [15] studied groundwater depletion and land subsidence in Dhaka city by using MODFLOW 2000. His study area was major six districts in Dhaka division and analysis of the data from the year 2000 to 2004. In the vertical direction, he divided the model into six geologic layers. The analysis of the existing data of the monitoring well found that the hydraulic head in the intermediate aquifer decreases towards the center of the city and increases towards the periphery of the rivers. The model estimated maximum land subsidence of 4.9 cm for the year 2000 to 2004. He found that land subsidence had increased sharply for the year 2000 (January to July) and then followed a constantly increasing trend. The model also predicted the groundwater would deplete 20 meters in 2020. [16] developed a groundwater model for DWASA. The model was used to assess the impact of additional groundwater abstraction on the aquifer system. It was based on the finite difference method. The aquifer system was simulated as a single aquifer unit overlain by a semi-confining layer. [16] reviewed the Parsons and Montgomery Model and used a USGS model to assess the groundwater resource considering the effect of rivers and the potential recharge values from Master Plan Organization and the hydrogeological parameters from BWDB. But the results were not satisfactory and similar to those of the previous model of Parsons and Montgomery. They did not calibrate their USGS model against historical data before the predictive run. However, they came to the conclusion that a detailed modeling of the Dhaka area is necessary with special emphasis on extending the model boundaries to the major rivers with the improved simulation of the recharge mechanism. [17] has conducted a unique study as they tried to analyze the impact of climate change on groundwater in the Isfahan-Borkhar aquifer. The future climate scenario was used from 2020 to 2044 under the conditions of RCP 2.6, RCP 4.5, and RCP 8.5. This analysis concluded that, to ensure sustainable management of groundwater, the abstraction rate should come down to half of what is being extracted today in the existing wells and agricultural water consumption should reduce by up to 40%.

The numerical model is widely employed for groundwater analysis and groundwater management systems [18]. Numerical methods comprise representing the flow domain by nodes. The study area is surrounded by major rivers, it was expected to maintain a good interaction between rivers and aquifer systems. But when the model was run in predictive mode to assess the impact of increased abstraction from 1980 to 2010, the results of the model showed poor relation between the rivers and the aquifers. It did not consider the effect of river contribution to the aquifer with the increase of abstraction from the aquifer [19].

1.1. Study Area

Dhaka is located in the center of Bangladesh between longitude 90°20'E and 90º30'E and latitude 23º40'N and 23º55'N. The area of the present city is 256 km^2 bounded by the Buriganga River in the south, the Demra in the east, the Tongi Khal in the north, and The Turag River in the west. The Metropolitan city is bounded by Gazipur in the north, Manikganj in the west, Rupganj in the east, Narayanganj in the southeast, and Keraniganj in the south [11]. A detailed map of the study area is depicted in Figure 1. In this map, the pumping wells and observation wells are shown clearly. The observation wells are situated on 8 thanas which are Cantonment, Mirpur, Mohammadpur, Sabujbagh, Dhanmondi, Motijheel, Lalbagh, and Sutrapur.

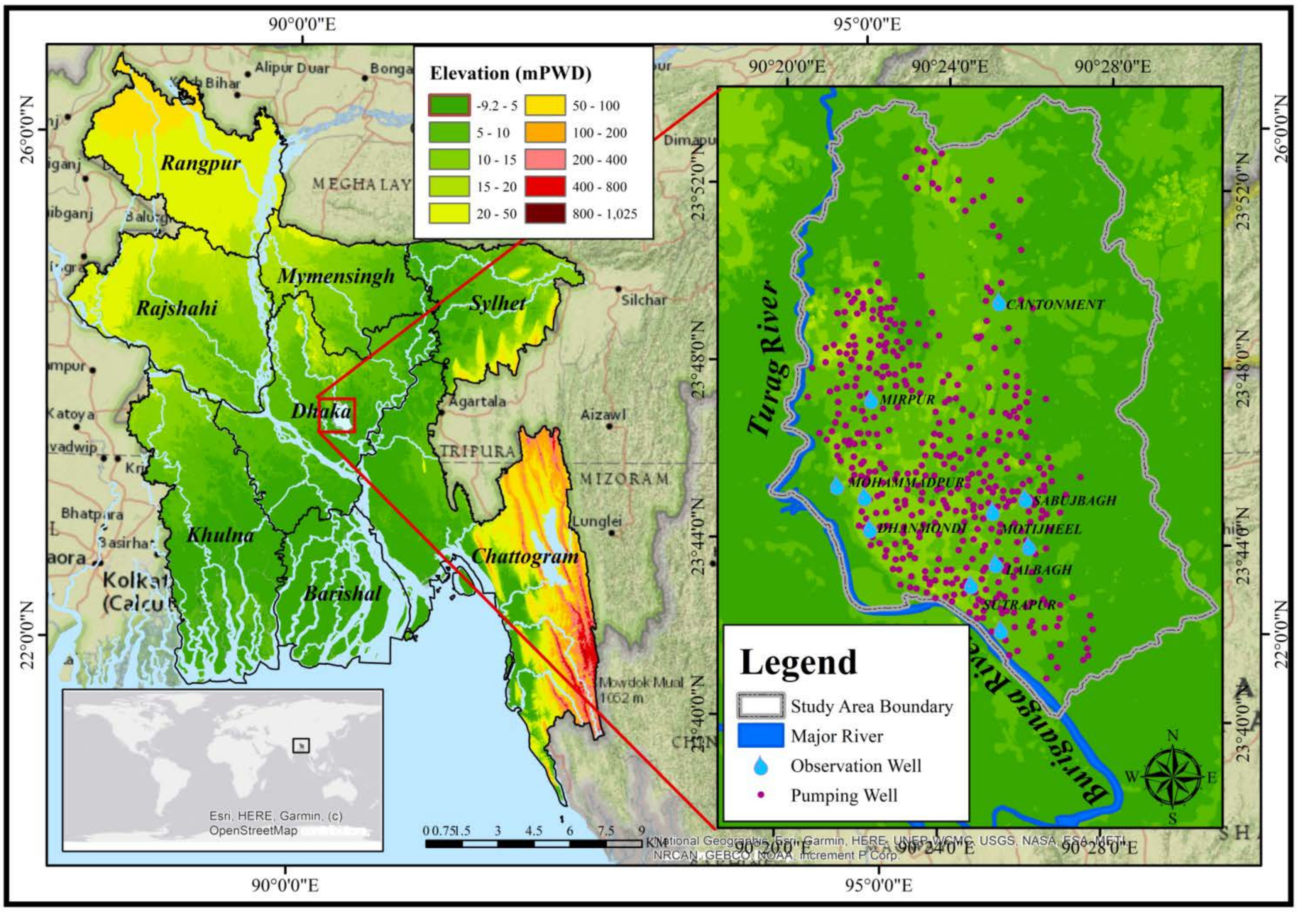


Figure 1. Study Area Map

2. Objectives and Data Collection

A lot of problems beset the megacity of Dhaka [20-24]. As mentioned earlier, the groundwater level depletion problem in Dhaka city is turning out to be unbearable day by day. However, effective scientific analysis can be done on how to reduce the extent of this problem. This study aimed to set up a calibrated & validated groundwater model of Dhaka city and assess the recent & predicted groundwater level depletion of Dhaka city. For Model schematization & aquifer delineation Visual MODFLOW Flex 6.1 and Rockworks software was used Methodology starts with data collection. Necessary data for commencing the study have been collected from Bangladesh Water Development Board & Water Supply and Sewerage Authority. Different types of data collected are listed below in Table 1:

Table 1. List of Data Used in This Study

Data Type	Data Source
Shapefiles of study area and rivers	www.barc.gov.in
Satellite image of the study area	Google Earth
Bore log data at observation well locations	Dhaka WASA
Soil layer properties	Dhaka WASA
River data (Tidal water level, cross-section, discharge)	BWDB
Pumping Well Data & Observation Well Data	Dhaka WASA

3. Methodology

The first and foremost step in this study was structure generation and property defining which included defining the study area, generating the stratigraphy, and defining different zone properties [25]. The next step was to process the collected river data, recharge data, and pumping data. Then the 3D grid was generated which was later converted into a numeric MODFLOW model [26]. In this study, time series groundwater level heads at observation wells were used as boundary conditions and also the method to determine the accuracy of the work [27]. After incorporating all the data into the model, the simulation was run. The calibration and validation were done by comparing the groundwater level head at the observation well which is situated in the Cantonment area. Calibration and validation were conducted for two different time frames to determine the maximum accuracy of the model. If satisfactory results were not gained from the simulation, the simulation was again run in order to find a satisfactory result. After getting the best result possible for groundwater modeling, the groundwater level for 2020 was finalized. Lastly, the prediction of the groundwater level in Dhaka city for the year 2030 was performed based on the future population and water abstraction prediction given by DWASA (Dhaka Water Supply and Sewerage Authority) [28].

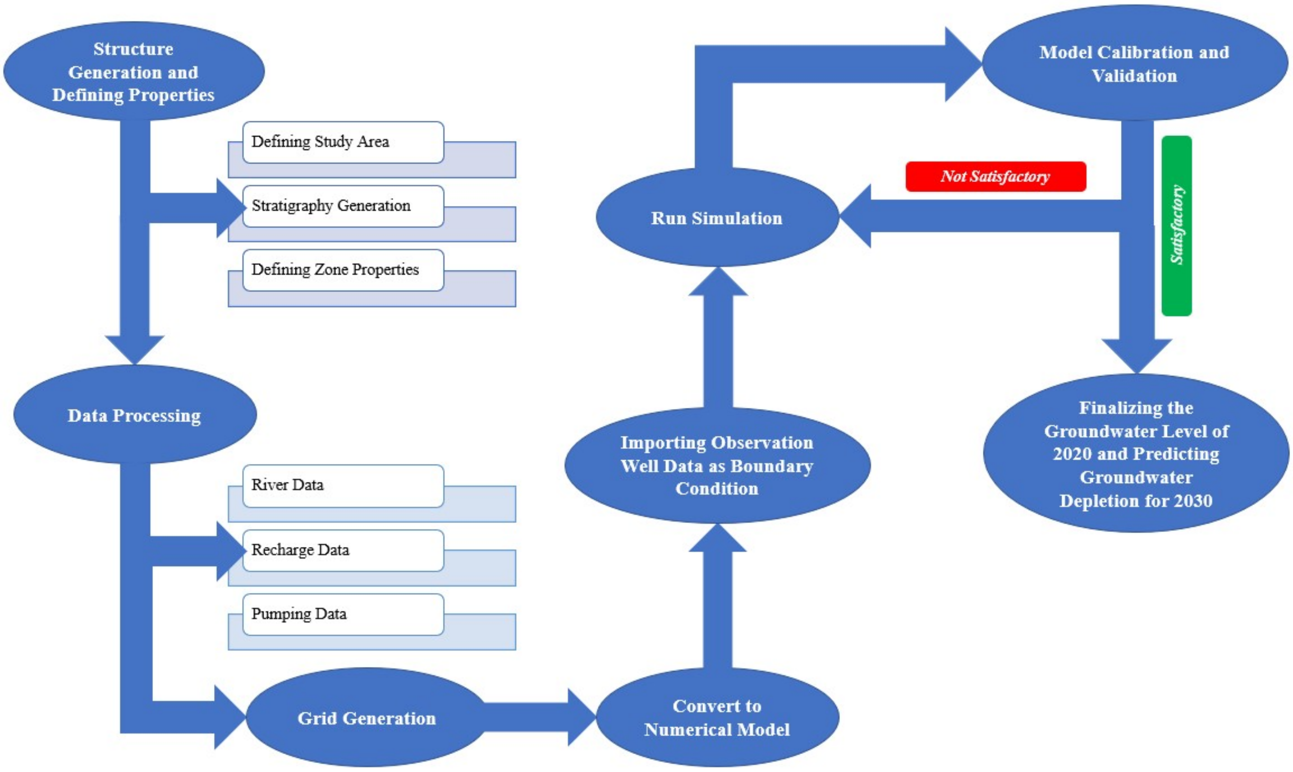


Figure 2. Workflow of the Entire Research

3.1. Define Modeling Objectives

The first step of the modeling approach is to set up the start date of the model which in my case is January 1, 2010. The groundwater flow is checked as transport inactive Because the model is intended to simulate & analyze the groundwater level depletion. The flow type has been considered saturated. The model coordinate was set as UTM 46N.

3.2. Collect Data Objects

At this step, we can bring the necessary data for the model. We can also come to this step from any certain point of modeling and import data as needed for that step. To define the conceptual model shapefile of the study area was needed. So first of all, the shape file of the study area was brought to the model. All the shapefiles needed were downloaded from the website www.barc.gov.in. Then the coordinate of the shapefiles was projected to UTM 46N in Arc-GIS. Then they were imported in MODFLOW.

3.3. Defining the Conceptual Model

This step of modeling involves naming the project and adding a suitable description. The shapefile of the study area needs to be selected as the model area from the data tree. Thus the conceptual model is defined at this step [29].

3.4. Define Model Structure

To define the model structure aquifer, aquitard, and top surface layers are needed in Excel data format. The elevation of the Dhaka metro was delineated from SRTM DEM data. And the aquifer and aquitard layers generation was a bit complicated procedure. The soil bore log data was collected as a pdf from DWASA. Then the scanned pdf bore log data was converted into Excel format manually. The soil bore log at a particular point shows the lithology of the soil there as the position of sand, clay, etc [30]. The stratigraphy of that particular point was made by applying judgment. Sand layers were referred to as aquifers and clay layers as aquitards. Then combining the stratigraphy of well positions in software named Rockworks the soil layers of aquifer and aquitard were generated. Locations of well positions were also needed to generate the layers. So, the location at a particular well position was needed. This data was also collected from DWASA as a map showing pumping well locations. Then the locations were taken from the map after georeferencing [31]. The top surface layer and aquifer-aquitard layers were imported to the model as point elevation (excel file format) then the surface was created for each layer. The individual surfaces as topsoil, aquitard-1 base, aquifer-1 base, aquitard-2 base, aquifer-2 base, aquitard-3 base, and aquifer-3 base total of seven surfaces were defined at this step one by one. The type of the first surface is defined as erosional, the last as a base, and others as conformable. Figure 3 illustrates the 3D diagram of the aquifer and aquitard layers of Dhaka city corporation.

Six zones have been created for the model Aquitard-1, Aquifer-1, Aquitard-2, Aquifer- 2, Aquitard-3, and Aquifer-3. Now at this step, these structural zones were selected and different properties such as conductivity, initial head, and storage for each zone were defined. Figure 4 shows the 3D diagram and contours of every layer that has been used in the modeling including the surface as well.

