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It's raining sand in Rayalaseema

Crop pattern changes, waning forest cover, an explosion of borewells, the death of a river, and more – have produced dramatic effects on land, air, water, forests and climate in Andhra Pradesh's Anantapur district

It's a classic Indian cinema fight-in-the-desert scene. Against the background of dunes and depressions with a tiny sprinkling of scrub vegetation, the hero rises from the burning sands of a barren wasteland to beat the bad guys to a pulp. Adding plenty of heat and dust to that already bestowed by nature, he brings the film to a happy conclusion (except for the villains). Countless Indian movies have staged those scenes in some desolate wilderness of Rajasthan. Or even in the ravines of the Chambal valley in Madhya Pradesh.

Only, this arid wilderness scene (see video clip) used no locations from Rajasthan or the Chambal. It was shot deep in the southern peninsula, in Andhra Pradesh's Rayalaseema region. This specific patch of some 1,000 acres in Anantapur district –

once covered by millet cultivation – has over many decades become more and more a desert. That has been driven by often paradoxical factors – and created the kind of space that filmmakers send out location scouts to look for.

In Dargah Honnur village, where the major landowners of this patch reside, it was difficult to get anyone to believe we were not movie location scouts. “Which film is this for? When is it coming?” was either an explicit question or one on their minds. With some, you could see a quick ebbing of interest when they learned we were journalists.

The makers of the Telugu film that made the place famous – *Jayam Manade Raa* (*Victory is Ours*) – shot those fight scenes here between 1998 and 2000. Like any diligent commercial filmmakers would, they tinkered with their ‘set’ to enhance the desert effect. “We had to uproot our crop (for which they compensated us),” says Pujari Linganna, 45, whose family owns the 34 acres where the fight was shot. “We also removed some vegetation and small trees so it would look more real.” Deft camerawork and the intelligent use of filters did the rest.

If the makers of *Jayam Manade Raa* were shooting a 20-years-after sequel today, they would have to do much less. Time and tormented nature, and relentless human intervention, have effected all the desert enhancements they could ask for.

This arid wilderness scene (see video clip) used no locations from Rajasthan or the Chambal. It was shot deep in the southern peninsula, in Andhra's Rayalaseema region

But it’s a curious desert patch. There is still cultivation – because there is still groundwater very close to surface. “We hit water in this patch at just 15 feet below,” says P. Honnureddy, Linganna’s son. In much of Anantapur, borewells won’t find water before 500-600 feet. In parts of the district, they have breached the 1,000-foot mark. Yet here is water gushing out of a four-inch borewell as we speak. That much water, so close to the surface, in this hot and sandy patch?

“That whole area lies in an extended riverbed,” explains Palthuru Mukanna, a farmer from a nearby village. What river? We can see nothing. “They built a dam [around five] decades ago, some 25-30 kilometres from Honnur, on the Vedavathi

river that ran through here. Our stretch of Vedavathi (a tributary of the Tungabhadra – also called the Aghari) simply dried up.”

“That is indeed what happened,” says Malla Reddy of the Ecology Centre (of Anantapur’s Rural Development Trust) – few know this region as well as he does. “And the river may be dead but, over centuries, it helped create an underground reservoir of water that is now being relentlessly mined and extracted. At a rate which signals a coming disaster.”

That disaster won’t be long in coming. “There was hardly a single bore 20 years ago,” says V. L. Himachal, 46, a farmer with 12.5 acres in the desertified area. “It was all rainfed agriculture. Now there are between 300-400 borewells in about 1,000 acres. And we strike water by 30-35 feet, sometimes higher.” That’s one borewell to every three acres, or less.

That’s high density, even for Anantapur which, as Malla Reddy points out, “has close to 270,000 borewells, though the carrying capacity of the district is 70,000. And almost half this huge number are dry this year.”

Twenty years ago, Pujari Linganna (left, and at right with his son P. Honnureddy), had to uproot vegetation for a film shoot. Today, time and human actions have brought the same desert enhancements

So what are the borewells in these badlands for? What’s being cultivated? What sticks out in the patch we’re exploring is not even the district’s all-pervasive groundnut crop, but *bajra* . That millet is cultivated here for seed multiplication. Not for consumption or the market, but for seed companies who have contracted the farmers for this job. You can see male and female plants laid out neatly in adjacent rows. The companies are creating a hybrid from two different strains of bajra. This operation will take a great deal of water. What’s left of the plant after seed extraction will at best serve as fodder.

“We get Rs. 3,800 per quintal for this seed replication work,” says Pujari Linganna. That seems low, given the labour and care involved – and the fact that the companies will sell those seeds to the same class of farmers at very high prices. Another cultivator on this patch, Y. S. Shantamma, says her family gets Rs. 3,700 a quintal.

Shantamma and her daughter Vandakshi say the problem of cultivating here is not water. “We even get water in the village though we have no piped connection at home.” Their headache is the sand which – besides the huge volume that already exists – can accumulate very rapidly. And trudging across even short distances on sand several feet deep can be tiring.

“It can simply destroy the work you’ve put in,” say mother and daughter. P. Honnureddy agrees, showing us the stretch beneath a sand dune where he had painstakingly laid out rows of plants – not four days ago. Now they are just furrows covered in sand. This place, part of an increasingly arid zone which sees strong winds hit the village, has sandstorms.

“Three months in the year – it’s raining sand in this village,” says M. Basha, another desert cultivator. “It comes into our homes; it gets into our food.” The winds bring sand flying into even those homes not so close to the dunes. Netting or extra doors don’t always work. “*Isaka varsham* [sand rain] is part of our lives now, we just live with it.”

Left: Honnureddy’s painstakingly laid-out rows of plants were covered in sand in four days. Right: Y. S. Shantamma and her daughter Vandakshi say, ‘It [the sand] can simply destroy the work you’ve put in’

The sands are not strangers to D. Honnur village. “But yes, their intensity has risen,” says Himachal. A lot of shrubbery and little trees that formed serious wind barriers have gone. Himachal speaks knowledgably of the impact of globalisation and market economics. “Now we calculate everything in cash. The shrubs, trees and vegetation went because people wanted to use every inch of land for commercial cultivation.” And “if sands fall when seeds are in germination or sprouting,” says farmer M. Tippaiah, 55, “the damage is total.” Yields are lower despite their access to water. “We get three quintals of groundnut an acre, at best four,” says farmer K. C. Honnur Swamy, 32. The district’s average yield is around five.

They see no value in natural wind barriers? “They will only go for trees that have commercial value,” says Himachal. Which, unsuited to these conditions, may not grow here at all. “And anyway, the authorities keep saying they will help with trees, but that hasn’t happened.”

“A few years ago,” says Palthuru Mukanna, “several government officials drove out into the dunes area for an inspection.” The desert safari ended badly and their SUV, mired in the sands, had to be towed out by the villagers with a tractor. “We haven’t seen any more of them since,” Mukanna adds. There are also periods, says farmer Mokha Rakesh, “when the bus cannot go that side of the village at all.”

The loss of shrub and forest is a problem across the entire Rayalaseema region. In Anantapur district alone, 11 per cent of area is classified as ‘forest’. Actual forest cover has dwindled to less than 2 per cent. That has had the inevitable impact on soil, air, water, and temperatures. The only large forest you see in Anantapur is the jungle of windmills – thousands of them – dotting the landscape everywhere, even bordering the mini-desert. These have come up on land purchased or leased long-term, by windmill companies.

Back in D. Honnur, a group of desert-patch cultivators assures us that things were always this way. They then go on to present compelling evidence to the contrary. The sands have always been there, yes. But their force, producing sandstorms, has grown. There was more shrub and cover earlier. Very little now. They’ve always had water, yes, but we learn later of the death of their river. That there were very few borewells two decades ago, hundreds now. Every one of them recalls a spike in the number of extreme weather episodes these past two decades.

Rainfall patterns have changed. “In terms of when we need the rains, I’d say they are 60 per cent less,” says Himachal. “There’s less rains around Ugadi [Telugu New Year’s Day, usually in April] these past few years.” Anantapur is touched – gingerly – by both south-west and north-east monsoons but derives the full-benefit of neither.



Top row: The sand is all pervasive, says M. Basha, another desert cultivator, 'it comes into our homes; it gets into our food'. Bottom row: The only large forest in Anantapur now is the jungle of windmills on the horizon everywhere

Even in years when the district receives its annual average rainfall of 535 mm – the timing, spread and dispersal have been terribly erratic. In some years, the rains have moved from crop to non-crop seasons. Sometimes, there's been a huge downpour in the first 24-48 hours and great dry spells afterwards. Last year, some *mandals* saw dry spells of almost 75 days during the crop season (June to October). With 75 per cent of Anantapur's population in rural areas and 80 per cent of all workers engaged in agriculture (either as farmers or labourers), this proves devastating.

“There have been just two really ‘normal’ years in Anantapur in each of the last two decades,” says Malla Reddy of the Ecology Centre. “In every one of the remaining 16 years, two-thirds to three-fourths of the district has been declared as drought-affected. In the 20 years prior to that period, it was three droughts every decade. The changes that began in the late 1980s have hastened every year.” A district once home to a multitude of millets switched increasingly to commercial crops like groundnut. And saw, correspondingly, a massive sinking of borewells. (A report of the National Rainfed Area Authority says there are now “pockets where groundwater exploitation has exceeded 100 per cent.”)

