Calculation of Water Demand for Multiple Uses in a Specified Region Using a SWAT Model

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Abstract. The calculation of water demand for multiple uses including the irrigation of crops and municipal uses in a specified region is an essential and urgent task for sustainable water management in such regions. To achieve the aim of this study, the Soil Water Assessment Tool (SWAT) was used with the aid of a Geographic Information System (GIS). The region of Jilawia and Muharam, which lies North of Babylon in Iraq, was selected as a case study so that the water available and demand for that water could be calculated. This region is irrigated from the Great Al–Mussiab Project out to a 12 km radius, covering a 20000 dunum (50 kM²) area, as well as receiving rainfall water. Four types of seasonal crops, Rice, Corn, Wheat, and Cucumbers, are grown, and several residential units have been suggested as planned investment projects in the region of study which will also need sufficient available water. The results of the simulation model in the SWAT covered the period from 2010 to 2020. The Curve Number (CN) and the surface runoff of the region were both calculated, and the SWAT model calibrated against the measured reference evapotranspiration. The results of this calibration were somewhat convergent, demonstrating an error of 12.5%. The results of the calculation of water available and demand showed that sufficient water is available for only municipal uses for 2,300 persons, fulfilling the full capacity of the investment projects, with a deficit of water more generally appearing where both irrigation and municipal use are taken into account. These deficits are 154.70%, 68.97%, and 11.53% with Rice, Corn, and Cucumber crops respectively; however, there is a surplus of water of 34.13% with a Wheat crop. The results also showed that the area of the study region could support 39.25%, 59.17%, and 89.65% of the total available area being turned to Rice, Corn, and Cucumber crops, respectively, to achieve the planned investment projects. SWAT is shown to be an appropriate time saving tool for calculating water demand for multiple uses in a specified region. It can also be concluded that Jilawia and Muharam is a suitable region for the planned investment projects, including managed agriculture and municipal projects, based on the available water in this region.

1. Introduction

Due to developments in human living conditions, the demand for water for multiple uses has increased recently, causing additional pressure on its judicious utilisation. Moreover, water has become a very complex commodity as it has been subjected to the principle of supply and demand. The dynamic variations of weather and the variable nature of landmasses has contributed to the need for a continuous response at watersheds for a varying level of water resource. This in turn requires continuous planning for the redistribution and exploitation of resources based on a calculation of water demand [1].

The challenges associated with the management of water resources have become increasingly common. Water scarcity has led to the need to find a balance of limited water resources among municipal,
agricultural, and environmental uses. To achieve this, water supplies, water quality, and ecological considerations must be fully integrated [2]. Water provided by municipal water supplies to meet water requirements for homes, business places, hospitals, and so on, is generally combined with agricultural water requirements to meet the vital and urgent needs of investment projects [3]. These investment projects are required for national development, and the calculation of water demand is thus essential to evaluate the capacity of these projects. Some of these projects are for multiple uses; however, the water demands for municipal areas and agricultural uses are often the most important issue facing such developments.

A balanced water supply supported by water demand management is a precondition for any water policy strategy. The demand for water for multiple uses, particularly in the agricultural sector, produces excessive pressure on water supplies that must then be efficiently and economically planned. These pressures are the result of increasing levels of food and water consumption, particularly from the municipal and industrial sectors [4].

The adequate planning of water resources management requires the calculation of water demand from multiple activities, including agricultural, industrial, and domestic activities. Any or all of these activities may be parts of investment projects. Different levels of water consumption are recorded for these activities according to the extent to which they require water. Generally, the consumption of water by agriculture crops, industry, and domestic uses are about 85%, 5 to 70%, and 20% of water worldwide, respectively [5].

The calculation of water demand for multiple uses and activities is a difficult task and can be time consuming. Modern developments in computer technology and software packages have, however, contributed to solving these issues. SWAT is an application tool used in numerous research projects. It was developed for the Jaldhaka watershed [6], though [7] rapidly modified and established a SWAT model for the Frenchman Creek Basin (FCB), allowing an examination of the causes of stream flow changes. SWAT was also used to evaluate the return flow coming from irrigation canal in a Palleru river basin located in the southern states of Andhra Pradesh in India [1], and [8] applied a SWAT model along with other tools to analyse the water balance components and their temporal and seasonal variations in the Kathmandu Valley, Nepal.

