IMPACT OF CLIMATE CHANGE ON IRRIGATED CROP WATER USE OF SELECTED MAJOR GROWN CROPS AND WATER DEMAND FOR IRRIGATION: A CASE OF ANGER SUB-BASIN, NILE BASIN OF ETHIOPIA

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Abstract - Understanding crop water use under changing climate condition is very important for developing irrigation projects to expand agricultural productivity. This study focuses on climate change impact on irrigated crop water use of major grown crops and water demand for irrigation in Anger sub-basin, Ethiopia. Single GCM from Coupled Model Inter-comparison Project Phase 5 with single regional climate model and delta change bias correction approaches were used to project crop water requirement for the developed scenario over the study periods of 2020s and 2080s and demand analysis for the current conditions. The result of the analysis shows that at the 2020s crop water requirement of the irrigated crops changes from the baseline period by 1.7% to 3.83% and 1.5% to 3.8% for RCP 4.5 and RCP 8.5 respectively. At 2080s it changes from 3.36% to 7% and 3.58% to 12.7% for RCP 4.5 and RCP 8.5 respectively over the study area for all crops in the future respectively. Additionally, the demand analysis shows that at the current condition irrigation water demand was 2.096Bm³ which takes a lion’s share with about 62% followed by environmental water demand about 35% and domestic and livestock shares the lowest water demand of 1.72% and 1.475% respectively over the sub-basin. This indicates crop water requirement is increasing due to climate change which is directly influencing the water demand of other sectors. Therefore, in the future period decrement of water resource due to climate change requires water management practices to keep water demand in place to continue agricultural practices and future development plans of agriculture in the sub-basin.

Keywords: Anger sub-basin, CWR, Water demand, Climate change, GCM, RCM

I. INTRODUCTION

Ethiopia is one of the most vulnerable countries to climate variability. The agriculture is the main source of livelihood for about 85% of Ethiopia’s population and contributes more than 45% of GDP, 80% to labor force and 85% to foreign exchange earnings is highly susceptible to climate change [1]. The warming trend and climate variability imposes its impact on crop production with raising temperature and evaporative demand. Subsistent and small holder farmers who have less capacity to adaptation of climate change produce more than 95% of crop production which is rainfall dependent [1] are influenced by climate change.

In addition to rainfed agriculture, climate change influence the irrigated crops since irrigated crops are vulnerable to climate change and climate change affect the soil moisture during growing season and the soil temperature and water content in crop root zone during non-growing season [2] and also affect crop yield, water demand, effective water supply and availability for irrigation [3].
Ethiopia has considerable potential for agricultural development involving the substantial variation in crops grown across the countries at different regions and agro ecologies. About 96% of the total area cultivated account by smallholder farmers and generate the key share of the total production for the main crops [4]. Similarly, Anger sub-basin is one of the Blue Nile river basin which is characterized nearly by all agro-ecological climatic distribution (tepid sub-humid mid highlands, warm moist highlands and Warm sub-humid lowlands) and the production of cash and cereal crops like (maize, potatoes, tomatoes, sesame, cotton, pepper, wheat etc) practiced on rainfed based mostly and some of them by irrigation system. However, both production systems are vulnerable to climate change which may affect the crop growth and yield.

Additionally, now a day in the sub-basin different irrigation projects are practiced, planned and start construction based on water availability in the sub basin ranging from small scale to large scale schemes to increase the income and food sufficiency of the peoples. In some of irrigation schemes in the sub-basin, climate change has significant impact on the crop yield [5]. But the analysis in relation to climate change on irrigated crop water use does not carried out yet. Therefore, it’s essential to assess the climate change influence on crop water use and water demand for irrigation. Hence the study is designed to assess the current and future crop water use of major crop grown under climate changing scenarios and estimate water available for irrigation by analyzing water demand of other sectors.

II. MATERIAL AND METHODS

2.1. Description of the study area

The research was conducted in Anger sub-basin of the Upper Blue Nile River Basin, which is located in Oromia region in Western, Ethiopia. Geographically, it is located in between latitudes 9° 08’ and 10° 05’ North latitude and 36° 01’ and 37° 07’ (Figure 1). The altitude varies approximately from 868 masl to 3144 masl in the sub-basin. The sub-basin is characterized by unimodal rainfall pattern from June to September (long and heavy summer rain), from October to January (Birra) season, when rainfall comes to end and medium to short dry season is characterized and from February to May (Bona) season of short rainy seasons is available (http://www.meteo-ethiopia.net/climate.htm October 2014).