“Forty years ago, we had a clear pattern – three droughts in 10 years – and farmers knew what to plant. There were between 9 and 12 diverse crops and a stable cultivation cycle,” says C.K. ‘Bablu’ Ganguly. He leads the Timbaktu Collective, an NGO which for three decades has focused on the economic betterment of the rural poor in this region. His own four-decade engagement here has given him tremendous insight into the region’s farming.

“Groundnut [now covering 69 per cent of cultivated area in Anantapur] did to us what it did to the Sahel in Africa. The monocropping we descended into didn’t just alter the water situation. Groundnut can’t take shade, people remove trees. Anantapur’s soil was destroyed. Millets were decimated. The moisture is gone, making a return to rainfed agriculture difficult.” Crop changes also undermined the role of women in farming. Traditionally, they were custodians of the seeds of the diverse rainfed crops grown here. Once farmers began to buy seed on the market for the cash crop hybrids that took over Anantapur (as with groundnut), the role of women was reduced largely to that of labourers. Also lost, over two generations, were the skills of many farmers in the complex art of growing multiple, varied crops on the same fields.



Linganna’s grandson Honnur Swamy (top row, left) and Nagaraju (right) are desert cultivators now, whose tractors and and bullock carts (bottom row) leave deep furrows in the sand. (Photos: Top left and bottom left: Rahul M. Top right and bottom right: P. Sainath)

Fodder crops now account for less than 3 per cent of cultivated area. “Anantapur once had one of the highest numbers of small ruminants in the country,” Ganguly says. “Small ruminants are the best asset – mobile property – of ancient communities of traditional herders like the Kurubas. The traditional cycle where the herders’ flocks provided post-harvest manure to the farmers’ fields in the form of dung and urine – that’s disrupted by changing crop patterns and chemical agriculture. Planning for this region has proved hostile to the marginalised.”

Himachal in Honnur recognises the shrinking agricultural biodiversity around him and its consequences. “Once, in this very village, we had *bajra*, cowpea, pigeon pea, *ragi*, foxtail millet, green gram, field beans...” he rattles off a list. “Much easier to cultivate, but rainfed agriculture doesn’t bring us cash.” Groundnut did, for a while.

The crop cycle of groundnuts is around 110 days. Of those, it only covers the soil, protecting it from erosion, for 60-70 days. In the era when nine different millets and pulses were grown, those offered the topsoil a protective shade cover from June to February each year, with one or the other crop always on the ground.

Back in Honnur, Himachal is reflective. He knows that borewells and cash crops brought great benefits to the farmers. He also sees the declining trend in that – and the growing out-migrations as livelihoods shrink. “There are always over 200 families seeking work outside,” says Himachal. That’s a sixth of the 1,227 households the 2011 Census records for this village in Anantapur’s Bommanahal *mandal*. “Around 70-80 per cent of all households are in debt,” he adds. Farm distress has been high across Anantapur for two decades – and it is the district in Andhra Pradesh worst affected by farmer suicides.

Left: Pujari Linganna. Centre: Palthuru Mukanna. Right: V. L. Himachal

“The boom time of borewells is gone,” says Malla Reddy. “So is that of cash crop and monocultures.” All three still proliferate, though, driven by that fundamental shift from production for consumption to “creating products for unknown markets.”

If climate change is simply about nature pressing its reset button, then what was it we saw in Honnur and Anantapur? Also, as the scientists tell us, climate change occurs across very vast natural regions and zones – Honnur and Anantapur are administrative units, mere specks, too small to qualify. Can it be that large canvas changes across much greater regions might sometimes aggravate existing freakish features of sub-regions within them?

Almost all the elements of change here resulted from human intervention. The ‘borewell epidemic’, the massive switch to commercial cropping and monocultures; the loss of biodiversity that could be Anantapur’s best defence against climate change; the ongoing exhaustion of the aquifer; the devastation of the little forest cover this semi-arid region had; the harming of the grassland ecology and a serious degradation of the soil; the industry-driven intensification of chemical agriculture; the crumbling of symbiotic relationships between farm and forest, shepherds and farmers – and the loss of livelihoods; the death of rivers. All these have clearly impacted temperatures, weather and climate – which have in turn further aggravated these processes.

If human agency, driven by a model of economics and development gone berserk, is a major driving factor in the changes upon us, there’s plenty to be learned from this region and many like it.

“Maybe we ought to shut down the borewells and return to rainfed farming,” says Himachal. “But it’s too difficult.”

P. Sainath is Founder Editor of the People’s Archive of Rural India.

Cover photo: Rahul M./PARI

PARI’s nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.

Human-wildlife conflict is escalating in Radhanagari, Kolhapur; where the gaur buffalo are raiding nearby farms. This is spurred by deforestation, cropping changes, drought and fluctuating weather patterns.



Buffaloed by the climate in Kolhapur

Human-wildlife conflict is escalating in Radhanagari, Kolhapur, where the gaur buffalo are raiding nearby farms. This is spurred by deforestation, cropping changes, drought and fluctuating weather patterns

How and why does a full acre of jowar disappear from your fields at short notice?

“It was the first time in two years that I left my village for a week during the season. In that time, they devoured all of it,” says Ananda Salvi. ‘They’ is a herd of gaur (*bos gaurus*, also sometimes called Indian bison) – the most massive bovine in existence in the world. Males can stand well over 6 feet at the shoulder and weigh anywhere between 500 and 1,000 kilograms.

Normally peaceful residents of the Radhanagari Wildlife Sanctuary in Maharashtra's Kolhapur district, the giant bovids have been getting out on to the highways and raiding the farms around them.

"There was no one guarding my field," says Salvi sadly in Rakshi village. "Luckily, I was able to save my one acre of sugarcane (about 80 tons of cane)]." So how do you 'save' anything from a bunch of 1,000 kilo behemoths? With firecrackers.

Two years ago, Salvi started sleeping in the fields every night. "We come at 8 p.m. daily and leave only at 4 a.m. after all the *gava* (local term for the gaur) have left," he explains. "And we burst crackers in the fields at night." That scares off the buffalo, he says, from entering his five acre farm. Several of his neighbours do likewise. Rakshi village, in Panhala *taluka*, has lost crops to bison for at least two years now.



The shrinking Savrai Sada lake is one of the main sources of water for animals and birds in the sanctuary

"We spend nearly Rs. 50 every day in season, buying those crackers," says Salvi's wife Sunita. Which adds a whole new element to cultivation costs. "It's still a risk," she says, "farmers sleeping in the fields at night." There's other wildlife active in the fields in those hours. Snakes, for instance.

People believe the buffalo will soon figure out that firecrackers won't do them real harm. So some farmers in Radhanagari *taluka* have begun using electrified fences. "But even those, they're getting used to," says Samrat Kerkar, co-founder of the

Bison Nature Club, a Radhanagari-based wildlife NGO. “We have seen gaur placing their hooves or legs slowly on the fence to check if it gives a shock. Earlier, they feared humans, but now they don’t run away so easily on seeing us.”

“We don’t blame the *gava*,” says Sunita. “It’s the forest department’s mistake. If the forests aren’t maintained properly, animals will come out.”

The gaur buffalo have increasingly been coming out of the wildlife sanctuary – in search of food and water. They’re seeking, amongst other things, *karvi* leaves (*strobilanthes callosa*) which seem to be withering in the drying forests. And also, other sources of water – with the sanctuary’s ponds shrinking. Further, forest guards and field researchers say they are also driven by the declining patches of grasslands within the sanctuary.

Left: Anand Salvi lost an acre of jowar to a bison raid. Centre: Sunita Salvi says she blames the forest department. Right: Farmers sleep on these metallic cots in the open at night, guarding their fields

Data of the Central Ground Water Board show that Radhanagari taluka received 3,510 mm of rainfall in 2004, 3,684 in 2008 and 3,072 in 2012. But it got just 2,120 mm in 2018 – a steep fall. Indeed, rainfall across the entire Kolhapur district has been increasingly erratic for a decade or more – like in many other parts of Maharashtra too.

Raju Patil, a 50-year-old shepherd, first saw a group of 12 gaur on the Devgad-Nipani state highway a decade ago. He had heard of the wildlife sanctuary, on the outskirts of his village, Radhanagari. But he had never seen the *gava* .

“Only in this last decade, I’ve seen them coming out of the forest,” he says. Since then, for the people of Radhanagari village, the sight of the massive herbivores crossing the roads has become commonplace. Villagers have shot videos of the animals on their cellphones. The gaur have started entering farms in Radhanagari, Shahuwadi, Karvir, and Panhala *talukas* in Kolhapur district to eat sugarcane, *s halu* (jowar or sorghum), corn and rice.

And to drink water – which has become increasingly scarce for them within the forest.

