Satellite Derived Evapotranspiration and Turbulent Heat Fluxes using Surface Energy Balance System (SEBS)

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Evapotranspiration

- Evaporation from water surface and Transpiration from plants collectively referred as evapotranspiration.
Introduction

• For the agricultural production, water is a fundamental component and as well as critical for future **global food security**.

• During the past few decades, fast growing world population, urbanization and industrialization caused **depletion** of fresh water resources.

• Since the 1950s, global demand for water has become three times greater than what it was used to be before (Hanjra & Qureshi, 2010).
Introduction

• SEBS is a single-source surface energy balance model, which is used in this project.
• SEBS model estimates atmospheric turbulent fluxes and surface evaporative fraction from remote sensing data.
• The SEBS algorithm was described in the article by Z. Su in Hydrology & Earth System Sciences in 2002.
Problem Statement

• For the better assessment and management of irrigation water requirement, the estimation of consumptive use of water for agriculture is very important because it is the main consumer of water.

• As large amount of irrigated water is lost through ET, therefore its accurate estimation can be helpful for efficient management of irrigation water.
Objectives

Major objective of the study is:

• To estimate actual evapotranspiration (ETa) using remote sensing data.
• To understand the most critical processes in surface energy balance.
• To familiarize with the applications of SEBS.
## Data Sources

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Specification</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat satellite data</td>
<td>TM/ETM sensor (30m res.)</td>
<td><a href="http://Glovis.USGS.gov">http://Glovis.USGS.gov</a></td>
</tr>
<tr>
<td>Metrological Data</td>
<td>Temperature, wind speed, Precipitation Data etc.</td>
<td>Pakistan Metrological Department</td>
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</tbody>
</table>
Study Area
Research Methodology

**SATellite DATA**
- Landsat TM (30 meter)
- NDVI
- Surface Albedo
- Surface Emissivity
- LST

**SEBS Model/Algorithm**
- Soil Heat Flux
- Net Radiation
- Sensible Heat Flux
- Evaporative fraction

**METEOROLOGICAL DATA**
- Air Pressure
- Air Temperature
- Humidity
- Wind Speed

**Actual Evapotranspiration**

**Results**
- Map Layouts
- Report Writing
- Analysis
Maps and Layouts
Land Cover Classification

Land Cover Map 2011, District Larkana

Land Cover Distribution

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Land Cover</th>
<th>Area (km²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Body</td>
<td>356</td>
<td>1.86</td>
</tr>
<tr>
<td>2</td>
<td>Built up Area</td>
<td>2227</td>
<td>11.66</td>
</tr>
<tr>
<td>3</td>
<td>Natural Vegetation</td>
<td>1220</td>
<td>6.39</td>
</tr>
<tr>
<td>4</td>
<td>Agricultural Land</td>
<td>12411</td>
<td>65.1</td>
</tr>
<tr>
<td>5</td>
<td>Open Land</td>
<td>2872</td>
<td>15.04</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>19086</td>
<td>100</td>
</tr>
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Classification Key

- Water Body
- Built up Land
- Natural Vegetation
- Agricultural Land
- Open Land

Courtesy: Muhammad Tayyab Afzal M. Arslan
NDVI:
Represents Range of vegetation.

\[ NDVI = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}} \]
Surface Albedo:

Measure of the reflectivity of surface of earth.
Land Surface Emissivity:

Relative ability of surface to emit energy by radiation.

\[ \varepsilon = 0.004 \times P_v + 0.986 \]

Where \( P_v \) = fractional vegetation
Land Surface Temperature: How hot or cold the ground feels to the touch.

$LST = \frac{(P*T)}{P + (\lambda*T*\ln E)}$

$T =$ Brightness temperature
$E =$ emissivity
$P$ and $\lambda$ are constants respectively
Net Radiation:

The balance between incoming and outgoing energy at the top of the atmosphere.

\[ Rn = (1-\alpha) \cdot Rswd + ERlwd - E\alpha T_o^4 \]

Rn = Net radiation
Rswd = shortwave radiation
ERlwd = long wave radiation
\( \alpha \) = Surface Albedo
E\( \alpha \) = Atmospheric emissivity
\( T_o \) = Surface temperature.
Soil Heat Flux:
Is the energy that is utilized in heating the soil.

\[ G_0 = Rn \times Ts / \alpha (0.0038 \alpha + 0.0074 \alpha^2) \times (1 - 0.98 \text{NDVI}^4) \]

\[ G_0 = \text{Soil Heat flux} \]
\[ Ts = \text{Surface Temperature} \]
\[ \alpha = \text{Surface Albedo} \]
Sensible Heat Flux: Heat energy that is transferred from the Earth's surface to the atmosphere.

\[ H = R_n - G_0 - \lambda ET \]

- \( H \) = Sensible Heat
- \( R_n \) = Net radiation
- \( G_0 \) = Soil Heat flux
- \( ET \) = Evapotranspiration
- \( \lambda \) = Constant
Actual Evapotranspiration: Estimation of consumption of water by vegetated and non-vegetated land.
Results
<table>
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Land Cover Distribution in District Larkana, March, 2011

- Water Body: 15%
- Built up Area: 12%
- Natural Vegetation: 6%
- Open Land: 65%
- Agricultural Land: 2%
Results

• **Evapotranspiration** is an important process in the water cycle because it is responsible for **15%** of the atmosphere's water vapor

According to this study the statistics are:

• ETa for urban area and Soil is **0 – 1.5 mm/day**.
• ETa for Water body is **1.5 – 2.0 mm/day**.
• Eta for Agricultural land and vegetation is **2 -2.8 mm/day**.
Results

• The surface temperature, vegetation cover, and relevant parameters are determined remotely with the help of satellite image.
Limitation

- Field data for LST measurement.
Conclusion

The Research work which we have conducted can be used as planning tool in order to analyze:

- Surface conditions i.e. temperature and Heat Fluxes.
- Vegetation health.
- Consumption of water by vegetated and Non vegetated Land.
- ET within wide spatial scales by integrating ground-based meteorological data with satellite observations is a useful tool for quantifying and controlling water consumption especially in areas of limited water supply.
References

Future Work

• Field validation and comparison with other models.
• Regression analysis by estimating Crop Yield and Irrigation water supply.
• Identification of spatial patterns of evapotranspiration for various crops.
• Proposal for efficient management of irrigation water.
Acknowledgments
THANKYOU

Questions ...?