![Figure 1. Location of the study area](image-url)
The mean annual rainfall ranges from 1246 mm at eastern lowlands to 2067 mm in highland areas of the sub-basin. The average annual daily maximum and minimum temperatures in the three main agro-ecological zones (tepid sub-humid mid highlands, warm moist highlands and Warm sub-humid lowlands) vary from 22.6 °C to 31.2 °C and 11.57 °C to 15.52 °C respectively over the sub-basin.

2.2. Data used and data analysis

Historical climate data required for the analysis are collected for about 29 year (1986-2014) from meteorological Agency for the stations available within the study area based on Agro-ecological zones.

Table 1: Location of meteorological station selected for analysis

| No | Station name | Latitude      | Longitude     |
|----|--------------|---------------|---------------|
| 1  | Anger        | 207009.2209   | 1025436.545   |
| 2  | Nekemte      | 221158.1145   | 1005036.575   |
| 3  | Didessa      | 181462.3886   | 1038544.347   |
| 4  | Gida Ayana   | 238623.8369   | 1091606.355   |

The data quality assessment for this study was carried out by RclimDex.1 software (http://cccma.seos.uvic.ca/ETCCDMI) for data quality control, XLSTAT software (www.xlstat.com) for outlier detection, RHtest R analytical tool [6] for homogeneity test and first order Markov chain simulation model of INSTAT used for filling the rainfall missed data [7] and interpolation techniques for temperatures data filling.

2.3. Future data Set

Future climate data set were obtained from the high resolution of 0.44° × 0.44° (~50 km × 50 km) regional climate models, Coordinated Regional Climate Downscaling Experiment (CORDEX-Africa database website; [8]. Accordingly, EC_EARTH driving model was used and the downscaling was accomplished by the latest version of Rossbey Center using their regional climate model_RCA4. In this study, RCP 4.5 and RCP 8.5 emission scenarios output data from (2015-2100) of the earth’s system model were considered. Due to the output of the regional climate models cannot use directly for impact assessment bias correction is therefore applied to compensate for any tendency to overestimate or underestimate the mean of downscaled control and future simulated variables prior to use for crop water use impact studies. For this study, Delta change method was used for post processing and bias correction of RCMs used by [9] and also developed in CMhyd software for simplification to extract and bias correct the dynamically downscaled climate data for further impact analysis according to the procedures in figure (2).

Figure 2: Bias correction Framework: Source [10]
2.4. Crop water use estimation

The most common procedure for estimating crop water use or crop evapotranspiration (ETc) is the crop coefficient (Kc) approach. The FAO Penman-Monteith equation (P-M) is widely recommended method to estimate ETo because of its detailed climatological data required and its accommodation to small time periods. Due to not all data used for crop evapotranspiration for the major grown crops in the study area [12] was employed

\[
ET_c = 0.0023(T_{\text{max}}-T_{\text{min}})^{0.5}*(T_{\text{ave}}-17.8) \cdot R_d
\]

Where; ETo = reference evapotranspiration estimated by Hargreaves (mm/d)
Tmax = maximum daily temperature (°C)
Tmin = minimum daily temperature (°C)
Tave = average daily temperature (°C)
Ra = extraterrestrial radiation (MJ/m2/d)

Crop evapotranspiration or crop water use can be assessed by multiplying/product of the two factors

The reference evapotranspiration (ETo) and the crop coefficient, based on the following relationship:

\[
ET_c = Kc \cdot ETo
\]

Where, Kc is crop coefficient, the combined effects of crop transpiration and soil evaporation into a single crop coefficient (Kc), based on the following relationship[13].

