Water Scarcity Index for Ninewa Governorate, Iraq

2022/2023

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- Average mean temperature and evapotranspiration will be higher in the months of August, September, and October 2022.
- The rainfall prediction model expects that the maximum monthly rainfall depth will not exceed 100mm (below normal for the northern Iraq). This will lead to a lower recharge of aquafers.
- The irrigation water demand will be higher till September 2022. Rainfall in November is expected to partially address the needs, while in December the irrigation needs will be fully met.
- The groundwater level will not have major changes, and the downward trend will continue.
- Water reservoir (Mosul dam) will have below-capacity storage due to lesser in flow.

ABOUT THE TOOL:

Iraq is facing an increasing water stress due to climate change and increased water demand. Iraq has been globally identified as the fifth most vulnerable country to decreased water and food availability. In order to address the challenge of water scarcity and take timely decisions, Action Against Hunger Iraq, in collaboration with the University of Mosul, developed a water scarcity prediction tool in June 2022. The tool is designed to use existing data for 7 para meters input variables, including: 1) inflow, 2) outflow of surface water, 3) measurements in temperature, 4) relative humidity, 5) wind speed, 6) sunshine hours, and 7) precipitation. These prediction tools use monthly data and can be updated and calibrated manually using data from the last year to predict the water scarcity over the next 12 months. The intestinal analysis of the data was done for the Ninewa governorate. The current report includes developing a water scarcity index for Ninewa Governorate through providing simple prediction tools that could be easily used by the stakeholders and beneficiaries. In summary, the prediction tools of climate change and those irrigation water requirements can be used in other governorates in Iraq when the input of tools are updated and calibrated based on the local data of that region and, of course, the irrigation water requirement of irrigation projects in that area. However, the simulation of surface water provided in this report needs Matlab Simulink programming for the water mass balance equation in case of dam lakes.

1.1. Temperature and Evapotranspiration Predication Tool

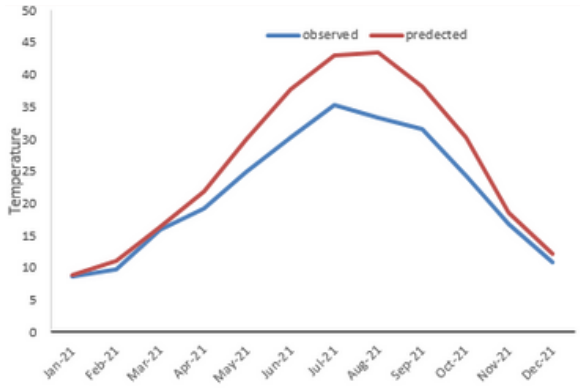

Figure 1: Observed and predicted current average monthly tempreture time series data for Mosul Weather Station from 1988 to 2021.

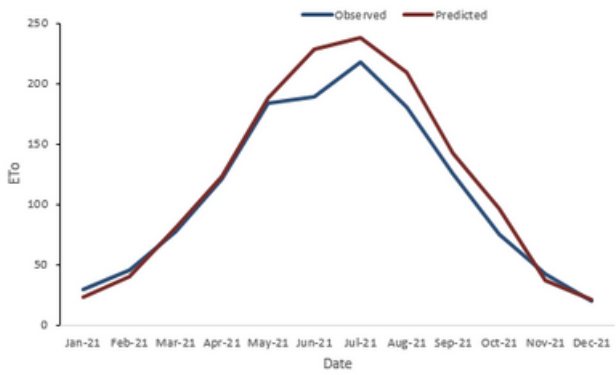

Figure 2: Observed and predicted current average monthly evapotranspiration timeseries data for Mosul Weather Station from 1988 to 2021

The data source of the temperature and evapotranspiration model was provided by the Weather Office of Ninewa for the Mosul Weather Station from 1988 to 2021. As shown in Figures 1 and 2, the model prediction results show an increase in average monthly temperature and evapotranspiration for the predicted period. This, of course, will lead to increased irrigation consumptive usage and water scarcity.

1.2. Rainfall Predication Tool

The data source of the rainfall model is provided by Weather Office of Ninewa for the Mosul Weather Station from 1988 to 2021. Where this data include monthly base measurements of precipitation. The monthly measurements are calculated based on the daily precipitation measurements for the whole month.

