Glacier Monitoring: WAPDA’s Initiative in the Upper Indus Basin

Asim Rauf Khan, Project Director GMRC WAPDA
17-18 February 2016
ICIMOD, Kathmandu
WAPDA’s mission statement
Manage the water resources of Pakistan for irrigation, energy and flood control.
## Contribution of Snow and Ice

<table>
<thead>
<tr>
<th>Western River Stations</th>
<th>Approximate Contribution of Snow and Ice</th>
<th>Period</th>
<th>Annual Inflows (MAF)</th>
<th>Ice and Snow Contrib. (MAF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus at Tarbela</td>
<td>85%</td>
<td>1961-2013</td>
<td>60.72</td>
<td>51.6</td>
</tr>
<tr>
<td>Kabul at Nowshera</td>
<td>75%</td>
<td>1961-2013</td>
<td>21.65</td>
<td>16.2</td>
</tr>
<tr>
<td>Jhelum at Mangla</td>
<td>65%</td>
<td>1961-2013</td>
<td>22.20</td>
<td>14.4</td>
</tr>
<tr>
<td>Chenab at Marala</td>
<td>50%</td>
<td>1961-2013</td>
<td>25.36</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>Western Rivers Average Inflows</strong></td>
<td></td>
<td></td>
<td><strong>129.93 MAF</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Western Rivers Snow and Ice Contribution</strong></td>
<td></td>
<td></td>
<td><strong>95.0 MAF</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Contribution of Snow and Ice in Western Rivers</strong></td>
<td></td>
<td></td>
<td><strong>73.1 %</strong></td>
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</tbody>
</table>
## Cryosphere Monitoring

### 1960s
- Installation of river gauging network and valley bottom weather stations in Upper Indus Basin.

### 1961-1969
- Snow surveys were carried out in Kaghan valley.

### 1985-1989
- WAPDA in collaboration with Canadian Universities carried out UIB snow and glacier field studies to develop flow forecasting system for UIB Rivers.

### 1991-1997
- WAPDA established high-altitude (2200-4750 m.a.s.l.) network in UIB comprising 20 weather stations.
- Record collect & transmit hourly weather data to Flow Forecasting Centre Lahore.
- High-altitude data and UBC Watershed Model are being used for forecasting flows on seasonal *(Rabi and Kharif)* and short-term (10-Daily) since 2003 for water management in Indus River System.
WAPDA DCP Station (4750 m.a.s.l.) at Khunjerab

SENSORS INSTALLED

- Temperature
- Precipitation
- Relative Humidity
- Solar Radiation
- Snow Water Equivalent
- Wind (Speed; Direction)
Flow Forecasting using UBC Watershed Model

- Seasonal
  - Kharif (April-September)
  - Rabi (October-March)
- Ten-daily
- Indus River @ Tarbela
- Kabul River @ Nowshehra
- Jhelum River @ Mangla
Glacier Field Activities during 2015

• Studying the melt behaviour of glacier
  • Pasu Glacier
  • Miar-Sumiyarbar-Barpur System
  • Biafo Glacier
  • Stakes, weather data recording, discharge observations

• Snout surveys for glaciers in the Hunza River Basin
  • Pasu
  • Barpu
  • Hoper
  • Yazghill
  • Malungutti
  • Khurdopin & Yushkin Gardan
  • Virjerab
Melt Rates for Biafo Glacier
Jul-Sep (2015)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Profiles</th>
<th>Month</th>
<th>Net Ablation Rates (cm/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mango Profile</td>
<td>July (11-31)</td>
<td>6.8</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>August</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>El. 3679 m</td>
<td>Sep. (1-9)</td>
<td>3.2</td>
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<tr>
<td>4</td>
<td>Baintha Profile</td>
<td>July (11-31)</td>
<td>6.5</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>August</td>
<td>5.0</td>
</tr>
<tr>
<td>6</td>
<td>El. 4051 m</td>
<td>Sep. (1-9)</td>
<td>4.1</td>
</tr>
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</table>
Nagar Valley: Temperature & Glacial Melt (July 2015)
Glacier Snout Surveys (November 2015)
Pasu Glacier
(initial work during 2010-11 in collaboration with ICIMOD)
Field Activities Plan for 2016

• Glacier Field Investigations
  • Hispar Glacier (Karakoram Range)
  • Biafo Glacier (Karakoram Range)
  • Rakhiot Glacier (Himalayan Range)

• Glacier Snout Surveys
  • Hispar, Biafo, Rakhiot, Yashkuk Yaz, Batura, Gulkin, Gulmit, Hussaini, Bualter

• Discharge Measurements
  • Nagar River
  • Hispar River
  • Shimshall River
  • Rakhiot stream
Joint Field Work with ITP-CAS during 2016

• Program under discussion
  • Glacier melt-behaviour studies
  • GPR survey
  • Isotope analysis
  • Water quality monitoring
Inflows (maf)

