Estimation of Potato Irrigation Requirement for Management Water Sustainability By Using FAO CROPWAT 8.0 in Central of Iraq

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Abstract

Declining availability of water resources across the Iraqi context has become a major ecological concern associated with climate change and reduced river flow caused by upstream dam construction. In semi-arid regions, accurate estimation of crop water needs is essential for supporting improved irrigation management and achieving more effective use of water resources. The present investigation estimated crop irrigation demand in Al-Qadisiyah Governorate, Central of Iraq, at 1144.2 mm/10. The water demand did not remain constant throughout the period of crop-growth. The frequency of irrigation was relatively low during the initial stage of development since the amount of reference evapotranspiration was low and root systems were not deep. It peaked at the middle of the season when evapotranspiration was at its peak and the soil was at its highest level of moisture loss. The paper also cites the importance of irrigation scheduling tools like CROPWAT and CLIMWAT in assisting farmers in Iraq.

Keywords: potato, Iraq, CROPWAT, CLIMWAT, Evapotranspiration, Rainfall, Water Requirement, Water Sustainability.

Introduction

Climate change has added a further strain to water scarcity in the semi-arid regions as the scarcity of water has caused irrigation water to become scarce. This has resulted in severe limitations in arid and semi-arid regions to have adequate water to engage in irrigation practices [1].

In such circumstances, water management in agriculture has remained a critical factor to help in sustaining development in the face of climate change and increased global water demands. Agriculture already consumes more than 70 percent of the total available freshwater in the world, the rest of which is consumed by household and industrial purposes [2]. The situation with water is especially severe in Iraq. Agriculture uses approximately 80 percent of the water resources of the country, and

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climate variability along with growing demands in other sectors of the economy has significantly cut down water supply in this sector [3].

CROPWAT 8.0 is generally recognized as an important tool that aids in estimating the evapotranspiration and water requirements of crops, as well as the irrigation schedules. The food and Agriculture Organization (FAO) developed this software package to assist the irrigation engineers and agronomists in performing standard computations pertaining to the study of irrigation, especially in planning, management, and designing irrigation systems [4]. Many studies have used FAO CROPWAT to determine the water demands of various crops and vegetables [5,6,7,8,9].

This experiment explored the irrigation of potato in the Governorate of Al-Qadisiyah in central Iraq. CROPWAT model was applied to find out the right time and volumes of irrigation water needed to grow potato to enhance irrigation management, save water resources, and solve the water. scarcity problem in a more reasonable way.

Material and Methods

The study area:

The Al-Qadisiyah Governorate is situated around 180 km southeast of Baghdad, positioned at coordinates (31° 51′ 0″ N) and (45° 3′ 0″ E). It is a significant agricultural governorate in Iraq, cultivating essential vegetables such Tomato and Potato are vegetables essential for supplying sustenance and revenue for rural inhabitants. The total land area in the governorate is 3,275,326 dunams (one dunam equals 2,500 m²). The agricultural land encompasses roughly 1,844,700 dunums (Figure 1). The regional climate is marked by aridity, exceedingly high temperatures, infrequent precipitation, and the hydrological regime is predominantly influenced along the Euphrates rivers [10].

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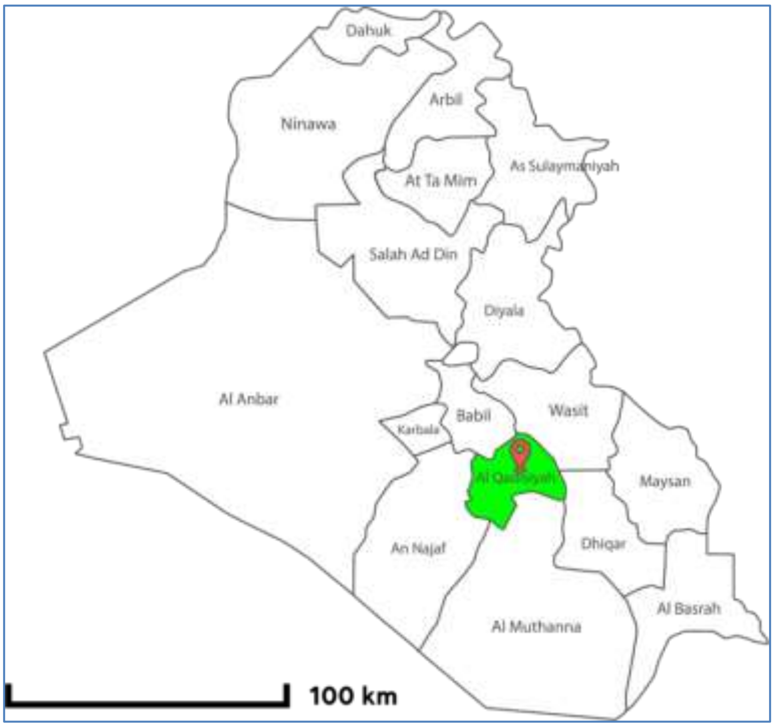

Figure. 1 The map show the Al-Qadisiyah Governorate in middle of Iraq

FAO CROPWAT Model

The food and Agriculture Organization of the United Nations (FAO) has developed the CROPWAT model. They are used to calculate crop water requirements (CWR) and irrigation water requirements (IWR) based on climatic, soil, and crop-related data according to FAO guidelines [11].