In Radhanagari *taluka*, villagers assert, the *gava* have made forays outside the forest only during the past 10-15 years. In Panhala *taluka*, it's a more recent occurrence. Yuvraj Nirukhe, 42, from Rakshi village whose farm is near the forest says, "We've seen the *gava* only in the last two years. Earlier wild pigs used to attack our crops." Since January, a group of 12 bison have thrice raided his 0.75 acre plot. "I lost at least 4 quintals of *shalu* and now I'm afraid to cultivate rice in this rainy season," he says.

People in Radhanagari taluka have shot videos on their cellphones of the gaur emerging from the sanctuary and crossing roads and highways

"The weather cycle has changed completely," says Prashant Tendulkar, forest range officer for Radhanagari. "Earlier, it used to rain at least once in March and April, which would recharge the ponds. If we are going against nature, who should be blamed? Some 50-60 years ago there was the forest land, then grazing grounds, farms and then the village. Now people have started settling on these lands and are slowly reaching towards the jungle. The land between forest and village is being encroached."

There's been 'encroachment' of a more destructive nature – bauxite mining. It's been on and off over some decades.

"Open cast bauxite mining devastated Radhanagari over many years," says Bittu Sahgal, founder editor of *Sanctuary Asia*. "There was great resistance to it, but mining companies such as INDAL [later merged with HINDALCO] had far greater clout in the corridors of power than the protestors did. The companies were writing policy in government offices. Grazing grounds, water sources, all these suffered grave damage from mining activity."

Indeed, since 1998, both the Bombay High Court and the Supreme Court of India have come down strongly on such activity, more than once. As late as October 2018, the apex court had ordered the presence of the chief secretary of the Maharashtra government over the 'total lack of concern' the state showed in the matter.



Top row left: Yuvraj Nirukhe fears cultivating rice this season. Right: Raju Patil lost 0.75 acre of sugarcane to the bison. Bottom row: Maruti Nikam found half an acre (right) of elephant grass devastated by bison raids

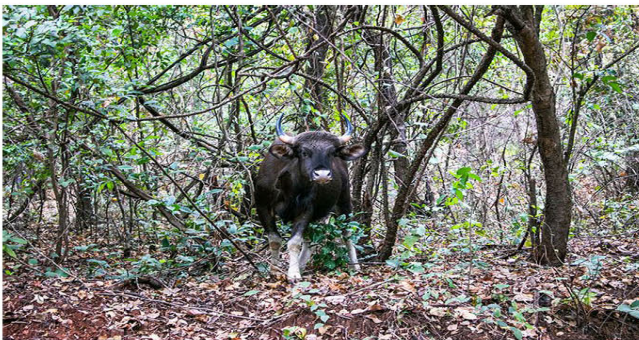
A 2012 study by researchers from Shivaji University, Kolhapur, pointed to the continuing long-term effects of mining. Their paper, *Studies On The Impact Of Bauxite Mining Activities On Environment In Kolhapur District*, noted that “legal and illegal mining activity has initiated serious environmental degradation in the region. Though mining initially provided job opportunities for limited inhabitants and generated revenue to Government, it would last only for a short period. However, the damage caused to the local ecology as a result of the changed land use is permanent.”

Just 24 kilometres away from Radhanagari is another wildlife sanctuary – Dajipur. Both were a single unit till the mid-1980s when they were split up. Together, they cover an area of 351.16 square kilometres. A patch of laterite plateau in Dajipur, called Savrai Sada, also holding a lake, remains one of the major sources of food and water for animals and birds in the region. But much of the lake had shrunk or dried up by May this year.

Also, “most of the deforestation here has happened in the past decade. This has affected the [climate] cycles,” says Amit Sayyed, a wildlife researcher and president of the Wildlife Protection and Research Society.

Savrai Sada is one of the sites where the forest department has created artificial 'salt licks' for animals. A salt or mineral lick is a place from where animals can consume essential nutrients. Salt and *konda* (husk/bran) have been stored at some sites in both Dajipur and Radhanagari.

There's another, less benign form of human intervention than salt licks: the spread of sugarcane. Kolhapur district, with its rich rainfall in some *talukas*, was for decades hospitable to sugarcane. It's growth, though, is a bit alarming. Data from the state Sugar Commissionerate and gazetteers show that cane was cultivated on 40,000 hectares in Kolhapur in 1971-72. Last year, 2018-19, it covered 155,000 hectares – a 287 per cent increase. (Sugarcane cultivation in Maharashtra takes between 18-20 million litres of water per acre).



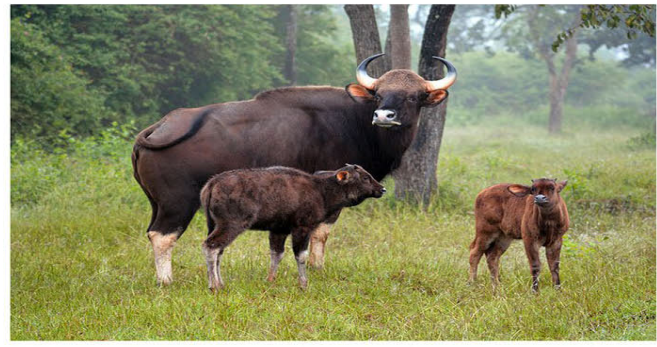
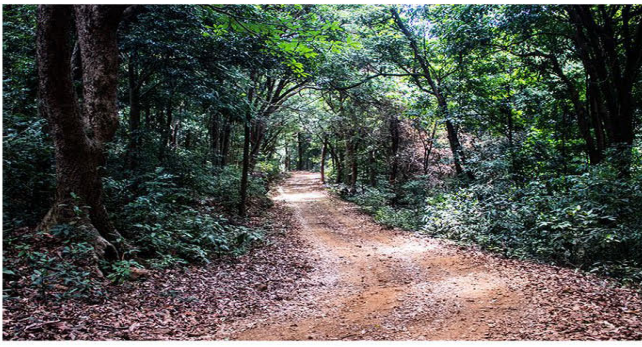
Top row left: A gaur isolated from its herd. Right: The laterite plateau and the retreating forest. Bottom row left: Salt and konda (husk/bran) kept as mineral lick for the wild animals at Savrai Sada. Right: A sugarcane farm near the sanctuary

All these processes have had an inevitable impact on land, water, forest, flora and fauna, weather and climate in the region. The forest types in this sanctuary are southern semi-evergreen, southern moist-mixed deciduous and southern evergreen forest. While the impact of all the changes goes way beyond these sanctuaries, they have had profound consequences for their denizens. Human activity is growing, but the gaur herds are not.

Believed to have had over 1,000 of these magnificent animals some decades ago, Radhanagari wildlife sanctuary now has 500, according to the forest department of Maharashtra. Forest range officer Prashant Tendulkar's personal estimate is 700. In India, the gaur is classified under Schedule 1 of the Wildlife Protection Act of 1972, which gives absolute protection to the listed species. Offences against these animals invite the highest penalties. Gaur also figure in the 'Red List' of threatened species of the International Union for Conservation of Nature, which classifies them as 'vulnerable.'

The gaur are on the move, but: "they [the forest department] do not have data on their migration record," says Amit Sayyed. "Where are they going? What kind of corridor are they using? What kind of groups? How many individuals in a group? If they are monitoring the groups, then these kinds of things will not happen. Water bodies should be set up in these corridors."

India Meteorological Department data show that rainfall in June 2014 in Kolhapur district was 64 per cent below the normal average for that month. In 2016, minus 39 per cent. In 2018, it was plus one per cent above the average. In July 2014, it was 5 per cent above the average for that month. In July the next year it was minus 76 per cent. This year, rainfall was above average by 21 per cent for the period June 1 to July 10. But, as many here point out, this April and May saw no real pre-monsoon showers. "The rainfall pattern has become erratic over the past decade," says Kerkar. That has sharpened the problem of fewer and fewer perennial water sources in these forests.



*Top row left: Inside Dajipur forest. Right: A gaur buffalo with her calves. (Photo: Rohan Bhate).
Bottom row left: An artificial pond created near a natural one for the bison. Right: Samrat Kerkar
pouring water into a pond from a 3,000-litre tanker*

In April and May 2017, some ponds in the Radhanagari and Dajipur forests were for the first time recharged artificially – with water from tankers. Around 20,000 litres of water in all were supplied this way at three spots in both forests by Kerkar’s Bison Nature Club. In 2018, that rose to 24,000 litres. (There are many other forest ponds maintained by the forest department itself).

However, “this year, the forest department permitted us to only supply water at one pond in the Radhanagari range for reasons unknown,” says Kerkar. This year, the NGO supplied 54,000 litres. In any case, “we stop supplying after the first two monsoon showers in June,” says Kerkar.

Deforestation, mining, major changes in cropping patterns, drought, a general drying up, the degradation of water quality, a sucking up of groundwater – all these processes have had their impact on forest, farm, soil, weather and climate in Radhanagari and the larger region it is located in.

But it’s not just natural climate that is deteriorating.

The incidence of gaur-human conflict is mounting. “The *gava* ate all the elephant grass I cultivated on 20 *guntha* [roughly half an acre],” says a miserable Maruti Nikam, 40, who owns six acres in Nikamwadi village of Panhala *taluka*. “They also wiped out the corn I had on another 30 *guntha* between January and April this year.

“In the rainy season, there will be a lot of water in the forest, but if they don’t find food, they will return to our fields.”