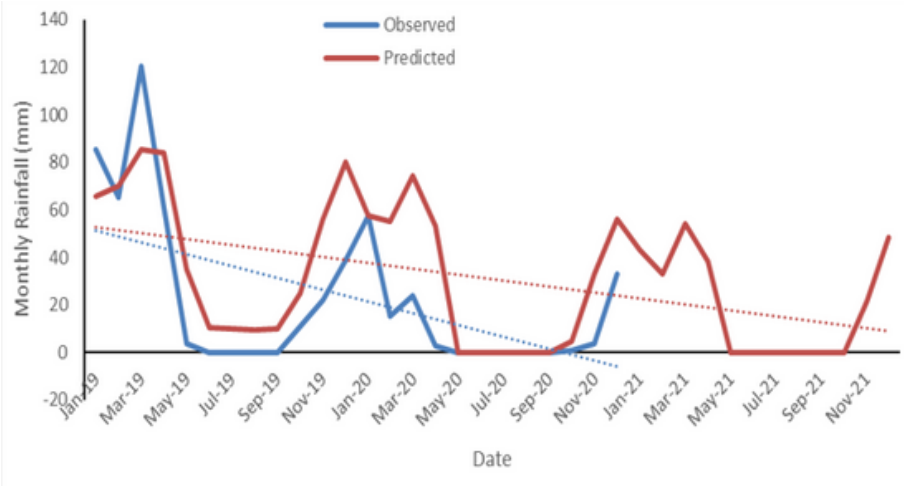

Figure 3: Observed and predicted current monthly rainfall timeseries data for Mosul Weather Station from 1988 to 2021.

It seems from the figure above that the model prediction results shown that the trend of rainfall for next 12 months is decreasing. The rainfall prediction model expects that the maximum monthly rainfall depth will not exceed 100mm. This is relatively low comparing with normal preciptation rate of north part of Iraq. Also, this results may refers to expected low recharge of surface water from the surface runoff prcesses.

1.3. Irrigation Consumpation Predication Tool

Irrigation problems in Ninewa Governorate are related to certain factors relating to current water resources availability and irrigation project management and practices. The data sources used for this model is a combination between local weather data and information related to current irrigation projects in the area. Many major irrigation projects in Ninewa and other Iraqi Governorates have been designed a few decades ago based on historical regional climate data. Due to climate change in terms of increase in local temperature and drop in precipitation rate, the current irrigation supply of water does not satisfy the actual crop requirement. Therefore, this model provides monthly irrigation consumptive use based on the prediction of rainfall and evapotranspiration.

Input of Irrigation Consumptive Use Prediction Model			Output of Irrigation Consumptive Use Prediction Model	
	This data prediced from rainfall model	*This data prediced from evapotranspiration model*		
Month	Predicted Monthly Rainfall (mm)	Predicted Monthly Evapotranspiration (mm/month)	Predicted Effective Rainfall (mm)	Predicted Irrigation Consumptive Use (mm/month)
January	43.1	25.4	34.48	Amount of Rainfall Satisfy Crop Requirement
February	33.1	42.4	26.48	15.92
March	54.3	82.3	43.44	38.86
April	38.1	128.2	30.48	97.72
May	0	194.8	0	194.8
June	0	238.1	0	238.1
July	0	260.9	0	260.9
August	0	236.3	0	236.3
September	0	169.1	0	169.1
October	0	111.6	0	111.6
November	21.4	45.3	17.12	28.18
December	48.5	25.2	38.8	Amount of Rainfall Satisfy Crop Requirement

Table 1: Example of predicted irrigation consumptive use model

1.4. Groundwater Level Tool

Groundwater level in Ninewa: The recent drought events have adversely impacted the groundwater level and caused a significant dropping in water table of local boreholes. Data from 8 different boreholes and location over administration border of Ninewa and Erbil from 2001 to 2010. Further, these data were linked with the annual precipitation of Mosul city for the same period to see the response between the amount of precipitation and fluctuations in groundwater level in area.

