

**TIMES
EVOKE**

THE COLOUR OF WATER

Water, we often think, has no colour. And yet, it is the underlying hue of all life, enabling us to paint rejuvenation, well-being and joy across existence. Indeed, the story of the only planet which lives and breathes is coloured in water. Earth formed 4.5 billion years ago but the earliest fossils are 3.7 billion years old. It took that long for hydrothermal vents — where water, warmth and chemicals fused — to develop on ocean floors. Cyanobacteria emerged, making nutrition using sunlight and water and releasing oxygen into the world. Microbes grew complex eukaryotic cells and the first animals, simple sponges, appeared 800 million years ago. Cradled by fluid, life speeded up and the 'Cambrian explosion' occurred 550 million years ago when organisms developed hard anatomies. Slowly, the first creature clambered out of the 'primordial soup', clumsily but determinedly, onto a new land.

Water binds this epic together. No wonder 71% of Earth's surface is covered by oceans. These salty seas, 96.5% of all water, leave only 2.5% freshwater which living beings can actually use. Water is thus the rarest resource on Earth — with 1,50,000 rivers running across our planet, we might think we enjoy a glorious profusion but in fact, over four billion people already lack access to safe water. By 2040, one in four children worldwide will experience extremely high water stress. The Anthropocene's unmistakable stamp is here. Global water waste surmounts 9.5 trillion litres a year. Agriculture worldwide uses 70% of freshwater withdrawals — inefficient practices then squander 60% of this. Industry's water deployment is often baffling — making a pair of jeans requires 10,000 litres while growing one kilogram of almonds needs 9,000 litres. These amounts appear even more staggering when you hear climate change's watery drumbeat — as the world heats, water in its atmosphere alters, causing storms instead of steady rain which could safely recharge rivers. As we use water, not to live but to giddily consume — making a smartphone demands 12,000 litres — aquifer levels worldwide are sharply declining. Yet, we extract more and more water for further clutter, seemingly oblivious to how we are dissipating the very source of life.

However, there are solutions to this situation. As Times Evoke's global experts emphasise, growing our awareness of water is essential. This involves knowing how we use — and waste and protect — water as well as learning the story of water itself. Its antiquity holds the origins of life. The forms it takes now will predict how Earth itself shall evolve. Join Times Evoke in discovering waters of remarkable rivers. Their colours can match an entire rainbow — which, incidentally, is also water.

'Groundwater extraction moved Earth's axis — tubewells changed the planet'

Historian and cartographer **Anthony Acciavatti** is Diana Balmori Assistant Professor at the Yale School of Architecture. Speaking to Srijana Mitra Das at Times Evoke, he discusses water — and humans reshaping it:

What is the core of your research?

■ My work centres on the ways in which water — and how people use it — has reshaped landscapes. I spent a decade mapping the Ganga by foot and boat, looking at the transformation of this river basin. Today, my research focuses on groundwater — I study how India, being the largest consumer on Earth of this, has used groundwater to radically reshape its landscape.



You say the tubewell has transformed the world — why?

■ The tubewell is a fascinating — even a fantastic — technology because it transforms groundwater quite literally into infrastructure or a substrate for us to survive. You might not have a river or lake nearby but a tubewell allows you to drill into the ground and use a pump to get water out. It lets people make an oasis — and because it's so often highly privatised, it also creates a false sense of security as when millions tap into an aquifer, massive urban growth takes place, alongside sharp disparities of access to water.

To my mind, the tubewell is, to parts of South Asia, what the elevator was to New York in the first half of the 20th century. The city survived on those — it was impossible to do otherwise. Finally, canals have an incredible history worldwide — in South Asia, people even wrote poetry about them — but no-one has ever written verse about the tubewell. It's overlooked — yet, it's such important technology.

What are some of its global impacts?

■ One of the main issues with ground-



BRIM-FULL: Ganga has bridges to dams



DROP BY DROP: India is the largest user of groundwater — the Ganga (R) has a huge number of tubewells, enabling millions to farm and grow cities but also keep extracting a rare resource

water extraction, whether this is in North America, South Asia, Mexico, Indonesia or Italy, is subsidence — the ground starts to sink because so much groundwater is extracted, the soil compacts at the loss of so much moisture. That can wreak havoc with sinkholes developing. Interestingly, in Dwarka, Delhi, significant land sinking took place some years ago — through community efforts and government incentives of rainwater harvesting, that land has now been uplifted and the aquifer restored. This shows people can come together to understand groundwater as a shared commons instead of only seeing it as a privatised resource.

