

NOT JUST ANOTHER DELUGE



In a warming world, floods are no longer an annual affair in Assam, but a year-round crisis. As people struggle to cope with the new reality, some are already changing their cropping patterns and architecture

A report by **AKSHIT SANGOMLA** and **SEEMA PRASAD** in Delhi, **SHAGUN** and **AATREYEE DHAR** in Assam



PHOTO: SHAGUN / CSE

ASSAM HAS been under waters for almost 100 days in a row since this year's first wave of floods broke the river-banks on April 6. Over the next three months, the floods have swamped almost every village and affected every fourth person in the state. Though floods are an annual affair for Assam, the ongoing wave typifies the new normal that the state has been experiencing in recent years.

Typically, floods in Assam begin in June with the arrival of southwest monsoon. But lately, they have been occurring much earlier, lingering through the four-month monsoon season, sometimes continuing till October, and making more and more areas vulnerable to the disaster. In 2016, over 90 per cent of the state was in the grip floods that started as early as in April. The next year, the flood season began in March and continued till October, impacting more than 4 million people. In 2019, the flood season extended till November 1, making it the longest-lasting in recent times. The following year too recorded a similar prolonged flood season, affecting 5 million people, shows data with the Assam State Disaster Management Authority (ASDMA). In fact, an analysis of the eight years of flood data available with ASDMA shows that the state has been under waters for more than six months on three years—2017, 2019 and 2020, with

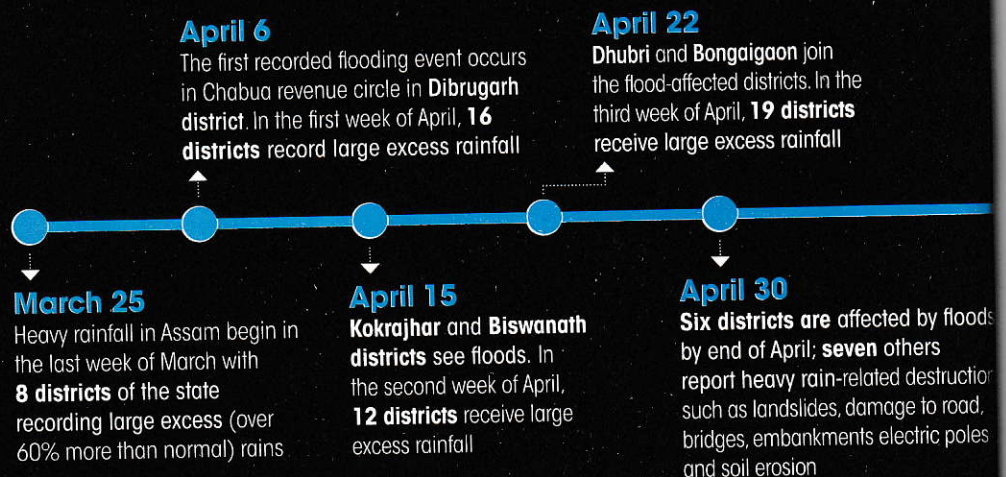
the flood season lasting till October in 2017, 2018, 2019 and 2020.

However, this year, the floods appear to be particularly fierce, even by the standard of the new normal. Within three months, the floods had spread to all of the state's 35 districts, affecting 8.9 million people. Till the magazine went to press on July 6, as many as 162 people had lost their lives, over 51,000 animals died, 98,000 people evacuated and 742,000 shifted to relief camps. On May 15, incessant rains in Dima Hasao district caused mudslides that enveloped the New Haflong Railway Station and nearly buried a tunnel on the national highway in the nearby Maibong town. Some 2,200 passengers in two trains were stranded due to the mudslides. Helicopters were brought in to evacuate 119 passengers, who were old and sick, along with 35 railway employees to Silchar in the neighbouring Cachar district. The others had to cross a damaged rail bridge to get to a rescue train. As rail and road links snapped, parts of the state were cut off from the rest of the country. This includes Barak Valley in southern Assam—comprising Cachar, Karimganj, and Hailakandi districts—and Darrang district in the central region of the state. According to ASDMA, by May 18, the floods affected 0.67 million people and displaced over half-a-million of them.

On June 16, as the flood water was starting to recede, residents of Darrang district

UNFOLDING DISASTER

The ongoing floods have swamped all 35 districts of Assam and affected 1 in every 4 people



woke up to storm water gushing into their homes and blocking almost every exit. The district became a confluence point where several tributaries of the Brahmaputra merged into the main channel of the river.

Nripen Nath is a resident of the district's Basachuba village, which is located along the Nona river, a tributary of the Brahmaputra. His locality had remained submerged by floods since May. But the June rainfall was the most intense spell he has ever seen, he tells *Down To Earth* (DTE). In all the flood seasons so far, only the waters of the Brahmaputra would overflow. But this time, as it rained incessantly for days, all the tributaries breached their embankments, drowning more than 80 villages. One embankment that was fixed after the floods in May collapsed again. "Water reached our knees even in the elevated parts of our house. We had no access to potable water or sanitation for four to five days, as both tubewells and toilets remained submerged," Nath says. The sudden and early onset of the floods meant that residents could not arrange to move livestock or save their crops.