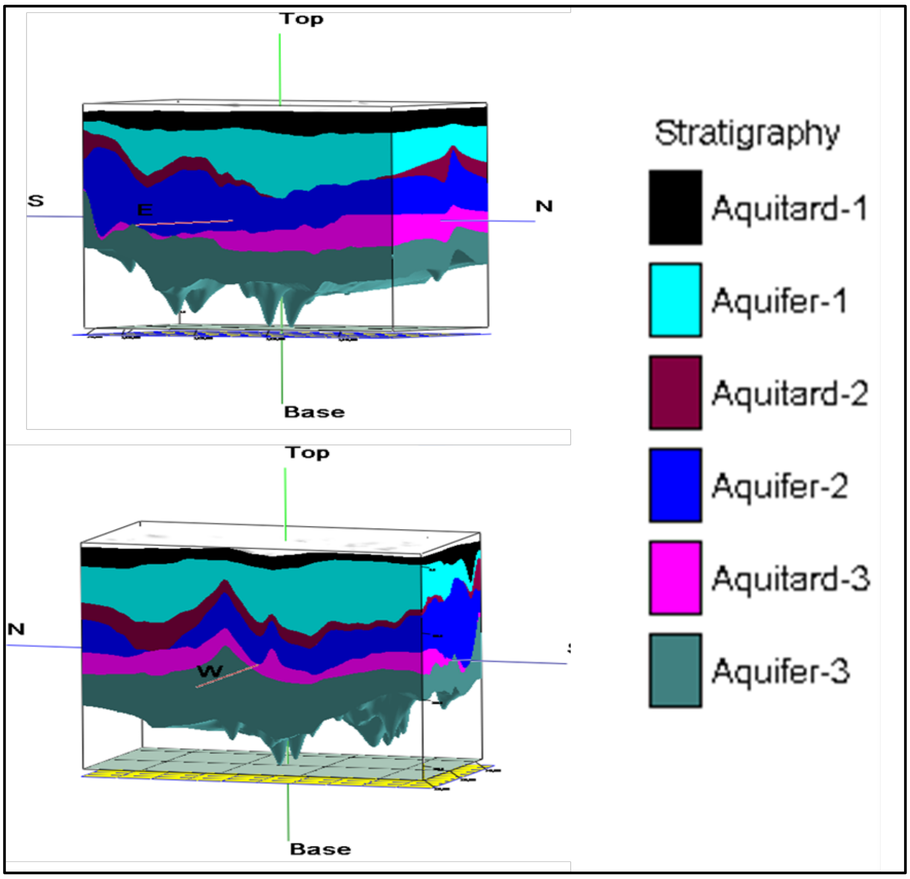
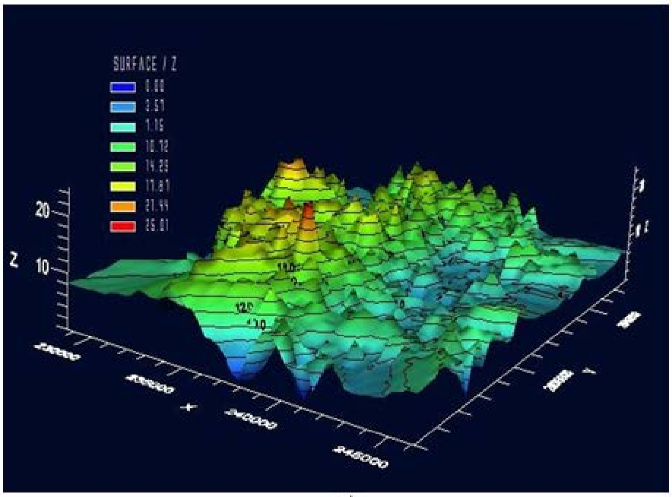
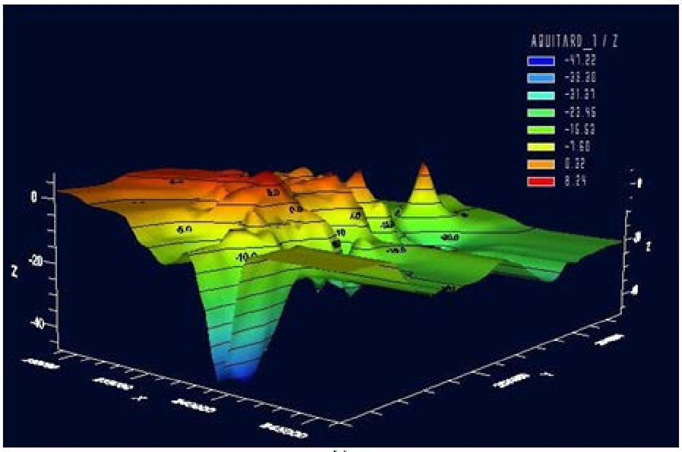


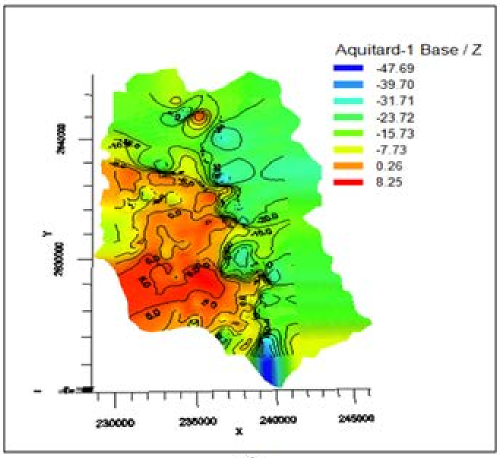
Figure 3. Aquifer and Aquitard layers generated in Rockworks



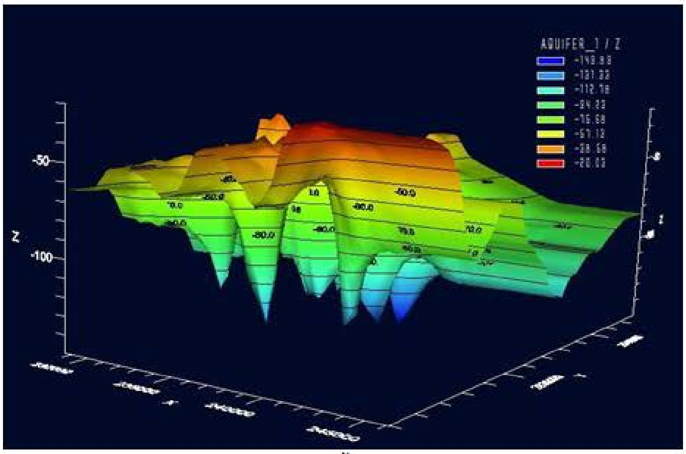
a)



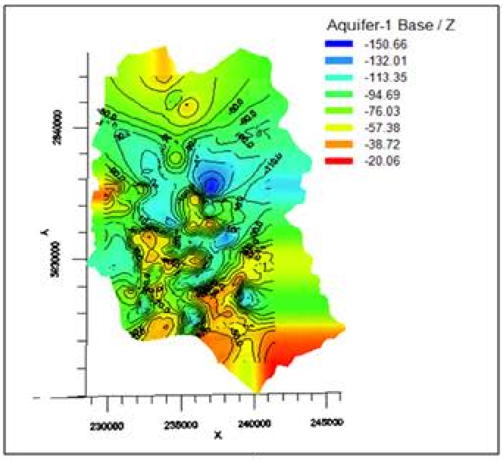
b)



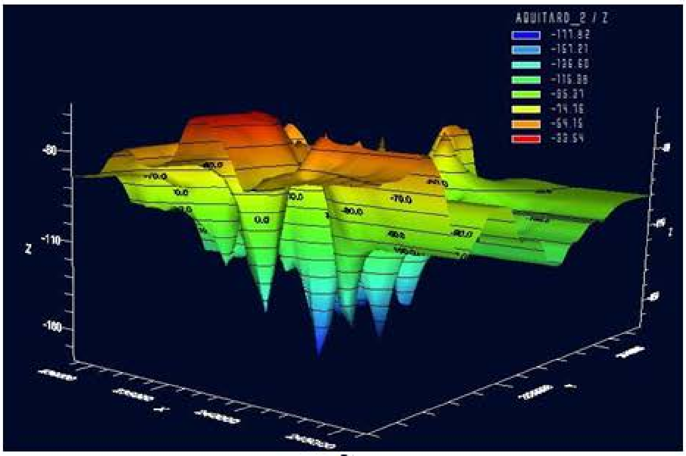
c)