The crop water use of major grown crops was then derived through a crop coefficient that integrated the

Table 2: Growth stages and crop coefficients of selected major irrigated crops in the sub-basin

| No | Crop    | Growth stages | Crop Coefficient |
|----|---------|---------------|-------------------|
|    |         | Initial       | Dev’t  Mid  Late  | Kcin  Kc Dev’t  Kc mid  Kc lat  |
| 1  | Maize   | 30            | 40      50   30  | 0.3   0.7   1.2  0.8  |
| 2  | Potato  | 25            | 30      40   20  | 0.5   0.75  1.1  0.9  |
| 3  | Cabbage | 20            | 25      60   15  | 0.48  0.8   1.1  0.9  |
| 4  | Tomato  | 30            | 40      42   25  | 0.5   0.7   1.15 0.8  |
| 5  | Sugarcane | 45           | 75      245  115 | 0.4  1.25  1.25 0.75 |

Source: [14, 27]

2.5. Impact assessment analysis

Crop water use for the selected irrigated crops grown in the study area was estimated from observed data and bias corrected future climate data. The impact of climate change on the irrigation water requirement for these selected crops was determined for monthly time step. For both RCP 4.5 and RCP 8.5 scenarios, the calculated irrigation water use is averaged in to monthly in two time horizons (2021-2040 and 2081-2100). Finally, the projected average of irrigation water use is subtracted from the corresponding average monthly irrigation water use of the base line time period which is calculated from [11] equation.

2.6. Water Demand Estimation

Estimation of water distribution for domestic, livestock and environmental water requirement is necessary to know the volume of water to be abstracted for irrigation. Domestic water demand was estimated based on sub-basin population [15] and the minimum standard required per person per day.

Accordingly, The World Health Organization (WHO) recommends about 100 liter of water per person per day to ensure that most basic needs are met and few health concerns arise [16]. For this study per capita water supply 100 l/c/day (36.5m³/c/year) is used.

Livestock water demand was estimated based on sub-basin livestock population [17] and their daily consumption rate (Table 4.1). For domestic and livestock water demand was estimated by multiplying the number of users by standard consumption. It is given according to the following equation [18].

\[
CR = \frac{N \cdot q \cdot t}{1000}
\]

Where,
CR is livestock and Human consumptive requirement (m³);
N is the user size (number);
q is the consumptive rate (lt/day)
t is the number of days
Environmental water requirement is key in order to protect natural reserves and preserve the ecosystems. It has been estimated that approximately (20–50) percent of the mean annual river flow in different basins needs to be allocated to freshwater-dependent ecosystems to maintain a fair condition [19]. For this study, 35% of mean annual river flow was considered.

![Flow chart for demand assessment in Anger sub-basin](image)

**Figure 3:** Flow chart for demand assessment in Anger sub-basin

The irrigation water demand was calculated based on irrigated crops in the sub-basin. Climatic data used for calculating irrigation water requirement of the major grown crops was selected depending up on the Agro-ecological zones and the mean areal of climatic Nekemte, Gumbi, Biyo, Leku Uke, Uke, Dale, Chigsa and Dembi Gusu projects as well as small irrigation projects are situated in Anger sub-basin are categorized under Anger agricultural water demand estimation. The total land area of 54435 ha covered by small to large irrigation projects of the study area was proposed to be irrigated by different crops during dry season (full irrigation). Also, some supplementary irrigation water requirement was considered in the study area. However, for determination irrigation water requirement of all crops over the whole Anger sub-basin, water requirement m³ per hectare for each crop was taken from the feasibility study of Anger irrigation project [22].

Data was used. According to study of [20] and [21] the existing and planned schemes for irrigation including large to medium irrigation projects like, Anger,

III. RESULT AND DISCUSSION

3.1. Regional Climate Model Improvements with Bias Correction

The outputs of the raw regional climate models underestimate and overestimate the mean monthly rainfall and temperatures as compared to areal mean monthly rainfall and temperatures (Figure 4 on left panel). These outputs are adequately corrected by delta change method for precipitation and temperature (Figure 4 on the right panel) and the results show good agreement. This implies that the bias corrected output of the model well captures the representativeness the study area.
Figure 4a: Comparison of simulated and observed mean monthly rainfall before (on the left panel) and after (on the right panel) of bias correction.

Figure 4b: Comparison of simulated and observed mean monthly Tmax rainfall before (on the left panel) and after (on the right panel) of bias correction.