Cover photo: Rohan Bhate. Special thanks to him for giving us permission to use his images, and to Sanctuary Asia.

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Nomadic Changpa pastoralists at the high grazing grounds of Ladakh find their yak-related economy in a crisis that is driven by major climatic shifts in their fragile mountainous ecosystems.



'Perhaps we made the mountain god angry'

Nomadic Changpa pastoralists at the high grazing grounds of Ladakh find their yak-related economy in a crisis that is driven by major climatic shifts in their fragile mountainous ecosystems

' 300 Himalayan yaks starve to death in Sikkim '

' Trapped in Snow Nearly 300 Yaks Die Due to Starvation in North Sikkim '

' Melting snow bares Sikkim yak tragedy '

Those headlines of May 12 this year hit me hard. From my own trips as a photojournalist into the Himalayas, I know that the nomadic pastoralists who rear these animals go to any length to protect them. Across vital stretches of those great mountains, yaks are the lifeline for high-altitude herders – nomadic pastoralists driving a seasonal movement of livestock between fixed summer and winter pastures. Yaks are among their primary means of earning and a food source during wintertime.

Some of the articles with those headlines linked the yak deaths to global warming. It was clear that if the hardy animals were taking such a hit, their herders would be in trouble too. I decided to return to the Changpa families in Ladakh's Hanle Valley and look at how both were doing.

The Changpas of the Changthang region in India – a western extension of the Tibetan Plateau – are among the foremost producers of cashmere wool, and they also rear yaks. Hanle Valley of Leh district's Nyoma block is home to several herding units of Changpa – Dique, Kharloog, Maque, Raque and Yulpa. The Dique and Raque are perhaps the finest yak herders there are.

"We are losing a lot of yaks," says expert Dique herder Jhampal Tsering, 35, in Hanle. "Now, the weather here [in the high mountains] is unpredictable." I met Tsering thanks to Sonam Dorjee of Khaldo village in the valley, who works at the Indian Astronomical Observatory in Hanle. Tsering talked to us in his spacious *khur* (army tent in the Ladakhi language) at the Taknakpo grazing ground located at about 14,000 feet.

Three years before the May 2019 disaster in Sikkim, the Nepal-based International Centre for Integrated Mountain Development had published a paper noting "the yak population in Bhutan, India and Nepal has shown a declining trend in recent years." The researchers found a fall in the yak population in India "from 132,000 in 1977 to 51,000 in 1997." A decline of over 60 per cent in just three decades.

Data from the local Department of Animal Husbandry and Dairying show that Leh district's yak population decreased from 30,000 in 1991 to 13,000 in 2010. That's a steep 57 per cent fall in two decades. The local data seem at variance with the 'official' figures at the top – which place the yak population in the district at 18,877 in 2012 (in which case the decline would still have been a sharp 37 per cent in 21 years)



A full grown Himalayan yak – the animal has for centuries been a lifeline for the Changpa pastoral nomads – at a high altitude pasture in Ladakh's Hanle Valley

It wasn't easy reaching the Dique settlement. Their grazing grounds are higher than those of other herding units. Besides, some of the areas they tent in are close to the India-China border – places where civilians aren't allowed. Since it was springtime, though, with Sonam Dorjee's help, I reached the settlement.

"Yaks are marvellous creatures," says Jhampal Tsering. "The yak is accustomed to freezing temperatures and can survive anything up to minus 35 or minus 40 degrees Celsius. However, it finds it troublesome when the temperature rises to 12 or 13 degrees. Throughout the harsh winter, because of their slow metabolism, they can conserve body heat and survive. But fluctuations in the weather put the yaks in trouble."

At Kala Pari (Black Mountain), around 40 kilometres from the Dique settlement, I met Tsiring Chonchum, one of the few women yak owners in Hanle Valley.

"Because it is warmer than earlier, the sheep, pashmina goats and yaks don't have the dense growth of hair on their body as they did in the past. It is a very sparse and light growth now," she says. "They seem to be weaker. Weaker yaks mean lower productivity for us. Less milk, lower income. Our earnings from yaks have gone down drastically over the last five years." Chonchum is a transhumance pastoralist from the Raque herding unit. Studies by independent researchers show that the average monthly income of a herder household here, from all sources combined, was around Rs. 8,500 a month in 2012.

Yak milk is a significant segment of the herder's income and may account for 60 per cent of the total earning from rearing yaks. The rest of the Changpas' income flows from *khuloo* (yak hair) and wool. So with the falling yak numbers and the decline in milk production, their earnings take a nasty hit. All these changes are placing the yak-related economy under great stress.

"It also doesn't rain on time or snow on time anymore," says Tsering Chonchum. "So there is not enough grass on the mountains. Because of this, the number of [pastoral] nomads coming here has gone down. I will say that they have reduced to about 40 per cent [of the estimated 290 families of herders there] because of these changes, due to the scarcity of grass and the problems arising out of that. My son works at the local observatory – which gives me some relief. Many young people from Changpa families have started working for the Border Roads Organisation or the General Reserve Engineer Force as daily wage labourers on road building schemes." Several have migrated in search of jobs elsewhere. That son working in the local observatory is Sonam Dorjee, who has helped me pull off this trip. Sonam himself has been a careful observer of the changes in the mountains.

'There have been many alterations in the weather. When I was 15 it used to be much colder here...those who knew say that it would dip to minus 35 Celsius'



"There have been many alterations in the weather," he says. "When I was about 15 (I'm 43 now, so I'm talking about almost 30 years ago), it used to be much colder here. I did not measure the temperature then myself but those who knew say that it would dip to minus 35 Celsius. So people's clothing had to be suited to bear that kind of harsh cold. Not the synthetic material jackets that they wear now. Everything they wore was woven from the wool of pashmina goats – caps, dresses, everything. The shoe soles had a flattened bit of yak skin on the inside and the shoe was made from local cloth and had strips to tie it up, right up to knee length. Now you don't see those kinds anywhere."

A warming is underway, say researchers Tundup Angmo and S.N. Mishra in their 2016 paper on *Impacts of climate change in Ladakh and Lahaul & Spiti of the western Himalayan region*. "Data obtained from the meteorological department (Air Force Station, Leh) clearly indicates that there is a rising trend of min temp at

Leh by nearly 1°C for all the winter months and nearly 0.5°C for summer months in last 35 years. There is a clear declining trend in precipitation from November to March i.e. reduction in snow fall.”

They also say: “Over the last few years, impacts of global climate change have been increasingly visible in Ladakh and Lahaul & Spiti. Rainfall and snowfall patterns have been changing; small glaciers and permanent snow fields are melting, affecting water runoff in the rivers/streams, and rise in temperature and humidity inducing favourable conditions for the invasion of insects and pest aggression.”

Back in Jhampal Tsering’s tent, his friend Sangda Dorjee had asked us: “How many *rebos* have you seen this time?”

The Changpas live in tents known as *rebos*. To make a *rebo*, yak wool is spun into yarn by the families, then woven and stitched together. The material protects the nomads from the extreme cold and icy winds.

“Most of the families do not own a *rebo* [now],” says Sangda. “Where’s the wool for stitching a new *rebo*? The quantity of yak wool has gone down drastically in the past few years. Without the *rebo*, a significant part of our nomadic lifestyle is gone, and I blame the warmer winter.”

I begin to realise that incident in May in Sikkim was not entirely random. Worse could be ahead. The herders do not use the words climate change but seem to describe its impacts quite well. And they do understand that very major shifts have occurred, as Sonam Dorjee’s and Tsering Chonchum’s words show us. They also understand that some of the major variations, even transformations, have been significantly driven by human agency. Maybe that’s why veteran herder Gumbu Tashi, in his 60s, told me: “Yes, I know the climate in the mountain is tricky. Unpredictable. Perhaps we made the mountain god angry.”



Across vital stretches of those great mountains, yaks are a lifeline for high-altitude Changpa herders, their primary means of earning and a food source during wintertime



Weather alterations are affecting the livestock of Changpa pastoral communities – yaks, pashmina goats sheep – who depend on high altitude pastures for grazing



With changes in living patterns, most of the Changa families no longer use the traditional rebo , a tent made from yak yarn; instead, they use army tents procured from Leh town



Still, communities do continue to make various other products derived from the yak. Here, little Donchen sleeps peacefully covered by a blanket of yak wool, while her mother is out grazing the family's animals



Yaks are also a source of food – milk and meat – for the nomadic pastoral communities of the Changthang plateau. Killing animals for meat is against community practice, but if a yak dies naturally, families use some of its meat to help them survive the long and extreme winters



Gumbu Tahsi, of the Raque unit of the Changpa community, owns around 80 yaks. He and others here speak of the challenges to their traditional life of nomadic grazing



Gonpo Dondrup points to a nearby grazing pasture where grass doesn't grow anymore, and he has to climb higher searching for food for his yaks



Tsiring Chonchum with an orphaned yak cub. She is one of the few women yak owners in Hanle Valley



With the growing scarcity of grasslands for their animals, the nomadic pastoralists change their locations more frequently than in the past



Life in the harsh winters here is tough for both humans and animals. Here, a Changpa herder leaves for Leh town to bring medical supplies for his family



At a high plain in Hanle Valley, Karma Rinchen (also in the cover image with Norla Dondrup) walks across barren land increasingly devoid of grazing pastures

PARI's nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.

