ESTIMATION OF ACTUAL EVAPOTRANSPIRATION USING REMOTE SENSING BASED SURFACE ENERGY BALANCE SYSTEM AT THE DATA SCARCE KABUL RIVER BASIN OF AFGHANISTAN

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Introduction

The Kabul River Basin (KRB) is the main provider of irrigation water to around 5611 km^2 area. It hosts the highest population of all river basins in Afghanistan. Industrialization drives the climate change impacts which need to be mitigated through innovative approaches. Trends estimated by climate change projection scenarios suggest ill-impacts over the river flow patterns of KRB in the future which may either enhance severe droughts or heavy floods in the region. Having these scenarios ahead, the unreliable water supplies will drive the unease to the livelihood of the poor communities who depend mainly on the flow supplies as a result of the snow-melt over the peaks of Hindukush mountainous series in Afghanistan. In this case, meeting the crop water demand or actual evapotranspiration (AET) is the major concern in a country where more than 80% of population earn their food from agriculture sector. Therefore, AET, is a key indicator required for the assessment of the strategical and operational performance of the large river basins and irrigation schemes such as KRB. This study incorporates remote sensing data with Surface Energy Balance System algorithm for the estimation of AET in KRB of Afghanistan.

Objective

To estimate the crop water demand (actual evapotranspiration) in Kabul River Basin of Afghanistan

Study Site

Nangarhar province is located in the lower reaches of Kabul sub basin bordered with Pakistan and in large is part of the main KRB.

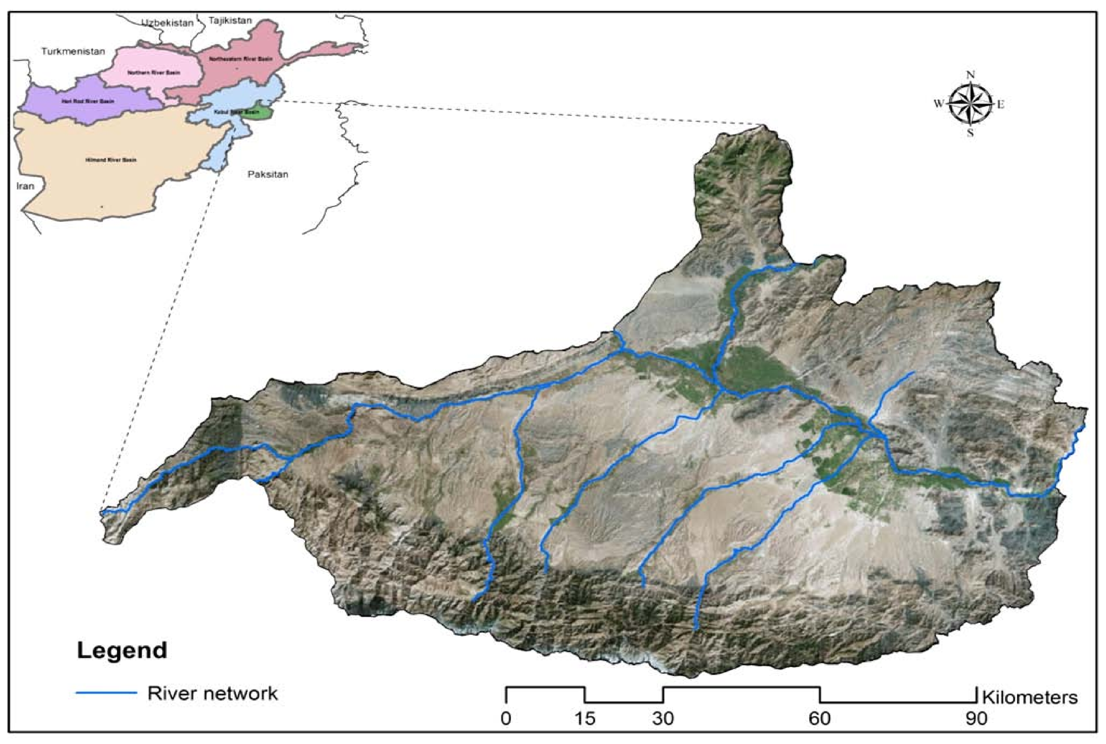


Figure 1: Location map of the study site (Nangarhar)

KRB covers an area of around 72,646 km^2 and is elevated between 575m and 3800m above sea level consisted of green valley diverse landscape patterns.

