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Analysis of Current Water Demand of the Shanafiyah-Nasiriya Irrigation Project

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Abstract

This research aimed to estimate the current water demand of the Shanafiyah-Nasiriya Irrigation Project by using the CROPWAT model. The estimated reference evapotranspiration (ETo) in Shanafiyah-Nasiriya Irrigation Project varies seasonally, with ETo values equal to or more than 200 mm/month during the dry season (May to September) and equal to or less than 175 mm/month during the rainy season (October to April). The total irrigation water requirement is 894 mm for the rainy season and 332 mm for the dry season. The Shnafiyah - Nasiriya yearly irrigation water requirement equals 796.5 million cubic meters (MCM). These results emphasize the importance of scientific planning for practical water usage in agriculture.

Keywords: CROPWAT model, Shanafiyah-Nasiriya, irrigation, water demand

تحليل الطلب الحالي على المياه لمشروع ري شنافية – ناصرية

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المستخلص

يهدف هذا البحث إلى تقدير الطلب الحالي على المياه لمشروع ري شنافية - ناصرية باستخدام نموذج CROPWAT . يختلف التبخر المرجعي المقدر (ETo) في مشروع ري شنافية - ناصرية موسميا ، حيث تساوي قيم ETo أو تزيد عن 200 ملم / شهر خلال موسم الجفاف (من مايو إلى سبتمبر) وتساوي أو تقل عن 175 ملم / شهر خلال موسم الأمطار (من أكتوبر إلى أبريل). يبلغ إجمالي متطلبات مياه الري 894 ملم لموسم الأمطار و 332 ملم لموسم الجفاف. وتبلغ متطلبات مياه الري السنوية في مشروع ري شنافية - ناصرية 796.5 مليون متر مكعب. تؤكد هذه النتائج على أهمية التخطيط العلمي للاستخدام العملي للمياه في الزراعة.

الكلمات المفتاحية : نموذج CROPWAT , شنافية – ناصرية , ارواء , استهلاك مياه

1. Introduction

Recent decades have seen a dramatic development of water resources in many regions of the world, particularly in semiarid areas with scarce water resources but mild climate favoring population growth, irrigation, and tourism (Garrote, 2017). Iraq faces interconnected environmental, security, political, and economic challenges, and 85% of its renewable freshwater resources are consumed by the agricultural sector (Al-Ansari, 2013).

Al-Mukhtar & Mutar , 2020 aimed to identify the optimal water allocation among the domestic, agricultural, and industrial sectors of Baghdad city under present and potential future scenarios. Al-Shammari & Al-Aboodi , 2020 used eight crops to show the correlation between the paucity of irrigation and yield reduction of Al-Hussainiyah irrigation project in Karbala, Iraq. Ewaid , et.al., 2019 used the CROPWAT model to evaluate the crop water requirements and irrigation schedules for some significant crops in Southern Iraq. Ewaid , et.al.,2020 assessed Iraq's significant cereal crop trade impacts on water and land security. Al-Ansari , et.al.,2020 used the models CROPWAT and CLIMWAT to calculate water requirements and footprints. Kia, 2013 evaluated water requirements for major crops in different agro-climatic zones of Iraqi Kurdistan by using CROPWAT 8.0. Wedaa , et.al., 2022 evaluated the agricultural water footprint of Al-Qadisiyah Governorate, southern Iraq, using CROPWAT 8.0.

The literature mentioned encompasses a range of studies conducted in Iraq, but none of them have specifically addressed the Shanafiyah-Nasiriya Irrigation Project. Therefore, the aim of this research mentioned is to fill this gap and estimate the current irrigation water demand of the Shanafiyah-Nasiriya Irrigation Project using the CROPWAT model.

2. Study Area

The Shnafiyah - Nasiriya irrigation project (SNIP) is in Diwaniyah, Muthanna, and Thi-Qar provinces, along the Euphrates River, starting in Shnafiyah (Diwaniyah province) and ending close to Nasiriya (Thi-Qar province). The land area of the SNIP is approximately 65000 ha. The Shnafiyah – Nasiriya irrigation project coordinates 44.20º E eastern of the Grinch line and 31.20º N north of the equatorial (JICA, 2016). Figure (1) shows the layout map of the study area.

