



## UNDERSTANDING CHANGES IN THE GANGES RIVER DELTA UNDER CLIMATE CHANGE

Much of the landscape of Bangladesh is dominated by rivers. Around 700 distinct rivers flow through the country, with the largest of these being the Ganges, Brahmaputra, and Meghna. Together, these rivers form the Ganges-Brahmaputra delta, also known as the Bengal delta – the largest river delta in the world. This delta covers most of lowland Bangladesh and parts of Eastern Bengal, India, draining into the northern Bay of Bengal.



Around 140 million people live and work within the Ganges-Brahmaputra-Meghna delta, and it is also home to ecologically important mangrove forests, as well as several endangered and threatened species such as the Bengal tiger, Irrawaddy river dolphin, and Indian elephant. In total, the delta is estimated to support the livelihoods of around 300 million people, and is one of the most densely populated regions on Earth, with around 400 people per square kilometre.

However, there is a serious risk of flooding within the delta. The river channels of the Ganges-Brahmaputra-Meghna are narrow and complex, and flows in these channels are controlled by a combination of large river discharge during the monsoon season, and tides from the open ocean. Much of Bangladesh is low-lying, and serious floods caused by cyclones are common. Destruction of farmland and poor availability of safe drinking water are major concerns during these floods, due to a number of factors including increased salinity of the water. The effects of future climate change on the delta could be devastating, with estimates suggesting that a sea level increase of 0.5m could displace up to six million people.

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Modelling the river delta to understand how water levels and salinity could be affected by climate change is therefore of significant interest. There is a lack of observed data regarding water levels and river salinity in the region, making model simulations all the more valuable. Researchers have used ARCHER to create a model of the river channels in the delta, which will allow for simulation of various properties of the river delta under a range of possible future climates.



As part of the Ecosystem Services for Poverty Alleviation (ESPA) Deltas project, researchers from the National Oceanographic Centre, Liverpool have used ARCHER to build a model of the Bangladesh delta. This model is intended to simulate hydrodynamics and river salinity using FVCOM, which is an open source finite volume coastal ocean model.

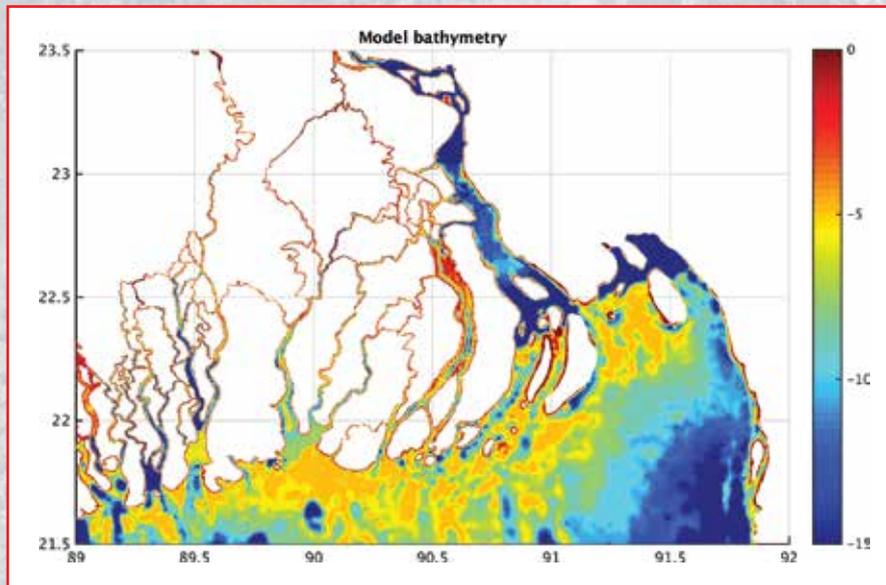
Any model of this area must capture a range of time and space scales; from daily tides to the annual cycle of freshwater discharge; from a single river channel to the Bay of Bengal. The model configuration contains 191,135 nodes and 343,039 elements in the horizontal and has 10 vertical levels. The unstructured nature of the model mesh allows variable resolution from 10km in the open ocean, down to 50m in the narrow river channels.

Several year-long model runs were required to help understand historic water levels and river salinity, as well as making projections under future climate and river management scenarios. The code and set-up was then

shared using ARCHER with partners at BUET (Bangladesh University of Engineering and Technology). This work has recently been published in the journal Estuarine, Coastal, and Shelf Science.

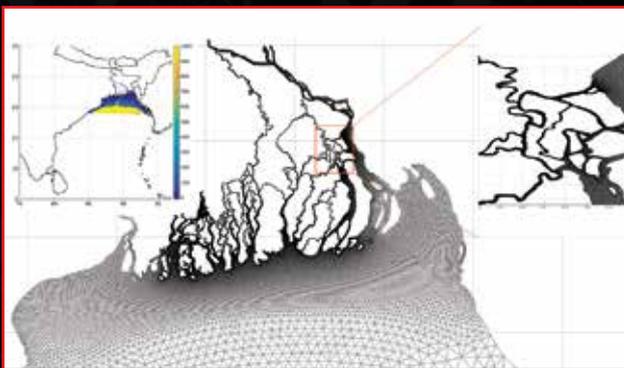
This technology has also contributed to the development of an integrated model, which takes into account human factors as well as

the physical environment. The integrated model (Delta DIEM) makes projections of agricultural crops, drinking water salinity, poverty and human well-being.





The outputs of using the model will inform a soil salinity and agriculture model of the area, as well as giving information about locations of safe drinking and irrigation water.



The creation of this model has had a number of benefits, both economically and scientifically. This was the first 3-D baroclinic model, which can simulate hydrodynamics, water levels, and salinity in a number of scenarios, from open-ocean to inland rivers. This means it will not only be useful to the Ganges delta where it was created, but also in modelling other areas of the world that are heavily affected by changing water conditions. This model will be used by stakeholders in the General Economic Division of Bangladesh, and the outputs of using the model will inform a soil salinity and agriculture model of the area, as well as giving information about locations of safe drinking and irrigation water.

Scientifically, the work that was undertaken to create the model has improved our understanding of the interactions between tides and rivers in a complex delta region, which is a key component of understanding how water levels in coastal areas change over time, and what factors influence these changes. The finite volume coastal ocean model (FVCOM) used in this study was used across the UK and Bangladesh, contributing further to understanding these changes, which will enable more accurate predictions of water changes in future. External partners have been trained to use the technology, further adding to its worldwide effectiveness. The authors have also been able to further understand factors affecting river salinity in a monsoonal and tidal environment such as the Ganges delta, which will allow them to predict which areas may be affected, preserving farmland and identifying safe areas of drinking water. This model is also a facet of the Integrated Delta-DIEM model which is used in stakeholder workshops, to demonstrate the physical and social impacts of future climate and river management scenarios.

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[www.archer.ac.uk](http://www.archer.ac.uk)



#### About ARCHER

ARCHER is the UK National Supercomputing Service. The service is provided to the UK research community by EPSRC, UoE HPCx Ltd and its subcontractors: EPCC and STFC's Daresbury Laboratory, and by Cray Inc. The Computational Science and Engineering (CSE) partners provide expertise to support the UK research community in the use of ARCHER. The ARCHER CSE partners are EPSRC and EPCC at the University of Edinburgh.

#### The eCSE Programme

The Embedded CSE (eCSE) programme provides funding to the ARCHER user community to develop software in a sustainable manner to run on ARCHER. Funding enables the employment of a researcher or code developer to work specifically on the relevant software to enable new features or improve the performance of the code.

#### The Case Study Series

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