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Study of Present and Future Crop Water Requirement of Babai Irrigation System Using Cropwat 8.0

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Abstract

This research study aims to determine the crop water requirement and irrigation water requirement of the Babai irrigation system using the Cropwat 8.0 model, focusing on numeric data. The study analyzed the discharge data obtained from the hydrological station, which was calibrated using the SWAT model. The cultivated crops included Monsoon paddy, Maize, Wheat, Potato, Pulses, and Spring rice. By calculating reference evapotranspiration, effective rainfall, and irrigation schedules, the study quantified the water requirements for each crop. The results showed that the maximum irrigation requirement occurred in May, with a value of 0.61 l/s/h. Furthermore, the study projected future climate change scenarios for the Babai irrigation system up to 2100 using CMIP6, GCMs model outputs under two shared socioeconomic pathways, SSP245 and SSP585. The findings revealed a gradual increase in maximum temperature over time, with a difference of 1.24° between SSP585 and SSP245 by the end of the 21st century. The intensity of rainfall also exhibited a gradual increase in future scenarios, particularly under SSP585. The analysis of future crop water requirements indicated variations in different time periods and scenarios, with the highest requirement occurring in June. Overall, the research provides valuable numeric data that can inform effective irrigation planning and water resource management strategies in the Babai irrigation system, considering future climate change impacts.

Keywords
Cropwat 8.0, evapotranspiration, CMIP6, Climate change

1. Introduction

Out of 121 countries Nepal has ranked at 81 based on the Global Hunger Index i.e, 19.1 which is moderate level of Hunger [1].To overcome the hunger there is necessity to improve the food security. About 4.6 million people are food insecure with 20 percent of households are mildly food insecure, 22 percent are moderately food insecure while 10 percent severely food insecure [2]. The irrigated area is approximate 40 percent of Agriculture land and Government of Nepal has prepared the irrigation master plan 2019 to reduce the food insecurity to overcome the food insecure by providing the adequate quantity of irrigation water. Climate changes affect in the precipitation and the overall rise of temperature from decade to decade. Climate change impacts may affect water quality, quantity and availability. This study projects the precipitation, maximum temperature and minimum temperature in the Babai irrigation System up to 2100 using CMIP6, GCMs model output under two shared socioeconomic pathways, SSP245 (4.5 Watt/m2) and SSP585 (8.5 Watt/m2).

Crop water requirement (CWR) means the required amount of water to compensate the losses due to evapotranspiration from cropped field a specified time period. The CWR is calculated in mm/day, mm/month of mm/season and are used for estimating the water required for irrigation, irrigation and delivery of water scheduling. According to hydrological term the crop evapotranspiration indicates the effectively occurrence of water losses meanwhile according to the irrigation management term the CWR indicates the amount of water supply to compensate the losses [3]. The total amount of water required from showing period to harvesting period is CWR and the different crops have different water requirement furthermore same crops have different water requirement at different location that depends upon the climatic condition, soil characteristics, cultivation practices etc. [4]. Though the CWR is the total sum of crop evapotranspiration (ETc) for the entire crop growth period and the ETc is the rate of evapotranspiration of a given crop influenced by climatic condition, different development stages of crops, and efficient management of crops to achieve potential crop production [5].The CROPWAT 8.0 is the computer-based model developed by FAO to calculate the irrigation water requirements, crop water requirements and irrigation schedule based on crop type, climate data and soil data.

2. Study Area, Data and Methods

2.1 Study Area

About 36,000 ha of Bardia district as shown in figure (1). Various activities are being conducted under the Babai Irrigation Project with the aim of providing irrigation facilities in the area. For the development of the irrigation system in this area, the Government of Nepal with the involvement of the International Development Agency (IDA) The study was started from the year 2024 BS. In the pre-feasibility study report of this project completed with the financial support of the United Nations Development Program, approximately 19,000 ha in the east of the Babai River and 21,000 ha in the west. The land was determined to be irrigable. In the first phase, for the purpose of developing the irrigation system on the eastern side of about 13,240 ha. The feasibility study of the area was completed in 2035 BS. In the first phase of loan assistance from the International Development Organization.