AQUIFER_1 / Z
-50
-100
Z

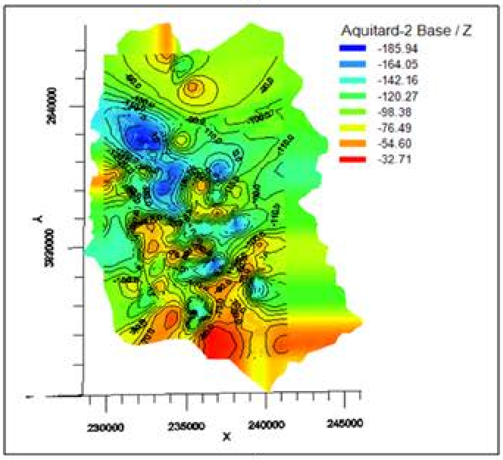
d)


Aquifer-1 Base / Z
-150.66
-132.01
-113.35
-94.69
-76.03
-57.38
-38.72
-20.06
230000
235000
240000
245000
X
Y

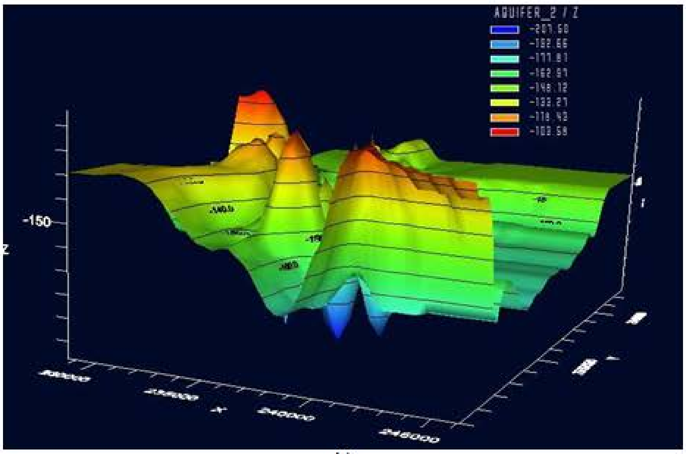
e)


AQUITARD_2 / Z
Z

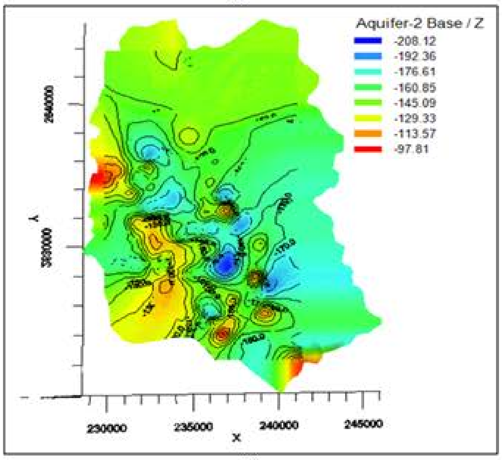
f)


Aquitard-2 Base / Z
-185.94
-164.05
-142.16
-120.27
-98.38
-76.49
-54.60
-32.71
230000
235000
240000
245000
X
Y

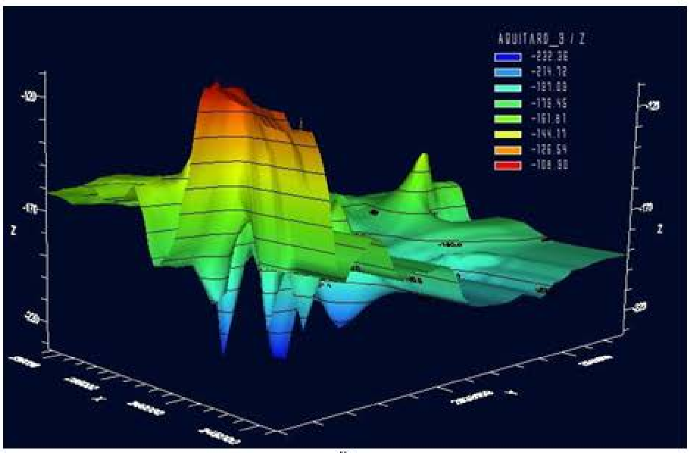
g)


AQUIFER_2 / Z
-150
Z

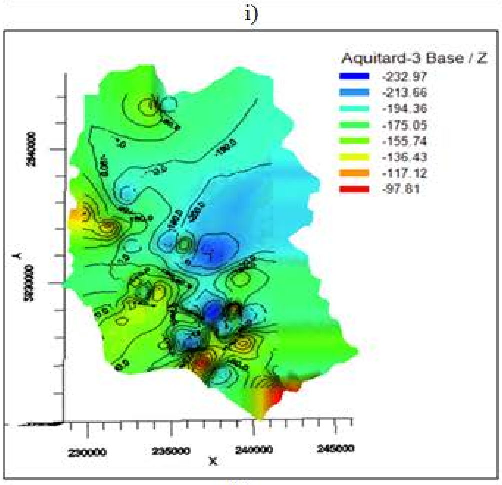
h)


Aquifer-2 Base / Z
-208.12
-192.36
-176.61
-160.85
-145.09
-129.33
-113.57
-97.81
230000
235000
240000
245000
X
Y

i)


AQUITARD_3 / Z
Z

j)


Aquitard-3 Base / Z
-232.97
-213.66
-194.36
-175.05
-155.74
-136.43
-117.12
-97.81
230000
235000
240000
245000
X
Y

k)

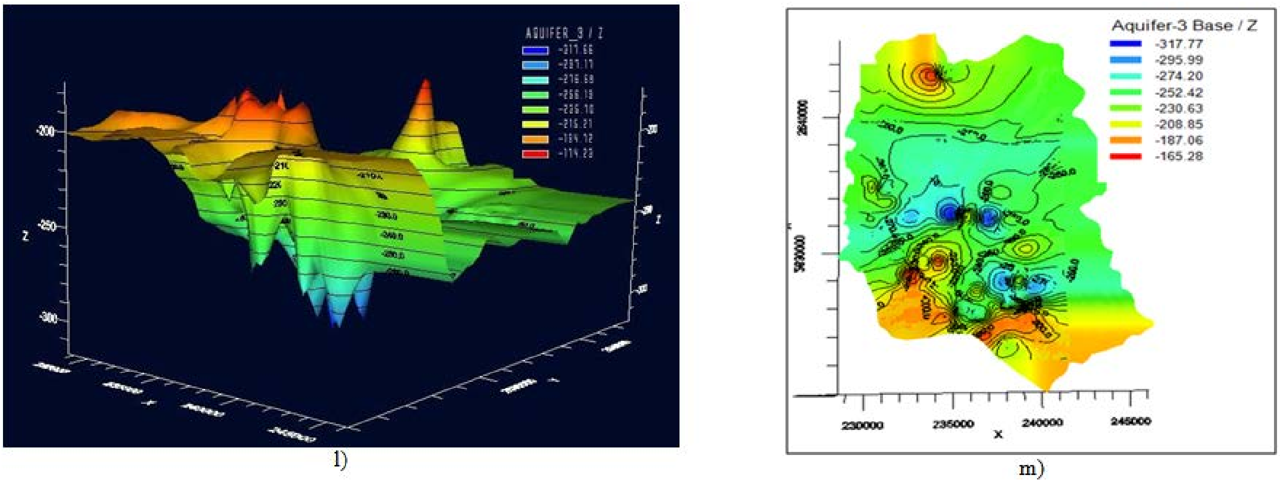


Figure 4. Different components of modeling. a) 3D view of the upper surface of the study area, b) and c) 3D View and Contour of Aquitard-1 respectively, d) and e) 3D View and Contour of Aquifer-1 respectively, f) and g) 3D View and Contour of Aquitard-2 respectively, h) and i) 3D View and Contour of Aquifer-2 respectively, j) and k) 3D View and Contour of Aquitard-3 respectively, l) and m) 3D View and Contour of Aquifer-3 respectively