Figure 4c: Comparison of simulated and Observed mean monthly Tmin before (on the left panel) and after (on the right panel) of bias correction.
3.2. Estimation of future reference crop evapotranspiration (ETo)

Reference evapotranspiration (ETo) was estimated for base period and future climate scenarios periods (2020, 2080s) by bias corrected future climate data (Figure 5 & 6). The result shows that at the baseline period ET0 varies in the range of 141.5 to 190.46 mm/month in the warm sub-humid agro ecological zones. The ET0 increases gradually from approximately 164.6mm/month in January to the peak value of about 190.46 mm/day in March due to hot temperature and low rainfall in this month. Then it decreases gradually to 141.5mm/month in August. The minimum and maximum ET0 was predicted to be in the range of 141.45 –196.3 mm/month at 2020s and 153.14 – 197.9mm/month at 2080s over the lowland areas under RCP 4.5 scenario (Figure 5) while in highland areas of the sub-basin the minimum and maximum ET0 was observed in July and March respectively having (106.4mm/month) and (149.3 mm/month) magnitudes at 2080s (Figure 6). Change in ET0 at 2080s was high as compared with 2020s due to increasing temperature and significant decreasing of rainfall over the study area in both RCP’s.

![Figure 5: Evapotranspiration (ET₀) at base period, 2020s, 2080s scenarios periods in warm sub-humid (lowland) AEZ of the study area](image1)

![Figure 6: Evapotranspiration (ET₀) at base period, 2020s, 2080s scenario periods in warm sub-humid (high land) AEZ of the study area](image2)
The analysis reveals that annual potential evapotranspiration are predicted to increase with increase in temperature. The average projected annual reference crop evapotranspiration increase with 2.8%, 7.3% at 2020s and 3.8%, 7.7% at 2080s in lowland and highlands parts respectively for RCP 4.5 scenario. Similarly, the projected annual ETo increase by 3.5%, 12.6% and 4.9%, 13.2% at 2020s and 2080s in lowland and highland parts of Anger sub-basin under RCP 8.5 scenario (Table 3). The seasonal ETo increases over the sub-basin and the highest increase were observed in kiremt seasons in future. This result is supported by [23, 24, 25] that at the end of the 21st century potential evapotranspiration was increase in all months of the year.

Table 3: Percentage change in Reference ETo (%) at seasonal and annual basis over Anger sub-basin

| Season | Lowland 2020s (%) | Lowland 2080s (%) | Highland 2020s (%) | Highland 2080s (%) |
|--------|-------------------|-------------------|-------------------|-------------------|
| ONDJ   | 4.2               | 4.9               | 4.6               | 4.7               |
| JJAS   | 1.3               | 10.2              | 3.2               | 11.6              |
| FMAM   | 3.1               | 6.7               | 3.6               | 6.7               |
| Annual | 2.8               | 7.3               | 3.8               | 7.7               |

3.3. Future water requirement of selected major grown crops

Crop water use estimation was carried out for different climate change scenarios and scenario period. The result reveals that crop water requirement increases in the future for all major crops grown (Maize, Tomato, potato, Cabbage and sugarcane) as compared to baseline period due to increasing temperature as well as evapotranspiration over the study area (Table 4). In the period 2020s and 2080s, maize shows increment in crop evapotranspiration by 2.38%, 3.22% and 3.36%, 7.81% for RCP 4.5 and RCP 8.5 scenarios respectively. Similarly, crop evapotranspiration of Tomato may increase by 3.83%, 3.26% and 3.45%, 3.58% at 2020s and 2080s respectively for RCP 4.5 and RCP 8.5 scenarios. Increase CWR also 2.78%, 3.74% and 3.35%, 7.59% at 2020s and 2080s respectively for RCP 4.5 and RCP 8.5 scenarios for cabbage crop. Potato water requirement increased by 3.3% and 4.0% and 3.8% and 7.9% at 2020s and 2080s respectively for RCP 4.5 and RCP 8.5 scenarios. In similar way, sugarcane water requirement increase ranges from 1.7% to 7.1% and 1.5% to 12.7% for both scenarios RCP 4.5 and RCP 8.5 scenarios during both time slices over the Anger sub-basin.

Table 4: Total water requirement during growth stages and Percentage changes under climate change condition of the selected crops in Anger sub-basin.