As per ASDMA's flood report, some 317 embankments had been breached till the first week of July. Most flood protection structures in Assam are 50-60 years old. They were constructed on the main stem of the Brahmaputra and its tributaries in the 1960s and 1970s, and weakened over the years.

As on July 6, Assam received 41 per cent more rains than normal. Actual rainfall since June was 720.3 mm, as against the normal of 509.8 mm, as per the India Meteorological Department (IMD). Assam and the neighbouring Meghalaya together received the highest rainfall in 121 years in June, according to IMD's climate summary for the month.

IT SMELLS LIKE FLOOD

A strong pungent odour filled the air at Singimari when DTE visited in early June this village in Morigaon district, located south of Darrang district along the Kopili river, another tributary of the Brahmaputra. Vast stretches of matured paddy and jute crops lay submerged. "The smell is familiar to us. It is the smell of flood," says Dilip Sarkar, a resident of Singimari, standing at a camp he had set up along an elevated road.

Sarkar had moved to the camp in the third week of May, when floodwaters entered his village of 900 households. There had been intermittent rains since May 19, triggering floods. On June 4, at the time of DTE's visit, it started to pour again. Goats and chickens scurried across the camp. But in no time, Sarkar and his wife Rita guided them to a tin shade. Their children, who had already taken shelter under the shade, made sure that the livestock stayed put until the rain stopped. This routine appeared well

May 9

Floods start affecting new districts with urban flooding in **Jorhat**, even though there is no report of large excess rainfall from any of the districts in the first week of May

May 18

Between May 12 and May 18, there is large excess rainfall in **25 districts**. A total of **27 districts** see floods.

May 13

The floods spread to **Dhemaji** and **Kamrup** as rainfall intensifies again.

May 21

Floods reach peak intensity with the total number of flooded districts at **33**. Rainfall decreases after **May 19**

June 7

Three districts are still flooded. Rains started again, bringing more floods from June 8. Only **two districts** see large excess rainfall on June 2-8.

June 14

The floods spread to **eight districts**

June 19

There are floods in **33 districts**. This is the maximum extent of the floods in the three months. After this date, floodwaters start to recede but slowly

June 15

Floods spread to **18 districts** with **17 districts** receiving large excess rainfall in the preceding week

Source: Assam State Disaster Management Authority and India Meteorological Department

practiced, and for a reason. Sarkar and his family call the roadside camp their second home. They had moved to Singimari from their earlier village Bahakajari, located 20 km away, in 2004 after a massive flood had washed away the latter. Since then, every year like clockwork, as soon as the Kopili is in spate, they move from Singimari to the camp with some essential belongings in hand. Over the past one-and-a-half decades, Sarkar remembers only two years when he did not have to shift to the camp.

This year, their stay appeared to be longer and chaotic. In early June, just when the floodwaters from the second wave started to recede, there was another bout of intense rainfall. So Sarkar's family and others decided to stay put. The heavy rains also saw more families moving to the roadside, all of them carrying tin sheets, tarpaulin and bamboo sticks to set up their "second homes".

Hundreds of thousands of people in Assam spend the better part of their lives in such flood camps. These are typically 1.8 sq m by 1.2 sq m enclosures, with a make-shift bed on one side and a temporary kitchen on the other, without any provision for toilets. People usually go by boat to the river to relieve themselves. While the government has also set up flood camps, these are usually far from the villages and so are not preferred.

"Our life goes upside down at least three times a year," says Minnoti Devi, a 58-year-old resident of Roinhapatthar village in Morigaon. For people here, moving to camps is like a ritual that happens first in June, then in August and in October. This year, they had to relocate earlier than usual and have set up camps along a road that connects to their village by a bridge over the Kopili.

Internal displacement in Assam this year began sooner, in late March, according to the Geneva-based Internal Displacement Monitoring Centre (IDMC). As on April 30, some 16,370 people were living in displacement camps. On May 19, IDMC's near-real-time displacement monitoring tool showed Assam as the only spot in India where people had been displaced due to disaster and were living in camps. The tool suggested people

Typically, floods in Assam begin in June. But lately, they have been occurring much before the southwest monsoon sets in and lingering through the four-month rainy season

were in camps even in the 100 days before March, indicating that those affected by floods last year were yet to return. Analysis from the last five years (May 2018-22) shows that at any point of time, around 20,000 people in the state lived in camps, displaced by disasters like flood. Most of them have spent an average five to six months in relief camps.

Little wonder, then, that these flood camps have become permanent shelter for some. At a camp in Dhemaji, 370 km from Morigaon, residents shudder at the thought of the floods that had wiped their village Lakshisuti off the map, less than a decade ago. Without any home or a place to call their village, they were displaced multiple times every year by recurring floods. In June, when DTE visited them, their address was a small camp at the side of a road connecting Ladanguri and Sagili Gura villages. "The river Brahmaputra is just 300 m from here. Earlier, the river used to flow some 4-5 km away, but it expands every year. Next year, most probably you won't find us here," says Komal Basu Mathari.

Data with Assam's water resources department also shows that the average number of people affected by floods annually has steadily increased. In 1970-79, some 2 million people were affected by floods in a year on an average; in 1988-2005, the figure rose to 4.5 million a year; in the last 15 years it hovers around 5 million a year.