This study focuses on building a model using the available SWAT applications to calculate water demand and available water required for multiple uses in investment projects in a specified region.

2. Multiple Water Demand Calculations

2.1. Water Demand of Agricultural Crops

The importance of knowing the water demand of agricultural crops is that, when water sources are limited, the selection of suitable crops for successful agriculture is essential. Even where water is available, the need for the proper utilisation of this water to meet the water demand of agricultural crops remains. To reduce excessive use of water, crops' maximum water demand is usually taken into account. The total water demand is defined as total water consumption from crops plus water losses as a result of evaporation and deep leakage within fields and irrigation canals or pipes, or evaporation from sprinklers during sprinkler irrigation operations.

The water–soil balance equation of the root zone is given by equation (1) and shown in figure 1 [9]

\[ I + P + CR = ET_c + DP + RO \mp SF \mp SW \]  

where:

- \( I \) = irrigation (mm/day);
- \( P \) = add water to the root zone (mm/day);
- \( CR \) = water transported upward by the capillary rise (mm/day);
- \( ET_c \) = calculated crop evapotranspiration (consumptive use of water) (mm/day);
- \( RO \) = surface runoff (mm/day);
- \( DP \) = deep percolation (mm/day);
$\Delta SF = \text{difference between subsurface flow of the root zone (mm/day)}$; and

$\Delta SW = \text{soil water content change over time period, (mm/day)}$.

**Figure 1.** Soil water balance of the root zone [9].

$ET_c$ refers to the evapotranspiration from a watershed under given climatic conditions. $ET_r$ is the evapotranspiration that depends on a climatic parameter that indicates the evaporation power of the atmosphere. Owing to the effects of crop growth, limited evapotranspiration, environmental impacts, and other constraints, $ET_c$ generally requires a correction as in [9].

$$ET_c = K_c \cdot ET_r$$

(2)

where:

$ET_c$= calculated evapotranspiration of crop (mm/day);

$ET_r$= reference evapotranspiration of crop (mm/day); and

$K_c$= crops coefficient, calculated depending on the stage of growth, as shown in figure 2.

**Figure 2.** Crop coefficient $K_c$ at various stages of growth [9].
Several experimental equations have been developed to calculate the rate of evapotranspiration, and these have been utilised by scientists in many different geographical locations. These equations depend on measured or estimated climate variables, and they vary in terms of their degree of complexity, the number of required variables, and the accuracy of the evapotranspiration rate produced. The accuracy of these equations thus varies widely from one geographical location to another, depending on climatic conditions, and thus several of the equations have been specifically further developed based on climate data. In general, the Penman–Monteith equation is the superlative option in terms of precision, both in wetlands and dry areas [9]. This equation takes into account solar radiation, soil–derived or lost temperature, air temperature, wind speed at two meters above soil surface, and relative air humidity, creating the following formula:

\[
ET_c = \frac{\Delta}{\Delta + \gamma} R_n + \frac{\gamma}{\Delta + \gamma} (0.35)(1 + 0.0062 W_2)(e_a + e_d)
\]  

where:

- \( ET_c \): as defined in equation (2) above;
- \( W_2 \): wind velocity at 2 m above earth surface (km/day);
- \( R_n \): net solar radiation (mm/day) \((R_n = 0.75R_s - R_L)\);
- \( R_s \): shortwave solar radiation;
- \( R_L \): net longwave solar radiation;
- \( \Delta \): the slope of the curve between vapour pressure at a certain saturation and temperature and at air temperature. The values of \( \frac{\Delta}{\Delta + \gamma} \) and \( \frac{\gamma}{\Delta + \gamma} \) thus depend on air temperature (°C);
- \( \gamma \): hard dampener;
- \( e_a \): vapour pressure at the corresponding saturation of air temperature (mmHg); and
- \( e_d \): actual air vapour pressure (mmHg).

### 2.2. Water demand for municipal uses

Precise specifications are even recommended tables of water demand for multiple municipal uses are not available. Thus, an approximation for water demand for municipal uses, as given in table 1, was used as the criteria in this study. As listed in the table, if all buildings are planned to be investment projects in the study region, the total water demand could be calculated as

\[
W_{di}^{munc} = \sum_{i=1}^{n} W_{di}
\]

where:

- \( W_{di}^{munc} \): total water demand from municipal uses, litre/person/day;
- \( W_{di} \): project water demand, litre/day; and
- \( n \): number of projects.