GOING IN-DEPTH

We don't think of groundwater much as it's under our feet and hidden away — yet, over half of our agriculture is irrigated with groundwater and half of our drinking water comes from this. Groundwater has been extracted so much that between 1993 and 2010, it's believed we've shifted Earth's axis by 80 centimetres. Tubewells operate on a planetary scale now — in 2017, 959 cubic kms of groundwater were extracted, which is around two Lake Eries. Water is one of the most heavily extracted resources on Earth today. Tubewells were integral to massive shifts like the Green Revolution and are still key to agriculture and cities — but they also threaten to bleed parts of Earth dry. I

study how to better integrate monsoons and groundwater recharging methods into our landscapes.

You say the Ganga river became one of the most heavily engineered landscapes on Earth — can you elaborate?

■ Consider how not only do we have the Ganges Canal, which is over 9,000 kilometres long, more water at Haridwar runs through this than in the channel of the Ganga pre-monsoon. It's a sort of constructed river that supports millions of people across the Ganga-Yamuna doab. That — coupled with the enormous number of other canal systems placed here and the volume of handpumps and tubewells — makes this one of the most hyper-



I MEANDER: Ganges branches to Hooghly

engineered landscapes on the planet. It's constructed also in a piecemeal sort of way — you need to figure out if this is a technology with a biology or the other way around.

What drove this level of hydro-engineering?

■ Canals on the Ganga Basin date back to the Mauryan empire. There were large numbers of baolis, kunds, stepwells, etc., built to capture rain and use groundwater. The eastern and western Yamuna canal systems were built and revitalised during the Mughal era and the East India Company period. The



Ganga Canal, built initially as a public works project in the 19th century by the East India Company, was supposedly for famine relief — however, it was also aimed at growing more lucrative cash crops. Many of these canals were later extended after Independence for agriculture and some land reform. Hydrological networks impose another kind of grid on the landscape — there was an interest in developing a highly centralised system to deal with a hugely variegated area like the Ganga-Yamuna doab and a capricious monsoon.

Does Gangetic engineering hold lessons?

■ We see canals and tubewells existing in a layered relationship now — one technology did not replace the other. Canals, kunds, baolis and tubewells have always been in conversation with each other — a canal would leach into

the ground, raise the water level and enable handpumps and tubewells to draw this out.

Today, as climate change grows, we will see more intersections like that — this is 'conjunctive irrigation' where you use multiple systems to access water. South Asia has engaged with altering monsoons for millions of years and developed unique systems to handle this. With climate change, more parts of the world will look like north India in terms of experiencing both droughts and floods — engineering systems on the Ganga will be an example of climate adaptation which other countries can learn from. Instead of importing models, there will be an exporting of these technologies which intelligently engage the rhythms of water, from rivers to rain.

You studied groundwater in the Sonoran Desert in North America — are there resonances with India there?

■ One fascinating aspect of looking at groundwater is that this draws together places we might not imagine as having affinities. Even though the political structure, land tenure rights or density of Arizona and northern Mexico seem so different from north India, patterns of urban growth and the highly privatised way of extracting ground-water produces many parallels in farming and cities. All these places also experience immense subsidence because of massive water extraction — importantly, with these private, often-competing systems, there are cascading effects similar to a cyclone in terms of who pays for a resource, who is responsible for damaging it, who manages public space, who adjudicates private responsibility, etc.

Which 'terrestrial and celestial technologies' have managed India's environmental resources?

■ I've looked at the history of remote sensing, especially under the Indian Space Research Organisation (ISRO), which monitors agricultural production, crop diseases, etc. 'Terrestrial' teaching practices took place about plant yields, etc., but a 'celestial' set of technologies, like satellites orbiting Earth, intensively took photos and recorded data to get a big picture of where practice and information could intersect. With India's long-standing focus on an agrarian economy, that mix has persisted today and is trying to better understand and manage the environment, from pesticides to tubewells.