Table 2. Properties Assigned for Aquitard and Aquifer Layers

Zones	Aquitard-1	Aquifer-1	Aquitard-2	Aquifer-2	Aquitard-3	Aquifer-3
Hydraulic Conductivity (Kx) m/d	0.001728	5.29	0.0501	5.29	0.0501	5.29
Hydraulic Conductivity (Ky) m/d	0.001728	5.29	0.0501	5.29	0.0501	5.29
Hydraulic Conductivity (Kz) m/d	0.0001728	0.529	0.00501	0.529	0.00501	0.529
Storage Coefficient	1.0×10-4	1.15×10-5	1.50×10-4	1.15×10-5	1.50×10-4	1.15×10-5
Effective Porosity	0.3	0.25	0.3	0.25	0.3	0.25
Total Porosity	0.5	0.3	0.5	0.3	0.5	0.3
Initial Heads(m)	-10	-35	-40	-50	-55	-60

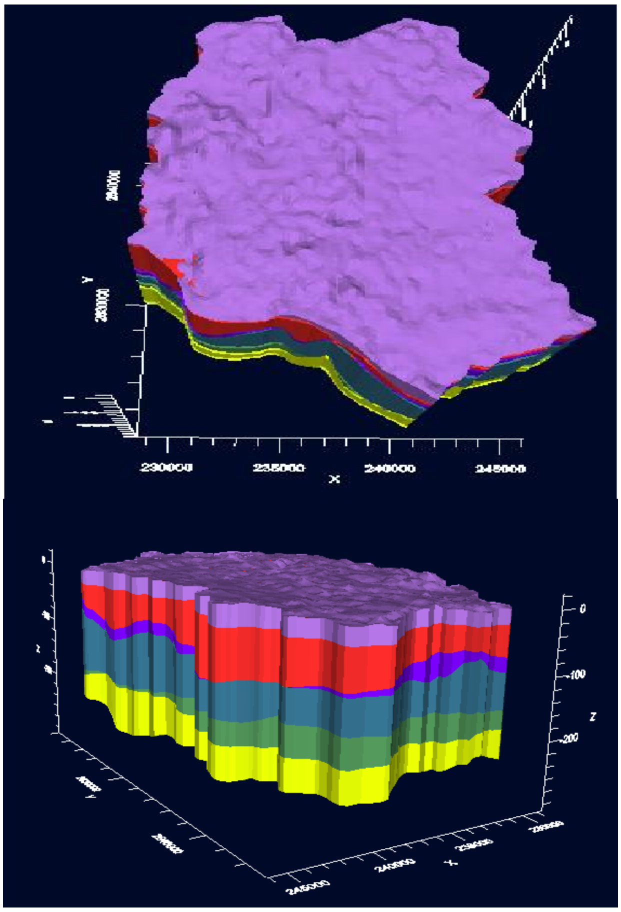


Figure 5. Model Structure in Visual MODFLOW

3.5. Boundary Conditions

The model requires some boundary conditions to run the analysis. In this model recharge data, river data, and pumping well data were considered as boundary conditions [32].

3.5.1. Recharge Data

Recharge data was imported to the model as time schedule data. 30% of rainfall per year from a particular station (Dhaka Banani CL 42) from 2010 to 2019 was considered as a recharge boundary for the model.

Table 3. Recharge Data Assigned per Year

Year	Recharge (mm)
2010	445.44
2011	582.86
2012	420.63
2013	562.2
2014	492.96
2015	694.47
2016	423.63
2017	830.25
2018	583.92
2019	488.55

3.5.2. River Data

Shapefiles of rivers were brought to the model as polyline shapefiles at this step. The properties of those rivers were defined such as river bottom, river width, and stage. For this model river properties were assumed static and constant. The constant data was given from observing data of river cross-section & tidal water level from Bangladesh Water Development Board (BWDB) [33].

Table 4. River Stage Data Assigned

River Name	Bottom(m)	Width(m)	Stage(m)
Balu	-3.8	85	3.18
Buriganga	-20.12	350	5.7
Lakhya	-7.45	285	3.15
Tongi Khal	-1.7	50	3.37
Turag	-6.9	60	3.13

3.5.3. Pumping Well Data

Pumping data was collected from DWASA in Excel format. There are 10 Mods zones of DWASA in the Dhaka metro. Well data was collected for all 10 zones in Dhaka. Around 428 wells are currently workable in Dhaka Metropolitan City. The Excel data was modified to bring it into the model. Pumping location, pumping start & end time, pumping rate, well/elevation, screen top, screen bottom, and well bottom these data were required for the pumping boundary.

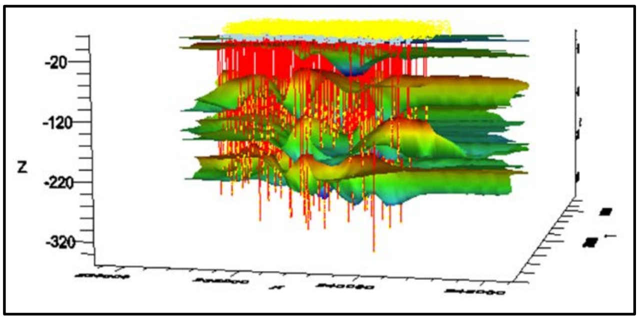


Figure 6. 3D View of Pumping Wells in Dhaka City

3.6. Difference Grid and Numeric Model

A finite difference grid was created for the model which consists of 200 rows and 150 columns. Layer refinement was considered 1 for aquitards and 10 for aquifers. The final step of conceptual modeling is converting it to a numerical model. To translate the model and run the analysis for different time steps numerical model is needed. We can also modify the model after converting it to a numerical model.

3.7. MODFLOW Modeling Approach

Visual MODFLOW 2000 was used to conduct the modeling part of this study. It can simulate both steady and unsteady flow in which the aquifer layers can be confined or unconfined [34]. A model is dependent on numerous internal equations and the same thing can be observed in the case of this model as well. The internal steps are quite complex as it is a quasi-3D model which is basically dependent on Dupuit-Forchheimer's assumption as well as Darcy's assumptions [35]. Darcy's law of hydraulic gradient is the basic equation that forms a relationship between the gradient and specific discharge [36]. It follows as:

$$q_x = K\frac{dh}{dx} \quad (1)$$

where q_x is the specific discharge along the x direction, dh/dx is the gradient of the head in the x direction and K is the hydraulic conductivity. From this law, the governing equation for a 3-dimensional confined aquifer can be obtained [34,36]. This equation can be written as:

$$\frac{\partial}{\partial x}\left(K_x\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z\frac{\partial h}{\partial z}\right)=S_s\frac{\partial h}{\partial t} \quad (2)$$

Here, K_x, K_y, and K_z are the hydraulic conductivities along the x, y, and z axes respectively. S_s is the specific storage and dh/dt is the change in hydraulic head with respect to time. Now, if the aquifer is considered to be horizontal and confined as well, equation 2 becomes 2-dimensional [37]. That equation is shown below:

$$\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial y^2}=\frac{S}{T}\frac{\partial h}{\partial t} \quad (3)$$

Here, T is called the Transmissivity of the aquifer and S is Storage Coefficient. This 2-dimensional equation is called the Diffusion Equation. The above equation is for unsteady flow conditions but for steady flow conditions, the equation takes the form of equation 3 which is known as the Laplace Equation [36]. That equation is:

$$\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial y^2}=0 \quad (4)$$

As only confined layers are considered in this study, equations 1, 2, and 3 are used throughout the study in the MODFLOW model. Apart from these equations, some other equations are also used in the models computation stage which includes different soil hydraulic property equations and continuity equations [38,39].