From the year 2038 to the year 2040, the detailed engineering design work was completed, and, in that design, it was proposed to build a siphon in the Babai River and develop the irrigation system towards the west. From the past survey, about 40,000 ha of Bardia district. Although the area is called irrigated area, the total irrigated area is 36,000 (approximately 21,000 ha in the east and 15,000 ha in the west) from the study conducted by the Bheri Babai Diversion Multipurpose Project in 2012. (DWRI,). The major crops that cultivated in this area are Monsoon Paddy, Wheat, Spring paddy, maize etc. Maize, wheat and monsoon paddy are the major crops grown in the command area under rain fed condition.

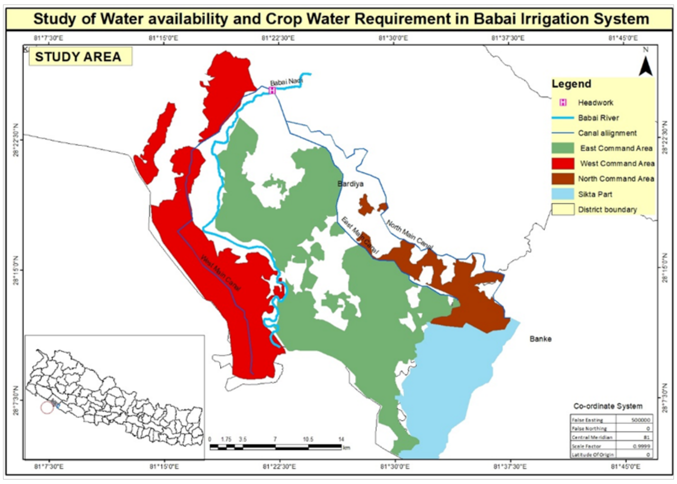

Figure 1: Study Area

2.2 Collection of Data

The required data such as temperature, Humidity, wind speed, sunshine hours, precipitation and potential evapotranspiration of Gulariya meteorological station were obtained from DHM. The soil data necessary for CROPWAT were collected from FAO database while thePresent and future cropping pattern data, command area data were collected from Babai Irrigation Project, BaidiBardiya.

2.3 Methodology

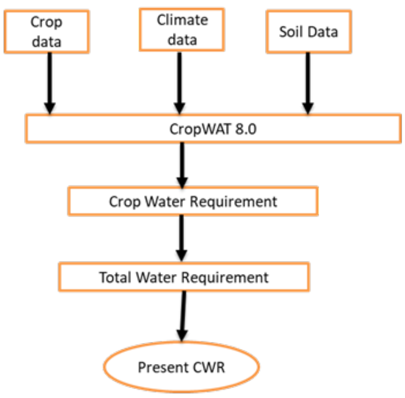

Figure 2: Present CWR

2.3.1 Global Climatic Models GCMs

Using 7 GCMs, three future time slices i.e., near (2025-2050), mid (2051-2075) and far (2076-2100) future under two emission

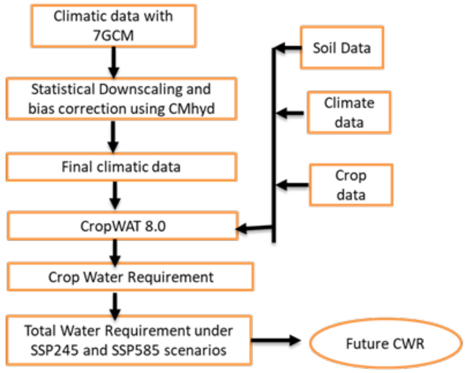

Figure 3: Future CWR

scenarios SSP 4.5 and SSP 8.5 the future climate change for the Babai Irrigation system were developed.

2.3.2 Climate Change for Watershed Modeling (Cmhyd)

"Climate Change for Watershed Modeling" refers to a methodology or approach used to incorporate climate change projections into watershed modeling studies. Watershed modeling involves the simulation and analysis of hydrological processes, land use, and water resources within a specific watershed or river basin. This modeling approach helps understand the interactions between various factors and their impact on water availability, water quality, and overall watershed management.

2.3.3 CROPWAT 8.0

CROPWAT is a strong simulation tool that analyzes complex relationships of on farm parameters such as the climate, crop, and soil, for assisting in irrigation management and planning. It estimates the crop evapotranspiration, irrigation scheduling and agricultural water requirements with different cropping patterns for irrigation planning [6].