### 2.3. Total calculation of water demand for investment projects

The total water demand is thus calculated depending on the principles of supply and demand for the investment project. This concept can be expressed mathematically as

\[
W_p = W_A - W_D
\]

in which:

\[
W_A = B.S. + R_t
\]

\[
W_D = ET_c + W_{di}^{munc}
\]

where:

- \( W_p \): water provided for investment projects, m³/year;
- \( W_A \): total available water (supply), m³/year;
- \( W_D \): total demand for water, m³/year;
- \( B.S. \): base flow, m³/year; and
- \( R_t \): total runoff, m³/year.
Table 1. Water demand for different project types [10].

| No. \( (i) \) | Project Type         | Water Demand (litre person\(^{-1}\) day\(^{-1}\)) |
|--------------|----------------------|--------------------------------------------------|
| 1            | Residential Units    | 100-180                                          |
| 2            | Offices              | 45-75                                            |
| 3            | Factories            | 20-100                                           |
| 4            | Hotels               | 100-240                                          |
| 5            | Restaurants          | 35                                               |
| 6            | Hospitals            | 500                                              |
| 7            | Schools              | 100                                              |
| 8            | Airport              | 20                                               |
| 9            | Meeting Places       | 10                                               |
| 10           | General Buildings    | 50                                               |
| 11           | Camps                | 75                                               |
| 12           | Swimming Pools       | 40                                               |
| 13           | Mosques              | 15–20                                            |
| 14           | Public Toilets       | 120                                              |
| 15           | 5 Stars Hotels       | 1000–1100                                        |
| 16           | Car Wash Garages     | 560                                              |
| 17           | Massacres            | 300–500                                          |
|              | Total Demand         | 3725                                             |

3. Water Demand Calculation using SWAT Model

3.1. Explanation of the SWAT model

The Agricultural Research Service (ARS) has participated in the creation of a progressive SWAT model. SWAT is a software package with facilities to simulate the hydrologic cycle of plant and root growth, as well as sediment and water routing from a specified region relative to major river basin systems. Moreover, weather, land cover, land use, and soil characteristics can also be simulated in this model. The SWAT model does not require much calibration and thus saves time in comparison with conventional conceptual simulation models [11].

The soil–water balance equation can be assessed using the SWAT model. Water use and water shortages are thus calculated, and the model has the capability to evaluate the quantities of water that are involved in the crop-water cycle from the initial stage of the cycle, supplied to the land by precipitation, and then as it enters the streams as surface runoff, to be used and returned to the atmosphere by natural vegetation, agricultural crops, and evaporation, finally percolating through the root zone and partially returning as groundwater.

Several packages are integrated with the SWAT model. The most versatile of these are the Arc View Geographic Information System (GIS), also referred to as AVSWAT. In the present study, the AVSWAT was used for preprocessing and postprocessing of input to output data for SWAT [12].

In the SWAT model, a curve number (CN) is decided by the Soil Conservation Service (SCS) method. After that, several important parameters are determined and calculated, such as the peak discharge and the maximum potential storage. The runoff is determined by deducting the storage from the rainfall, allowing the time of concentration and the peak discharge to be determined. As a result of these, the discharge can be calculated [13].

The weighted curve number \( (CN_w) \) is used to determine the potential storage by applying equation (8):

\[
S_r = \left( \frac{1000}{CN_w} \right) - 10 \tag{8}
\]
where:

\[ CN_w = \text{average weighted curve number}; \] and
\[ S_r = \text{the possible retention, mm.} \]

For this method, the determination of the runoff \((Q)\) in mm is the first step. Eliminating losses from precipitation \((P_t)\) over the drainage area is also required. Thus, the SCS equations that are necessary to determine the quantity of runoff are [14].

\[
\frac{P_t - Q - la}{S_r} = \frac{Q}{P_t - la}
\]

(9)

which can be rearranged to

\[
Q = \frac{P_t - 0.25S_r}{P_t - la + S_r}
\]

(10)

where:

\[ S_r \] is defined as in equation (8);
\[ Q \] is actual runoff, (mm);
\[ P_t \] is potential runoff as total rainfall, (mm); and
\[ la \] is the initial abstraction which represents all losses before runoff. This includes water retention in surface depressions and water intercepted by vegetation, infiltration, and evaporation, as shown in figure 3.