Post Treaty Western Rivers Inflow Trend

Falling Trend
Man-Kendall Trend Significance Level = 69%
Annual Average (1961-2014) = 129.833 MAF
Inflow Volumes (MAF)

Kharif Flows Falling Trend at Tarbela During 1961 - 2012
Tarbela Rabi Flows Rising Trend During 1961 - 2012
## Monthly Trends of Western Rivers During 1962 - 2014

**Trend Method:** Mann Kendall

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</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>1.013</td>
<td>Rising</td>
<td>95%</td>
<td>0.628</td>
<td>Rising</td>
<td>88%</td>
<td>0.530</td>
<td>Rising</td>
<td>61%</td>
<td>0.570</td>
<td>Rising</td>
<td>82%</td>
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<tr>
<td>Feb</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>0.988</td>
<td>Rising</td>
<td>100%</td>
<td>0.587</td>
<td>Rising</td>
<td>98%</td>
<td>0.795</td>
<td>Rising</td>
<td>95%</td>
<td>0.706</td>
<td>Rising</td>
<td>69%</td>
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<tr>
<td>Mar</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>1.410</td>
<td>Rising</td>
<td>99%</td>
<td>1.014</td>
<td>Rising</td>
<td>84%</td>
<td>1.776</td>
<td>Rising</td>
<td>91%</td>
<td>1.242</td>
<td>Rising</td>
<td>15%</td>
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<tr>
<td>Apr</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>2.010</td>
<td>Rising</td>
<td>24%</td>
<td>2.037</td>
<td>Falling</td>
<td>58%</td>
<td>2.711</td>
<td>Rising</td>
<td>29%</td>
<td>1.475</td>
<td>Falling</td>
<td>35%</td>
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<tr>
<td>May</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>4.479</td>
<td>Rising</td>
<td>100%</td>
<td>3.129</td>
<td>Falling</td>
<td>40%</td>
<td>3.608</td>
<td>Falling</td>
<td>1%</td>
<td>2.283</td>
<td>Rising</td>
<td>61%</td>
<td></td>
<td></td>
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<tr>
<td>Jun</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>9.959</td>
<td>Falling</td>
<td>85%</td>
<td>4.012</td>
<td>Falling</td>
<td>96%</td>
<td>3.520</td>
<td>Falling</td>
<td>96%</td>
<td>3.528</td>
<td>Falling</td>
<td>84%</td>
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<tr>
<td>Jul</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>15.012</td>
<td>Falling</td>
<td>92%</td>
<td>4.156</td>
<td>Falling</td>
<td>91%</td>
<td>3.325</td>
<td>Falling</td>
<td>92%</td>
<td>5.327</td>
<td>Falling</td>
<td>92%</td>
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<tr>
<td>Aug</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>14.082</td>
<td>Falling</td>
<td>92%</td>
<td>3.010</td>
<td>Falling</td>
<td>88%</td>
<td>2.610</td>
<td>Falling</td>
<td>84%</td>
<td>5.407</td>
<td>Falling</td>
<td>93%</td>
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<tr>
<td>Sep</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>6.380</td>
<td>Rising</td>
<td>13%</td>
<td>1.326</td>
<td>Rising</td>
<td>14%</td>
<td>1.536</td>
<td>Rising</td>
<td>50%</td>
<td>2.763</td>
<td>Rising</td>
<td>1%</td>
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<tr>
<td>Oct</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>2.473</td>
<td>Rising</td>
<td>96%</td>
<td>0.700</td>
<td>Rising</td>
<td>84%</td>
<td>0.797</td>
<td>Falling</td>
<td>24%</td>
<td>0.943</td>
<td>Rising</td>
<td>70%</td>
<td></td>
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<tr>
<td>Nov</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>1.496</td>
<td>Rising</td>
<td>100%</td>
<td>0.549</td>
<td>Rising</td>
<td>1%</td>
<td>0.548</td>
<td>Falling</td>
<td>6%</td>
<td>0.525</td>
<td>Rising</td>
<td>69%</td>
<td></td>
<td></td>
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<tr>
<td>Dec</td>
<td>1962</td>
<td>2014</td>
<td>53</td>
<td>1.186</td>
<td>Rising</td>
<td>99%</td>
<td>0.549</td>
<td>Falling</td>
<td>58%</td>
<td>0.521</td>
<td>Rising</td>
<td>32%</td>
<td>0.489</td>
<td>Rising</td>
<td>33%</td>
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<tr>
<td>Annual</td>
<td>1962</td>
<td>2014</td>
<td>60</td>
<td>60.488</td>
<td>Falling</td>
<td>52%</td>
<td>21.698</td>
<td>Falling</td>
<td>65%</td>
<td>22.278</td>
<td>Falling</td>
<td>22%</td>
<td>25.260</td>
<td>Falling</td>
<td>53%</td>
<td></td>
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</tr>
</tbody>
</table>

**Note:** The Falling Trend in Summer UIB Flows is attributed to falling summer temperatures in UIB.
Thank You