3. Results and Discussion

3.1 Temperature

The maximum temperature was computed CMISP6 under SSP245 and SSP585 scenarios for near future (2025-2050), Mid future (2051-2075) and far future (2076-2100). The obtained result were analyzed from figure showing the average monthly maximum temperature rise and fall in figure(4) and also the projection of yearly temperature upto 2100 AD under two scenarios in figure(5).The figure(4) shows the rise in maximum temperature is ranges from 26.76° at January to 40.56° at May in far future while the maximum temperature is ranges from 25.41° at January to 39.79°at May at mid future and moreover the maximum temperature is 24.01° at January and 38.17°in May at near future. As this results shows the maximum temperature is gradually increases day by day. From figure(5) the maximum temperature at about 2067 AD seems similar under SSP245 and SSP585 but at the end of 21st century the rise in maximum temperature of SSP 585 is 1.24° more than the SSP 245.

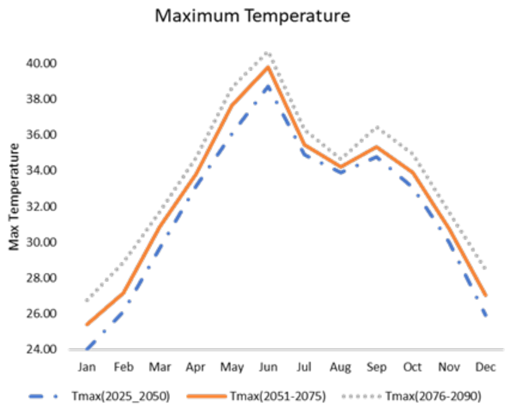

Figure 4: Monthly average Tmax of near future, Mid future and far future

Figure 5: Yearly Tmax projection under SSP245 and SSP585

3.2 Precipitation

The data collected from DHM was projected by CMISP6 under two scenarios upto 2100AD as shown in figure(6) and figure(7). Figure(6) presented the long term average rainfall by slicing into Near future (2025-2050), Mid Future (2051-2075) and Far future (2076-2100). The precipitation in far future is seems higher than mid future and near future as shown in figure(6). Figure(7) illustrates the yearly projection of rainfall of SSP245 and SSP585, this figure shows the intensity of rainfall under SSP245 is overall uniform meanwhile the intensity of rainfall under SSP585 is increases in far future.

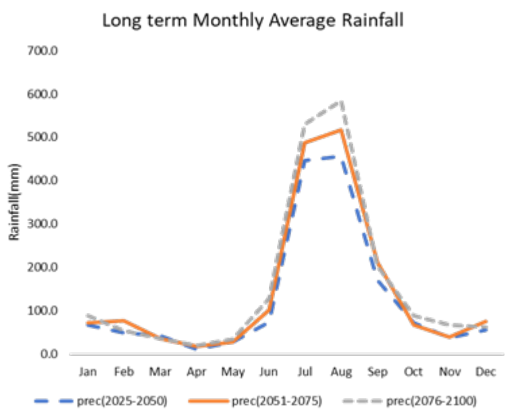

Figure 6: Long term monthly average rainfall

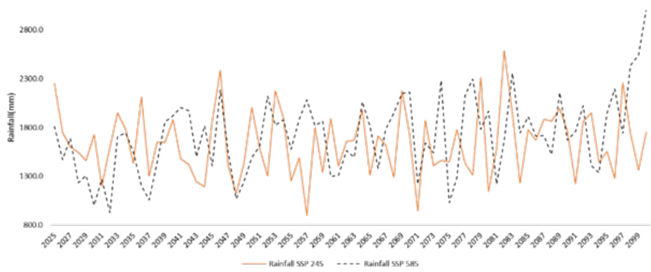

Figure 7: Projection of yearly rainfall up to 2100

3.3 Crop Water Requirement

The crop water requirement obtained by using CROPWAT 8.0. The existing crop water requirement is higher at April i.e., 80.97 l/s as shown in Figure (8). Figure (3) illustrates the future crop water requirements of Near future, mid future and far future under both scenarios SSP 245 and SSP 585 and this figure shows the crop water requirement is highest at June ana lowest at December. Crop water requirement in Near future under SSP 585 is higher than SSP 245 while the CWR in Far future seems reverse of Near future. CWR at mid future is slightly similar as in SSP 245 scenario and SSP 585 sceanerio. In accordance of Figure (12) the percentage of change in Future CWR on the basis of existing CWR, the future CWR at Near future under SSP 245 is rise to 27.63% than existing CWR while the CWR at mid future will be decreased by 399.83% as shown in figure(12).

