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 km² 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 uncease 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 strategic and operational performance of the large rivers 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.

Rainfall-Temperature relationship

Nangarhar province has a hot semi-arid climate with a temperature variation between 3°C (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.

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:

\[ R_{\text{net}} = G_0 + H + L_E \]  

Where \( R_{\text{net}} \) (net radiation, \( \text{W m}^{-2} \)), \( G_0 \) (soil heat flux , \( \text{W m}^{-2} \)), \( H \) (sensible heat flux, \( \text{W m}^{-2} \)), \( L_E \) (turbulent latent heat flux, \( \text{W m}^{-2} \)), \( \lambda \) (latent heat of vaporization, \( \text{kg g}^{-1} \)) and \( E \) (evapotranspiration, \( \text{mm day}^{-1} \)).

The daily AET was estimated using the following equation:

\[ E_{\text{daily}} = 8.67 \times 10^7 \frac{\text{J (R}_{\text{net daily}} - G_{\text{dail})}/ \rho \text{pw}}{\text{J (R}_{\text{net daily}} - G_{\text{dail})}/ \rho \text{pw}} \]  

where \( \rho \text{pw} \) (density of water, \( \text{kg m}^{-3} \)), \( G_{\text{dail}} \) (daily average soil surface heat flux), \( \lambda \) (latent heat of water taken as 2.47x10^6 \text{J kg}^{-1}).

Main Input Data

<table>
<thead>
<tr>
<th>Climate Parameters</th>
<th>MODIS Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Wind Speed</td>
<td>-Emissivity/LST (MOD11A1)</td>
</tr>
<tr>
<td>-Long-wave &amp; short-wave radiation</td>
<td>-NEVI (MOD13A2)</td>
</tr>
<tr>
<td>-Air temperature</td>
<td>-LAI (MOD15A2)</td>
</tr>
<tr>
<td>-Air Pressure</td>
<td>-Albedo (MCD43B3)</td>
</tr>
<tr>
<td>-Specific Humidity</td>
<td>-Land Cover (MCD12Q1)</td>
</tr>
</tbody>
</table>

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.

- 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).

Conclusion

The decadal 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.

Acknowledgement

This study is part of author’s doctoral study funded by the Federal Ministry for Economic Cooperation and Development, Germany via DAAD (German Academic Exchange Service, Dr. Hermann Eiselein Doctoral Program of the Foundation (FIAT PANIS) and Centre for Development Research (ZEF) for academic guidance and platform provision. The author also thanks International Centre for Agricultural Research in the Dry Areas (ICARDA) for technical insights in carrying out this study.