4. Results and Discussions

4.1. Calibration and Validation

Visual Modflow flex version 6.1 was used for numerical modeling of the study area. There are numerous methods to test the reliability of the Visual Modflow model [40,41,42]. However, in this study, the calibration results were obtained by comparing the predicted and observed head at GT2608001 (Observed Well Location: Cantonment) which is a very widely used technique [43]. Calibration was done for different months in 2015 (January to December) and 2016 (January to April). The result of the calibration was reasonable and the correlation between the results (R^2) was obtained to be 0.266. Validation results were obtained by comparing the predicted and observed head at GT2608001 (Observed Well Location: Cantonment). Validation was done for different months in 2010 January to December) and 2011 (January to June). The result of the validation was also proved to be more impactful than the calibration analysis as the correlation value (R^2) was obtained to be 0.698. This value is well in between the satisfactory limit of a model as any value above 0.6 is considered to be enough for numeric analysis [44] These statistical values show how the model is performing under futuristic scenarios [45]. Figures 7 and 9 show the performance of model calibration and validation against the observed value graphically. Whereas, Figures 8 and 10 are showing the best-fit trend of the model simulated and observed cases in the study area.

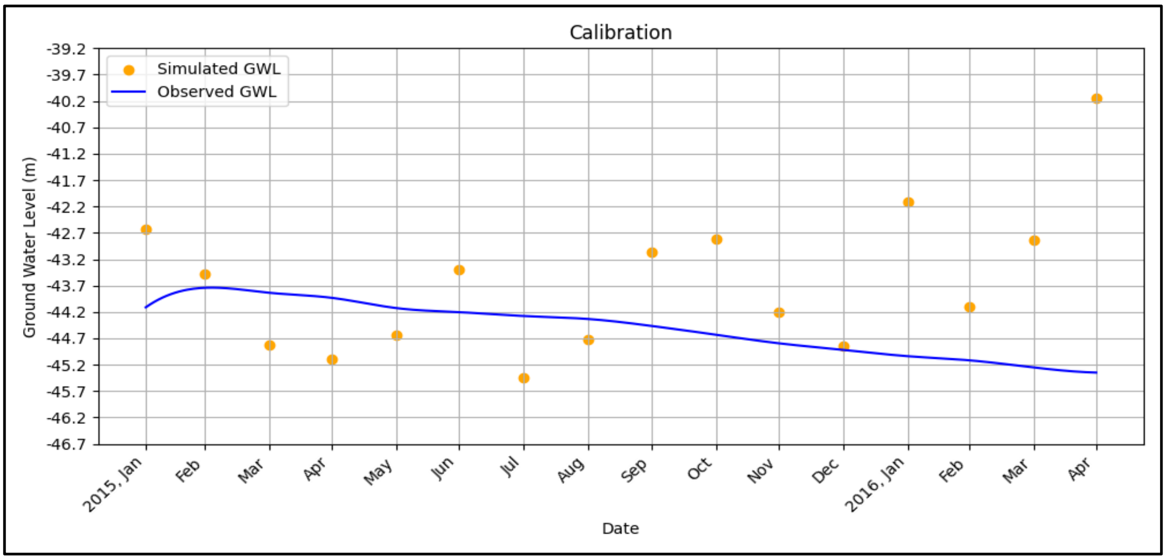


Figure 7. Model Calibration against Observed Groundwater Level

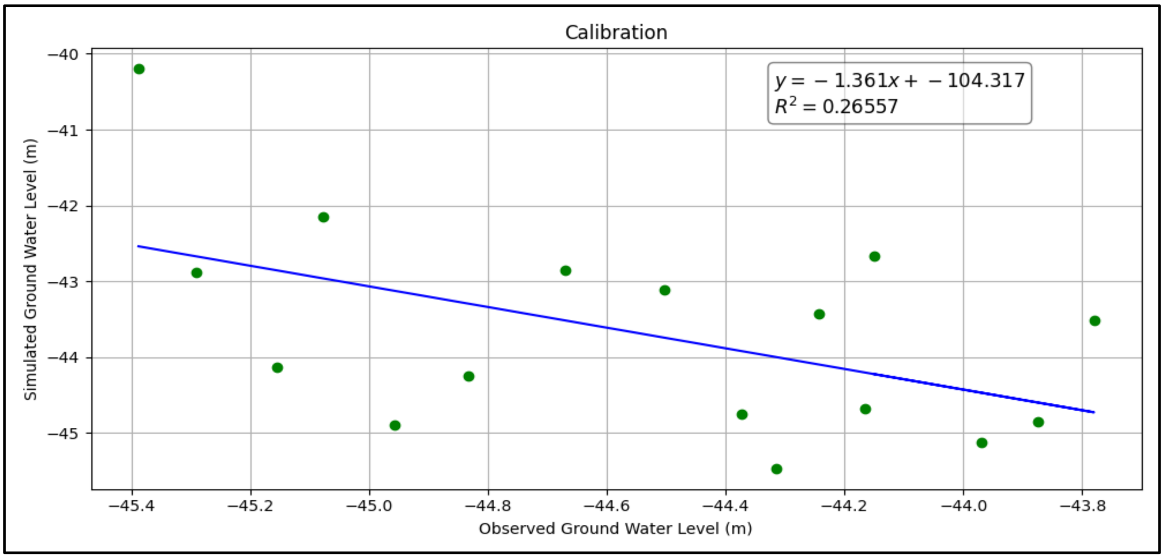


Figure 8. Simulated Groundwater Level vs Observed Groundwater Level Curve for Model Calibration