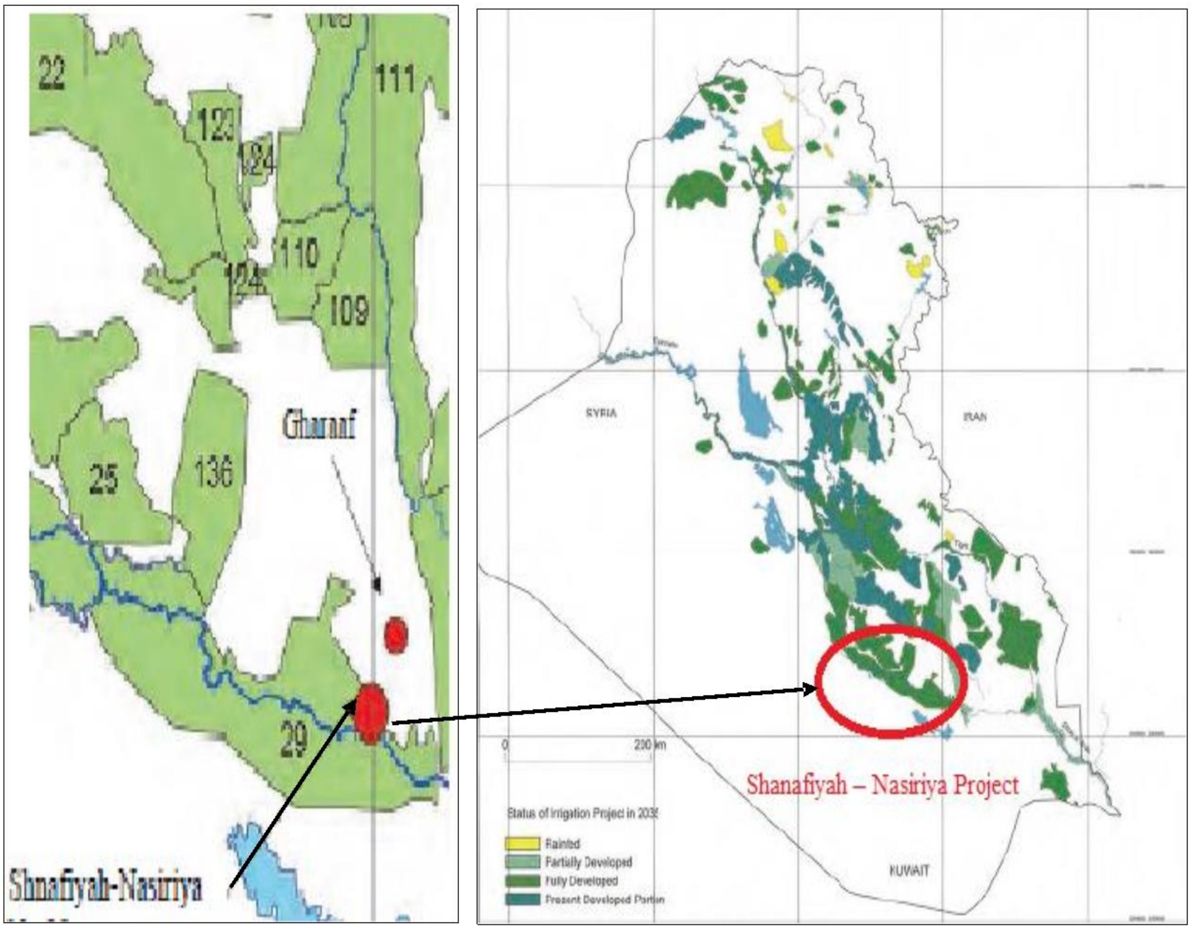

Figure (1): Layout map of the study area (JICA, 2016)

3. Research Methodology

3.1. Climate Data

The CROPWAT model was used to calculate the irrigation water demand of Shnafiyah – Nasiriya irrigation (SNIP) based on the reference period. The reference period (RP) depends on the historical data collected from 1995 to 2014. Figure (2) shows the minimum and maximum temperature data of the SNIP. The data was sourced from the Climate Change Knowledge Portal (CCKP, 2023). Also, Figures (3 and 4) show the time series of precipitation and relative humidity data, respectively.

