Blunting the Shark's Teeth with Data

By Team H_2OX
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"Best of all things is water"
- Pindar (c. 522-443 BC), an Ancient Greek lyric poet from Thebes

CLIMATE CHANGE AND WATER

Post-COP26 in Glasgow, there is a growing recognition of the importance and scope of climate change and the urgency to meet the challenges brought about by it. Notwithstanding the coming decades of decarbonisation, a large amount of change is now locked in. The disruption and damage it causes will depend on preparedness and the ability to adapt.

"If climate change is a shark, then water is its teeth." Humanity's most precious resource, we rely on it for everything from drinking, cooking, and cleaning, to growing crops and supplying industrial processes. And yet, most people, especially in the Global South, are at the whim of capricious weather systems for this precious liquid! Some places will get wetter, some drier, some more variable: all will need data and systems to plan and secure scarce water supplies.

NEEDS FOR FORECASTING

Water departments around the world require accurate forecasts in order to manage water supply and meet water demand. Long-term planners also need insight into potential long-term changes, so they can direct investments sustainably towards potential solutions including climate adaptation.

In 2017 and 2018, the Cape Town water crisis revealed to the world how vulnerable a large city can be to prolonged drought. Day Zero was avoided by careful planning, severe water restrictions, and eventually rainfall. Improved data and forecasts are just one part of the strategies needed to anticipate and avoid disasters in other cities.

WATER STRESS IN BENGALURU

India poses many quandaries for water security and resource management. There is plenty of rainfall, but it is unequally distributed in time and space; mostly during the monsoon, and mostly in the north of the country. Bengaluru, in the south, faces a particular challenge. ***A large city of over 12 million people, it is reliant on reservoirs in the Kaveri river system to the west for most of its water supply. The principal reservoirs in this river system, the Krishnaraja Sagar and Kabini reservoirs, have held water volumes below the critical "minimum drawdown level" several times in the last decade.*** These events cause downstream curtailment which impacts food and energy security, domestic water availability and the environmental goods and services on which a healthy society thrives. These impacts are especially felt by poor and vulnerable populations.

Bengaluru showing surrounding water system.

THE H_2OX MODEL

Typically, hydrological models are built "bottom-up", requiring detailed information on soil types, land use, water extractions and more. To create something scalable to diverse geographies and water systems, we instead used a more general-purpose machine learning model. This is advantageous because it only requires precipitation data, and historical reservoir water level data.

Local static conditioning variables, runoff patterns, and demand patterns are learned implicitly by a neural network. Neural networks are algorithms whose data processing mimics the human brains functioning and seek relationships between diverse sets of data. There is a wide body of research examining the efficacy of neural network-based approaches to hydrological modelling, and the emerging consensus suggests that they are very effective for these tasks. This same code that we have developed can be applied for any reservoir, quickly returning predictions.