GATOR-RAID: Gharials are Gangetic species



WATER BABIES

■ The **Betta splendens** was once called **Siamese fighting fish**. Endemic to **Thailand**, these gorgeous, territorial fish were bred in the 15th century for gambling matches, similar to cockfighting. Now, this 'designer fish' is seen far more in aquariums — yet, the betta must remember **rice paddies and streams in Thailand, Cambodia, Laos, etc.**, where it breathed calmly at water's surface, using its labyrinth lung

■ We imagine **jaguars** as prowlers — but the **world's third-largest cats are also terrific swimmers**. In the Amazon rainforest, **jaguars live near rivers, diving in and submerging themselves, hunting fish, turtles and caiman**. Today, half their range has been lost — those left face poachers seeking their beautiful skin, teeth, etc., used as 'medicine' for humans beyond cure



■ The **Mandarin duck** is a stunning waterfowl — it's **dimorphic with gorgeous males and subtly-shaded females**. Found in **China, Japan and Russia**, the lovely bird — the male has 'whiskers' while both genders sport stripes — was also raised in captivity in the UK. It escaped, **found by streams, nesting in tree holes** from where parents coax ducklings to take their first swim



Research: National Geographic, Encyclopaedia Britannica, Smithsonian Magazine

'Tectonics pushed up the Himalayas — they brought monsoons, creating the Indus 50 million years ago'

Part of Peter Clift's research is based 66 million years ago — but the geologist conveys an excitement which makes you feel his subject emerged just yesterday. In fact, it didn't, as Clift explains, 'I'm interested in the Indus river; when it was born and how it developed. Recently, I've studied the evolution of the river over the last 10,000 years,' — a blink in the eye of geophysical time — 'To see how it may have interacted with human societies. More broadly, I'm interested in the Indus as a way to look at evolving environment and climate in South Asia.'



How old is the river after whom our very civilisation is named, TE asks? Clift outlines, 'The Indus seems to have been formed when the Indian continent collided with mainland Asia — it's probably at least 50 million years old. The big eastern tributaries in Punjab joined the mainstream coming out of Tibet and flowing through Ladakh around then. But there's some discussion about how

Peter Clift is Professor of Earth Sciences at University College London (UCL). He tells Srijana Mitra Das at TE about the Indus River's birth — and shape-shifting journey:



FIFTY SHADES OF BLUE: The iconic Indus river meets the Zaskar in Sangam within the lap of the Himalayas — it flows northwest across Ladakh, forming its famed tributaries

with geophysical entities — the Thar desert moved a little bit east and west through time. That pushed some rivers to the west — when the Thar moved, so did the Sutlej.

There are further forces at play. TE asks Clift about how South Asia's tectonic landscape shaped the Indus — and vice versa. He replies, 'It's a chicken and egg story. Essentially, when India and mainland Asia collided, the first large mountains formed — they attracted rainfall. Those early rains allowed the Indus to form. That was also a trigger for making the Jhelum, Ravi, Sutlej and Beas. As the monsoon grew stronger, those got bigger. There's a feedback effect then — these rivers cut into the mountains. When

they scooped out rock and sediment, high peaks rose and became even taller. So, there's a virtuous circle between rainfall and tectonic activity — tectonic activity makes the Himalayas, Karakoram and the Tibetan plateau. Those strengthen the monsoon — as the Himalayas go up, the monsoon grows stronger and the rivers get bigger.'

Fascinatingly, these rivers are intricately linked to erosion. Clift

elaborates, 'The greater Himalayas are made of deep buried rocks, brought to the surface by shallower rocks being eroded away. This is why there are high mountains on the south side of the Tibetan plateau but not on the north side. There are no mountains like these in the Tarim Basin in western China — that's because it doesn't rain there and the monsoons cause the erosion. There's even a feedback here,' he points out, 'As you smash up Himalayan rocks into small sand grains, they break down into clay material which is washed into the Indian Ocean. As the Himalayas are so big, there's a lot of sediment. This process of breaking down these minerals removes carbon dioxide from the atmosphere. So, erosion by the big Himalayan river systems, including the Indus, is possibly one reason Earth grew cooler.'