| Crop   | Total CWR (mm/growth period) | Percentage change (%) per growth period |
|--------|------------------------------|----------------------------------------|
|        | 2020’s | 2080’s | 2020’s | 2080’s | 2020’s | 2080’s | 2020’s | 2080’s | 2020’s | 2080’s | 2020’s | 2080’s |
|        | Baseline | RCP 4.5 | RCP 8.5 | RCP 4.5 | RCP 8.5 | RCP 4.5 | RCP 8.5 | RCP 4.5 | RCP 8.5 | RCP 4.5 | RCP 8.5 |
| Maize  | 653.4  | 668.9  | 674.5  | 675.4  | 704.4  | 2.38  | 3.22  | 3.36  | 7.81  |
| Tomato | 610.1  | 633.4  | 629.9  | 631.1  | 631.9  | 3.83  | 3.26  | 3.45  | 3.58  |
| Cabbage| 503.3  | 517.3  | 522.1  | 520.1  | 541.5  | 2.78  | 3.74  | 3.35  | 7.59  |
| Potato | 472.271| 487.6  | 490.2  | 491.3  | 509.6  | 3.3   | 3.8   | 4.0   | 7.9   |
| Sugarcane | 2620.57 | 2665.3 | 2660.9 | 2804.3 | 2958.0 | 1.7   | 1.5   | 7.0   | 12.9  |
Figure (7) below shows crop water use of the representative crops at different growth stages and it indicates that for all crops, crop water requirement is increasing from the initial stage to the maximum at mid-stage and decrease at the late season both under current (Figure 7a) and future time periods (Figure 7b).

![Current conditions graph](image)

**Figure 7a:** Crop water requirement of major grown crops at baseline period in Anger sub-basin

![Crop water requirements graph](image)

**Figure 7b:** Crop water requirements of major irrigated crops over Anger sub-basin at 2020s, 2080s during full irrigation (dry seasons) under RCP 4.5 and RCP 8.5 Scenarios

3.4. Irrigation water demand analysis

The total annual surface water availability over Anger sub-basin was estimated in my first paper and it was 3.396 BCM/year at base period [26]. Accordingly, the total domestic water requirement of the sub-basin will be 0.059274 BCM/year. 0.051 BCM/year were consumed by livestock over the sub-basin (Table 5).
Table 5: Livestock population in the Basin and their Water Requirement

| Type of animal in the sub-basin | Livestock population (million) | Average water requirement (L/day/head) | Water requirement (BCM/year) |
|---------------------------------|--------------------------------|--------------------------------------|-----------------------------|
| Cattle                          | 2.186415                       | 54                                   | 0.0446                      |
| Sheep/goat                      | 0.765113                       | 7.14                                 | 0.0021                      |
| Equine                          | 0.231435                       | 45.6                                 | 0.0034                      |
| Poultry                         | 1.121751                       | 450L/1000birds/day                   | 0.00019                     |
| Total                           |                                 |                                      | 0.051                       |

Source: [19]

The environmental water requirement was estimated to be about 1.19 BCM/year based on the recommended range considered. Then, the rest water volume available within the sub-basin is used for irrigation. So, about 2.096 BCM/year of water is available for irrigation purpose in Anger sub-basin. This analysis reveals that the irrigation water demand takes a lion’s share with about 62% followed by water needed by environmental protection water demand about 35% and the domestic and livestock shares the lowest water demand of 1.72% and 1.475% respectively over the sub-basin.

Agricultural water demand over Anger sub-basin determined based on the annual water requirement for each crop per hectare as estimated by [22]. The area covered by each crop for identified irrigable area was calculated in addition to data achieved for small scale schemes from East Wollega Irrigation Development authority report [5, 21]. The productive of the two factors gives the water requirement by crop annually and accordingly the total agricultural water requirement during dry season (full irrigation) was about 114.64 Mm³ (Table 6).

Table 6: Crop water requirement (Mm³) per hectare for proposed and functional projects in the sub-basin during dry seasons [22]

| Dry season proposed and irrigated crops over Anger sub-basin | Crops                  | Area (ha) | m³/ha | Mm³  |
|-------------------------------------------------------------|------------------------|-----------|-------|------|
| Tomatoes – fresh                                            | 226.94                 | 9485      | 2.15  |
| Peppers – fresh                                             | 53.85                  | 9578      | 0.52  |
| Onions                                                      | 242.33                 | 9009      | 2.18  |
| Cabbage                                                     | 380.80                 | 5153      | 1.96  |
| Sweet potatoes                                              | 69.24                  | 8446      | 0.58  |
| Carrots                                                     | 53.85                  | 8169      | 0.44  |
| Eggplants                                                   | 53.85                  | 7963      | 0.43  |
| Potatoes                                                    | 226.94                 | 8509      | 1.93  |
| Leaf vegetables                                             | 242.33                 | 5157      | 1.25  |
| Melons & Watermelons                                        | 53.85                  | 7125      | 0.38  |
| Cucurbits                                                   | 34.62                  | 6085      | 0.21  |
| Beans                                                       | 138.47                 | 5709      | 0.79  |
| Maize - fresh ears                                          | 692.36                 | 7583      | 5.25  |
| Maize – grains                                              | 3461.81                | 8242      | 28.53 |
Sorghum 865.45 7518 6.51
Soybeans 2423.27 7788 18.87
Castor beans 865.45 7680 6.65
Peppers – spice 173.09 8295 1.44
Fodder Legumes 865.45 5385 4.66
Cotton 1730.90 7455 12.90
Paprika 1384.72 6822 9.45
Tomatoes – industry 865.45 8731 7.56