Climate activist Rituraj Phukan recalls that 30 years ago, people used to welcome floods as an annual brief event. They used to last for a week or two, and were predictable. Now, floods come in waves with increasing ferocity. "Even rainfall used to be moderate. But now there are sudden heavy downpours," Phukan adds.

"The rich biodiversity of Assam is due to the fertility of the topsoil that used to get replenished by the floods every year. Today, it is being washed away and there is widespread soil erosion," says Walter Fernandes, a senior researcher at the North Eastern Social Research Centre in Guwahati, adding that the infertile land is indicative of the changing nature and increasing frequency of the floods.



Frequent displacement of people in Assam has become a norm, with floods sometimes wiping out entire villages

Victim of its origin

Assam is naturally prone to flooding. Accelerating loss of forests, wetlands in recent years make it further vulnerable

ASSAM'S GEOLOGIC history makes it naturally susceptible to floods. The state is traversed by two mighty river systems—the Brahmaputra in the north and the Barak in the south. Of the 35 districts, 24 lie in the Brahmaputra valley and three in the Barak valley. This means a majority of the state's 31 million people are concentrated in these two river valleys, with 87 per cent of them living in rural areas.

What makes these two rivers ferocious is the unique geomorphic foundation of the

state. Assam is located at the easternmost part of the Indian tectonic plate. This is also the point where the Indian tectonic plate has been thrusting underneath the Eurasian plate, creating a subduction zone and the Himalayas. This means this land of plains and river valleys is surrounded by high hills and steep gorges, through which the Brahmaputra, Barak and their 44 major tributaries flow into the state.

Of the 33 major tributaries of the Brahmaputra, 20 are on the north bank and

have very steep slopes, braided channels, boulders, pebbles and coarse sand beds with heavy siltation, which makes them prone to flash floods. The other 13 tributaries on the river's south bank are less prone to floods, as they are flatter with comparatively less siltation. On the other hand, the Barak is highly meandering due to the erosion of its banks and riverbed, which makes it prone to flooding. Its 11 tributaries are also flood-prone as they are mainly rainfed. Together, these rivers drain 99.3 per cent (77,858 sq km) of the total area of the state. Since Assam also receives heavy rainfall due to its unique geography—the southwest monsoon winds take a swirl over the state before moving westward and causing heavy rainfall as Assam is surrounded by the hills of Arunachal Pradesh, Meghalaya and Nagaland—the rivers overflow the banks almost around the same time, causing widespread floods.

The heavy siltation and the role it plays in changing the rivers' flood plains makes the situation worse. Both Brahmaputra and Barak are young and unstable, and hence more prone to erosion, according to the Assam State Disaster Management Plan. A lot of silt and other debris come in with the tributaries flowing down the hills of Arunachal Pradesh, Meghalaya and Nagaland, and raise the level of the riverbeds. During heavy rainfall, these raised riverbeds augment flooding as the main channels fail to handle the sheer volume of water.

THE ROOT CAUSE

Trees usually act as a natural protection against floods, more so in hills, as their root systems bind the soil and along with other vegetation reduce surface run-off that can add to the floods. Over the last two decades, tree cover loss in many districts of Assam has been drastic. Between 2000 and 2021, the state lost tree cover over 287,000 hectares (ha), which is a 10 per cent decrease from the 2000 level, according to the Global Forest Watch, an initiative of global research organisation the World Resources Institute.

Assam is traversed by the Brahmaputra in the north and the Barak in the south. A majority of the state's 31 million people are concentrated in these two river valleys

The hill districts of Karbi Anglong and Dima Hasao together accounted for 60 per cent of the tree cover loss during the period, the highest in the state. The Kopili river that has flooded copiously since May this year inundating huge swathes of land even far away from its banks, also flows through both the districts. The other five districts that have recorded more tree cover loss than the state average also have major tributaries of the Brahmaputra flowing through them. All of them have flooded this year (see 'Barriers erased', p34). Cachar, another hill district, has the sixth highest tree cover loss in the state—just below the state average. The Barak flows through it, and in June the river brought extensive floods to Silchar and its surrounding areas in the district.

In Arunachal Pradesh, the districts with the highest tree cover losses—West Siang, Lohit and Lower Dibang valley—also have tributaries of the Brahmaputra flowing through them. The resultant increase in soil erosion in these areas deposits sand and debris that raises the riverbeds and intensifies the floods as the tributaries flow into Assam.