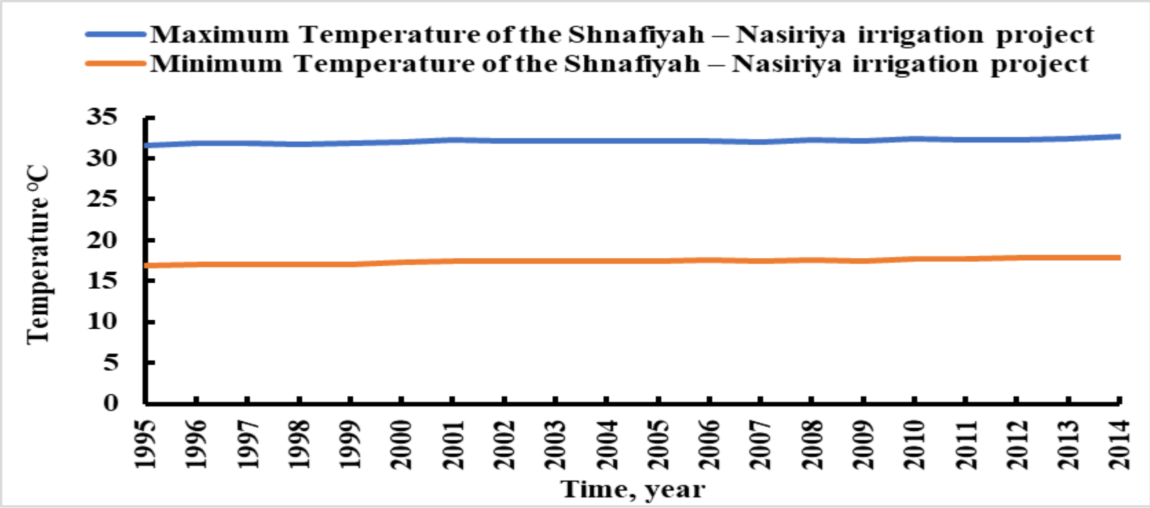

Figure (2) : Maximum and minimum temperature of the Shnafiyah – Nasiriya irrigation project's RP scenario (CCKP, 2023)

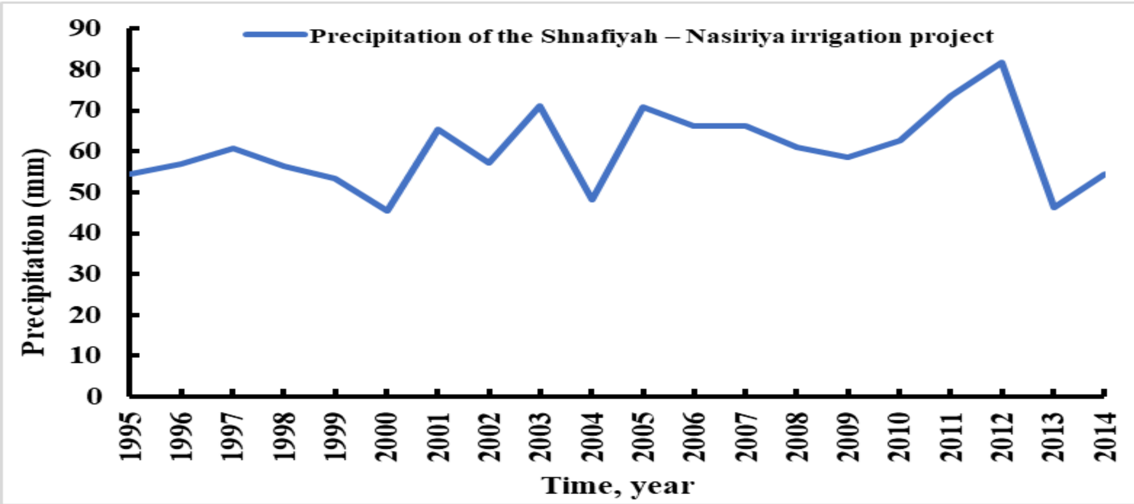

Figure (3): Precipitation of the Shnafiyah – Nasiriya irrigation project's RP scenario (CCKP, 2023)