The CWR approach refers to the method used in the CROPWAT model to estimate crop evapotranspiration (ET) under optimal growth conditions. Optimal growth conditions refer to conditions in which sufficient soil moisture is maintained at all times through rainfall and/or irrigation. To utilize the CWR strategy in the CROPWAT model, four primary categories of data is needed. They are climate, rainfall, crop and soil data. In the period (1971–2000) climatic data were obtained from the Iraqi meteorological station in Diwaniya (center of Al-Qadisiyah).

CLIMWAT 2.0 is a climatic database developed for use with the CROPWAT model [12]. Essentially, The monthly mean reference evapotranspiration (ET_0) based on food and agriculture organization (FAO) penman-monteith method [11] was calculated from

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CROPWAT climatic data and ET_0 values. The rainfall data acquired from CLIMWAT, effective rainfall (Eff. rain) estimate was made using the US soil conservation method [13]. Crop input data in CROPWAT contains crop coefficient (Kc), stages of growth, rooting depth and similar information. Soil conditions of a medium [14], November and May were assigned as planting and harvesting periods, respectively [15].

Estimation of Crop Water Requirement (CWR)

Agricultural water demand signifies the volume of water required to offset the loss of water due to evapotranspiration occurring in agricultural areas, and it is conventionally quantified in millimeters per day. This demand is estimated based on crop evapotranspiration (ETc), which is calculated utilizing the formula introduced by Pereira et al. [16].

$$ETc = Kc \times ET_0 \qquad (1)$$

In this formula, ETc signifies the rate of crop evapotranspiration quantified in mm/day, ET_0 refers to the reference evapotranspiration measured in mm/day, and Kc represents the coefficient associated with the crop.

Irrigation Water Requirement (IR)

The CROPWAT model serves to assess the soil water balance in the root zone and daily depletion levels through a specific equation.

$$Dr,i = Dr,i-1 - (P - ROi) - Ii - CRi + ETci + Dpi \qquad (2)$$

This equation delineates (Dr,i) as the water depletion in the root zone on day (i) in millimeters, (Dr,i−1) as the residual moisture from the previous day, (Pi) as daily rainfall, (Roi) as runoff on day (i), (Ii) as irrigation water depth for the same day, (Cri) as groundwater's capillary rise into the root zone, (ETci) as crop evapotranspiration on day (i), and (DPi) as the water volume sourced from the root zone on day (i), also measured in millimeters.

Irrigation Scheduling

The scheduling of irrigation is significant in the timing of watering crops to achieve the best timing that reduces unnecessary water wastage. CROPWAT model produces irrigation plans in various field conditions and water availability [11].

Results and Discussion

Evaporation(E0)

According to Table 1, the Al-Qadisiyah Governorate, central Iraq, had a significant seasonal variation in the reference evapotranspiration. The maximum was experienced in

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July 10.04 mm/day and the lower value was 2.1 mm/day in January. Higher temperatures and increased sunshine period explain why evapotranspiration increased in July. On the contrary, low values in January were related to lower temperatures, which indicated less water needs in crops [14]. The time and the strength of solar radiation are closely connected with evapotranspiration. Similarly, in their research with the focus on different crops in Iraq, Ewaid et al. [17] found out that the rates of evaporation increase in summer seasons.

Table 1. Climate parameters of the study area at 2024

Month	Temp. (°C)		Humidity (%)	Wind (km/day)	Sun (h)	Rad. (MJ/m²/day)	ET0 (mm/day)
Jan	4.1	17.1	67	233	6.5	11.5	2.1
Feb	5.8	19.7	61	242	7.2	14.4	2.85
Mar	9.6	24.4	50	259	7.5	17.5	4.33
Apr	14.5	30.1	43	251	8.1	20.7	5.88
May	20	34.8	35	233	9.1	23.3	7.25
June	23.1	41	27	294	10.9	26.3	9.94
July	24.3	42.7	29	285	10.9	26.1	10.04
August	23.6	42.9	29	259	10.4	24.3	9.33
Sept	20.3	40.1	31	225	9.6	21	7.63
Oct	15.8	34.5	42	199	8.3	16.4	5.36
Nov	10.4	25.6	55	199	6.8	12.2	3.34
Dec	5.4	18.6	65	216	6.3	10.6	2.2
Average	14.7	31	45	241	8.5	18.7	5.85

Assessment of Effective Rainfall

Figure 2 indicates that effective rainfall varied from 29.5 mm in January to 0% during the summer months (June, July, August, and September). The seasonal pattern of effective rainfall for crops differed over time, with higher values recorded in winter than in the other seasons [18].