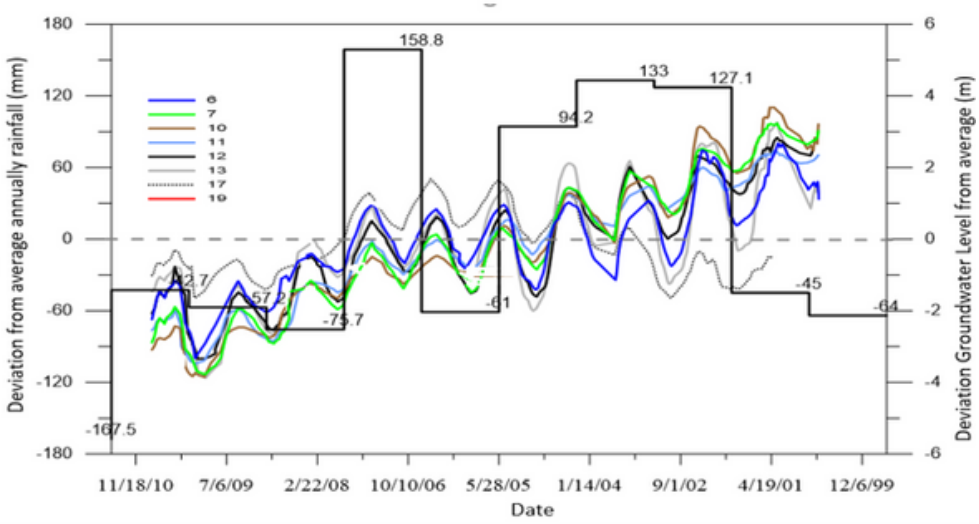

Figure 4: Net change in groundwater level (color line) and precipitation rate (solid black line) of Mosul City for period of 2001 to 2010.

It is obvious from the figure above that the levels of groundwater in all wells are subject to seasonal and annual changes. In the figure above, the increasing depth of the water table with time means a dropping in groundwater level The trend of groundwater level shown nonlinear decreasing with time. This usually associates with shortage in precipitation rate and high pumping rate. With the given situation, the aquafers will further deplete.

1.5. Water Balance Equation of Reservoir

Surface water balance of Mosul Dam storage based on future expected scenarios of Tigris River inflow from Turkey were simulated using Matlab Simulink to show the change in volume of water storage in dam lake and see if it is able to satisfy the water requirment of irrigation project, domestic use and hydropower generation. The data observed were monthly inflow, demand, mean monthly precipitation and evaporation as a depth, and the supply water to North Jazeerah irrigation project. The outputs of this model represented the releases from different outlets of reservoir, in addition to elevations, areas, and storages of reservoir during each period of operation. The minimum annual inflow during thirty years

extended from October 1989 to December 2019 was analysed. Six scenarios were adopted in the operation of this simulation model. These scenarios are observed inflow 90% of observed inflow, 80% of observed inflow, 70% of observed inflow, and finally, 60% of observed inflow.

Month	100% of inflow	90% of inflow	80% of inflow	70% of inflow	60% of inflow
Oct. 1989	4025.79	4013.71	4001.63	3989.56	3977.48
Nov. 1989	3644.37	3612.66	3580.95	3549.24	3517.53
Dec. 1989	3397.50	3334.64	3271.77	3208.91	3146.05
Jan. 1990	3354.89	3241.58	3128.27	3014.96	2901.65
Feb. 1990	3567.27	3377.87	3188.48	2999.09	2809.69
Mar.1990	4089.40	3790.84	3492.30	3193.77	2895.23
Apr. 1990	4788.57	4359.68	3930.85	3502.12	3073.40
May. 1990	5427.07	4871.64	4316.26	3761.21	3206.45
Jun. 1990	5917.47	5250.25	4582.95	3916.21	3250.73
Jul. 1990	6027.12	5287.34	4547.31	3808.21	3071.85
Aug. 1990	5795.20	5018.77	4241.85	3466.98	2696.00
Sep. 1990	5511.56	4706.17	3900.19	3097.94	2300.00

Table 2: The storages (MCM) according to the inflow conditions adopted

The results of the simulation model using five scenarios indicated a decrease in storage, specifically in the last month of the operation year. In Table 4, it could be noted that volumes of storage are lesser compared to the reservoir capacity during the scenarios used. In addition, the quantities of outflow during 12 months of the year stay at the minimum demand, as shown in Table 5. According to these results, can be conformed that it is necessary to establish more storage projects, either on the Tigris River or in valleys that have good capacities to harvest the water to achieve more water storage sources.

1.6. Water Scarcity Index of Ninewa Governerate

This index is designed based on the flow components of water mass balance of Mosul Dam lake. Where different scenarios for inflow reduction are assumed and minimum constant level of flow release for domestic use (200m3/sec based on formal letter from the Ninewa Directorate of Water Resources) is used. The other component of water demand is the irrigation water requirment for North Jazira Irrigation project. In this model, the percent of reduction in volume of Mosul Dam storage are computed based on reduction in inflow from Turkey by precent of 90%, 80%, 70% and 60%. Figure below shows the summary of major finding of this model and also shown in the Appendix F.