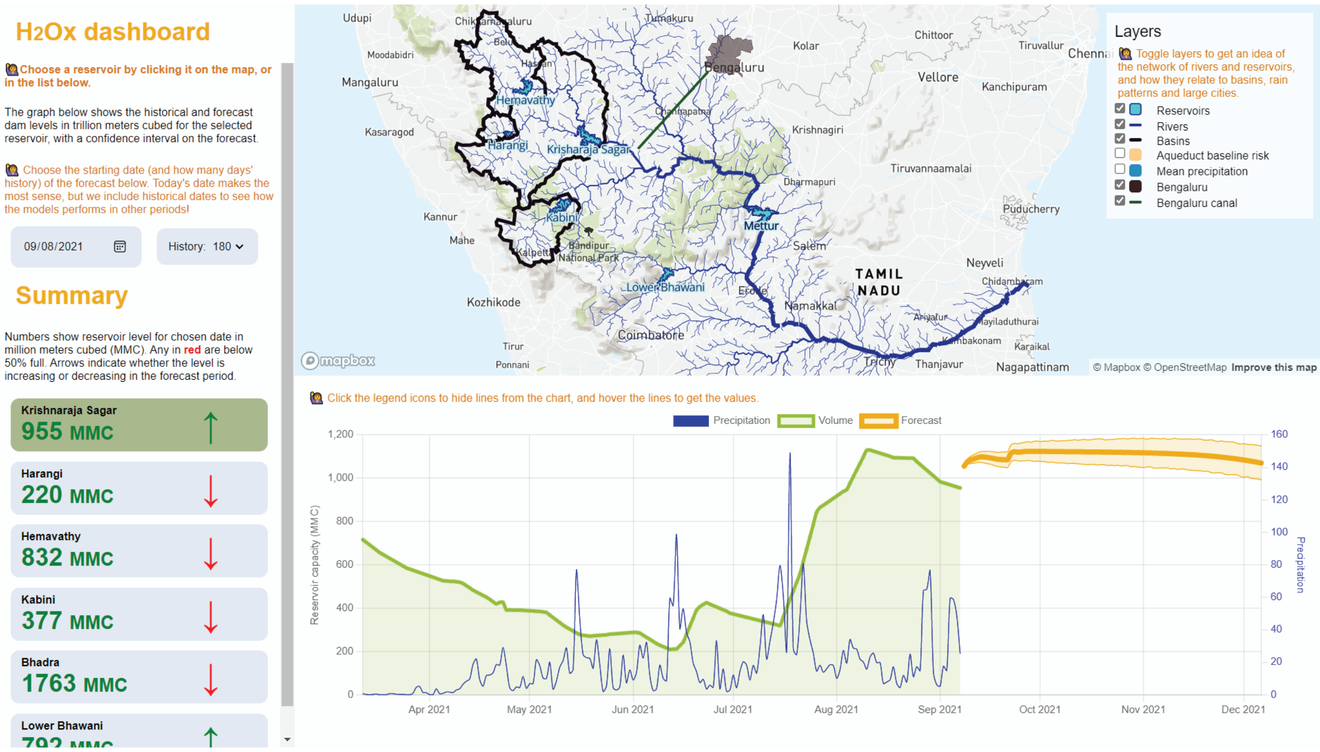
In addition to historical inputs, we have incorporated 15-day weather forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF), conditioning the model to predict reservoir levels on past and future weather data. ***The model has currently been trained for six reservoirs near Bengaluru, providing a three-month forecast from the present day, but also for any day in the past ten years, so its accuracy can be easily validated.***

LIMITATIONS

From this starting point, modelers and planners should certainly add some of the detail from traditional models. Neural network are limited in that they can only make predictions based on events that have occurred in the past. Thus, for example if a new industrial park with massive water demands is being opened in two months a neural network model cannot predict such an unique event. ***One solution here could involve forcing the neural network (to learn) with different scenarios to help plan for future changes and future weather conditions. Better data on land types and agricultural use could be incorporated to better constrain the different responses from different catchment areas.*** As the neural network is trained on historical data, it may not predict unprecedented changes in weather or usage, unless it shows up in the weather forecasts, or is explicitly included. That said, recent research suggests that these neural network models produce better forecasts of extreme events than any other family of hydrological models. In addition, there is an inherent range of uncertainty built into all climate data and subsequently, the model should be treated as a guide rather than an oracle.

DASHBOARD

To share the model with those that need it most, we created a dashboard at www.h2ox.org, which provides user-friendly access to historical data, forecasts from the model, as well as useful contextual geographic information, to help a variety of different types of users amongst reservoir operators and water departments. There are also quick figures on current levels and trajectories that can help planners understand the situation at a glance. An essential part of our approach was making the model results useful, and we welcome any feedback from end-users about how to best utilise the model insights.



Screenshot from H2Ox dashboard

OPEN DATA AND OPEN SOURCE

The tool is built using open data from India-WRIS (Water Resources Information System), the ECMWF, and others, and pays it forward by providing open application programming interfaces (APIs) that can be incorporated into other models and tools. ***The models and dashboard code will also be open sourced, so that other modelers and planners can contribute to them, and benefit from them.***

WAY FORWARD

The H2Ox team is keen to continue collaborating with WRI and the other teams in the Wave2Web hackathon, to improve the models, APIs and dashboards, and to increase the impact they have on water planners and citizens around the world. It's a small step, but hopefully a useful one towards securing sufficient clean water for all.

Graphics are created by authors.