Impact Assessment of Climate Change on the Water Resources and Agriculture in Banas basin in Western India using Climate Change Indicators (CIIIs)

Archana Sarkar, Surjeet Singh, T. Thomas, NIH (India)
Rajasthan is the largest state of India with 10.4% of the country’s area and 5.5% of its population, but only about 1% of the country’s water resources producing 5.49% of the nation’s total food grains and 21.31% of its oil seeds.

The Banas River Basin is the largest river basin (45833 km²) within the Rajasthan State of India. The Bisalpur dam project in the Banas basin plays an important role in the economy of the region, providing water for drinking to various cities and irrigation in the Tonk district.

The water availability in this reservoir in coming years will play a crucial role in the overall economy of the entire region including other socio-economic issues.
Bisalpur drinking water cum irrigation project is constructed across river Banas with an ultimate irrigation potential of 55224 hectare (irrigation during the months of October/November to February/March for the Rabi crop), besides providing 458.36 million m³ of drinking water for Jaipur, Ajmer, Beawar, Kishangarh, Nasirabad and enroute cities, towns and villages.

Available Water at Bisalpur Dam site = 33.15 TMC (at 75% dependability)
Net Useable water available = 24.2 TMC (After accounting for evaporation & other loses)
Drinking Water Supply allocation = 16.2 TMC
Left for Irrigation = 8 TMC
Major Crop = Mustard (75%)
Other crops = Wheat, Gram, Fennel, Vegetables
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Case Study Area: Banas River Basin in Western Rajasthan, India

Global climate data to use:
- Daily Min and Max Air temperature
- Daily Precipitation

Periods we are interested in:
- Reference period (1971-2000)
- 2011-2040, 2041-2070
Statistics of observed precipitation data showed:

- Annual average precipitation in Banas basin: **585.60 mm**
- Annual Precipitation varies from: **416.80 mm to 861.90 mm**
- Very high variability in the annual precipitation affects the water availability as well as the crop yields in the basin

Temporal variation of the annual average precipitation in Banas basin

*(increasing trends found only at few stations)*
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Temporal variation of the Minimum average temperature in Bisalpur dam command area

Statistics of observed temperature in Bisalpur dam command area:
- Max average temp.: 32.60 °C
- Min average temp.: 18.95 °C
- Mean average temp.: 25.77°C

Results of Trend analysis:
- Max temp.: Falling (non significant)
- Min temp.: Rising (significant)
- Mean temp.: Rising (non significant)
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Indicators for Banas basin (water and agriculture):

i. Mean Temperature over various time horizons

ii. Max Temperature over various time horizons

iii. Min Temperature over various time horizons

iv. Max Temp > 30°C for mustard

v. Max Temp > 25°C for wheat

vi. Mean Precipitation over various time horizons

vii. Standard Precipitation Index (SPI) for drought

viii. Mean Flows over various time horizons

ix. $Q_{75}$ Flow for dependable flows
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**Workflow Progress**

- **Step 1** Ensemble climate variables: In progress
- **Step 2** Bias Correction: In progress
- **Step 3** Production of Indicators: In progress
- **Step 4** Mapping: In progress
- **Step 5** Adaptation Measures: In progress
Climate Change
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Step 1
Ensemble climate variables

- Daily rainfall - Gridded (0.5°) and Station rainfall data collected and analysed.
- Daily temperature - Gridded (1.0°) data collected and analysed.
- CDS seasonal data downloaded but November to March Temperature & Precipitation data is not available.

Trends of Annual Rainfall
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**Step 2**

**Bias Correction**

- To be carried out after:
  - Getting complete datasets from CDS for the study area.
  - Learning the Bias Correction Tool at the GA.

**Step 3**

**Production of Indicators**

- 9 Climate Impact Indicators (CII’s) finalized for the water and agriculture sector climate change impact assessments.
- Indicators applied for the historical climate datasets:
  - 9 grids (0.5°) selected for rainfall.
  - 4 grids (1.0°) selected for temperature.
Initial inputs for Story Mapping has been provided to C3S.

Work on the interactive atlas is in progress.

Will be updated as and when the results from the analysis becomes available and also based on the future interactions with the stakeholders.

The initial adaptation strategy based on the interactions with the stakeholders has been planned for the study area, particularly with respect to the agricultural sector.

The complete set of adaptation measures shall be designed based on the outcomes of the application of the CII’s for the reference period and the future time horizons.
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Knowledge Brokering

- Field visits have been made to interact with clients (WRD, Rajasthan & Agriculture Dept, Rajasthan) including farmers.
- We have presented the objectives of the project to clients and taken their feedback on the type of CIIs that will help them in their decision making of reservoir operation and crop management practices.
- The clients are sharing field data required for hydrological modelling and bias correction.