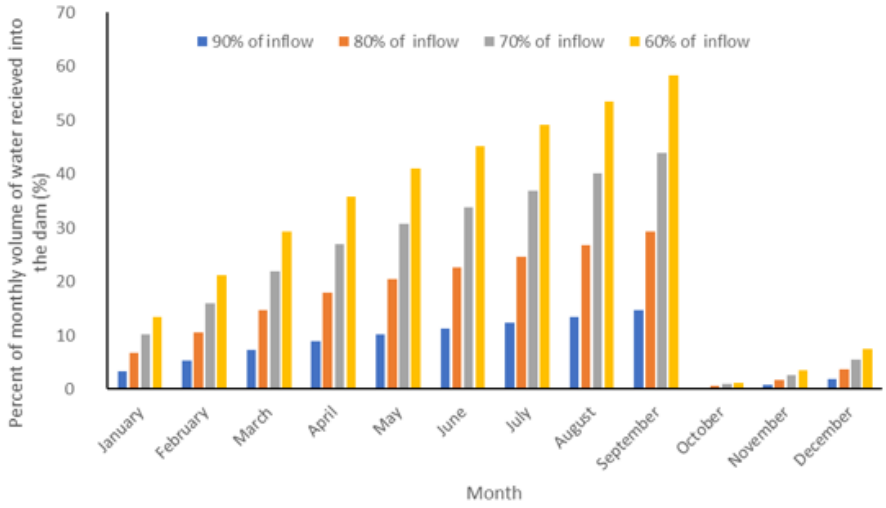

Figure 5: Percent of Expected redcution in volume of water in storage of Mosul Dam Lake

It is very clear from the figure above that the percent of reduction in water storage of Mosul Dam decrease remarkably with decrease of inflow when satisfying the water demand of irrigation and domestic demand. Therefore, it is expecting that the future of water storage will not able to provide the minimum level of demands for domestic use (which is limited here by 200m3/sec) and irrgation water requirment if the current scenario of Tigris River.

1.7. Surface Water Shortage Indicator for Domestic Use

This index is designed based on the flow components of water mass balance of Mosul Dam lake. Where different scienarious for inflow reduction are assumed and minimum constant level of flow release for domestic use (200m3/sec based on formal letter from the Ninewa Directorate of Water Resources) is used.

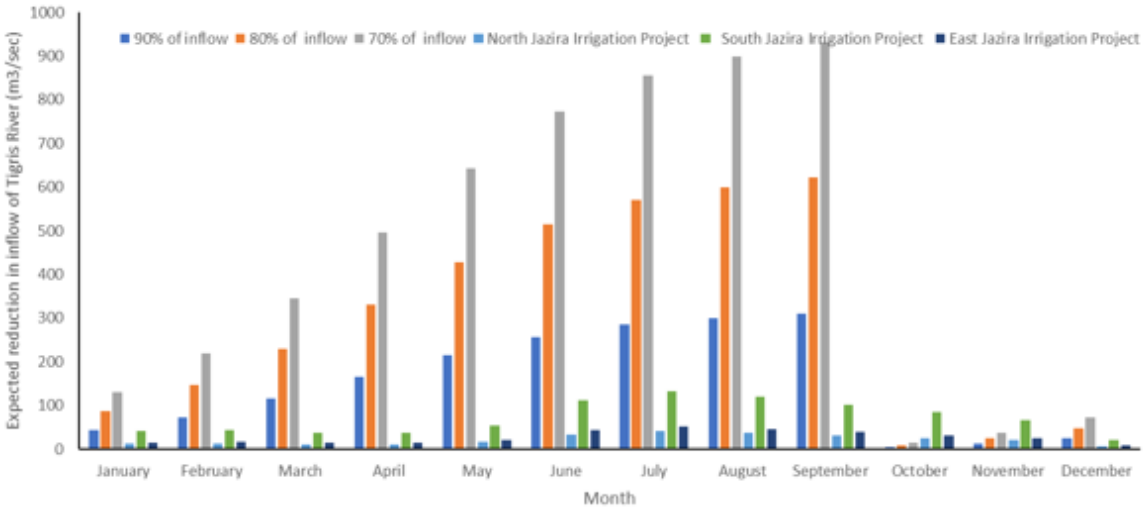

Figure 6: Reduction in Inflow (m3/sec) of Tigris River based on reduction in inflow from Turkey by precent of 90%, 80% and 70%. Also, the water requirment of Jazira Irrigation project are plotted to for comparision purposes.

