An important part of our research is investigating how reinforced riverbanks, like this one at Chandpur, influence the river's evolution. Do they reduce the problem of bank erosion, or do they simply move it elsewhere?

Hidden from view at the bottom of Bangladesh's large rivers are gigantic holes up to 50m deep and several kilometres long. Mark E Vardy explains how studying them is vital for understanding how large rivers evolve and affect the lives of hundreds of thousands of people living on their deltas.

Scouring **Bangladesh**

It's 6am on Thursday 25 September 2014, and the sun is beginning to rise over Bangladesh. I am sat on the bow of our survey boat, MV *Kokilmoni*, watching the Meghna River slowly emerge from the pre-dawn gloom. Around me the river is a hive of activity, despite the early hour. In the far distance, large cargo vessels are leaving Chandpur for up-river ports such as Dhaka and Aricha. Along the banks, men and women are bathing and washing, breaking the eerie silence with the slap of clothes on water. Around us dozens of small wooden fishing vessels loom out of the mist, making the most of the relative cool.

This scene is played out every morning of our ten-day survey, and shows the close bond between the people of Bangladesh and their rivers. The relationship, however, is complex. The World Bank estimates a third of Bangladesh's population – about 50 million people – still live in extreme poverty, surviving entirely on what they can farm or fish. These people depend on their rivers for fresh water, fertile soil and fish. But the rivers can also be deadly; each year, flooding during the monsoon and cyclonic storms kills an average of 6,000 people and leaves many thousands homeless.

In Europe, we think of the hazard associated with rivers primarily in terms of them overtopping their banks and causing flooding as happened in the UK in February 2014. In Bangladesh, though, loss of land to bank erosion is also a significant problem. On average, the River Brahmaputra discharges almost 40,000m^3 of water – enough to fill 16 Olympic swimming pools – into the Bay of Bengal every second, making it the third-largest river on Earth. Rivers this big can erode up to a kilometre of river bank in a single year, destroying houses, roads and other infrastructure

We have come to Bangladesh as part of an international research project to try and improve our understanding of how these rivers evolve. In particular, we want to get a better understanding of what factors influence how a river alters its course and develop models of how these rivers might change in the future. We hope to apply our results by working closely with organisations such as CEGIS (Center for Environmental and Geographic Information Services) in Dhaka. CEGIS has direct responsibility for predicting bank erosion for the hundreds of thousands of people living near the river banks.

This is our second field season in Bangladesh, after another ten-day expedition in June 2013. We have targeted specific locations where the rivers are most dynamic and have the greatest potential to erode their banks. This includes where the rivers narrow, when two rivers join together and at sharp bends.

Our work is a unique collaboration between marine geophysicists and river scientists, and for the first time we're using high-resolution geophysical techniques normally used in the ocean on these rivers. These techniques – which include multibeam bathymetry and seismic reflection – use sound to map the shape of the riverbed and the structures in the sediment beneath it, allowing us to understand not just the river's current state, but also where it was in the past. These data allow us to confirm new models that help to predict where erosion may occur in the future.

Greg Sambrook Smith

In 2013, we went north-west from Dhaka and acquired data from two of the largest and most dynamic study areas: where the Brahmaputra and Ganges rivers join, and where the Brahmaputra meets the Meghna. In 2014, we headed south from Dhaka, acquiring repeat data at the confluence of the Brahmaputra and Meghna, but also visited new study areas closer to the coast where the influence of ocean tides also becomes important. Together, these sites cover a broad spectrum of environments that can influence river migration.

Hot days on the river

Bangladesh is not an easy place to work during the latter stages of the monsoon. Daytime temperatures regularly top 35°C and the humidity rarely drops below 80 per cent. At night there is little respite from these punishing conditions; temperatures drop a little, but humidity stays high.

But the hot days and sleepless nights were all worthwhile given the quality of the data. We mapped features that illustrate the dynamic nature of these rivers; huge depressions cutting tens of metres into the sediment beneath the riverbed. In these big rivers, these depressions – known as scours – can be very large, becoming 'megascours' that are several kilometres long, about a kilometre wide, and up to 50m deep.

To put these megascours into perspective, they are isolated, steep sided, roughly the size of five Wembley stadiums laid end to end, and are formed in channels typically just a kilometre or two wide and 10m deep.

They are a dramatic feature in the hidden landscape of the riverbed that has never previously been studied in this detail. Scours are not unique to big rivers; smaller ones are found on all rivers, but the scale and mobility of these scours is unparalleled. Our 2013 data indicate they can move several kilometres in a single year and are an important indicator of the same processes that drive rapid bank erosion. Understanding the behaviour of these scours is therefore key to predicting future erosion.