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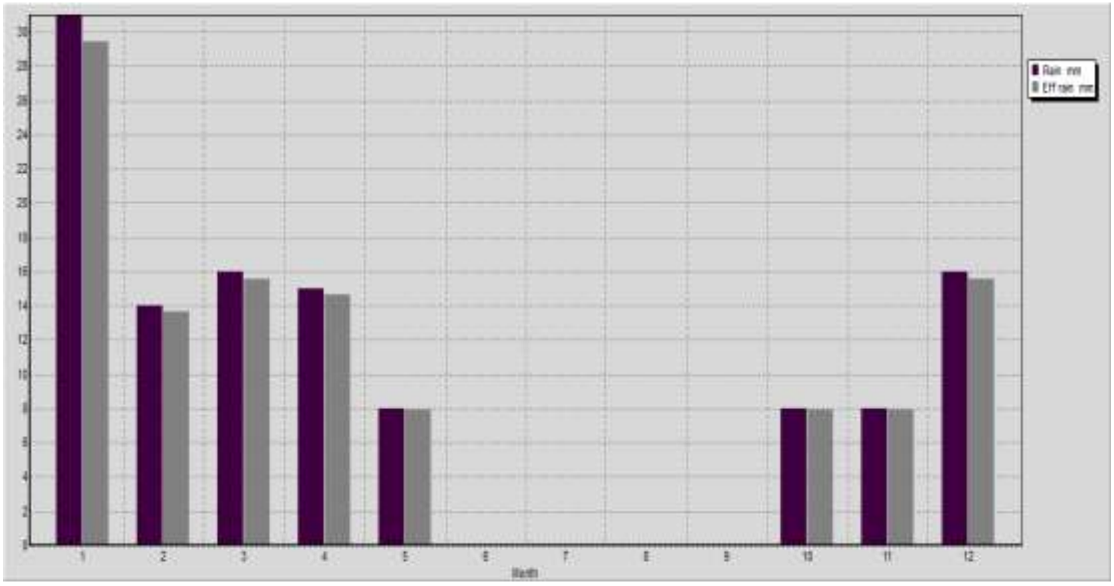

Figure. 2 The effective rainfall pattern in Central of Iraq

Estimation of Potato Water Demand

Figure 3 shows the water requirement of potato in light soil (sand) which has a total value of 899.4 mm. Against this background, estimating the agricultural water demand requires the knowledge that crop moisture needs vary depending on various factors among which are the characteristics of the soil, geographical location, and the climatic conditions. Besides this, the overall water needs of a crop are not evenly distributed among all stages of development. These findings agree with the results reported by Vishnoi et al. [19], who used the CROPWAT model to study potato cultivation in the Tarai region of Uttarakhand. Similar results were also reported by Gabr [20] in a study on potato in Egypt.

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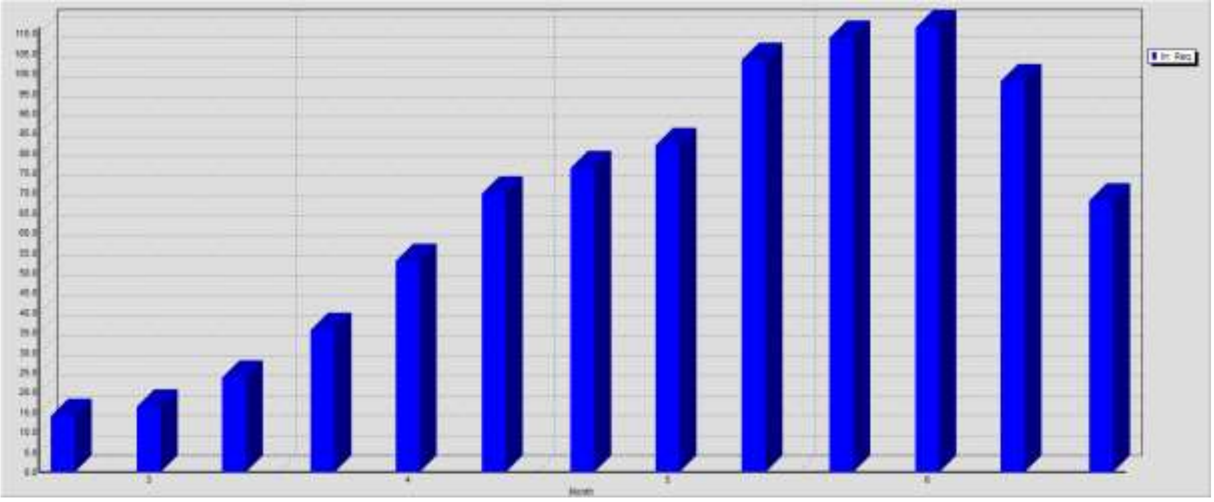