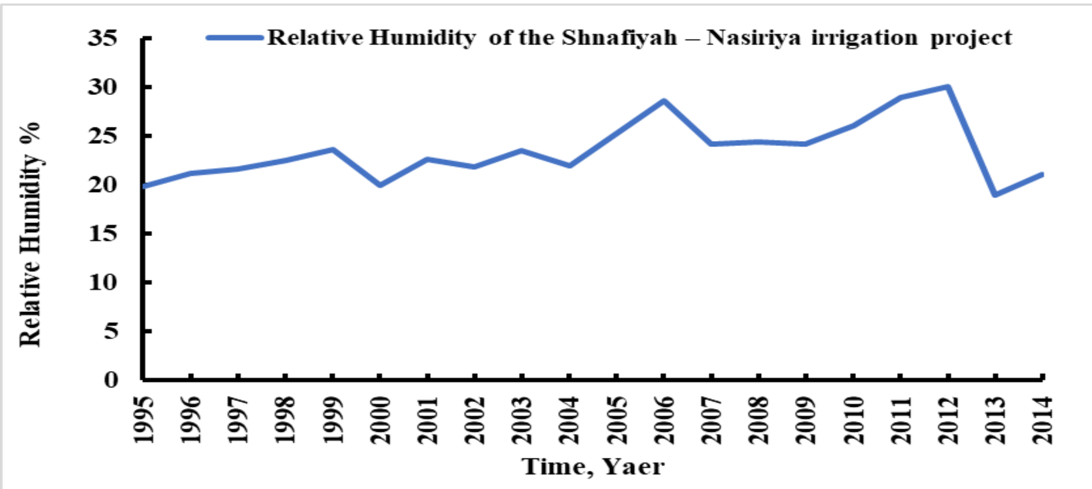

Figure (4): Relative humidity of the Shnafiyah – Nasiriya irrigation project's RP scenario (CCKP, 2023)

3.2. Estimation of Irrigation Water Demand

Many software packages already use the Penman-Monteith equation to assess the reference evapotranspiration. One of the outputs of the CROPWAT Model is irrigation scheduling. The Penman-Monteith method can be adapted to calculate the reference surface evapotranspiration (ETo). ETo expresses as:

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

Where ETo is the reference evapotranspiration (mm/day), R_n is the net radiation at the crop surface (MJm^2/day), G is the soil heat flux density (MJm^2/day), T is the daily air temperature at 2 m height (°C), u_2 is the wind speed at 2 m height (m/s), e_s is the saturation vapor pressure (KP_a), e_a is the actual vapor pressure (KP_a), $(e_s - e_a)$ is the saturation vapor pressure deficit (KP_a), Δ is the slope vapor pressure curve ($KP_a/°C$), γ is the psychrometric constant ($KP_a/°C$).

$$Etc = Kc \times ETo \quad (2)$$

Where Etc is the crop evapotranspiration (mm/day), Kc is the crop coefficient (Allen, et al.,1998). Net irrigation water requirements (NIWR) were evaluated by using the equation:

$$NIWR = Etc - Re \quad (3)$$

Where Re: is the effective rainfall (Naidu & Giridhar, 2016). These areas grow seasonal and annual crops, including Wheat, Barley, Broad bean, Rice, Maize (spring), Sorghum, Onion, Kidney beans, Green gram, Groundnut, Cotton, Tobacco, Sunflower, Sesame, Cauliflower, Cabbage, Potato (spring), Cucumber, Tomato, Eggplant, Sweet pepper, Okra, Water melon, Sugarcane, Alfalfa, Soya bean, Olive, Pomegranate, Grape, Date palm, Stone fruit trees, and Citrus (JICA, 2016). The crop coefficient, which reflects the difference in evapotranspiration between field crops and a reference grass surface, varies throughout the growing period as the ground cover changes with crop development stages. The crop coefficient curve, which has three values, illustrates typical trends during the growing season. The crop coefficient (Kc), maximum crop height, and lengths of crop development stages for various planting periods were collected from the study of Allen, et al. (1998). Figures (5,6, and 7) show the crop coefficient (Kc), maximum crop height, and lengths of crop development stages for various planting periods.