Coffee and pepper farmers in Wayanad, Kerala, are reeling under losses caused by a rise in temperatures and erratic rainfall in a district whose residents once boasted of its 'air-conditioned climate'.



'Why is the climate changing like this?'

Coffee and pepper farmers in Wayanad, Kerala, are reeling under losses caused by a rise in temperatures and erratic rainfall in a district whose residents once boasted of its 'air-conditioned climate'

"By 4 p.m. we had to light a fire to stay warm here," says Augustine Vadakil on his struggling farm in Kerala's hilly Wayanad district. "But that was 30 years ago. Wayanad is no longer the cold, misty place it once was." From a maximum of 25 degrees Celsius by early March, temperatures here now easily cross 30 degrees by that time of the year.

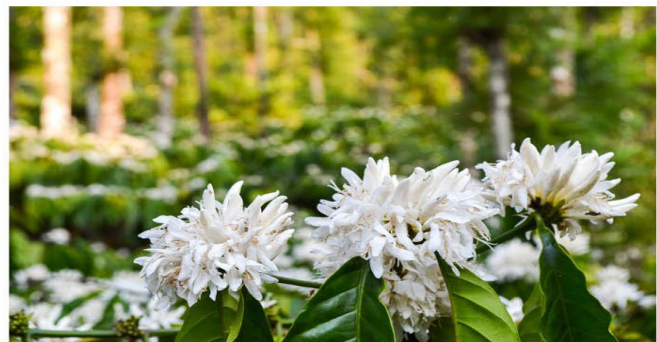
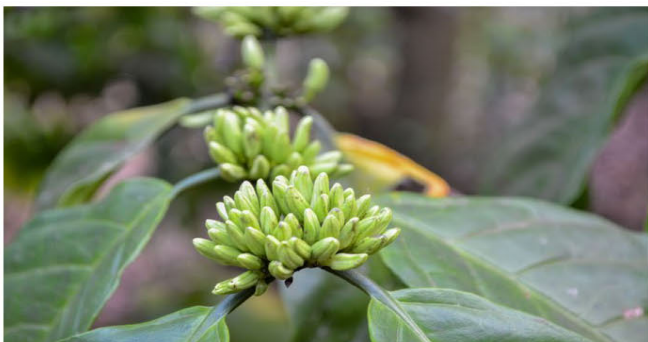
And the number of warmer days has more than doubled in Vadakil's lifetime. In 1960, the year he was born, "the Wayanad area could expect about 29 days per year to reach at least 32 degrees [Celsius]" says a calculation from an interactive

tool on climate and global warming posted online by the *New York Times* this July. “Today the Wayanad area can expect 59 days at or above 32 degrees per year, on average.”

The changing weather patterns, Vadakil says, hurt heat-sensitive and vulnerable crops like pepper and orange trees that were once abundant in this district in the Western Ghats at the southern tip of the Deccan Plateau.

Vadakil and his wife Valsa own a four-acre farm in Cherukottur village in Mananthavady *taluk*. His family left Kottayam for Wayanad around 80 years ago to try their luck in the booming cash crop economy here. That was a period of heavy migration which saw thousands of small and marginal farmers from central Kerala settle in this district in the north-east of the state.

But over time, the boom seems to have gone bust. “If the rains prove to be erratic, like they have been in the last year, then the [organic Robusta] coffee we grow is doomed,” says Vadakil. “Coffee is profitable, but the weather is the biggest problem in its growth. Heat and erratic rainfall ruin it,” adds Valsa. The ideal temperature to grow [Robusta] coffee is between 23-28 degrees Celsius, say those working in the sector.



Top row: The coffee crop in Wayanad needs its first rain by late February or early March and it starts to flower a week later. Bottom row: Either dry spells or untimely rain can destroy the flower (left) that produces the Robusta coffee beans (right)

All of Wayanad's coffee, which is of the stronger-in-body Robusta family (a tropical evergreen shrub), is cultivated between December and late March. The coffee plant needs its first rain by late February or early March – and starts to flower a week later. It is crucial that there are no rains for a week after the first shower as that destroys the delicate flowers. The second shower is needed a week after the first one for the coffee fruit or 'cherries' to start growing.' Once the flowers bloom and fall off the tree, the cherries that contain the beans begin to mature.

"Timely rains guarantee you an 85 per cent yield," says Vadakil. When we met in early March, he was hoping for this outcome, but anxious if it would happen. It did not.

By early March, at the beginning of Kerala's severe summer, temperatures had already gone up to 37 degrees. "The second shower (*randamatha mazha*) came too soon this year and everything was destroyed," Vadakil told us at the end of March.

For Vadakil, who gives two acres to this crop, that translated to losses of Rs. 70,000 this year. The Wayanad Social Service Society (WSSS), a cooperative that purchases coffee from local farmers, gives them Rs. 88 for one kilogram of unprocessed organic coffee, while non-organic fetches Rs. 65.

From 55,525 tons in 2017-2018, coffee production in Wayanad plummeted by 40 per cent this year, Father John Choorapuzhayil, a director at the WSSS, told me over the phone. There is no official figure out, yet. "This fall in production is largely because changes in climate have proved the biggest threat to coffee growing in Wayanad," Fr. John says. Across the district, farmers we met spoke of the wild variations in yields from both excess rainfall – and sometimes the lack of it – in different years.

Augustine Vadakil and his wife Valsa (left) grow coffee as well as rubber, pepper, bananas, paddy and arecanut. The growing heat, however, has begun to affect coffee (right) and all the other crops too

Fluctuating rainfall leaves the fields water-starved. "Only 10 per cent of Wayanad's farmers," estimates Fr. John, "can work around drought or erratic rainfall with irrigation facilities like borewells and pumps."

Vadakil isn't among the lucky few. His irrigation pump was damaged during the floods that ravaged Wayanad and other parts of Kerala in August 2018. The Rs. 15,000 it would cost him to repair it is too large a sum in such trying times.

On his remaining two acres, Vadakil and Valsa grow rubber, pepper, bananas, paddy and arecanut. The growing heat, however, has begun to affect all these crops as well. "Fifteen years ago, pepper was all we needed to survive. But [since then] diseases like Dhruthavaattam [Quick Wilt] have destroyed acres of it across the district." Since pepper is a perennial crop, the farmers' losses have been devastating.

"As time passes, it seems like the only reason to farm is if it is a hobby. I have all this land, but look at my situation," Vadakil says. "All you can do in these times is grind some extra chilli because that's about all you can afford to eat with rice," he adds, laughing.

"It began 15 years ago," he says. "Why is the *kalavastha* changing like this?" Interestingly, the Malayalam word *kalavastha* means climate, not temperature or weather. We were asked this question many times by farmers across Wayanad.

Sadly, a part of the answer lies in the cultivation patterns adopted by farmers over the decades.

This coffee estate in Mananthawady (left), like other large estates, can afford to dig artificial ponds and install pumps when rainfall is low. But smaller farms such as Vadakil's (right) have to entirely depend on the rain or inadequate wells

"We say that it is healthy for multiple crops to be growing one each patch of farmland as opposed to the mono-cropping culture that now exists," says Suma T. R. She is a scientist at the M. S. Swaminathan Research Foundation, Wayanad, who has worked for over 10 years on land-use change issues. Mono-cropping drives the spread of pests and diseases, which are then treated with chemical pesticides and fertilisers. These make their way into groundwater or become airborne, causing contamination and pollution – and severe environmental damage over time.

It began, says Suma, with the deforestation unleashed by the British. "They cleared the forests for timber and converted many high elevation mountains into plantations." The alteration in climate is also linked, she adds, to "how our

landscape too changed with large-scale migration [into the district starting from the 1940s]. Prior to this, farmers in Wayanad primarily practised shifting cultivation.”

In those decades, the major crop here was wetland paddy, not coffee or pepper – even the word ‘*wayanad*’ comes from ‘*vayal nadu*’ or land of paddy fields. Those fields were vital to this region’s – and Kerala’s – environment and ecological systems. But the area under paddy – around 40,000 hectares in 1960 – is down to barely 8,000 hectares today. That, according to government data for 2017-18, accounts for less than 5 per cent of the district’s gross cropped area. And coffee plantations now cover nearly 68,000 hectares in Wayanad. That’s 79 per cent of the total coffee area in Kerala – and 36 per cent more than all Robusta acreage in the entire country in 1960, the year Vadakil was born.

“Farmers were cultivating crops like *ragi* on hillocks,” says Suma, instead of clearing the land for cash crops. Farmlands were able to sustain the ecosystem. But with growing migrations, she adds, cash crops took precedence over food crops. And with globalisation’s arrival in the 1990s, even more people started to depend completely on cash crops like pepper.