![Figure 3. SCS Curve Number (CN) method][1]

3.2. Description of the study region

The region of Jilawia and Muharam is located in the North of Babylon in the middle of Iraq between 44\(^{\circ}\) 16' 32.7829" to 44\(^{\circ}\) 25' 06.8254" E and 32\(^{\circ}\) 48′ 19.1776" to 32\(^{\circ}\) 45′ 49.1529" N. Figure 4 shows the area selected as a case study for which the water available and demanded were calculated. This region is irrigated from the Great Al‒Mussiab Project to a distance of 12 km, covering a 20000 dunum (50 km\(^2\)) area, which also receives rainfall water [16]. The system of irrigation in this region depends mainly on the surface irrigation method using furrows and border strips.

3.3. Explanation of a Digital Elevation Model (DEM) of a Study Region

The United States Geological Survey (USGS) Land 8 [16] is useful source of information about the DEM study area. Figure 5 shows the DEM at a resolution of 30 m, covering the Jilawia and Muharam region; this was obtained from the Landsat8 website. The first step required for building a SWAT model is to define the properties of elevation, including elevation above sea level, which resulted in 196 sub-catchments.
3.4. Climate Data
Climate data, including the rainfall, the maximum and minimum temperatures, wind speeds, relative humidity, and solar energy, were obtained using weather generating data from a monthly database (WGEN–CFSR World), for selected past, current, and future periods over the chosen 11-year case study (2010 through 2020). Geographically, the position of Hilla leads to warm and dry summers throughout June, July, and August, with average maximum and minimum temperatures of 29.5 °C and 14.79 °C, respectively, for the studied period. The weather station [17] located in the study region indicates that the city is usually windy during the winter; data collected from this station show that this season extends from December to February, and that average relative humidity, evaporation, average wind speed, and sunshine duration in winter are recorded as 73%, 87.4 mm, 2.8 m/sec, and 9.55 hours, respectively. Moreover, the recorded data shows differences in weather conditions between summer and winter seasons in terms of the average relative humidity, evaporation, average wind speed, and sunshine duration. These were recorded in summer as 22%, 469 mm, 1.3 m/sec, and 26 hours, respectively.
3.5. Explanation of Land Use (LU), Land Cover (LC), and Soil Digital Map (SDM)

Satellite imagery, ASTER, is obtained from the USGS website [18]; this offers three bands with 30 m spatial resolution that were thus used to produce a LU/LC map. Thematic mapping of different LU and LC classes were constructed through supervised classification into five types: Palm land general (20.74%), Corn (46.31%), Water (10.90%), Forest (15%), and Orchard (6.93%). By using an exploratory soil map of Iraq from 1960 and a land–use map with unified classification of Food and Agriculture Organization (FAO) [19], soil classes were also achieved through supervised classification using GIS software: four classes of soil (Sand, Clay, Silt, and Silty Clay) were identified in the case study. Analysing the texture of the soil was done using the Soil Plant Air Water (SPAW) tool. This program can estimate several soil properties such as conductivity, water tension, and water holding capability based on the important components of soil such as soil texture, organic matter, gravel content, and compaction. Once the ratio of soil characteristics is derived from the SPAW tool, it can be used to support the database of SWAT soil classifications.

3.6. Calibration Method

The general calibration strategy is to validate and accurately reproduce the SWAT model. SWAT may be calculated $ET_r$ with the Priestley–Taylor, Penman–Monteith or Hargreaves [9 formulae]. Here, the Penman–Monteith formula was selected to calculate $ET_r$. The calibration of evapotranspiration $ET_r$ is imposed through a period of calibration from years 2013 to 2016. The results of the calibration between evapotranspiration calculated by SWAT and that measured by Al–Mussiab station are given in table 2. This table shows that the average percentage error is 12.5%.

| Year | $ET_r$\textasciitilde{a}, (mm year$^{-1}$) | $ET_r$\textasciitilde{b}, (mm year$^{-1}$) | Error % |
|------|---------------------------------|---------------------------------|--------|
| 2013 | 140                             | 95.84                           | 31.54  |
| 2014 | 136                             | 128.19                          | 5.74   |
| 2015 | 134                             | 126                             | 5.97   |
| 2016 | 115                             | 107                             | 6.95   |
| Average |                                |                                 | 12.50% |

\textasciitilde{a} measured from Al–Mussiab station [17].