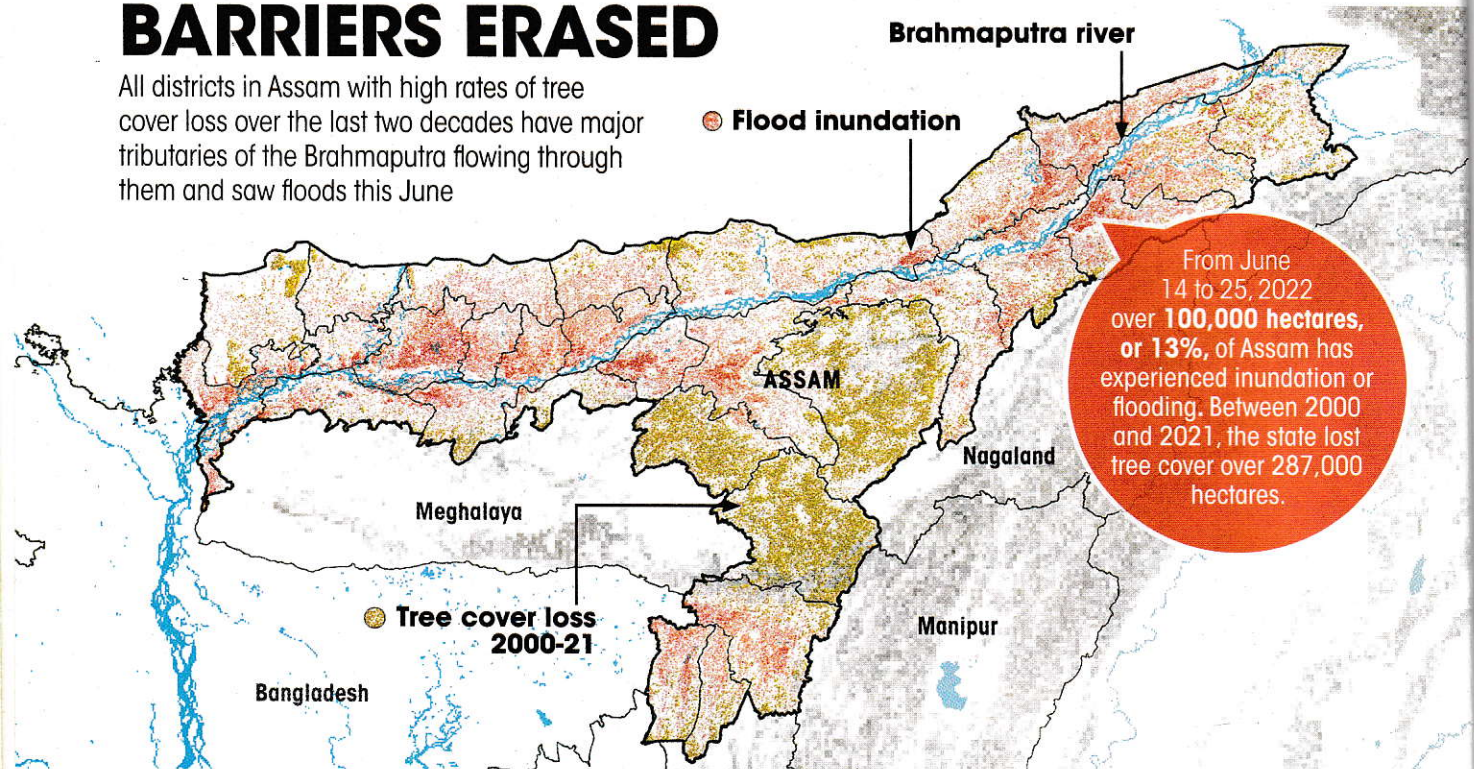
Wetlands or *beels* in Assam are another source of natural protection against floods. These act as sponges, breaking the flow of the floodwaters. Many of these ecologically important natural resources have deteriorated in recent years. While a wide-ranging analysis of the health of Assam's *beels* is unavailable, some studies of individual wetlands point to some of the possible causes.

A 27-year (1992-2019) analysis of the Khamranga wetland close to Guwahati shows that the wetland degraded each year, its size decreasing by almost 22 per cent during the period. The study by Jayanta Goswami from the directorate of census operation in Assam and his team shows most of the decline occurred between 2000 and 2010. The study identifies rapid urbanisation, industrial activities and lack of government intervention as the major factors for the degradation.

Another study on the Deepor *beel*,

BARRIERS ERASED

All districts in Assam with high rates of tree cover loss over the last two decades have major tributaries of the Brahmaputra flowing through them and saw floods this June



Note: Districts mapped as per 2011 Census data

Source: Copernicus Sentinel-1 SAR via Google Earth Engine, Global Lakes and Wetlands Database, Tree Cover Loss - Hansen et al., Science 2013

also close to Guwahati and Assam's only wetland of international importance under the Ramsar convention, shows a decrease in the storage capacity of the highly biodiverse site over the last two decades. The study by a team of researchers from various universities across the country shows that the storage capacity decreased by almost 27 per cent between 2001 and 2019. If these wetlands had been healthy, they could have lessened the impact of extensive flooding in Guwahati in June. The same could be said for other urban flooding events that have happened this year in Cachar, Darrang, Goalpara, Karimganj and Morigaon districts.

Another cause for the floods is the rapid change in the courses of rivers. An increase in heavy rainfall in shorter spans of time can alter the natural flow of the river. This trend is clearly visible in at least two major tributaries of the Brahmaputra: Subansiri and Dibang. They have drastically altered their course in recent years,

uprooting several villages along the way. The Subansiri has been confined within its embankments since 1954, because of which silt is deposited on the river bed instead of the floodplain.

Evidence from maps along with records of flood history data show that recurring large floods have breached the embankments, causing erosion of banks and changes in the river's course, according to a research paper published in the journal *Current Science* in April 2014. The paper traces the river's course since 1828 and finds that the river basin is moving from east to west. This would make the western region of Lakhimpur district and the other places on its path more prone to floods.