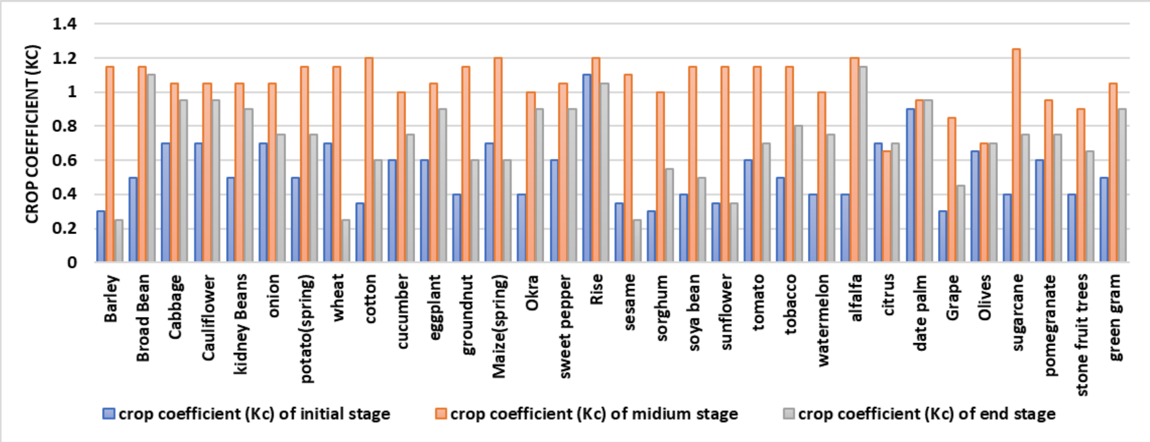

Figure (5): FAO coefficients crops and maximum plant heights (Allen, et al., 1998)

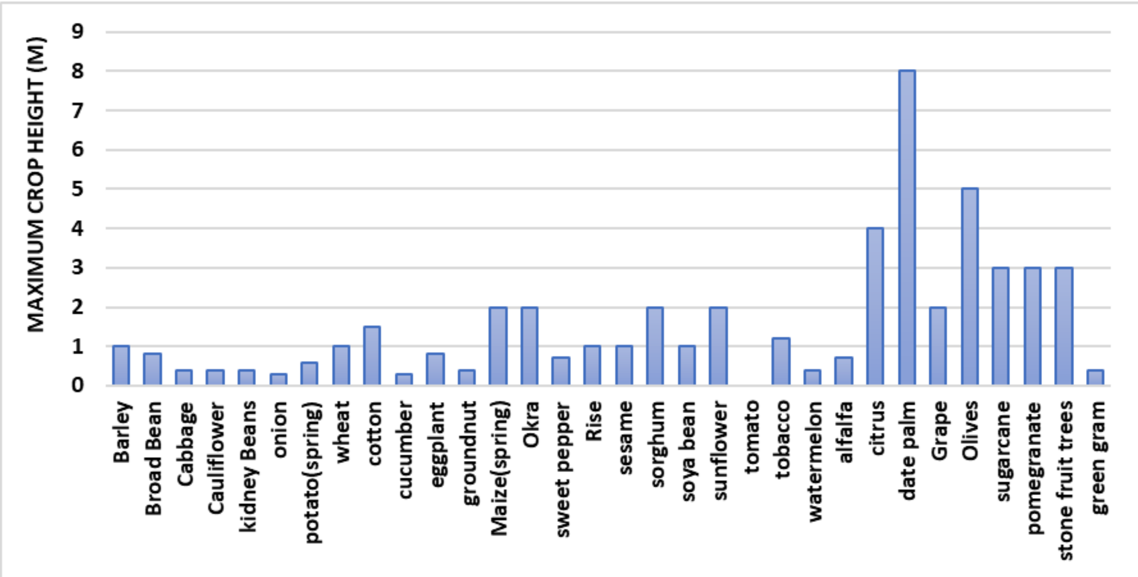

Figure (6): The maximum plant heights (Allen, et al., 1998)