Rainfall-Temperature relationship

Nangarhar province has a hot semi-arid climate with a temperature variation between 3°C (monthly mean of coldest month) to 40°C (monthly mean of hottest month) on average basis. Precipitation usually occurs in the months of February – April and the mean annual rainfall received at Jalalabad (provincial capital) is around 210 mm.

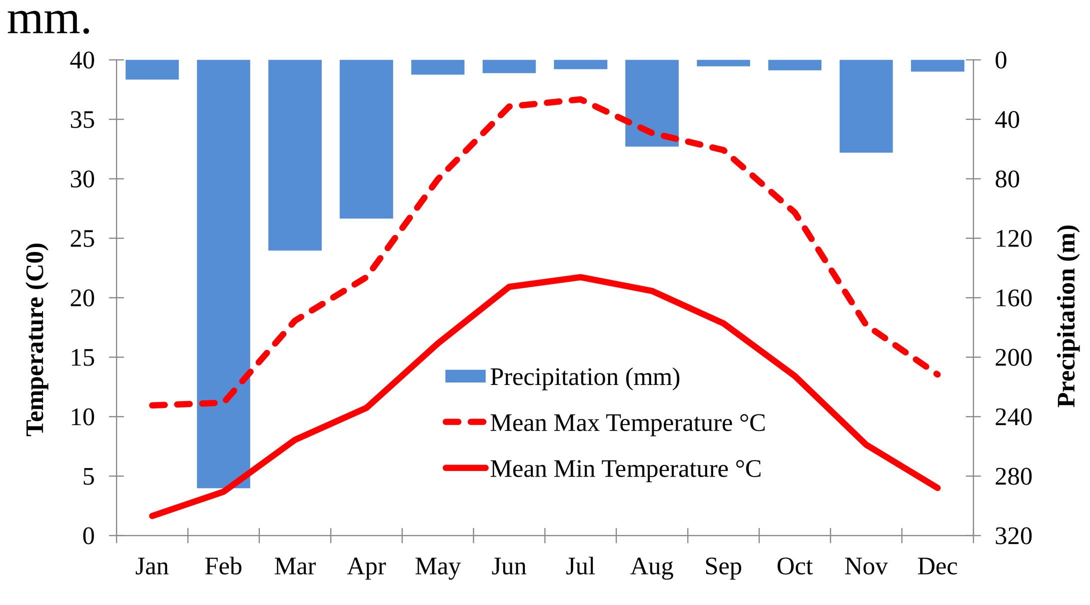
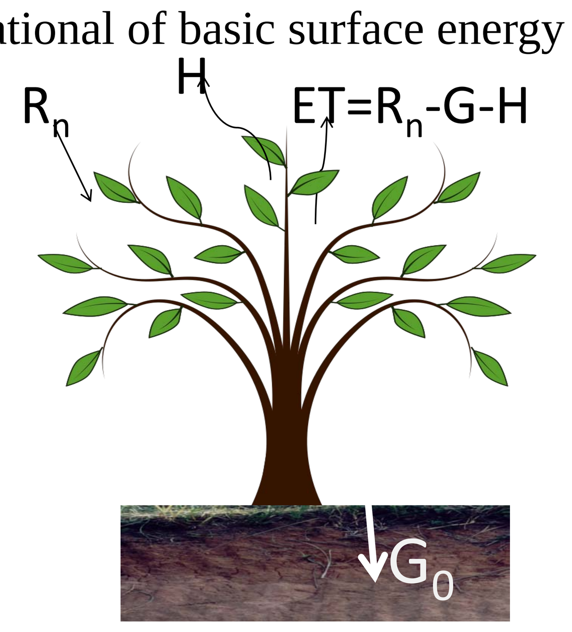


Figure 2: Decadal average (2003-2013) temperature-rainfall relationship in Nangarhar province

Materials and Methods

Surface Energy Balance System:

The surface energy balance system (SEBS) was used for the estimation of AET in this study. SEBS is fully based on the rational of basic surface energy balance equation:



$$R_n = G_0 + H + \lambda E \quad (1)$$

Where R_n (net radiation, W m^{-2}), G_0 (soil heat flux , W m^{-2}), H (sensible heat flux, W m^{-2}), λE (turbulent latent heat flux, W m^{-2}), λ (latent heat of vaporization, J kg^{-1}) and E (evapotranspiration, mm day^{-1})

The daily AET was estimated using the following equation:

$$ET_a\ daily = 8.67 \times 107[\Lambda.(R_{n\ daily} - G_{daily}) / \lambda \rho w] \quad (2)$$