Figure. 3 Crop water requirements for Potato in Central of Iraq

Irrigation schedules for Potato in middle of Iraq

Total Available Moisture (TAM) is the water available to the crop as shown in Figure 4. Readily Available Moisture (RAM) in its turn is the amount of said water that can be utilized by the plant, prior to stress. Depletion refers to the decrease in soil water, and hence, the stage where irrigation is required [21].

Figure 4 demonstrates that more frequently the irrigation of the potato was organized in the first stage of the growth as the reference evapotranspiration (ET o) was lower and the depth of the root was shallow. The frequency of irrigation rose in the mid growing season when the degree of evapotranspiration rose to the peak and the depletion of soil moisture was maximum. The findings coincide with the results obtained by Amini et al. [22], who studied potato and other crops in Iraq.

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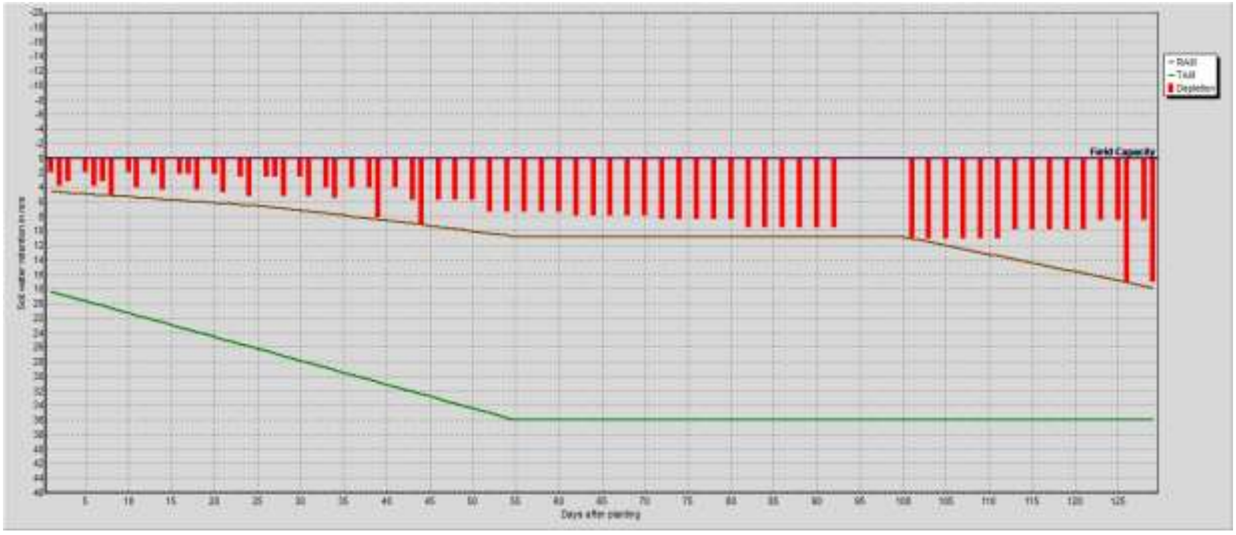

Figure. 4 Irrigation schedules for Potato in pattern in Central of Iraq

Conclusions

The use of the software which is FAO CROPWAT 8.0 gave a significant results to the study area. The water needs of crops and irrigation times were particularly established regarding the seasonal and biological peculiarities of central Iraq. The crop demand of water is estimated based on a number of factors that interact with each other, such as soil, geographical conditions and climate. Secondly, crop moisture demand does not occur even across all development stages.

In the case of potato, the frequency of irrigation was less in the early growth period since reference evapotranspiration (ET 0) was also lower and root depth remained low. This frequency was higher at the middle of the growing season, at which evapotranspiration was maximum and soil moisture was at the lowest point. Greater values of evapotranspiration were connected with increase in temperatures and increase in sunshine duration and decrease in values with a decrease in temperatures, showing that crop water demands were lower. The length of time and strength of solar radiation is related closely to evapotranspiration. Effective rainfall also exhibited definite seasonal variation whereby it was high in winter and lower in the rest of the seasons.

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