‘The fall in production is because changes in climate have proved the biggest threat to coffee in Wayanad’ – across the district, farmers we met spoke of the wild variations

“Today, farmers make Rs. 12 for one kilogram of paddy and Rs. 67 for coffee. Pepper, however, fetches them between Rs. 360 and Rs. 365 a kilo,” says E. J. Jose, a former project officer at WSSS, and an organic farmer in Mananthavady town. That huge price difference pushes even more farmers to abandon paddy and opt for pepper or coffee. “Everyone is now growing what is most profitable, not what is needed. [We are losing] paddy too, a crop that helps absorb water when it rains, and restores the water tables.”

Many paddy fields in the state have also been turned into prime real estate plots, reducing workdays for farmers skilled in cultivating that crop.

“All these changes have a continuing effect on Wayanad’s landscape,” says Suma. “The soil has been exploited through mono-cropping. A growing population [less than 100,000 till Census 1931 to 817,420 by Census 2011] and land fragmentation come with it, so it’s no wonder Wayanad is getting hotter.”

Jose too believes that these changing farming practices are closely tied to the rise in temperatures. “The change in agriculture patterns has influenced changes in rainfall,” he says.

In nearby Thavinhal *panchayat*, walking us around his 12-acre farm, 70-year-old M. J. George says, “These fields were once so full of pepper, it was hard for light to pass through the trees. We’ve lost tons of pepper in the past few years. Changing climatic conditions are causing diseases like Quick Wilt.”

Caused by the fungus *phytophthora*, Quick Wilt has eaten into the livelihoods of thousands across the district. It thrives in conditions of high humidity which have “significantly increased in Wayanad over the last 10 years,” says Jose. “The rains now are irregular. The increasing use of chemical fertilisers has also helped the disease to proliferate, steadily killing the good bacteria called *trichoderma* that helped combat the fungus.”



Top left: M. J. George says, ‘ We were famous for our rainfall’. Top right: ‘We had the least amount of coffee production this year’, says Subadhra Balakrishnan. Bottom left: It began, says, Suma T. R., a scientist, with the deforestation unleashed by the British. Bottom right: ‘ Everyone is now growing what is the most profitable, not what is needed’, says E. J. Jose

“Earlier we had air-conditioned climate in Wayanad, but not anymore,” says George. “Rainfall, consistent throughout seasons earlier, has significantly decreased in the last 15 years. We were famous for our rainfall...”

The India Meteorological Department, Thiruvananthapuram, says rainfall in Wayanad between June 1 and July 28, 2019, was 54 per cent below the normal average for the period.

Normally a high rainfall region, parts of Wayanad receive over 4,000 millimetres in some years. But the district average has fluctuated wildly for a while. It was 3,260 mm in 2014, saw a steep fall the next two years to 2,283 mm and 1,328 mm. Then, in 2017, it was 2,125 mm and in 2018, the year of Kerala’s floods, was a high 3,832 mm.

“The inter-annual variability of rainfall has changed in recent decades, most conspicuously from the 1980s, and accelerating in the ’90s,” says Dr. Gopakumar Cholayil, scientific officer at the Academy of Climate Change Education and Research of the Kerala Agricultural University, Thrissur. “And the incidence of extreme rainfall events in both monsoon and post-monsoon periods has risen across Kerala. Wayanad is no exception to this trend.”

That, in fact, confirms the observations by Vadakil, George and other farmers. Even when they mourn the ‘decrease’ – and the long-term averages do suggest a decline – they mean the rain is much less on the days and seasons they need and expect it. That can happen in years of high as well as low rainfall. The number of days over which the rain is spread has fallen, while its intensity has risen.

Wayanad could still have downpours in August-September, though July is the main month for the monsoon here. (And on July 29, the IMD issued an ‘orange alert’ warning of ‘heavy’ to ‘very heavy’ rainfall in this and a couple of other districts.)

Vadakil's coconut and banana plantations in Wayanad are slowly going downhill due to the erratic weather

“Changes in cropping patterns, erosion of forest cover, forms of land use...all these, among other factors, have had a serious impact on the ecosystem,” says Dr. Cholayil.

“With last year’s floods, all my coffee crops were lost. We had the least amount of coffee production this year across Wayanad,” says Subadhra ‘Teacher’ as she is fondly called in Mananthavady. The 75-year-old farmer (Subadhra Balakrishnan)

oversees cultivation on her family's 24 acres in Edavaka *panchayat* and grows coffee, paddy and coconut, among other crops. "Many Wayanad [coffee] farmers are now increasingly dependent on their cattle [for an income]."

They may not use the term 'climate change', but all the cultivators we met are worried about its effects.

At our last stop – Aden Valley, an 80-acre plantation in Poothadi *panchayat* of Sulthan Bathery *taluk* – we met Girijan Gopi, an agricultural labourer for the last 40 years, just as he was finishing half his shift. "It's very cold at night and very hot in the day. Who knows what is happening here," he said, before walking away to his lunch, muttering to himself: "Must be the gods. How else do we understand all this?"

Cover Photo: Vishaka George

The author would like to thank researcher Noel Benno for his time and generous help in doing this story.

PARI's nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.

Kadal Osai, a community radio of and for fisherfolk on Pamban island of Tamil Nadu's Ramanathapuram district, turns three this week. And it's making waves – with climate change as its latest focus.



‘Today we seek those fish in Discovery Channel’

Kadal Osai, a community radio of and for fisherfolk on Pamban island of Tamil Nadu's Ramanathapuram district, turns three this week. And it's making waves – with climate change as its latest focus

“It's past 11.40 this morning, so next comes an update on speed,” announces A. Yashwanth on the Kadal Osai radio station. “For the last one week, or even a month or so, *kachaan kaathu* [the south wind] was very strong. The speed was as high as 40 to 60 [kilometres per hour]. Today, as if to help fishermen, it is down to 15 [kmph].”

That's great news for the fisherfolk of Pamban island in Tamil Nadu's Ramanathapuram district. “It means they can go to sea without any fear,” explains Yashwanth, himself a fisherman. He is also a radio jockey at Kadal Osai (The Sound of the Sea), a neighbourhood station for the community in this region.

As a prelude to a special broadcast on blood donation, Yashwanth reels off the weather report, ending with: “The temperature is at 32 degrees Celsius. So stay hydrated, do not go in the sun.”

It’s a necessary precaution, because Pamban now sees far more hotter days than it did in 1996, when Yashwanth was born. Then, the island could expect at least 162 days a year where temperatures hit or crossed that 32C mark. When his father Anthony Samy Vas – still a full-time fisherman – was born in 1973, that was no more than 125 days annually. Today, those warmer days number at least 180 a year, according to a calculation from an interactive tool on climate and global warming posted online by the *New York Times* this July.

So Yashwanth and his colleagues are trying hard to understand not just the weather, but also larger issues of climate. His father, fellow fish workers, indeed the close to 83,000 people in Pamban and Rameswaram – the two main towns on the island – are looking to them to make sense of the changes.

RJ Yashwanth with his father Anthony Samy, and with their boat (right): ‘We used to calculate the winds and weather as we set out. None of our calculations hold good today’

“I have been fishing from age 10,” says Anthony Samy. “The seas have definitely undergone a huge change [since then]. Earlier, we used to calculate the winds and the weather as we set out. None of our calculations hold good today. The changes are so drastic, they defy our knowledge. It is also much hotter than before. Previously, it was never so warm when going to the seas. Today, the heat is making it more difficult for us.”

Sometimes, the unquiet sea that Samy speaks of, becomes fatal. As it did on July 4 this year when Yashwanth – who goes fishing on his father’s boat whenever he can – came in after 9 p.m. with news of four men losing their way in the rough seas. Kadal Osai was closed at the hour – it broadcasts from 7 a.m. to 6 p.m. – but an RJ (radio jockey) went on air, calling attention to the fishermen in distress. “We always have an RJ on the premises, even when officially shut,” says Gayathri Usman, the radio station’s chief. And other employees live nearby. “So we can always go on air in an emergency.” That day, Kadal Osai’s staff worked with unrelenting urgency to alert the police, coast guard, the public and other fisherfolk.

A couple of sleepless night later, only two men were rescued. “They were holding on to the damaged *vallam* [country boat]. The other two gave up midway, their hands were aching,” says Gayathri. They let go, asking their two comrades to convey their love to their families and explain that they just could not hold on any longer. Their bodies washed ashore on July 10.

“It is no longer like the old days,” frets 54-year-old A. K. Sesuraj or ‘Captain Raj’, who earned that title from the name of his boat. He asserts that “the sea was friendlier” when he began going out to it at the age of nine. “We knew what to expect in terms of catch and weather. Today, both are unpredictable.”

‘It is no longer like the old days’, frets A. K. Sesuraj or ‘Captain Raj’. He asserts that ‘the sea was friendlier...We knew what to expect in terms of catch and weather. Today, both are unpredictable’

Raj seems baffled by the changes, but Kadal Osai has a few, if partial, answers for him. The station had been running shows on the sea, weather patterns, and climate change since it was launched on August 15, 2016 by the NGO Nesakkarangal.

“Kadal Osai has a daily programme titled *Samuthiram Pazhagu* (*Know the Oceans*),” says Gayathri. “Its idea is conservation of the seas. We know the larger issues involved will affect the community long-term. *Samuthiram Pazhagu* is our effort to keep a dialogue on climate change going. We talk about practices detrimental to the health of the seas and how to avoid those [for example, over-fishing by trawlers, or how diesel and petrol are polluting the waters]. We have callers on the show narrating their own experiences. Sometimes, they speak of their mistakes – promising not to repeat them.”