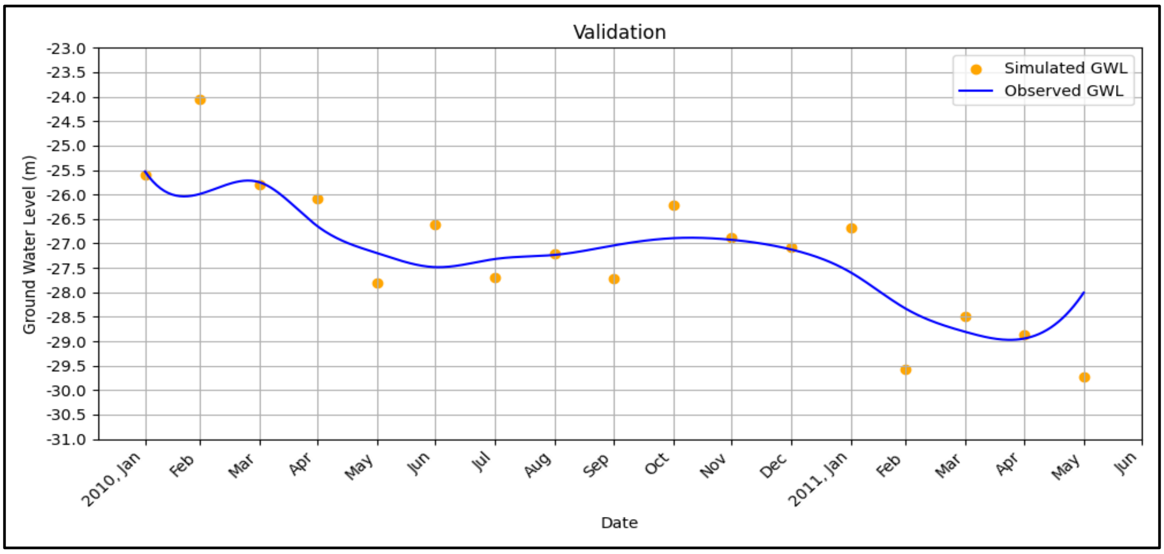


Figure 9. Model Validation against Observed Groundwater Level

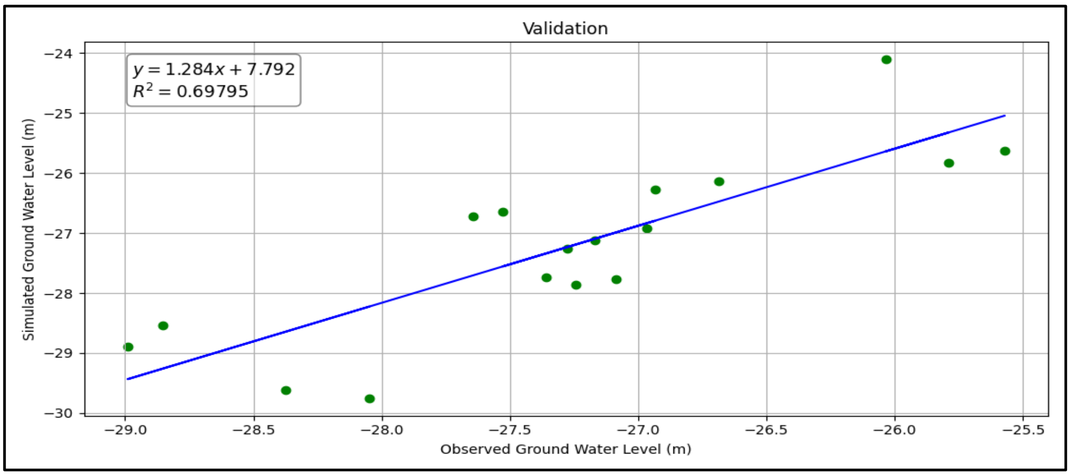


Figure 10. Simulated Groundwater Level vs Observed Groundwater Level Curve for Model Validation

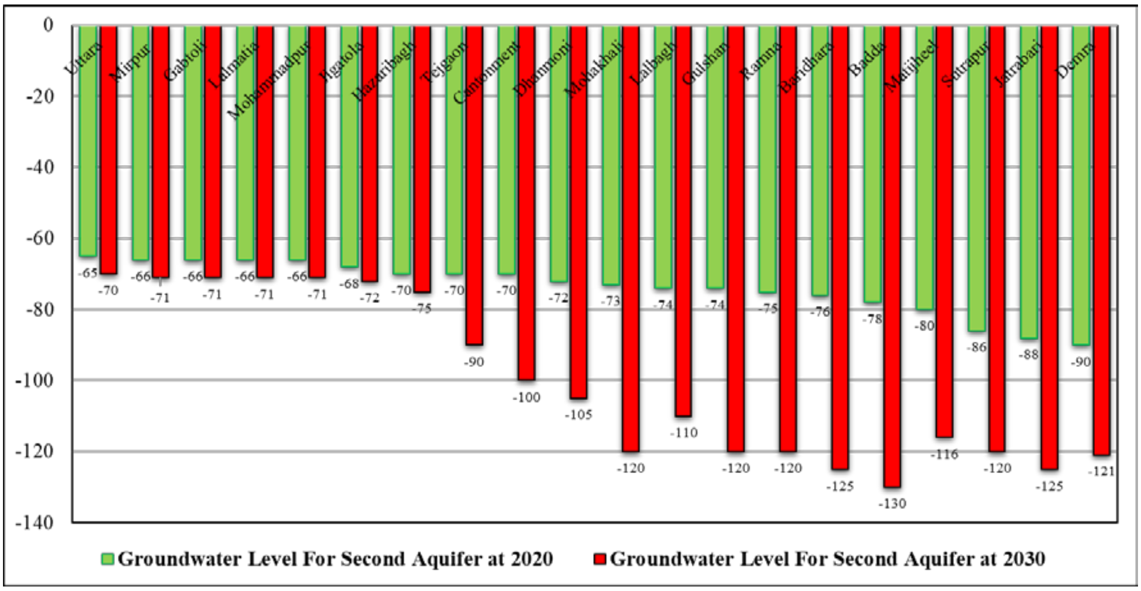
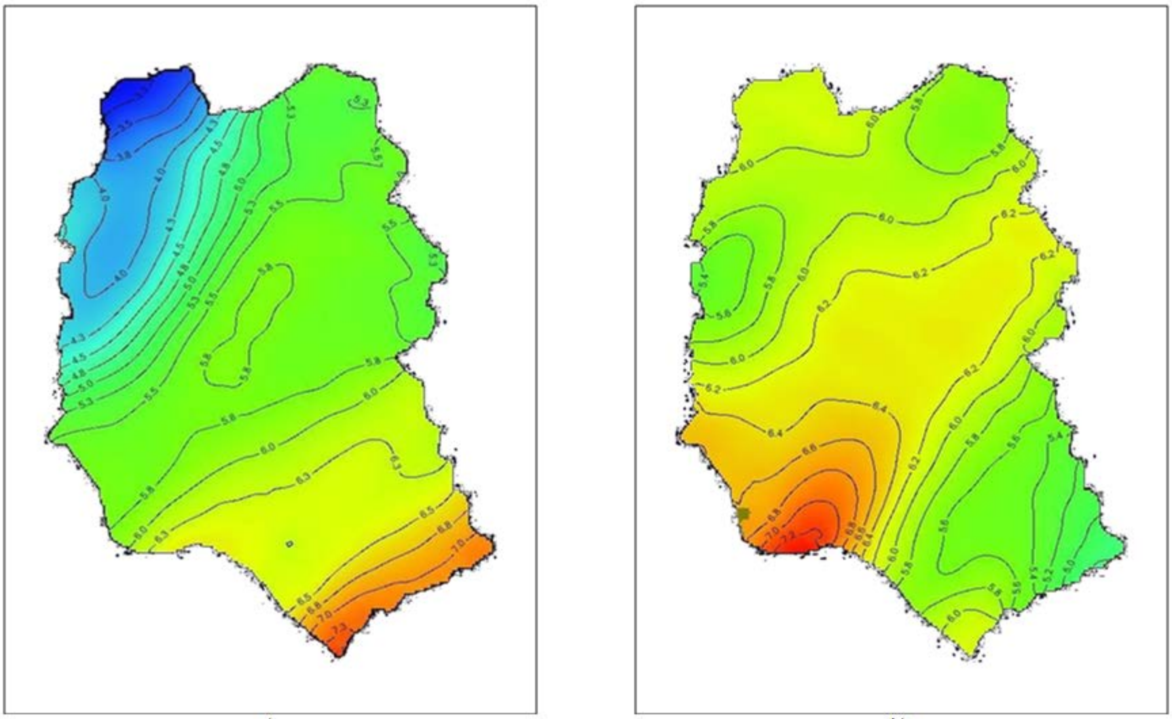


Figure 11. Groundwater Level for Second Aquifer in 2020 & 2030 vs Locations of Dhaka Metro



a) b)