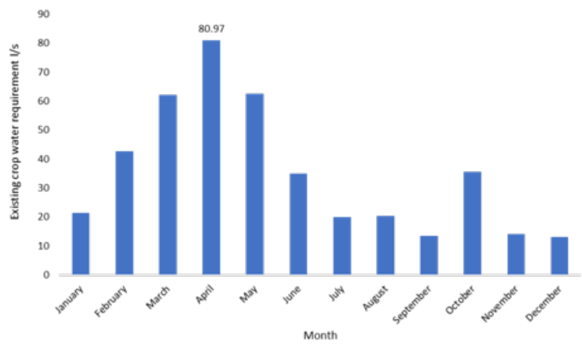

Figure 8: Existing Crop water requirement

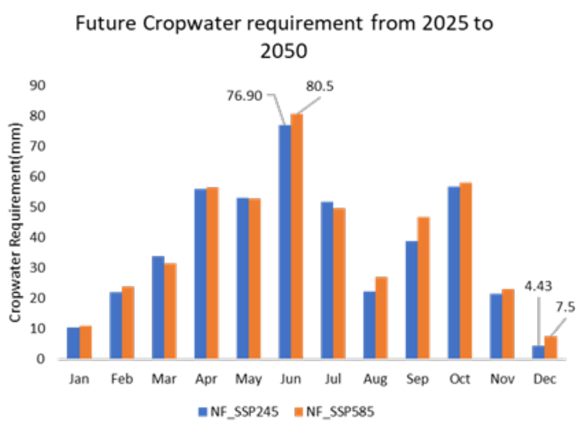

Figure 9: Future crop water requirement (2025-2050)

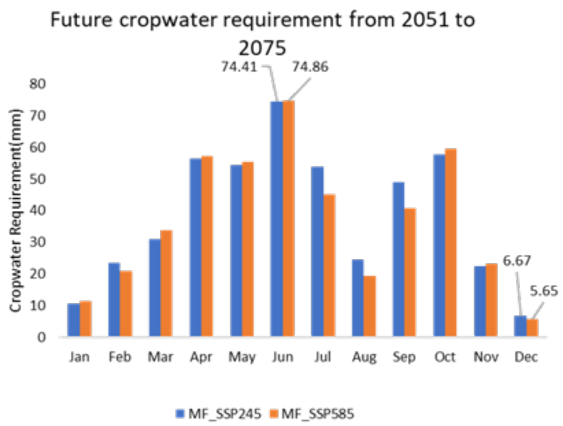

Figure 10: Future crop water requirement (2051-2075)

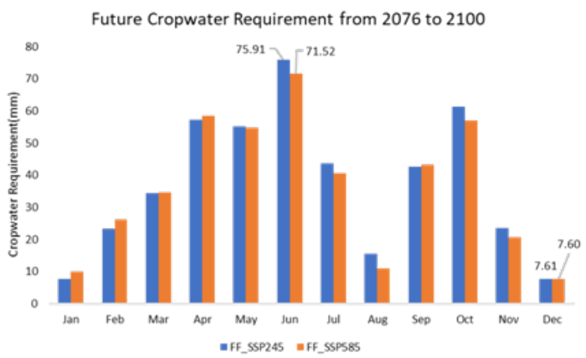

Figure 11: Future crop water requirement (2076-2100)

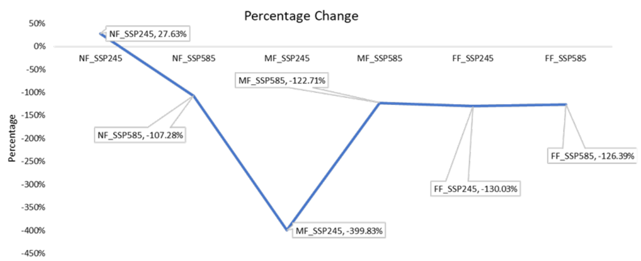

Figure 12: Change in percentage of future CWR as compared to Existing CWR

4. Conclusion

Using CMISP6 under two scenarios the climatic data are projected and downscaling and bias correction of climatic data with 7 GCMs. Though, rise in maximum temperature of SSP 585 by 1.24° more than the SSP 245 but intensity of rainfall seems gradually increases in future shows that the crop water requirement is lower at future than present crop water requirement. The crop water requirement is maximum at October in present situation while the CWR is maximum at June in future scenarios. The CWR change in future is -126% in far future of SSP 585 wrt present CWR and -130% in far future of SSP 245 wrt present cwr. The availability of water is required more in near future under SSP 245 because of the change in percentage of CWR is 27.63% more than existing CWR.

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