Did this combination, red earth to falling rain, as it were, also shape the ecologies of the Indus? 'Oh, yes,' replies Clift, 'That certainly influenced animal life, especially fish and the famous dolphins that live in the Indus and Ganges. Ecology in South Asia is more strongly linked to rain than rivers. About eight million years ago, the monsoon got weaker — with a strong shift in ecology. It changed from forests to a lot more grassland and drier conditions in northwest India and Pakistan.'

ple sustained themselves in a desert, given a nice water supply from a small river? If you live by a big river and it keeps flooding, that makes your life hard, but a smaller river is simpler to control and easier to grow crops next to. That could have been something the Indus Valley civilisation used. Of course,' Clift adds, just as you settle comfortably into the thought of a happy little Harappan farming community, 'As the climate got drier, the Ghaggar no longer held enough and communities were left with no water.'

Were there crops which survived such ebbs and flows? Clift replies, 'There were certainly more drought-tolerant crops like millets. Farmers across Asia always adapted. Rice is very water-intensive, wheat, a little less, hence millets were likely a more sustainable choice. There are lessons here as with global warming, the monsoon could grow stormier and crops will need to be rethought.'

Finally, TE asks what sources Clift uses to study the Indus, born millions of years ago? 'I've worked with marine sediment cores from the Indian Ocean and Arabian Sea. We collected a long record offshore Mumbai with a consor-



INDUS DOLPHIN: Echolocating in the swirl

gium of countries. I also have shorter cores, like one kilometre deep under the ocean floor. I'm working on sediment from the continental margin offshore the Indus river mouth now. We also work onshore, drilling into the floodplain to collect sediment pores, etc.' Clift chuckles, 'Sometimes you can use things which other people have dug — we've had good luck with quarries where people made bricks. There, the mining company had dug a pit and we didn't have to drill. We could just go right in.' Perhaps 'dive in' would be quite accurate as well.



THE ELEMENTS DANCE: Indus, hill and cloud

much material also came from the East — in particular, there's a question about the Yamuna. Clift pauses here, like he's unveiling a detective story. He says, 'Now, 50,000 years ago, the Yamuna, which flows east into the Ganges today, was flowing west into the Indus. We think that stopped about 20,000 years ago. But it used to join the Sutlej and Beas once.' The Yamuna wasn't the only enigmatic river. Clift says, 'Rivers are constantly evolving and meandering, maybe not a lot but with implications for the people they interact with. Rivers also interact

THE TIMES OF INDUS



TOWN & GOWN: The Indus Valley civilisation grew in 2600 BCE, with nobles, seals and crops

READERS WRITE

Dear Times Evoke,
You are always excellent when it comes to catching the pulse of news! TE's interview (26th April) on the Indus Water Treaty (IWT) was so timely. Daniel Haines explained this very lucidly. With terrorism from Pakistan, India has decided to keep the IWT in abeyance and Pakistan will soon experience drastically reduced water flows. Environmental resources must be balanced with international responsibilities. Thanks, TE, an excellent interview.
— **MK Goel, Delhi**

I am a big admirer of TOI's TE as it has the most distinguished global experts. The IWT discussion featured Daniel Haines, one of the best-known world scholars on the Indus. Beautifully presented, the piece raised some interesting angles, including how the IWT could have been influenced by Cold War pressures acting upon India. Thank you for a wonderful article, TE.
— **T. Meenakshi Iyer, Chennai**

TE's discussion on aquatic contamination (19th April) and wildlife was excellent. Teachers could use this important information to discuss water pollution, drug manufacturers to make green drugs with less chemicals, environmentalists to work out safe medicine disposal and animal caretakers to protect wildlife from such hazards. Thank you for your forward-thinking mindset, TE!
— **Jayashree, Bengaluru**

Marcus Michelangelo's research on medicine pollution was such an eye-opener. There is hardly any data on this topic. Strict laws should be made for pharmaceutical companies on appropriate disposal and awareness must be raised among people about the impacts of our usage of medicines which are now poisoning delicate ecosystems. We must learn about this. Thanks, TE, for such an insightful article.
— **Rashi Beriwal, Gurugram**

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