

An Indian-Australian research partnership

**Project Title:** **Droughts in a changing climate: an integrated multivariate approach**

**Project Number** **IMURA0665 (5)**

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## Research Academy Themes:

**Highlight which of the Academy's Theme(s) this project will address?**

(Feel free to nominate more than one. For more information, see [www.iitbmonash.org](http://www.iitbmonash.org))

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. Clean Energy
4. **Water**
5. Nanotechnology
6. Biotechnology and Stem Cell Research
7. Humanities and Social Sciences

## The research problem

*Define the problem*

Droughts are one of the most important natural hazards that affect the society significantly in terms of mortality and agricultural productivity. The interaction of extreme temperature regimes and limited water availability in both India and Australia have historically shaped the way people live and how agriculture is managed (in particular through irrigation). Recently growing populations, a rapid economic growth and subsequent urban development, has led to a sharp increase in water demand. Coupled with the intensifying climate change this is likely to exacerbate drought conditions in semi-arid countries such as

India and Australia. As a consequence, it is expected that heat-related health issues will lead to a higher mortality within the older generations (in particular in India), as well as putting crop yield and therefore food security at risk. The latter is caused by a combination of rising temperatures, shifts in precipitation dates, and reduced availability of water resources for agricultural applications due to anthropogenic pressure.

This necessitates robust methods for characterization, monitoring and prediction of droughts, if the above issues are to be managed under the changing climatic conditions. Understanding the interplay of several confounding factors affecting drought is important for long-term planning and management of water resources and for better drought preparedness in the short- and long-term. Most common drought indicators that are used to represent severity of droughts rely on a single variable. For example, the India Meteorological Department (IMD) uses the Standardized Precipitation Index (SPI) for real-time drought monitoring and prediction, which is solely based on precipitation observations alone, that may be inaccurate, depending on the measurement technologies.

This study aims at deriving an integrated multivariate drought index considering multiple hydrometeorologic and socio-economic factors for arriving at comprehensive drought risk maps for India and Australia. This will be achieved via a synthesis of observed ground and satellite-based data, land-surface/hydrologic model output and socio-economic indicators, exploring advances in statistical learning techniques. Such a definition of drought risk integrates drought hazard, in terms of hydrometeorologic conditions, and vulnerability, in terms of population density and water demands. Changes in severity-duration-frequency curves that connect drought magnitudes and their chance of occurrence will also be studied with an aim to understand and quantify the influence of climate change and other stressors. Finally, this study aims to arrive at projections of integrated drought risk maps for future socio-economic and climatic scenarios that can aid drought mitigation and long-term planning and management of increasingly scarce water resources.

## Project aims

*Define the aims of the project*

The following are the broad aims of the proposed research:

- 1) To propose a multivariate drought index considering several hydrometeorological variables and their influence on each other. This step involves integration of multiple station and satellite-based observation as well as running a land surface/hydrologic model at fine spatial resolution over India and Australia.
- 2) To obtain drought severity-duration-frequency curves at fine spatial resolution over India and Australia, and study changes therein, including examining links with global warming. This step involves multivariate statistical analysis incorporating non-stationarity due to climate change.
- 3) To integrate information on drought magnitude, frequency and vulnerability based on hydrologic as well as socio-economic indicators to develop risk maps for drought characterization and monitoring across India. This step involves fusion of observed and model-simulated datasets within a probabilistic framework. Advances in data-mining and statistical techniques will be explored for this purpose.
- 4) To obtain future projections of drought risk over India and Australia. This step involves preparing drought risk maps under changing socio-economic and/or climatic conditions using seasonal and long-term climatological forecasts.

## Expected outcomes

*Highlight the expected outcomes of the project*

Each of the broad aims of the proposed research mentioned above are likely to spawn new methodologies resulting in good quality journal publications. A first such study was published in *Water Resources Research* (Azmi, **Rüdiger**, Walker, 52, 2222-2239, doi:10.1002/2015WR017834). The severity-duration-frequency curves and integrated drought risk maps will be prepared for drought monitoring and characterization for the Indian region at fine spatial resolution (~25 sq km) over the entire

country. Investigations on the links between climate change, socio-economic factors such as population and water demands and varying severity, duration and frequency of droughts are likely to lead to a more comprehensive understanding of drought behaviour. Such an understanding will better inform future projections and aid real-time drought monitoring and mitigation, through an improved water resources management.

### **How will the project address the Goals of the above Themes?**

*Describe how the project will address the goals of one or more of the 6 Themes listed above.*

Droughts reflect water-deficient conditions. A comprehensive understanding of droughts is necessary for long term planning and management of water resources, and for disaster preparedness. India is a largely agriculture-dependent country with links between water shortage and the socio-economic health and prosperity. A major contributor to the Australian gross domestic product (GDP) is also agriculture, which depends on water availability. Therefore, information on droughts will aid manage water issues for both the countries. Moreover, these two countries also witness large climate variability that has inherent links with the hydrologic cycle and can complicate water availability. In the light of global warming and climate change, therefore, information on characteristics of droughts and their variations is all the more important. The proposed research aims at characterization, monitoring and prediction of droughts taking into consideration a comprehensive multivariate approach and incorporating the projections of climate and socio-economic changes. Thus, it suits the IITB-Monash Research Academy's water-themed (Theme#4, and partially Theme#7) goal of sustainable management of water resources.

### **Capabilities and Degrees Required**

*List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.*

The candidate should have an exceptional academic background and a strong interest in research. Candidates with BTech/MSc./MTech degrees related to the fields of Civil Engineering and/or Hydrology, or Environmental Science and/or Engineering, or Atmospheric Science, or Earth Science, or Applied Mathematical/Physical Sciences are encouraged to apply. A background on hydrometeorological processes, computer programming and basic mathematics including probability and statistics is favourable. Any prior experience of using numerical models (esp. hydrologic models) or handling large hydroclimatic datasets will be considered as advantage.

### **Potential Collaborators**

*Please visit the IITB website [www.iitb.ac.in](http://www.iitb.ac.in) OR Monash Website [www.monash.edu](http://www.monash.edu) to highlight some potential collaborators that would be best suited for the area of research you are intending to float.*

Please provide a few key words relating to this project to make it easier for the students to apply.

**Droughts; Climate Change; Extreme Weather; Hydrology; Water Availability; Data Mining**