



**Report on**

**Climate and water-food-energy nexus**

***Pakistan***

The GEOSS Joint Asia – Africa Water Cycle Symposium  
**Tokyo, November 25-27, 2012**

# Natural Resource Base

- Out of 79.6 m ha, only 20 m ha area available for farming
- 16 m ha irrigated and 4 m ha under rainfed farming
- Pakistan is predominantly arid and semi-arid with 68 m ha (85%) where rainfall is less than 300 mm.
- Pakistan has diverse landscapes including:
  - high mountain ranges of the Himalayas, Karakorams and Hindu Kush,
  - snow-covered peaks, eternal glaciers, and the inter-mountain valleys in the north,
  - undulating highly vulnerable agri. areas of rainfed Pothwar
  - vast rich irrigated plains in the Indus basin,
  - stark deserts and rugged rocky expanse of plateaus in the south-west of Balochistan.
  - snow and glacier melt keeps the Indus Basin rivers perennial
  - climate changes in Himalayan region can thus have a significant influence over the water resources of the country

# Recent Climate Change Trends

- **Rise in Mean Temperature 0.6 to 1.0 °C**
- **10 – 15% decrease in rainfall in coastal/ arid area**
- **18 – 32% increase in rainfall in sub-humid to humid areas of monsoon zone**
- **Occurrence of 19 extreme climatic events during 1992 – 2011 (heavy rains causing floods, droughts, cyclones, heat waves)**
- **26-57% increase in winter rains in sub-mountain, central & southern Punjab, and north-eastern Balochistan**

# Major Issues:

- # **High river flows variability-high flows in July, August and very low in the rest of year**
- # **Vulnerability of floods, drought and GLOF**
- # **Highly topographic heterogeneity and remoteness making in-situ measurement difficult**
- # **Lacking in capacity of development/application of distributed hydrological modeling**
- # **Degradation water quality due to exploitation of groundwater, effluent from agriculture and industries**
- # **Arid coastal strips and mangrove areas are under increased environmental stress from reduced fresh water flows**

# **Improving water cycle observations and prediction of hydro-met disasters in Pakistan**

## **Specific objectives of proposed project:**

- + Improve monitoring capacity in the country**
- + Distributed hydrological modeling to improve forecasting of floods/drought**
- + Climate change impact assessment on drought, floods, GLOF water-nexus and food security (agriculture, in particular)**
- + Data access and sharing – Inter-organizational and transboundary**

# Outputs

- **Enhancement of water cycle observations**
- **Improve capability of flood and drought forecast and early warning**
- **Assess climate change impacts on floods, droughts and water-food nexus (agriculture, in particular)**

# **Output-1: Enhancement of water cycle observations**

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- ✚ Develop comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle.**
- ✚ Develop long-term and comprehensive climate observation data archives**
- ✚ Improve observational, modeling and application capacity in the country.**

## Output–2: Improve capability of flood and drought forecast and early warning

- + Develop hydrological model (WEB-DHM)**
- + Develop inundation model and update flood hazard maps.**
- + Couple hydrological model with a crop model.**
- + Develop and disseminate agro-climate predictions (soil moisture, crop water requirement) for crop water management**
- + Develop a Decision Support System (DSS) by using observations and model outputs.**



## **Output–3:** Assess climate change impacts on floods, droughts and water-Food nexus (agriculture, in particular)

- # Select GCMs which can express the regional climate properly.**
- # Apply bias correction and downscaling (statistical- and dynamic-) of the selected GCMs by Regional Climate Models.**
- # Develop/improve socio-economic data archive**
- # Analyse changing climatic extreme's trend in terms of frequency and intensity of flood, drought**

# Methodology

## **WP -1: To develop long-term climate trends and short-term climate variability**

- 1.Improve hydro-met observational, modeling and application capacity in the country**
- 2.Improvement of near-real time rainfall and riverflow observation and data dissemination systems**
- 3.Coupling satellite and in-situ measurements of cryosphere to be input to hydrological models**
- 4.Develop/improve hydro-meteorological data archive to analyze the past behavior and recent trends for monitoring capability of water cycle.**
- 5.Integrate climate observation/model data archives, which are used for climate change assessment, climate projections and model bias correction.**