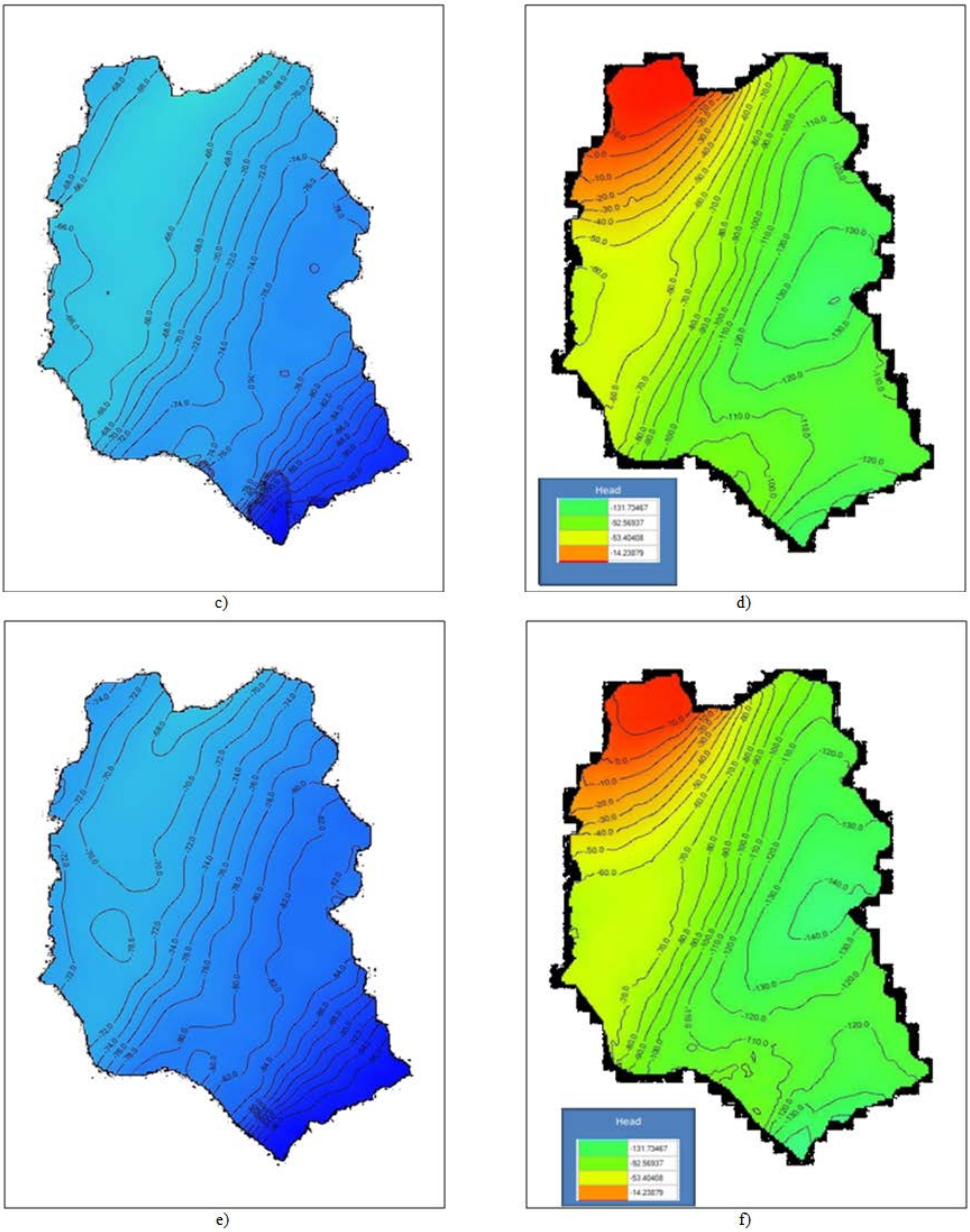


Figure 12. a) Groundwater Head in Aquifer-1 in 2020, b) Groundwater Head in Aquifer-1 in 2030, c) Groundwater Head in Aquifer-2 in 2020, d) Groundwater Head in Aquifer-2 in 2030, e) Groundwater Head in Aquifer-3 in 2020, f) Groundwater Head in Aquifer-3 in 2030

4.2. Aquifer Groundwater Level Projection

The predicted groundwater head in the year 2020 for the First aquifer in Dhaka Metro ranges in between 3 to 7 mPWD which is reasonable and lies above mean sea level. This is because the abstraction rate from the first aquifer is very low. Most of the abstraction is done from the second and third aquifers. That's why it is inevitable that the groundwater level in these aquifers is declining at an alarming rate. From the model prediction, we can see for the year 2020 the groundwater head in the second aquifer ranges between -66 mPWD to -92 mPWD and for the same year the groundwater head in the third aquifer ranges between -74 mPWD to -100 mPWD, which is far below mean sea level. If artificial groundwater recharge is not regulated properly, the present groundwater level might go down rapidly.

As the model predicted for 2030 groundwater level in the third aquifer can reach -130 mPWD which is very alarming for our safe living and environment. Pumping water out of the ground faster than it is replenished over the long term causes severe problems. The volume of groundwater storage is decreasing in many areas of the Dhaka metro in response to pumping [46]. Groundwater depletion is primarily caused by sustained groundwater pumping. So alternate measures should be taken to decrease the daily abstraction from pumps around Dhaka city. The simulated head of groundwater for 2020 and 2030 in all 3 aquifer layers is shown in Figure 12.

4.3. Zonal Analysis

The Dhaka Metropolitan Area (DMA) consists of 41 major thanas among which 20 are very important when it comes to financial, social, and population aspects [47]. These areas are, Uttara, Mirpur, Gabtoli, Lalmatia, Mohammadpur, Jigatola, Hazaribagh, Tejgaon, Cantonment, Dhanmondi, Mohakhali, Lalbagh, Gulshan, Ramna, Baridhara, Badda, Matijheel, Sutrapur, Jatrabari, and Demra. All of these areas are high in population density which indirectly indicates the over usage of water consumption as well [48]. Figure 11 shows the current and future conditions of groundwater levels in those selected areas. The prediction is alarming for Baridhara, Badda, Mohakhali, Lalbagh, Gulshan, and Ramna as the depletion of water level touches even up to 40% which is alarming indeed. On the other hand, areas like Uttara, Mirpur, Gabtoli, Lalmatia, Mohammadpur, and Jigatola shows some sign of relief even though it’s not enough comforting as well for future city dwellers. In areas like Cantonment, Dhanmondi, Mohakhali, Lalbagh, Gulshan, Ramna, Baridhara, Badda, Motijheel, Sutrapur, Jatrabari, and Demra the groundwater head will drop down to more than 100 m depth by 2030 from the top of the soil surface above which will be very concerning for these areas as all of the areas are very populous and residential areas while even some areas have a population density of more than 40,000 people as well [48]. For this reason, these areas are highly in danger of facing a water scarcity.

5. Conclusion and Recommendations

The model provides an overview of the declining trend of the groundwater level of Dhaka Metropolitan City. Groundwater is declining at an alarming rate in places where the abstraction rate is higher. One of the most effective ways to address the issue of groundwater depletion is to find alternative sources of water. An excessive amount of groundwater extraction will not only cause water scarcity but also it can beget some major threats that are yet to occur in Bangladesh. One of them is sinkhole which is at present a serious threat in countries throughout the world. If the water extraction rate in this mega city doesn’t reduce to a noticeable extent, sinkholes will eventually start to generate and the consequences will be catastrophic [49]. Modern technology should be used to tackle the current scenario and recover the depletion which has already been made. Alternative water sources can be used to help replenish aquifers. Deriving water from other sources would also give aquifers time to refill instead of pumping too much water from them at once. Application of Managed Aquifer Recharge (MAR) should be imposed at different locations of Dhaka city to ensure sustainable usage of groundwater. In this case, the natural canals of Dhaka city should be used to implement MAR. This will not only provide an adequate amount of groundwater supply but also will ensure sufficient recharge as well. As the model shows Dhaka city’s groundwater head is in a declining trend and in recent future it will decline more rapidly if effective measures aren’t taken. The abstraction of wells in Dhaka is excessive and needs to be reduced. If the groundwater declines like this it can greatly impact the environment of Dhaka. So city dwellers should consider it a common concern and act accordingly. If not acted promptly in this case, the consequences will be catastrophic.

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