Total 114.64

The water requirement volume needed by crops as supplementary is to be about 384.43 Mm$^3$ (Table 7).

Therefore, the irrigation water demand of the crops grown over potential irrigable area at present time was estimated about 529.07 Mm$^3$.

Table 7: Crop water requirement (Mm$^3$) corresponding to area covered requires supplementary irrigation [22].

| Crops                        | Area(ha) | m$^3$/ha | Mm$^3$ |
|------------------------------|----------|----------|--------|
| Tomatoes – fresh             | 85.57    | 857      | 0.07   |
| Peppers – fresh              | 23.77    | 857      | 0.02   |
| Onions                       | 85.57    | 857      | 0.07   |
| Sweet potatoes               | 23.77    | 857      | 0.02   |
| Carrots                      | 23.77    | 857      | 0.02   |
| Eggplants                    | 23.77    | 857      | 0.02   |
| Potatoes                     | 109.35   | 857      | 0.09   |
| Leaf Vegetables              | 42.79    | 857      | 0.04   |
| Beans                        | 23.77    | 857      | 0.02   |
| Maize - fresh ears           | 1283.62  | 857      | 1.1    |
| Maize – grains               | 7487.77  | 857      | 6.42   |
| Sorghum                      | 2995.11  | 857      | 2.57   |
| Groundnuts                   | 3209.04  | 857      | 2.75   |
| Noug                         | 109.35   | 857      | 0.09   |
| Sesame                       | 427.87   | 857      | 0.37   |
| Flax                         | 109.35   | 857      | 0.09   |
| Sugar Cane -small holders    | 1069.68  | 9128     | 9.76   |
| Legumes (green manure)       | 2139.36  | 857      | 1.83   |
| Various crops                | 66.56    | 857      | 0.06   |
| Sugarcane                    | 39329.98 | 9128     | 359    |

Total 384.43

The water abstracted for irrigation purpose from the analysis 2.096Bm$^3$ and the crop water requirement estimated is 529.07Mm$^3$. This indicates that there is water available over the sub-basin at baseline period for expansion of
IV. CONCLUSION

Estimating amount of water requirements for crop under climate change in particular area is necessary for agricultural production and its management. Due to the increase of temperature the rate of evapotranspiration would increase which directly increase the rate of crop water use. Thus, the result shows that crop water use of the major grown crops were higher at the mid stage than others both at baseline and scenario periods. The crop water use of tomato and potato increase in higher by 3.83% and 3.8% respectively in 2020s for both RCPs than other crops and the increment of sugarcane water use were 7% and 12.9% in 2080s for both RCP 4.5 and RCP 8.5 respectively. This increasing crop water requirement results crops water stress in scenario periods. In response to such condition some water management and adaptation were required to reduce water consumption by crops based on crop varieties that has short growth period, water stress tolerant crops and providing new varieties especially of cabbage, potato, tomato, maize and sugarcane which could resist high evapotranspiration under changing climatic condition.

Irrigation water demand was estimated based on current conditions and the analysis reveals that the irrigation water demand takes a lion’s share with about 62% (2.096Bm³) followed by environmental water demand about 1.19Bm³ (35%) and the domestic and livestock shares the lowest water demand of 1.72% (0.059274Bm³) and 1.475%(0.051Bm³) respectively over the sub-basin.

The results of this study should be taken with care and be considered as representative of the likely future rather than accurate predictions of crop water use of crops. The analysis is based on single GCM driving model and regional climate model for future crop water use projections. Therefore, to increase the accuracy of the prediction, the studies on climate change impacts should include different GCM driving model with different RCM output is necessary but the obtained result helps the policy makers and planners of water resources for future and suggest that water saving techniques are required to satisfy increasing crop water use under scenario periods.

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