"Heavy rainfall days accelerate soil erosion along hill slopes that are devoid of forest cover. This increases the surface runoff of the rivers, which in turn results in their changed course," Partha Jyoti Das, head of climate and water hazards division of Aaaranyak, a non-profit based in

Guwahati, tells *Down To Earth* (DTE).

The new courses are often palaeo-channels or remnants of inactive courses of the river. These channels have been abandoned by the rivers for centuries, and where people have settled over the years. The flow of water from rivers changing course and resultant floods puts these settlements at risk. For instance, the recurring course changes in Kumutiya river, another tributary of the Brahmaputra, have led to the shifting of the entire Mas Dihiri village in Dhemaji district several times since 2007. Since 1960, the river has shifted by more than 3 km, and the village has had to move with it. In 2009 alone, the village had to shift by around 400 m towards the north of the river, according to residents. They claim that the river's course changes are becoming more unpredictable.

Because of the myriad channels and accompanying erosion, the river bed of the Brahmaputra has expanded significantly from around 3,870 sq km estimated between 1916 and 1928, to 6,080 sq km in 2006 and continuous load of silt has made the river bed shallow, as per the Assam State Action Plan on Climate Change (SAPCC). Another research paper published in the *Journal of Earth System Science* in July 2019 says that the total area of erosion and deposition on the river in 1973-2014 was 1,557 sq km and 204 sq km, respectively. "Increase in area (28 per cent) of the Brahmaputra during 1973-2014 is not solely due to bank erosion, but also for the bifurcation of streams without the loss of land," the study explains.

"Three factors could determine the changes in a river's course: changes in the type of material brought down by the rivers, high rainfall events and earthquakes and landslides in the upstream catchments of the rivers," says Chandan Mahanta, head of the civil engineering department at Indian Institute of Technology (IIT), Guwahati.

Coarse sand that is not normally found in the region is also being brought down from construction projects upstream.

An increase in heavy rainfall in shorter spans of time can alter the natural flow of the river. At least two tributaries of the Brahmaputra have altered their courses in recent years, uprooting several villages along the way

"Much of this coarser sand is being carried downstream by the Brahmaputra every year and is replacing fertile alluvial soils," says Arupjyoti Saikia, professor of economics at IIT, Guwahati and an expert on the Brahmaputra.

Assam's water resources department has built many embankments to prevent changes in the river course and floods, but these are often built with material from the river itself, which contains a lot of sand. "When the river flows with full strength during a flooding event and touches the embankments, the sand starts to sink or slump. Within a single season of flooding, the embankments are lost," says S K Patnaik, professor of hydrology at the Rajiv Gandhi University in Arunachal Pradesh. Moreover, some 70 per cent of the 423 embankments in Assam have already crossed their life span, which is 25 years after construction. All the embankments in the flood-prone Lakhimpur district were built between 1956 and 1965. "Over time, structural interventions in the form of dam projects and embankments have cropped up on the Brahmaputra's tributaries to serve short-term economic interests, without keeping long-term ecological concerns in mind," writes Prarthana Sen, a research assistant at the Observer Research Foundation in Kolkata.

In May this year, water from the Kopili hydro electric project in Dima Hasao district was released, causing the first wave of floods in the surrounding areas. Other under-construction dams also release water from sluice gates occasionally, and can influence the impact of floods.

"With reductionist engineering goals of 'training the river' without understanding the course and the flow regimes, these structural interventions raised the river beds, impeded the width of the flow regime during high monsoons, and led to the rising water levels of the Brahmaputra and its tributaries. Irrespective of whether these dams carry or do not carry a flood protection aspect, flood prevention as a strategy simply stands as a mere illusion," Sen adds.



Soaked and sceptical

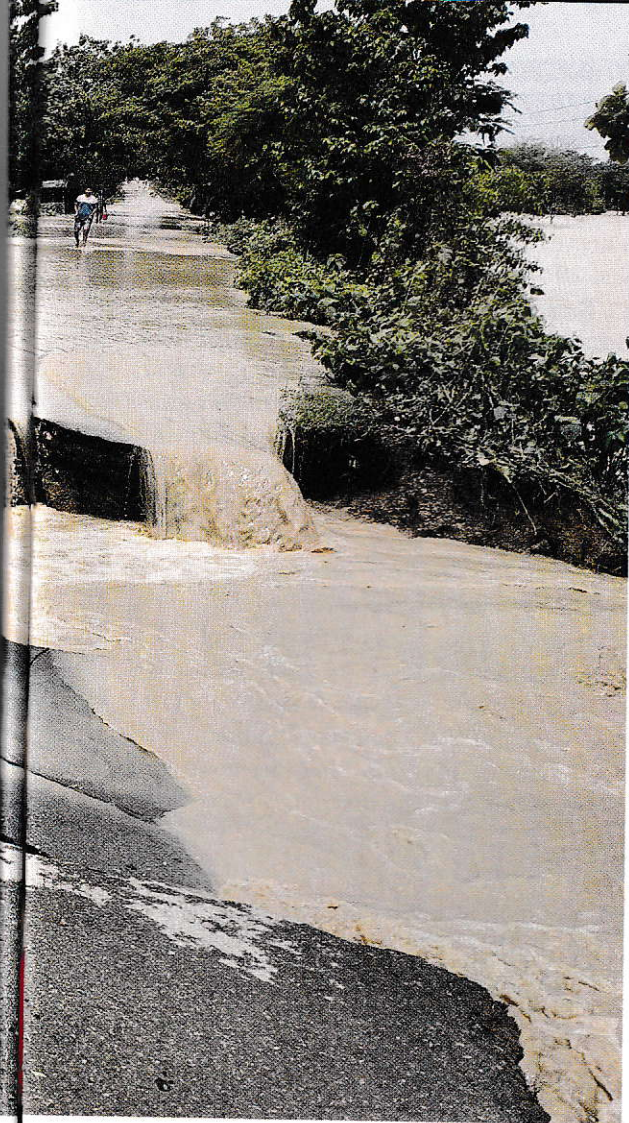
In a warming world, changes in Assam's rainfall patterns and floods are inevitable. Can the state cope with it?