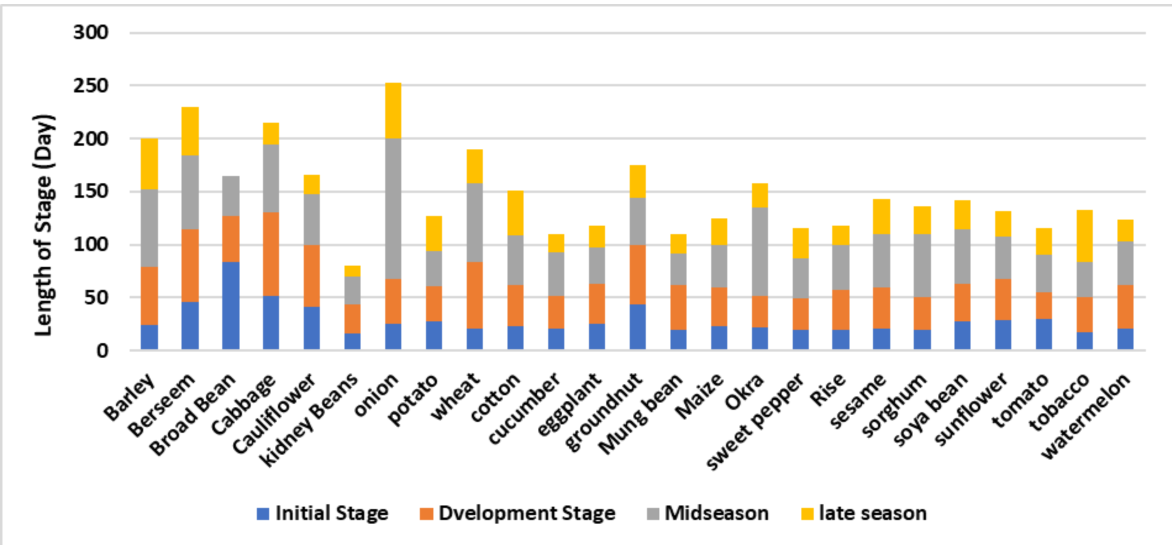

Figure (7): The lengths of crop development stages (Allen, et al., 1998)

4. Results and Discussion

4.1. Estimation of the ETo

Figure (8) shows the estimated ETo for the current period. The months of May to September have relatively high values, equal to or more than 200 mm/month, and the months of October to April showed the lowest ETo, equal to or less than 175 mm/month, coinciding with the dry and rainy seasons, respectively. In the dry season, the resulting low relative humidity combined with high temperatures led to increased evapotranspiration. Inversely the low values of ETo in the rainy season may be due to the high frequencies of rainfall combined with high relative humidity and relatively low temperatures. With the variations of these parameters, ETo will vary significantly within and between seasons.