The 2014 data also suggest that, even though the rivers get smaller and branch into numerous distributaries nearer the coast, the size of the scours does not change, although they may become less mobile. This illustrates the complexity of river erosion processes.

Our aim over the next few years is to use these data to develop a better understanding of the physical processes that control the formation and growth of these massive scours. This will allow us to confirm models that predict future river movement, which is critically important for low-lying countries, such as Bangladesh, where many thousands of people each year lose their homes, land, and whatever possessions they cannot carry to the cycle of erosion. With the predicted rise in sea level over the coming decades, there is real urgency in our efforts to understand these large, dynamic rivers better.

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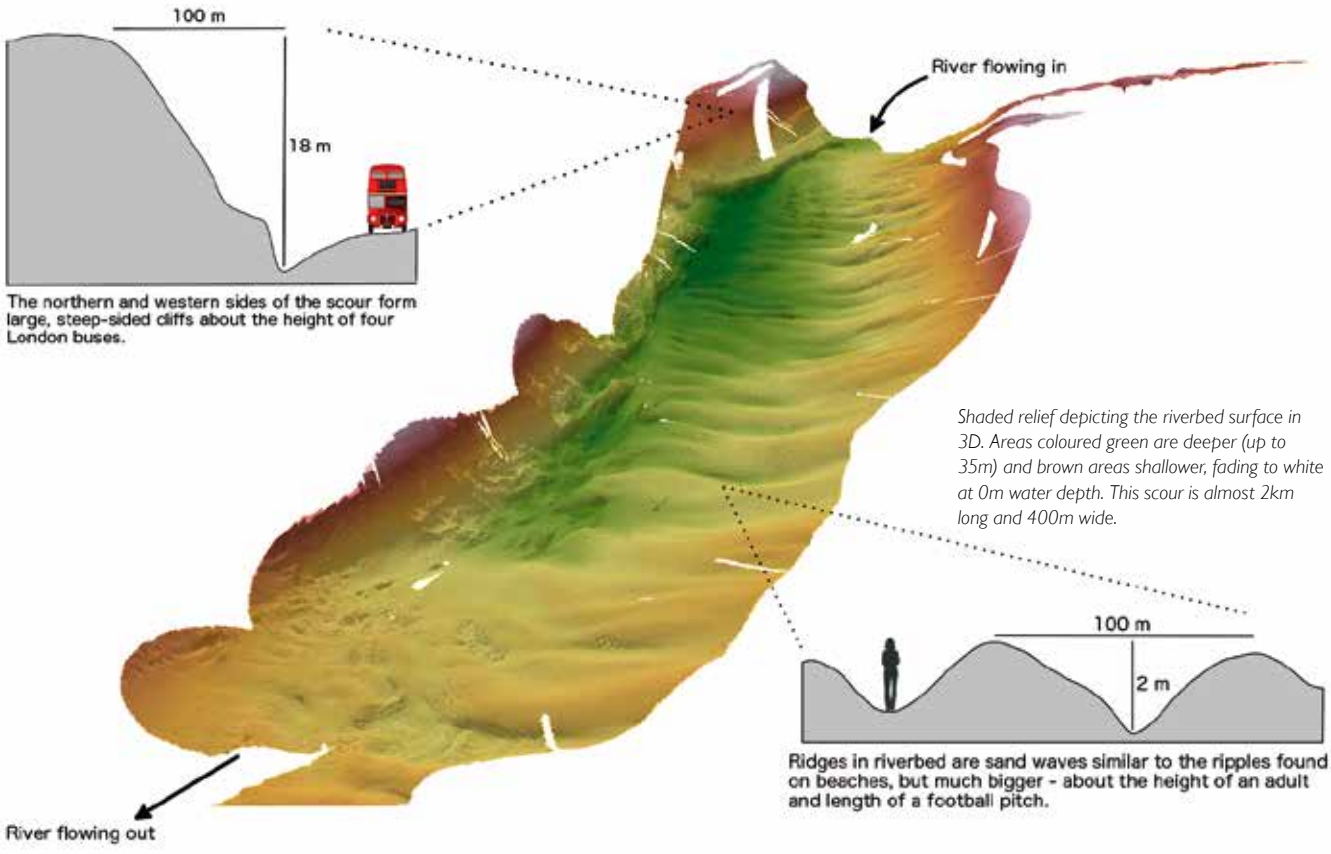
www.megascours.org



Shaded relief depicting the riverbed surface in 3D. Areas coloured green are deeper (up to 35m) and brown areas shallower, fading to white at 0m water depth. This scour is almost 2km long and 400m wide.