The expected shortage in surface water of Tigris River is relatively high with the proposed scenario of inflow shortage. Where the most shortage of inflow may reach 900m3 during flood periods. This, of course, is a dangerous indicator showing that the flow of the Tigris River may be fully controlled and seized if more dam construction is built on the main stem of the river. In general, the amount of water surface shortage is expected to be higher than the combination of water demand for irrigation and domestic use.

1.8. Spatial Distribuation of Model Predication with GIS

As explained in the description of the prediction model, the water scarcity index focuses on water availability for Irrigation and domestic water supply projects in Ninewa. The projects expected to be affected by water shortage are explained in spatial maps to provide more details. Below is a spatial map of the major planned and exist irrigation project of Ninewa.

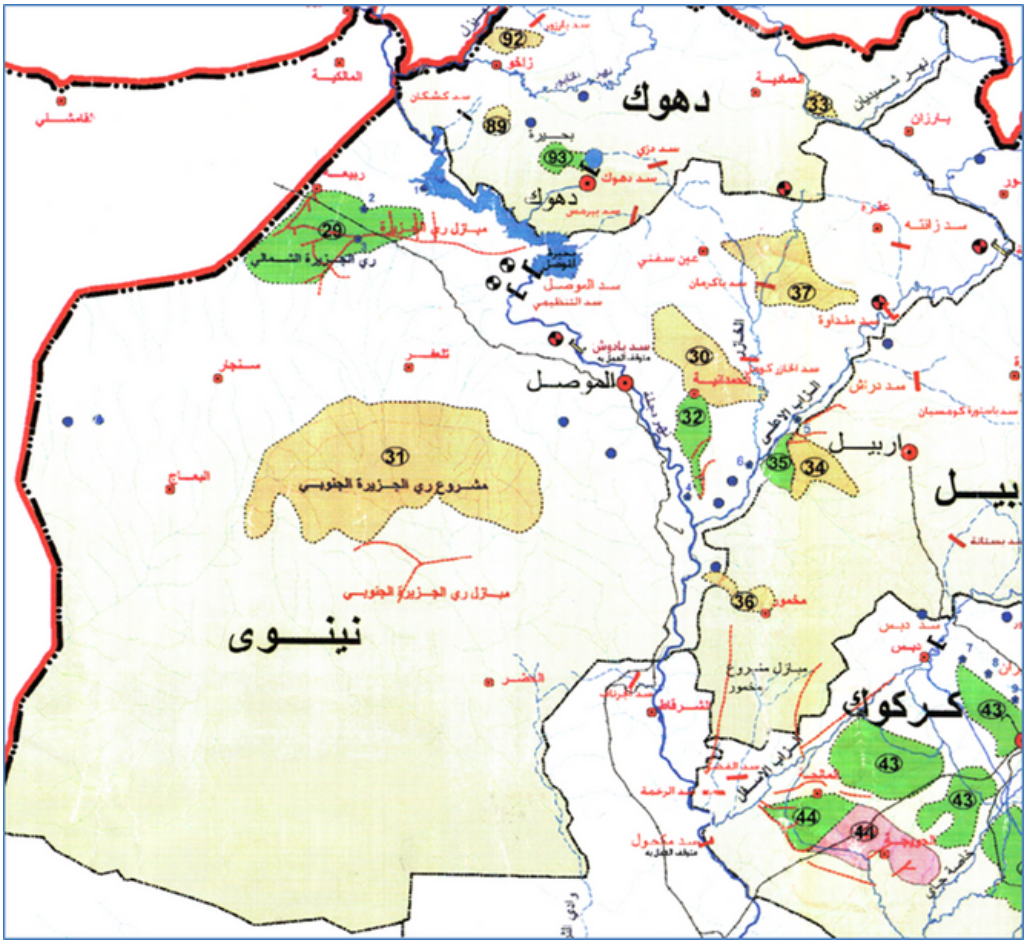

Figure 7: Spatial distribution of planned and exist irrigation project in Ninewa the water requirment of Jazira Irrigation project are plotted to for comparision purposes.