# Methodology

**WP -2: To improve cryosphere monitoring using in-situ observations and remote sensing data for better understanding of its dynamics and spatial variability**

**1.The seasonal snow cover dynamics**

**2.Updating/refinement of glaciers inventory of using high resolution RS data**

**3.Selection of benchmark glaciers and their monitoring for long-term glacio-hydrological characteristics**

**4.Development of high resolution Remote Sensing based Digital Elevation Model data sets for application to the distributed hydrological model**

**5.Promote field measurements on glaciers for mass balance, surface velocity, changes of moraine/terminus and behavior of ablation and accumulation zones.**

# Methodology

## **WP -3: Distributed hydrological modeling to improve forecasting of Floods/Drought modeling**

- 1. Develop distributed hydrological model (WEB-DHM)**
- 2. Couple hydrological-crop-economic model for improved understanding of socioeconomic impacts of water cycle variability.**
- 3. Strengthening of field based monitoring of hydro-meteorological variables at high elevation areas**
- 4. Hydrological modeling to derive water availability and demand scenarios at the basin, sub-basin and catchment scales.**
- 5. Quantification of contributions of rainfall, snow-melt, glacial-melt to runoff through hydrological modeling**
- 6. Impact of climate change on each runoff component (rainfall, snow-melt, glacial-melt, permafrost-melt)**
- 7. Future water demand and availability scenarios based on demographic scenarios, increased crop water requirement etc.**

# Methodology

## **WP -4: Risk assessment of climate induced hazards of drought, floods and GLOF**

- 1. Selection of suitable GCMs and assessing their data sets.**
- 2. Bias correction and downscaling (statistical- and dynamic-) of GCMs by RCMs.**
- 3. Collection of socio-economic data and its archiving**
- 4. Identification of changes in frequency and intensity of hydro-meteorological extremes.**
- 5. Land use changes, Inundation modeling and revision of flood hazard maps**
- 6. Updation of inventory of lakes, GLOFs and promote indigenous knowledge to manage GLOF risks**
- 7. Investigate the adaptive capacity to adverse climate change impacts due to lack of technical knowhow and low financial resources**

# Methodology

**WP -5: Impact of hydrologic extremes on food security and socio-economic conditions of community**

**1.Study/ Assess /simulate climate change impacts on agriculture and local crop production pattern**

**2.Simulate evapo-transpiration and irrigation water requirement of major crops (wheat, rice, cotton, sugar cane)**

**3.Development of a Decision Support System (DSS) incorporating crop-water-climate-socioeconomic scenarios.**

**4.To identify and propose potential adaptation measures**

# Lead Local Organizations

- 1. Pakistan Meteorological Department (PMD), Islamabad**
- 2. Pakistan Agricultural Research Council (PARC), Islamabad**
- 3. Water and Power Development Authority (WAPDA), Lahore**
- 4. Global Change Impact Studies Center (GCISC), Islamabad**
- 5. National University of Science and Technology (NUST), Islamabad**
- 6. University of Agriculture Faisalabad (UAF)**
- 7. Foreman Christian College Chartered (FCC) University, Lahore**

## International Organizations

- 1. Remote Sensing data –JAXA, NASA**
- 2. Hydrological Modeling - University of Tokyo-Japan, AWCI**
- 3. In-situ Croosphere Monitoring - ICIMOD**
- 4. Crop Water Management - Wageningen University-Netherland**
- 5. Watershed adaptations- Colorado University-USA, ICARDA, ICIMOD**
- 6. Agriculture and food security adaptation - BIOFORSK Norway, ICIMOD-Nepal**

# Lead Contributors

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# International Projects

**1. Impact of Climate Change on Melting Glaciers and Water Cycle Variability in Asian River Basin. Funding Agency - APN**

**2. Differentiation of solid and Liquid Precipitation in Upper Indus Basin (UIB) for Hydrological Models. Funding Agency: DFID**

**3. Strengthening Flood Forecasting Capabilities in Pakistan. Funding Agency: UNESCO**

**4. Climate Change adaptation in water and agriculture: IDRC and DFID funding**

**5. Early Warning System for Glacial Lake Outburst Floods (GLOF) in UIB. Funding Agency: UNDP**

**6. Demonstration of adaptation technologies at watershed scale. USAID funding**