\textasciitilde{b} calculated from SWAT.

3.7. Runoff Modelling with SWAT

The SWAT model with components as mentioned in the previous sections was applied to the study region (Jilawia and Muhamar Region) to estimate runoff amounts. This model simulates crop yields on different surface and ground hydrological components. In the SWAT model, the catchment area is divided into smaller discrete calculation units using a distributed rainfall–runoff model; here, the spatial variation of the major physical properties is limited, and hydrological procedures can be conserved as homogeneous. The total catchment behaviour is a net result of multiple small sub basins. Soil and land use maps were used within sub basin borders to create exclusive combinations, with each combination being considered to have homogeneous characteristics. Additionally, the SWAT split the river basin into units with similar characteristics in terms of soil and land cover located within the same sub basin. Furthermore, the SWAT divided the rainfall into several different components, including evaporation, surface runoff, infiltration, plant uptake, lateral flow, and groundwater recharge. Surface runoff from daily rainfall was estimated with a modification of the SCS curve number method produced by the United States Department of Agriculture Soil Conservation Service (USDA SCS), and peak runoff rates were calculated using a modified rational method [20]. Unique land use, soil, and slope incorporation
Hydrologic Response Units (HRU) were generated for all sub basins. The application of HRUs by subdividing the catchment area into numerous areas with the same land use and soil incorporation assists the model with reflecting changes in the hydrologic situations caused by various land covers, crops, and soils, increasing the accuracy of the load predictions and providing a physical description of the water balance.

Water flow was predicted individually for all HRUs and routed to define the whole overland for the study region. Slope characterisation was established based on the DEM defined in the watershed delineation. Datasets of the land cover were connected to the SWAT database, along with information about soil texture, and the results were incorporated into the SWAT datasets (Soil Hydrologic Groups). The land use, soil and slope reclassifications, and dispersals for the watersheds were delineated for all respective sub watersheds. Figures 6 and 7 illustrate the land cover and soil analysis using DEMs [21].

4. Results and Discussion

As given in equation (2), \( ET_c \) is calculated once \( ET_s \) and \( K_c \) are known. In this study, four famous crops, Rice, Corn, Wheat, and Cucumbers were selected for their different seasons of growth throughout the
year. These crops are also suitable as an investment agriculture projects to support municipal projects in the study region. The net area sufficient for such agriculture projects is 16000 dunum (40 kM²) and the remaining area, 4000 dunum (10 kM²), is thus reserved for municipal projects. The value of $K_c$ in the middle stage of growth is $K_{c_{mid}} = 1.30$, as shown in figure 2, and the average annual consumptions of water, $ET_c$ as calculated by the SWAT model, for the four selected crops are approximately 198.73 mm, 131.82 mm, 51.36 mm, and 87 mm, respectively, as illustrated in table 3.

| Crops       | $ET_c$ (mm/year) |
|-------------|------------------|
| Rice        |                  |
| 2010        | 200              |
| 2011        | 201              |
| 2012        | 170              |
| 2013        | 218              |
| 2014        | 201              |
| 2015        | 196              |
| 2016        | 198              |
| 2017        | 191              |
| 2018        | 200              |
| 2019        | 205              |
| 2020        | 206              |
| Average of years |    |

In order to simulate the average runoff in the catchment area, the net area of the watershed given by DEMs is 50 kM². The curve number value is 69.26. The results for average annual runoff ($R_t$) for the period of simulation is 16.38 mm/year, and the results show that the maximum value was 29.5 mm/year in 2016, with the average annual volume of runoff being 840,863.6 m³/year, as illustrated in table 4 and shown in figure 8.

| Year | $R_t$ (mm year⁻¹) | $R_t$ (m³ year⁻¹) |
|------|------------------|------------------|
| 2010 | 4.05             | 202500           |
| 2011 | 12.25            | 612500           |
| 2012 | 13.48            | 674000           |
| 2013 | 8.00             | 400000           |
| 2014 | 23.00            | 1150000          |
| 2015 | 20.06            | 1003000          |
| 2016 | 29.50            | 1475000          |
| 2017 | 10.25            | 512500           |
| 2018 | 18.00            | 900000           |
| 2019 | 25.40            | 1270000          |
| 2020 | 21.00            | 1050000          |
| Average| 16.40           | 840863.60        |
Figure 8. Average annual runoff

The base flow (B.S.) of the Great Al–Mussiab Project, which provides irrigation water to the study region in a 12.00 km radius was calculated by finding the water level in Google earth and applying it in a GIS. Therefore, the B.S.=2,280,600 m³/year, and consequently, the total available water from equation (6) is $W_A = 3121463.60$ m³/year.