“Since its launch, the Kadal Osai team has been in touch with us” says Christy Leema, communications manager at the M.S. Swaminathan Research Foundation (MSSRF), Chennai, which supports the radio station. “They use our experts in their programmes. But since May, we have also worked with them on creating awareness about climate change. It’s easier to do this through Kadal Osai, since as a community radio they are already hugely popular in Pamban.”

The station has aired four episodes in May and June specifically on climate change issues under the title *'Kadal oru athisayam, athai kaapathu nam avasiyam'* (The sea is a wonder, we must protect it). Experts from the Coastal System Research unit of MSSRF, led by its head, V. Selvam have featured in these episodes. "Such shows are extremely important because when we talk about climate change, we mostly do that at the top or expert level," says Selvam. "It needs to be discussed at the ground level, among those actually experiencing its impact on a day-to-day basis."

Left: Kadal Osai's office on a Pamban street that sees a busy trade in fish. Right: D. Redimar is one of the station's 11 employees who still goes to the seas

One episode on May 10 helped people in Pamban get a better understanding of a major change on their island. Till two decades ago, at least 100 families lived close to the 2,065-metre Pamban bridge that connects Rameswaram town to the Indian mainland. Rising sea levels forced them to leave and relocate. In the episode, Selvam explains to listeners how climate change accelerates such movements.

Neither the experts, fishermen, nor the station's reporters attempt to oversimplify the issue and resist the temptation of finding single-event or uni-causal explanations for the changes. But they do point to the role of human activity in spurring the crisis. Kadal Osai seeks to lead a community in search of answers, on a voyage of discovery.

"Pamban is an island eco-system and consequently more vulnerable," Selvam says. "But the presence of sand dunes protects the island from some forms of climate impact. Also, this island is somewhat protected from cyclones by the Sri Lankan coast," he explains.

But the loss of sea wealth remains real, and caused by a combination of climatic and non-climatic factors, he adds. Reduced catch has much to do with over-fishing, mainly by trawlers. Shoal movements go awry with the warming of the seas.

Left: M. Saelas interviewing women who, like her, are from the fishing community of Pamban island . Right: Gayathri Usman, the radio station chief, has brought a clear direction to the community platform

“Varieties like *ooral, sira, velakamban* ... have completely vanished,” explains B. Madhumita, a Kadal Osai RJ who is also from the fishing community, in an episode aired on May 24. “Some like *paal sura, kalveti, komban sura* continue to exist, but in greatly reduced numbers. Oddly, the *mathi* fish once found in abundance in Kerala, is rich in numbers on our side now.”

Another variety, *mandaikalugu*, that has disappeared here, was available in tons till about two decades ago, says Leena, an elderly woman (her full name is not available), in the same episode. She recalls how her generation consumed the eggs of that fish by opening its mouth and extracting them. That’s a concept younger women like M. Saelas, though from the community herself (and a full-time Kadal Osai anchor and producer, who holds an MCom degree), cannot quite comprehend.

“Till the 1980s, we used to get *kattai, seela, komban sura* and other such varieties, in tons,” says Leena. “Today we seek those fish on Discovery Channel. My grandparents [who used non-mechanised country boats] would say engine sounds chase the fish away. And that petrol or diesel poisoned the waters and altered the taste of the fish.” Those were also the times, she recalls, when women would catch fish by simply casting a net after wading into the seas, close to the shores. With fish not found near the shores anymore, women are going much less to the seas. One episode of May 17 also discussed traditional fishing methods and more recent technologies – and how to combine both to preserve marine life. “The fishermen are encouraged to set up a cage near the shores and breed fish. The government is supporting this ‘cage culture’ since it addresses the issue of eroding sea wealth,” says Gayathri.

Resonating with the fishing community

Pamban fisherman Antony Inigo, 28, is keen to try it. “Earlier, we would not let dugongs (a marine mammal) back into the seas if we found them in our catch. But after a Kadal Osai programme, we learned how climate change and human action have brought them to near-extinction. We are ready to cut our expensive nets to return them to the sea. And the same with turtles.”

“If we have an expert speaking on how climate change affects fish, we have fishermen connecting to us saying how true they find it to be,” says Gayathri.

“We blamed the gods and nature for disappearing fish. Through our shows, we have realised it’s almost entirely our fault,” says Saelas. Like her, all Kadal Osai staffers are from the fishing community – except Gayathri. She is a qualified sound engineer who joined them a year and a half ago, bringing a clear direction and purpose to the community platform.

Kadal Osai’s nondescript office is located on a Pamban street with a busy trade in fish most days. The name board in blue bears the tagline *N amathu Munnetrathukkana Vaanoli* (A Radio for our Development). Inside is the FM station with an up-to-date recording studio. They have segments for children, women, fishermen – and between programmes, play Amba songs – of fisherfolk going to sea. Of the station’s 11 employees, only Yashwanth and D. Redimer still go to the seas.

Yashwanth's family shifted to Pamban from Thoothukudi several years ago.

“Fishing was not a lucrative option there,” he says. “My father found it hard to get a good catch.” Rameswaram was relatively better, but “over the years, the catch has deteriorated here, too.” Kadal Osai made him realise the setbacks were not the “result of ‘black magic’ by others but perhaps the result of the ‘black magic’ that we wrought on this environment.”

He worries about the obsession with profit. “Some elders still believe they are poor because their ancestors didn’t do much in terms of the catch. They try to maximise profit, leading to over-exploitation of the seas. Some of us youngsters now understand the dangers in this, so we’re trying to undo that ‘black magic’”

He worries about the obsession with profit. ‘Some elders still believe they are poor because their ancestors didn’t do much in terms of the catch...They try to maximise profit, leading to over-exploitation of the seas’

Still, the traditional knowledge of the larger community remains a rich source of learning. “What experts often do,” says Madhumita, “is to validate that knowledge and remind us why we should put it to use. Our radio station respects and offers traditional knowledge an important platform. In turn, our community makes use of the expertise provided on our broadcasts.”

S. P. Rayappan, president of the Pamban Country Boats Fishermen’s Association Pamban, agrees. “We have always spoken about over-exploitation of marine life and its dangers. The awareness created among fisherfolk by Kadal Osai is more emphatic, our people now sometimes sacrifice imported nets to save a dugong or turtle.” And maybe one day, hope Saelas and Madhumita, their radio station will help bring back the *mandaikalugu* to the island’s waters.

Like most community radio stations, its broadcasts reach no further than 15 kilometres. But people in Pamban have embraced Kadal Osai – “and we get ten letters a day from listeners,” says Gayathri. “When we started, people wondered who we were and what ‘development’ we were talking about. Now they trust us.” It’s only the climate they’re losing faith in.

Cover photo: Children at a UN World Oceans Day celebration on June 8 in Pamban, holding a board that says Kadal Osai. (Photo: Kadal Osai)

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Villages in Sangole taluka of Maharashtra's Solapur district are brimming with stories of how the old cyclical pattern of good rainfall and dry spells has been broken – and why and with what impact.



‘Everything has turned upside down’ in Sangole

Villages in Sangole taluka of Maharashtra's Solapur district are brimming with stories of how the old cyclical pattern of good rainfall and dry spells has been broken – and why and with what impact

“People will call me crazy if I say this,” says 53-year-old Dnyanu Kharat, sitting on the mud floor of his brick house one afternoon. “But 30-40 years ago, during the rains, fish would flood our fields [from the nearby stream]. I caught them with my own hands.”

It's mid-June and just a little while before we reach his house, a 5,000-litre water tanker has trundled into Kharat Wasti hamlet. Kharat, his wife Phulabai, and others in their joint family of 12 persons, are busy storing water in all available vessels, pots, cans and drums. The tanker has come after a week, the shortage of water is acute.

“You won't believe, 50-60 years ago, we used to get such a heavy downpour, one could not keep the eyes open,” 75-year-old Gangubai Gulig tells us, sitting in the shade of *neem* trees near her house in Goudwadi, a village of around 3,200 people, some five kilometres from Kharat Wasti in Sangole *taluka*. “You saw those *babool* trees on your way here? That entire land produced excellent *matki*

[mothbean]. The *murum* [basaltic rock] used to hold rainwater and springs would start from our fields. Just four rows of *bajra* in an acre would yield 4-5 sacks of grain [2-3 quintals]. The soil was *that good*.”

And Hausabai Aldar, who is in her 80s, remembers the twin wells on her family farm in Aldar Wasti, a hamlet not far from Goudwadi. “Both the wells would be full of water in the rainy season [around 60 years ago]. Each had two *mote* [a system of bull-drawn pulleys] and all four would run at the same time. Be it any time of the day or night, my father-in-law would draw water and give it to the needy. Now, one can’t even ask for a pot full. Everything has turned upside down.”

With the joint Kharat family, Dnyanu (far left) and Phulabai (to the left of the door): he remembers a time of fish floating in the fields

Sangole *taluka* in Maharashtra’s Solapur district is awash with such tales, even though it is located in Maandesh, a ‘rain shadow’ region (sheltered from rain-bearing winds by a mountain range). The region comprises Sangole (also commonly spelt as Sangola) and Malshiras *talukas* in Solapur district; Jat, Atpadi and Kavathemahankal *talukas* in Sangli district; and Man and Khatav *talukas* in Satara district.