OTHER THAN the unique geomorphology, human-induced factors have made Assam devastatingly flood-prone. This factor is the changes in climate, particularly in rainfall patterns.

The floods this year was foreshadowed by heavy rainfall events that started in the last week of March, when eight districts recorded large excess rainfall (over 60 per cent more than the normal). This rainfall intensified further in the first week of April, when 16 districts recorded large excess rainfall. In tandem with the rainfall events,

the first flooding was recorded in the Chabua revenue circle of Dibrugarh district in northeastern Assam on April 6, according to data with the Assam State Disaster Management Authority (ASDMA). Floods then impacted Kokrajhar district on April 12 and Biswanath district on April 15. In the second week of the month, 12 districts had recorded large excess rainfall, which increased to 19 districts in the third week. The rains became subdued in the last week of April. By the end of the month, a total of six districts suffered from floods while

PHOTO: PITAMBER NEWAR



◀ Recurring large floods have breached embankments, causing erosion of banks and changes in the course of the rivers

According to latest data with NITI Aayog, Assam is home to 10 of the top 13 districts in India that are most vulnerable to climate change. All 10 districts in the state experienced floods this year

seven others experienced landslides, damage to roads, bridges, embankments, electric poles and other infrastructure. These were not recorded officially as floods by ASDMA.

Between the second and third weeks of May, some 25 districts of Assam received large excess rains, according to data with the India Meteorological Department (IMD). On May 18, floods were recorded in 27 districts, which increased to 31 on May 21. By then, 33 districts had been impacted by floods. Rainfall decreased substantially after May 19, though many districts remained flooded till the end of the month and some even till the second week of June.

From June 14, monsoon winds enhanced with local moisture and winds from the west brought another bout of intense rainfall and floods, with 19 districts recording large excess rainfall on that day,

as per IMD. The number increased to 25 districts the next day. Between June 16 and June 22, as many as 19 districts received large excess rainfall. Arunachal Pradesh, the origin point of many tributaries of the Brahmaputra, also started receiving heavy rainfall on June 15.

Flooding in Assam, meanwhile, started again from June 13. The number of districts flooded jumped from eight on June 14 to 18 the next day. On June 19, the floods were at their peak with 33 districts impacted.

This early start of rainfall and floods, and flooding during the withdrawal and after the monsoon, has been observed in the last few years. "My observations show that the rainfall and flooding seasons have become longer in Assam," says Partha Jyoti Das, head of the climate and water hazards division of Guwahati-based non-profit Aaaranyak. He says that while the hills of Arunachal Pradesh sometimes see rainfall as early as March, they pick up in April and stay till October. So, the season for heavy rainfall has widened from June-September to April-October. The flooding season is between May and October. The unique flat terrain of Assam surrounded by the hills of Arunachal Pradesh, Meghalaya and Nagaland means that rainfall in any of these regions may lead to floods in the state.

Data from IMD, analysed by *Down To Earth* (DTE), also hints at this change. In 11 of the 14 years since 2009, there has been excess or large excess rainfall in Assam, Meghalaya or Arunachal Pradesh in at least one month during the pre-monsoon months (March, April or May), in the withdrawal month of September, or in October (after the monsoon officially ends). The main monsoon months—June, July and August—have not yielded much rainfall in these years, barring some months sporadically recording high rainfall that may have led to floods. Even in the other three years, there has been normal rainfall in only one of these months, while the season has remained relatively dry. An analysis by IMD shows Assam has recorded

Waters from Assam inundated Sylhet too

The northeastern region of Bangladesh faced the impact of heavy rains in Assam and Meghalaya. Destruction of its own wetlands exacerbated the situation

RAFIQUL ISLAM MONTU

THE SPELLS of floods in Assam and Meghalaya have had a severe impact on Bangladesh. In particular, the Sylhet division in the northeastern part of the state saw massive destruction in June, leaving four million people fighting for survival after their houses, paddy fields, fish ponds and livestock were washed away. Both Assam and Meghalaya have catchments for most rivers flowing into the Sylhet division. A part of the river from Assam's Barak valley flows into Sylhet as the Surma river. The town of Haflong in Assam's North Cachar Hills also saw devastating floods; it is upstream of Sylhet.