As is shown in the figure, the border, and locations of all irrigation projects. It is important to mention here that the irrigation project with green-filled color already exists and works, and the project with yellow color is designed but not constructed yet. One of the main reason for not constructing the planned irrigation projects are the current issue of water shortage and also due to the high concern level of local authorities about the future of water resources in Iraq. Therefore, the spatial map of this network and that already affected by a drop in water level of Tigris River is shown below. For domestic water supply, the water distribution network of Mosul city is the largest water supply in Ninewa Governorate.

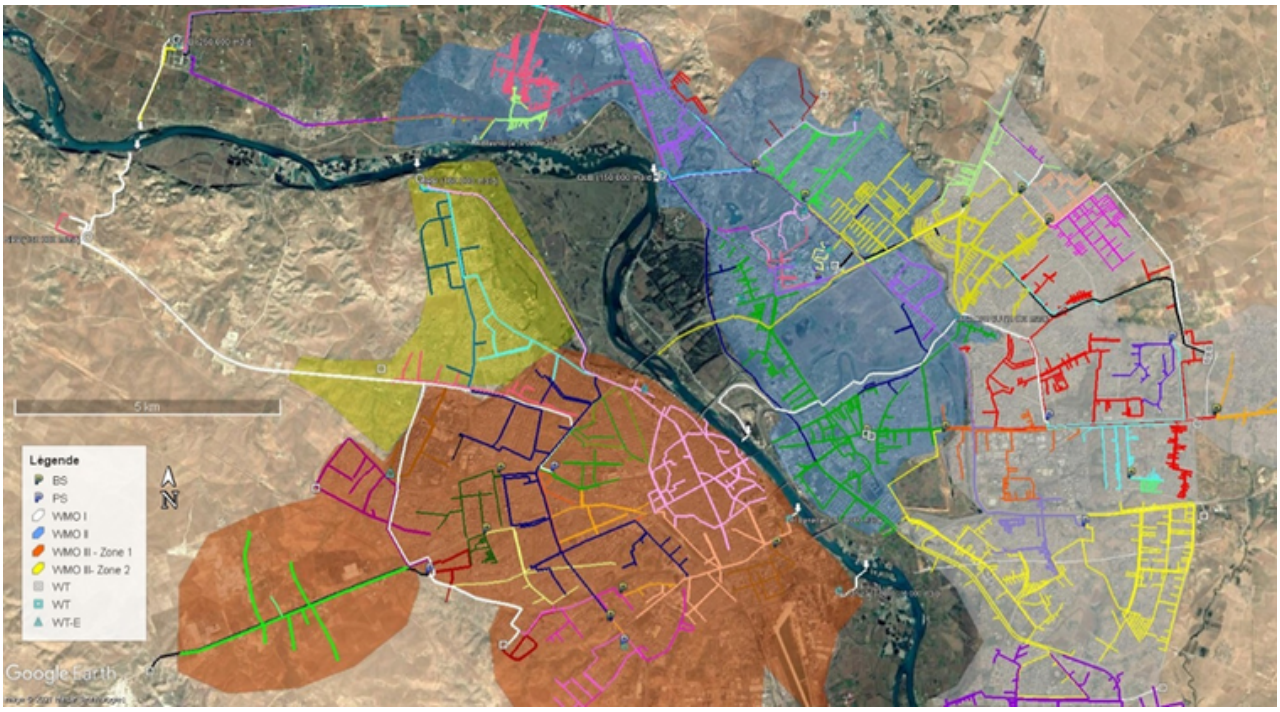

Figure 8: Water distribution network of Mosul City as example of water domestic project in Ninewa. the water requirment of Jazira Irrigation project are plotted to for comparision purposes.

There are other major districts that take water from the Tigris River downstream of Mosul Dam for domestic uses, like Tal Afar city. The city has already faced a serious issue when the water level above the intake of Badoush and Aski Mosul water supply project decreased and forced the pump units to stop frequently during the week.

2. Prediction

In general, the climate prediction model expects less rainfall and higher demand for irrigation water in the next 12 months. There will be an increase in temperature and reference evapotranspiration and a decrease in precipitation rates for the remaining year of 2022. In particular, the results showed that the amount of increase in monthly evapotranspiration ranged from 43 to 56 mm per month for the summer months (June, July, August, and September) of 2022 compared with the year 2021.

According to the model prediction results, the irrigation water needs will be very high due to the increase in evapotranspiration and it is expected that the degree of water scarcity will be very high during this year.

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