The total municipal water demand $W_{dmunc}$ is calculated from equation (4), and depends on the upper limits given in table 1; here, it is 3.725 litre/person/day = 1360 m³/person/year. The annual consumption of water $ET_c$ as calculated from equation (2) are 794,090.91 m³/year, 5,273,090.91 m³/year, 2,054,545.45 m³/year, and 3,480,000.00 m³/year for Rice, Corn, Wheat, and Cucumber crops, respectively. Thus, the total water demands calculated from equation (7) are $W_D = 7,950,450.91$ m³/year, 5,274,450.91 m³/year, 2,055,905.45 m³/year, and 3,481,360.00 m³/year for Rice, Corn, Wheat, and Cucumber crops, respectively.

The calculations for water demand $W_D$, water available (supply) $W_A$, and water provision $W_P$ for uses in study region in terms of investment in both agricultural and municipal purposes are given in table 5.

| Year         | $W_A$ (m³ year⁻¹) | Crops       | $W_D$ (m³ year⁻¹) | $W_P$ (m³ year⁻¹) | Deficit/Surplus (%) |
|--------------|------------------|-------------|------------------|------------------|---------------------|
| Average of 11 years | 3121463.60        | Rice        | 7950450.91       | -4828987.31      | -154.70%            |
|              |                   | Corn        | 5274450.91       | -2152987.31      | -68.97%             |
|              |                   | Wheat       | 2055905.45       | +1065558.15      | +34.13%             |
|              |                   | Cucumber    | 3481360.00       | -359896.40       | -11.53%             |

Table 5 shows that the water provision, $W_P$, is insufficient for the purposes of both agriculture and municipal investment projects for Rice, Corn, and Cucumber crops due to the deficit percentage of water if these crops are used. However, the provision is sufficient for wheat crops. The deficit is due mainly of the consumption rates of water $ET_c$, which differ from crop to crop, as given in table 3; it also depends on the parameters of the Penman–Monteith $ET_0$ method given in equation (3), which depend on the crop season and thus the temperature, wind velocity of the air, humidity, and so on. The soil–water balance given by equation (1) and shown in figure 1 also plays a role in this deficit.

It is thus important to identify some solutions to overcome this problem. One of these is a determination of the effective area that is suitable for the quantity of water available for crops. This will make sure that the aims of the planned projects are achieved, thus meeting the goals of this study. Thus, the areas that
should set aside for agricultural water uses are 15.70 km$^2$ (6,280 dunum), 23.66 km$^2$ (9,467.05 dunum), and 35.86 km$^2$ (14,344 dunum) for Rice, Corn, and Cucumber crops, respectively. That means that 39.25%, 59.17%, and 89.65% of the total available area of the study region (16,000 dunum) must be set aside for Rice, Corn, and Cucumber crops, respectively, to achieve the planned investment. In other hand, the water available as calculated by the SWAT model is sufficient for municipal use only, with 2,300 persons as the full capacity of the investment project.

5. Conclusions
Several conclusions can be drawn from this study:
1. SWAT is an adequate tool to calculate water demand for multiple uses (irrigation of crops and municipal uses) in a specified region efficiently, saving time.
2. The Jilawia and Muharam region which lies North of Babylon in Iraq, is a suitable region for planned investment projects such as agriculture and municipal projects that will use the available water in this region.
3. The available water (including runoff and base flow) in the Jilawia and Muharam region is sufficient for both wheat crops (or other crops in the same season of growth) and municipal projects.
4. Rice, corn, and cucumber crops, as well as other crops with the same season of growth, could be irrigated using the available water, but only at 39.25%, 59.17%, and 89.65%, respectively, of the total available area of the Jilawia and Muharam region.
5. The available water (including runoff and base flow) in the Jilawia and Muharam region is sufficient for municipal uses only, with 2300 persons being the full capacity of such investment projects.

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Acknowledgment

This study was achieved with assistance of Al–Mussiab Weather Station and was also partly supported by Al-Great Al–Mussiab Project. Other official letters from persons of interest have been beneficial in terms of improving the quality of this article.