The first round of floods in Sylhet occurred on May 10, with the waters starting to recede after two weeks. But the second round, which occurred on June 16, exacerbated the adverse effects of the floods. Residents and officials of Companiganj and Gowainghat *upazilas* (subdistricts) of Sylhet district said that afternoon, water was knee-deep in several places, while in others it reached up to waist-level. The next morning, on June 17, water levels increased so much that people were forced to take shelter on the roofs of their houses.

The Bangladesh Flood Forecasting and Warning Centre says that apart from the heavy rains in Assam and Meghalaya, unplanned embankments along the region are also responsible for the heavy flooding. Experts say the destruction of Sylhet's traditional wetlands, known as *haors* (or *beels* in Assam), are also a factor. A *haor* is a bowl or saucer-shaped shallow depression. During the monsoon season, *haors* receive surface runoff from rivers and canals to become vast stretches of water. The purpose of such wetlands is to act as sponges and absorb excess rainwater. Encroachment and destruction of *haors* has resulted in the excess water flows through Sylhet, say experts.

"Excess rainwater cannot move. Various types of infrastructure have been constructed on Sylhet's *haors*. This is obstructing the flow of water. That is why the floods in Sylhet division have been so intense," says Saiful Islam, a professor at the Institute of Flood and Water Management, Bangladesh University of Engineering and Technology.

M Zakir Hossain Khan, a climate and sustainable finance analyst and executive director of the Change Initiative, an environmental research organisation in Dhaka, adds, "The *haors* have been ruined without conducting any kind of environmental impact survey. Various structures have been built on the *haors*. The rivers of Sylhet are also full of silt, as there is no dredging." Hence, the devastation in Sylhet is both natural and human-made.

a decrease in monsoon rains between 1989 and 2018.

Rainfall patterns have also changed. Between 1989 and 2018, monsoon rainfall in Assam showed a decreasing trend, recording below the long period average of 1,486 mm, as per the "Observed Rainfall Variability and Changes Over Assam State" report published by IMD. The state receives its maximum rainfall in July and over the period recorded, the month shows 21 per cent variability in rainfall. Overall, monsoon rainfall variation was close to 13 per cent.

The district analysis, however, shows dry drought-like conditions mixed with floods because of rainfall in other upstream districts. Most of the districts to the north of the Brahmaputra, like Barpeta, Sonitpur, Lakhimpur and Nalbari, show an increasing trend in rainfall, as per IMD's data. These districts host all the tributaries of the Brahmaputra that flow from the Himalayan mountains in Arunachal Pradesh. An increase in rainfall in these districts meant that tributaries overflowed more often, increasing chances of floods. Most districts also show a decreasing trend in the number of rainy days, indicating intense rainfall that further increases chances of flooding.

In many districts on the south bank of the Brahmaputra, tributaries flow down from other states, and so flooding is also mostly due to rainfall elsewhere. Golaghat district, where the Kaziranga National Park is located, is an example of such flooding due to the Doyang river which flows down from Wokha district of Nagaland.

Climatic factors also contributed to the deluge in June. "We are looking at how the moisture supply from the west is combining with additional moisture from the Ganga basin and the Bay of Bengal," Raghu Murtugudde, a climate scientist at the University of Maryland, tells DTE. Roxy Mathew Koll, a climate scientist at the Indian Institute of Tropical Meteorology, Pune, says excess moisture from the Bay of

Bengal could be due to the La Niña event in the equatorial Pacific Ocean and the developing negative Indian Ocean Dipole.

There are indications that some of these factors may be changing the rainfall patterns in the long term as well, as a possible impact of global warming. The low level jet-stream over India, a band of winds in the lower atmosphere circulating the Earth, brings moisture from surrounding oceans to the country and is an important component of monsoon rainfall. "This jet-stream has shifted north in the last few decades, so when the monsoon trough becomes well-defined, southwesterly winds pump more moisture into the northern part of the Western Ghats and carry moisture over to the mountains in the northeast, which can squeeze out heavy rain," says Murtugudde. This factor is also responsible for decrease in rainfall in Kerala.

The combination of climatic and non-climatic factors make Assam extremely vulnerable to climate change. According to latest data with Union government think-tank NITI Aayog, 10 of the top 13 districts in India most vulnerable to climate change are in Assam. All 10 saw floods this year.

Assam's State Action Plan on Climate Change (SAPCC) identifies change in rainfall patterns as one of the major causes of the state's vulnerability to climate change. The vulnerability may only rise as the planet warms and people make unscientific interventions in the ecology. Vulnerability and erratic monsoon have made 40 per cent of the state prone to floods (10 per cent of the country's total flood prone area), as per the Rashtriya Barh Ayog (National Commission on Floods). Consistent and persistent floods have been eroding 8,000 hectares every year; the state has lost close to 7 per cent of its land to erosion since 1954.

According to a 2017 study by the Tata Institute of Social Sciences, Mumbai, people living on the river banks are most prone to displacement as they are engaged in agriculture. An unstable cycle is



currently in place: people living on the fringes clear out forests to make a living, only for the land to be eroded. This erosion consequently decreases the water retention potential of the Brahmaputra and causes flooding.

A study by researchers from the Rajiv Gandhi University in Arunachal Pradesh and Guwahati University in Assam finds that from 1982 to 2019, more than one village was eroded annually in the northern part of Morigaon district, consisting of foothills and plains on the Brahmaputra's southern bank. The study states that 93 villages were eroded during the period and 16,918 families displaced.