Visit to Bisalpur Damsite on 8 Nov 2017 with WRD Engineers

Meeting at Bisalpur Dam office in Deoli for discharge data collection on 15 Feb 2018

With lady WRD Engineers at Bisalpur Damsite on 8 Nov 2017

Meeting at Bisalpur Damsite (control room) on 14 Feb 2018
Field visit to KVK, Tonk, a research extension centre of Agriculture Dept in Rajasthan was made. The KVK covers the entire Tonk district including four blocks (Tonk, Toda Raisingh, Deoli & Uniyara) of Bisalpur Dam command area.

Tonk District Details:
- Agro climatic Zone – Semi Arid Eastern plain zone III A
- Population : 14,21,326 - Male : 7,28,136  Female : 6,93,190
- Literacy – 61.6%
- Total Geographical Area – 717958 ha
- Total Cultivated Area – 3347528 ha (2016-17)
- Cropping Intensity – 140%
- Total Irrigated Area – 275366 ha (2016-17)
- Soil type
  1. Deep Brown Loamy
  2. Medium Brown Loamy
  3. Red Gravelly Loam Soil
  4. Deep Dark Brown Sandy Soil
- TEMP. Max – 43.4°C
- TEMP. Min – 4.2°C
- Average Rainfall – 559.8 mm
Visit to Irrigation Dept office in Jaipur (under WRD, Rajasthan) was made.
Discussed operation aspects of Bisalpur Dam with the Director (Hydrology) and objectives of our project.
Collected observed rainfall data of about 50 rain gauge stations within the Banas basin.

It has been informed by the client that the inflow to Bisalpur dam is estimated based on the discharge at Triveni G&D site which is about 55-60% of the area contributing inflow to the dam.
Based on the calculated total inflow in the month of October, water allocation for drinking water and irrigation is done.
If the inflow is less, irrigation supply is curtailed.
Work on climate change effects has not been carried out for this region so far.
The government of Rajasthan recognised the water resources and agriculture vulnerability being in the state with one of the lowest adaptive capacity which makes immediate action on climate change crucial.

The Rajasthan State Action Plan on Climate Change (under Prime Minister Council on Climate Change) proposes many strategies for state mission on water resources and agriculture among other sectors.
The methods and results generated in the present study will help the clients namely, Water Resources Department and Agriculture Department of Rajasthan State in their actions like:

(i) Setting up dedicated facilities with advanced computing systems and customize information on impacts of climate change for regional water basins/sub basins/watersheds

(ii) Conducting training programs for government officials to facilitate the understanding of the impacts of climate change on water resources and familiarize them with modelling outputs and its significance for decision making

(iii) Educating farmers about matching land-use systems with water availability by adopting water efficient practices and low water requiring crops for agriculture, etc. Moreover, all the information produced within this study will be open source which will prove to be useful for other socio-economic sectors in terms of climate change awareness
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**Failure of Irrigation supplies in 2017**  
Due to less inflow (less than normal rainfall in monsoon) in the Bisalpur reservoir in 2017, irrigation supply was curtailed to half, i.e., only 4 TMC released from Nov to Dec against normal supply of 8 TMC from Nov to Feb.  
Farmers in the head reach took to pumping (using diesel pumps) from the right main canal having some stagnant water in the month of February 2018 in order to save the crops.

- The results of this case study will help decision making at a local/regional scale (approximately 40000 km² including Banas catchment up to Bisalpur dam and the downstream irrigation command area).
- Long-term adaptation strategies could be developed on the basis of CIIIs produced using CDS global climate data, and hydrological models, e.g., future scenarios of water availability will be helpful in improving reservoir operation, future scenarios of temperature and precipitation will help in best crop management practices.
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**Overview of Progress**

- Observed data of daily precipitation collected
- Gridded data of daily Temperature procured
- Observed data of daily Discharge collected
- Trend analysis of historical data carried out
- GIS based thematic maps of basin, sub-basin and command area prepared
- Field visits and meetings with clients carried out
- Evaluated few CIIs for reference period using observed data
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Work Plan for remaining work elements

- Extraction of global temperature and precipitation data from CDS for all the 19 GCMs for both emission scenarios
- Bias correction of the GCM data
- Calibration of hydrological model for the sub basin up to Triveni G&D site
- Production of CIIs for future time periods
- Provide regular inputs for Story mapping and interactive atlas
- Regular interaction with Clients and presentation of results to them
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Expectation from the General Assembly

- Access to global climate data from CDS for all the 19 GCMs for both emission scenarios
- Learn bias correction/downscaling techniques
- Understanding quality assurance using QUACK