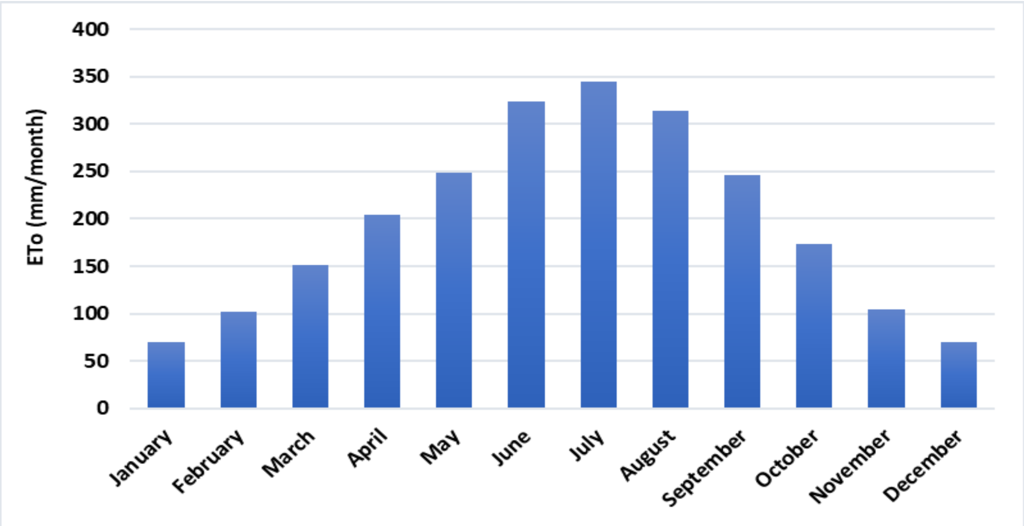

Figure (8): The estimated ETo values of the SNIP

4.2. Estimation of the NIWR

Figure (9) shows the irrigation water irrigation requirement of the SNIP. The total irrigation water equals 894 mm for the dry season and 332 mm for the rainy season. The high irrigation requirements during the dry season may be explained by the severe drought conditions and the resulting low relative humidity due to the lack of rain combined with high temperatures, which led to increased evapotranspiration. High evaporation occurs during the hottest period with the highest temperature, and soil moisture decreases rapidly, implying the highest agricultural water requirement. The changes in irrigation water demand indicate the differences in water requirement even within the same season; hence it shows the significance of the requirement of scientific planning for irrigation.

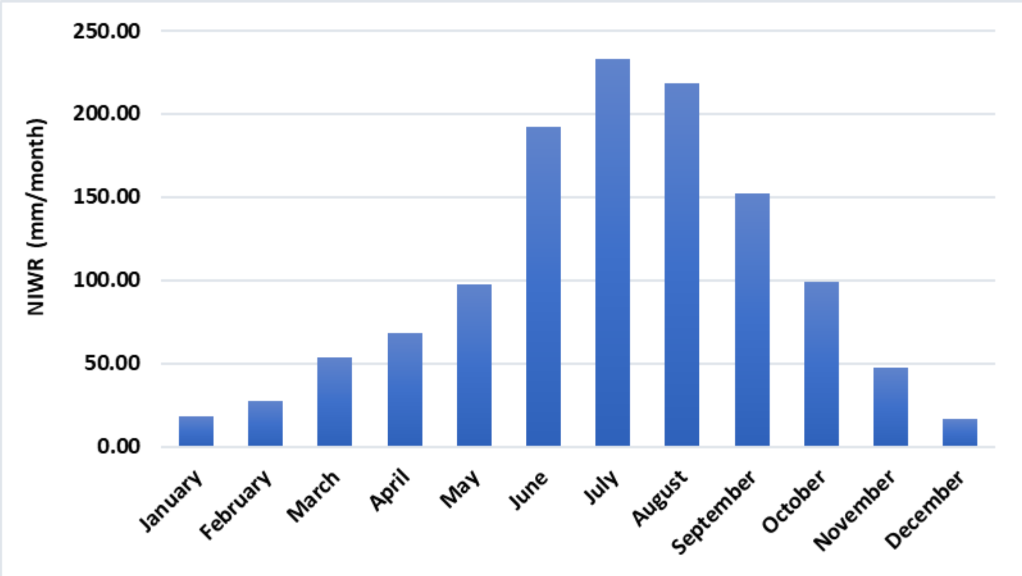

Figure (9): The estimated NIWR values of the SNIP

5. Conclusions

The pattern of the NIWR results is as the same ETo. The maximum monthly NIWR is in July, while the minimum monthly NIWR is in October. The Shnafiyah - Nasiriya yearly irrigation water requirements equal 796.5 million cubic meters (MCM). Depending on the weather, the average values of reference evapotranspiration ETo and net irrigation water requirements (NIWR) change over the development of a crop's growth cycle and across seasons. Additionally, these results demonstrated the significance of the need for scientific planning for irrigation, which can be applied for the most effective use of water.

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