This also means a huge economic loss for the state that dominantly depends on agriculture for sustenance. A look at the last seven years (2015-21) points to accumulative losses of ₹25,000 crore. This is 5 per cent of the state's projected GDP (gross domestic product) for 2022-23.

PHOTO: SUNNY GAUTAM



CHANGING WITH CLIMATE

People of Assam have been living with floods for centuries; they have become an important aspect of their economic, cultural and social fabric. Partha Jyoti Das says, "In Assam floods are a certainty and we will just have to adapt better to them. People need to be protected from the large-scale floods that happened in 2022 and have been happening much more frequently than before."

Dhemaji, one of the worst flood-affected districts, has some important lessons to share. The district is in the foothills of the Himalayas, traversed by the Brahmaputra and its tributaries flowing from the hills of Arunachal Pradesh. The river naturally changes its course frequently and flows through several channels. However, changes in rainfall patterns, especially heavy rainfall events upstream, have made it more volatile. The river has changed its course thrice in the past four years, say

People of Dhemaji district have adapted to small floods by raising their houses so that water does not enter them

residents. "We keep running as it shifts. We can never predict as to when floods will strike. We have to always be prepared," says Joynath Hajong of Ajarbari village in the district.

Residents of the village have developed many adaptations and coping mechanisms. When the surging waters of the Brahmaputra submerged Ajarbari in July 2020, people quickly shifted their families and livestock to a high, raised flood shelter. The shelter was built in 2017, on the demand of 57 households of the village. It currently serves as an immediate shelter when the floods come every year, with the river flowing 1 km from the village. However, is too small for all households and their animals. "Even if we have to run to camps, we can leave our animals tied up in the shelter for some time," Joynath says.

Almost all houses here are raised above the ground to protect them from frequent

small floods. The residents have also formed a village disaster management committee, comprising 13 people, with helps from Rural Volunteers Centre (RVC), a non-profit that works in Dhemaji and Majuli districts.

On the other hand, families in Nepalipatthar, Banai and Nalbari villages of the district have shifted their cropping patterns by cultivating more rabi crops. "We have started cultivating vegetables such as potato, tomato, eggplant, okra, mustard, pulses and peas instead of kharif paddy, which is slowly fading. We have also shifted more land towards boro rice, which is sown in November and harvested by March or April. We have also started rearing ducks," says Swadesh Hajong of Nalbari village.

The villages have also built elevated child-friendly spaces and constructed raised hand pumps to access water, with RVC's help. Similar efforts have been undertaken in Nalbari and Kamrup districts as well.

The state government is working on flood mitigation and adaptation, but the latest wave raises questions on its adequacy. Assam's SAPCC, which was prepared in 2015, is still under revision. "This was done to take into account the various events that have happened after the preparation of the last plan, such as India's submission of the Intended Nationally Determined Contribution in 2015 and the ratification of the Paris Agreement in 2016," says K S P V Pavan Kumar, the state's additional principal chief conservator of forests.

The new SAPCC has retained many flood adaptation projects and strategies from the previous document, and has also included new ones on flood resilience of river banks, plantations and flood resistant crops. The earlier draft of the plan had nine strategies, including detailed studies on understanding the river flow, impact and control of erosion and land reclamation; increase in frequency of floods due to climate change, extent and depth of flooding in 14 flood prone districts. The new plan has also retained development of indigenous and new adaptation strategies

and community-based flood early warning systems, along with a new project to develop of 100 climate change resilient villages.

The old SAPCC included a plan to construct multipurpose flood shelters in six flood-prone districts; this is already done in Majuli, Barpeta and Lakhimpur. "Work in the other three districts, Dhemaji, Jorhat and Morigaon, will begin soon and may be expanded to more flood-prone districts in the future," says Alakananda Medhi, state project coordinator at the Assam State Disaster Management Authority (ASDMA). But the shelters were not used this time as water did not come up to levels where evacuation was needed, claims Medhi.

ASDMA had to prepare a Flood Hazard Atlas and a Hazard Risk and Vulnerability Assessment for the state. The Atlas has been prepared but has not been updated in the last three years, while the assessment is yet to be implemented, says Medhi. The authority has also prepared disaster management plans for the state, districts and three cities—Guwahati, Dibrugarh and Silchar. These need to be expanded, as many towns and cities saw floods this year.

The authority also has in place the Flood Reporting Information Management System (FRIMS) which generates flood alerts up to the village level in all districts and collects data on loss and damage happening due to the floods. ASDMA also runs a state emergency response centre in all districts.

However, Das believes that there have to be more locally led initiatives on flood mitigation and adaptation in Assam. Grand ideas will not work in the state. For instance, big storage dams that are used elsewhere for controlling floods are not suitable in the Himalayan region. "Only 7 per cent of the districts have updated their disaster management plans until 2020 in Assam," said Abinash Mohanty, programme lead of the risks and adaptation team at the Council on Energy, Environment and Water, a Delhi-based think-tank. Updating and implementing the plans can help manage floods better, he adds. **DTE**

 @down2earthindia

Changing rainfall patterns are one of the major causes of Assam's vulnerability to climate change. The vulnerability may only rise as the planet warms and people make unscientific interventions in the ecology