Main Input Data

Climate Parameters	MODIS Products
-Wind Speed -Long-wave & short-wave radiation -Air temperature -Air Pressure -Specific Humidity	-Emissivity/LST (MOD11A1) -NDVI (MOD13A2) -LAI (MCD15A2) -Albedo (MCD43B3) -Land Cover (MCD12Q1)

where ρw (density of water, kgm^{-3}), G_{daily} (daily average soil surface heat flux), λ (latent heat of water taken as 2.47x10^6 J kg^{-1})

Results

Mean annual AET

- The average AET per annum was estimated was 552±76 mm throughout the study period (2003-2013).
- The minimum and maximum AET recorded was 428mm and 728mm in the year 2004 and 2006, respectively.
- The relatively lower AET in 2004 was because of the country-wide grip of debilitating drought conditions in that specific year.

Seasonal AET

The dominant crops grown in KRB are wheat, barley (winter season and maize and rice (summer season). Usually wheat is the main staple food and is widely grown across the country. AET was estimated for both the seasons under this study:

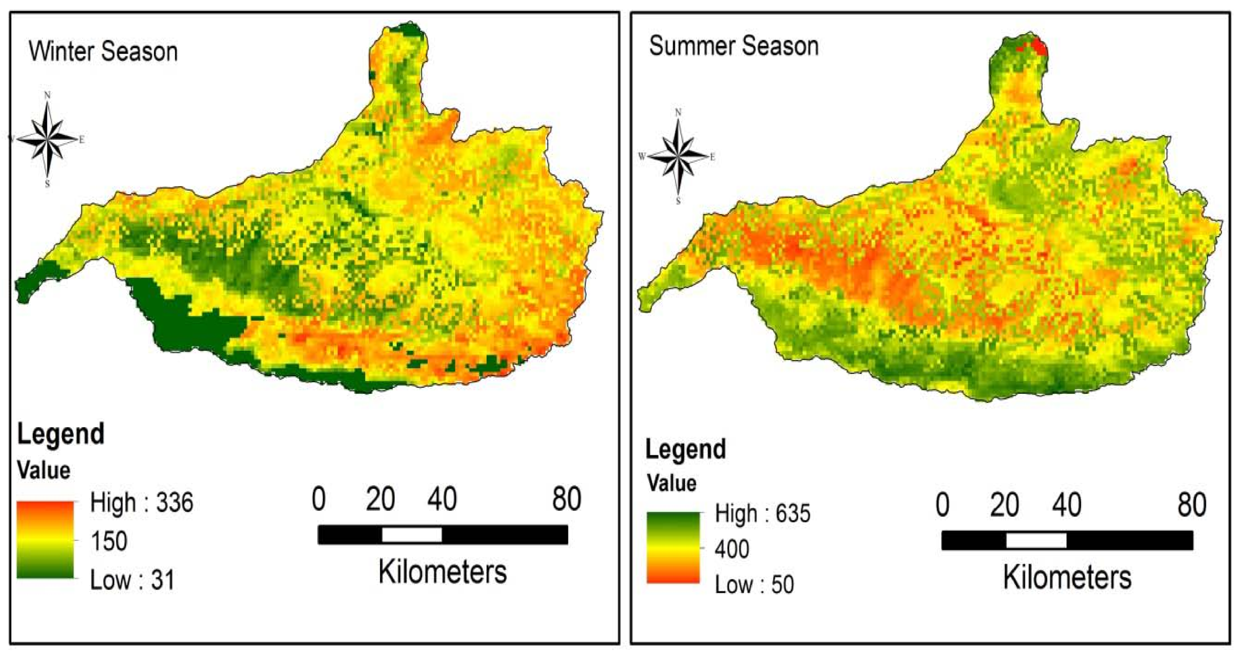


Figure 3: Mean seasonal AET during 2013

- The decadal mean AET for winter (October-April) was 215±68 mm (Figure 3 and Figure 4)
- The decadal mean AET for summer (May-September) seasons were and 340±29 mm (Figure 3 and Figure 4)

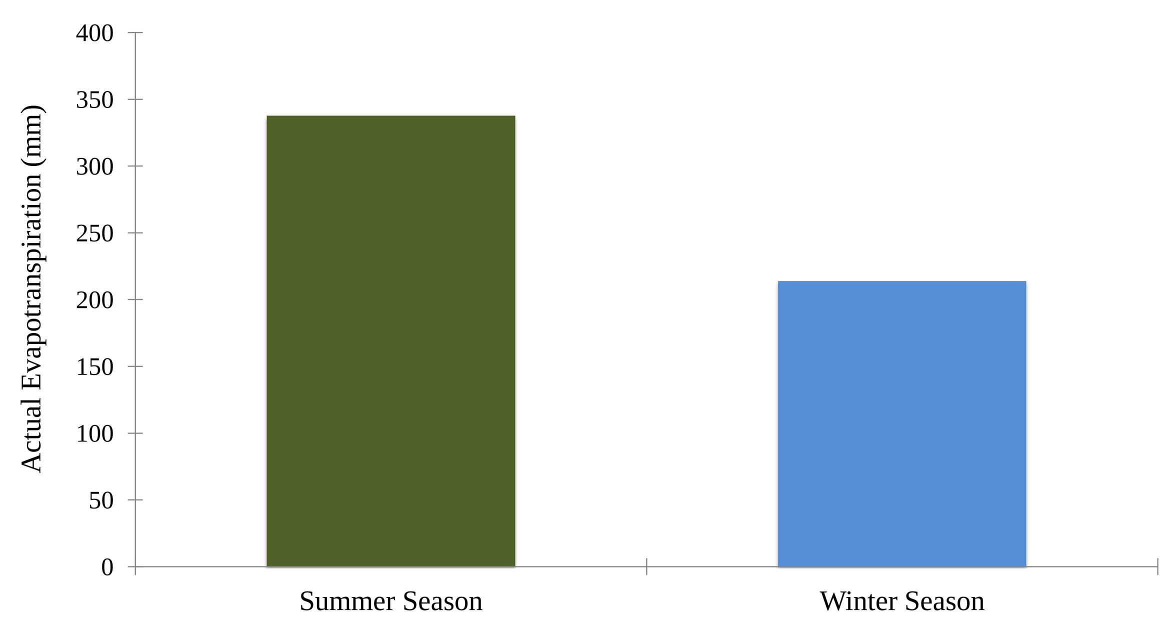


Figure 4: Decadal mean Seasonal Actual Evapotranspiration (mm) during (2003-2013)

The monthly mean AET during (2003-2013) shows higher values mostly in the summer months e.g. May-August (Figure 5).

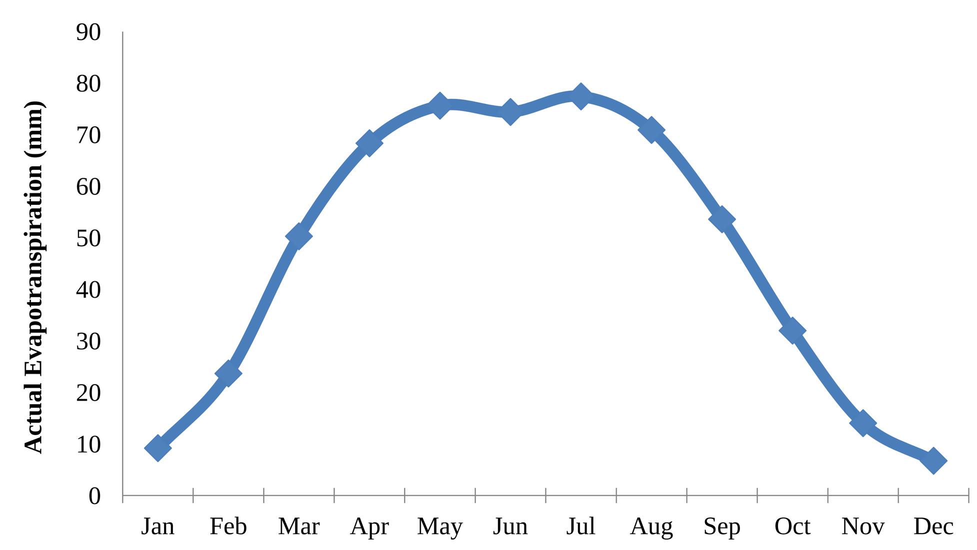


Figure 5: Decadal monthly mean AET during (2003-2013)

The higher AET in these months is driven by several factors among which temperature , solar radiation and relative humidity during the peak summer period (coinciding with the peak irrigation season) are most influential.

Conclusion

The decade long analysis of the AET under this study can be efficiently utilized for the assessment of irrigation performance at the sub-units of larger Kabul River Basin. It provides key information for improving the water allocation among different water users and stakeholders which is vital for optimized strategic and operational performance urgently needed to meet future demand by adaptive water management under challenging conditions of climate change.

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BMZ Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
Foundation fiat panis
agrinatura
ICARDA Science for Better Livelihoods in Dry Areas