Good rainfall and drought have for long been cyclical here, and memories of abundance are as embedded in people’s recollections as times of scarcity. But these villages are now brimming with stories of how “everything has turned upside down,” of how the abundance seems to be in the past, of how the old cyclical pattern has broken. So much so, that Nivrutti Shendge of Goudwadi says, “The rain has even stopped appearing in our dreams.”

“This land, where the camp is right now, was famous for its *bajra* . I too have cultivated it in the past...” says 83-year-old Vithoba Soma Gulig, fondly called Tatyā, while preparing a *paan* for himself one blazing May afternoon at a cattle camp in Goudwadi. “Everything has changed now,” he adds, worried. “The rain has simply vanished from our village.”

Tatyā, who is from the Dalit Holar community, has spent all his life in Goudwadi, as have 5-6 generations of his family before him. It’s been a hard life. For more than 60 years, he and his wife, Gangubai, migrated to Sangli and Kolhapur to cut

sugarcane, laboured on people's farms and worked on state-run sites in and around their village. "Our four-acre land was bought just 10-12 years ago. Till then, it was sheer hard labour," he says.

At a cattle camp in May near Goudwadi village, Vithoba Gulig or 'Tatya' says, 'The rain has simply vanished from our village'

Now, though, Tatya is worried about the persistent drought in Maandesh. The natural cycle of good rain after a dry spell never returned to normal after 1972, he says. "It is less and less every year. We neither get [enough] *waliw* [pre-monsoon] showers nor the returning monsoon showers. And the heat is increasing day by day. Though last year [2018] we did get good *waliw* showers at least, this year... nothing till now. How will the land cool down?"

Many other elderly residents of Goudwadi recall the 1972 drought as a turning point in their village's cyclical rhythms of rain and drought. That year, Solapur district received just 321 millimetres of rain (shows the [indiawaterportal](#) using India Meteorological Department data) – the lowest since 1901.

For Gangubai, memories of the 1972 drought are recollections of hard labour – even harder than her usual – and hunger. "We constructed roads, built wells, broke stones [during the drought, for wages]. The body had energy and the belly had hunger. I have worked for 12 *annas* [75 paise] grinding 100 quintals of wheat. Things only got worse after that [year]," she says.

In 2018, Sangole received its lowest in 20 years and groundwater in the taluka's villages fell by more than a metre

"The drought was so severe, I walked with my 12 cattle for 10 days and reached Kolhapur, all alone," says 85-year-old Dada Gadade at the chai stall in the cattle camp. "The *neem* trees on Miraj road were all bare. All the leaves and shoots were fed to the cattle and sheep. Those were the worst days of my life. Nothing came back on track after that."

The prolonged droughts even led to a demand, in 2005, of a separate district of Maandesh comprising all the drought-prone blocks carved out of the three districts of Solapur, Sangli and Satara. (The campaign eventually lost steam when

some of its leaders shifted focus to issues such as irrigation schemes for the region).

Though it is the 1972 drought that many in Goudwadi recall as a milestone, data from the Solapur government website shows the district received even less rainfall in 2003 (278.7 mm) and in 2015 (251.18 mm).

And in 2018, Sangole received just 241.6 mm of rainfall, its lowest in 20 years, with only 24 rain days, says the 'Rainfall Recording and Analysis' portal of the Department of Agriculture, Maharashtra. A 'normal' rainfall for the block, the department notes, would be around 537 mm.

So the periods of water-abundance seem to have diminished or vanished, while the dry days, heat and months of water-scarcity are growing.

In May this year, the temperature had reached 46 degrees at the cattle camp at Goudwadi. Extreme heat has added to the drying of the air and soil. Data from an interactive portal on climate and global warming of the *New York Times* shows that in 1960, when Tatya was 24 years old, Sangole saw 144 days where temperature could rise to 32 degrees Celsius. Today that number has increased to 177, and if he lives to be a 100, by the year 2036, it will reach 193 days.

Sitting in the cattle camp, Tatya recalls, "Earlier, everything happened on time. Mirig showers [with the arrival of the Mrug or Orion constellation] always came on June 7 and it rained so well that the waters from the Bhivghat [stream] lasted till Paush [January]. "When you sow on Rohini [constellation, around the end of May] and Mirig rains, the crop is protected by the skies. The grain is nutritious and one who eats such grain, is healthy. But the seasons are no longer the same."

The loss of crop cover and growing heat have added to the soil's drying

Other farmers sitting with him at the cattle camp agree. All are worried about the growing uncertainty of the rain. "Last year, the *panchaang* [the Hindu almanac based on the lunar calendar] said ' *ghaveel* to *paveel*' – 'who gets to sow on time, will reap a good yield'. But the rain is now sporadic, it will not cover all the fields," explains Tatya.

Across the road, sitting at her tent in the camp, 50-year-old Phulabai Kharat from Kharat Wasti – she belongs to the Dhangar community (listed as a Nomadic Tribe), and has brought along three buffaloes – also reminisces about the "timely rain in

all constellations.” She says, “Only with the arrival of Dhondyacha *mahina* [one extra month every three years in the Hindu lunar calendar], the rain would go quiet. The next two years we would get good rainfall. But for the last many years, the rain has been silent even otherwise.”

To adapt to these changes, many farmers have altered their cultivation schedules. The typical cropping pattern for Sangole, farmers here say, was *matki* (mothbean), *hulage* (horsegram), *bajra* and *tur* for the *kharif* season; and wheat, chickpea and *jowar* in the *rabi* season. Summer varieties of maize and *jowar* are cultivated especially as fodder crop.

“Since the last 20 years, I have not come across any person in this village sowing [indigenous] *matki*. The same with *desi* varieties of *bajra* and *tur*. The *khapli* variety of wheat is no longer sown, neither *hulage* nor sesame,” says Hausabai of Aldar Wasti hamlet.

Left: Phulabai Kharat says, 'But for last many years, the rain has been silent...! Right: Gangubai Gulig says, 'Things only got worse after 1972'

With the monsoon arriving late – by late June, even early July – and leaving early – September now barely sees any rain – farmers here are switching to shorter-duration hybrid varieties of crops. These require around 2.5 months from sowing to harvest. “The indigenous five-month [longer-duration] varieties of *bajra*, *matki*, *jowar*, and *tur* are close to becoming extinct as there is just not enough moisture in the soil,” says Navnath Mali. He, along with 20 other farmers from Goudwadi, is a member of the Amicus Agro group in Kolhapur which provides, for a fee, weather forecasts via SMS.

To try their luck with other crops, some farmers here shifted to cultivating pomegranate around 20 years ago. State subsidies helped. Over time, from *desi* varieties, the farmers shifted to hybrid, non-indigenous types. “We earned around 2-3 lakhs per acre in the beginning [around 12 years ago]. But over the last 8-10 years, the orchards are infested with *telya* [bacterial blight]. I feel this is due to the changing weather. Last year, we had to sell our fruit at 25-30 rupees a kilo. What can we do about the whims of nature?” asks Mali.

The cropping patterns have also been greatly impacted by changes in the pre and post monsoon showers. The post monsoon rainfall – from October to December – in Sangole has perceptibly decreased. In 2018, the block received just 37.5 mm of

post monsoon rain, Department of Agriculture data show, against an average of 93.11 mm for a two-decade period from 1998 to 2018.

“The most worrisome trend for the entire Maandesh region is the disappearance of the pre and post monsoon showers,” says Chetna Sinha, founder of Mann Deshi Foundation, which works with rural women on issues of farming, credit and enterprise. (The foundation started the first cattle camp in the state this year, on January 1, in Mhaswad in Man block of Satara district, which sheltered more than 8,000 cattle). “The returning monsoon has been our lifeline as we depend on *rabi* crops for foodgrain and fodder for livestock. The absence of the returning monsoon since 10 or more years has had far-reaching impacts on pastoral and other communities in Maandesh.”

The scarcity of fodder has given rise to cattle camps in the dry months in Sangole

But perhaps the biggest change in cultivation practices here is the spread of sugarcane. In 2016-17, Solapur district cultivated 633,000 tons of sugarcane on 100,505 hectares of land, says data of the Finance and Statistical Directorate, government of Maharashtra. According to some news reports, by January this year, Solapur was at the top in the sugarcane crushing season that started in October, with more than 10 million tons crushed by 33 registered sugar mills (Sugar Commissionerate data) in the district.

Crushing just one ton of sugarcane, says Rajneesh Joshi, a Solapur-based journalist and water conservation activist, requires around 1,500 litres of water. This means that in the last sugarcane crushing season – October 2018 to January 2019 – over 15 million cubic metres of water were used for sugarcane in Solapur district alone.

With this gigantic use of water on one cash crop, the water available for other crops drops even more drastically in a region already struggling with low rainfall and a lack of irrigation. In Goudwadi, a village located on 1,361 hectares (Census 2011), most of it under cultivation, only 300 hectares are irrigated, estimates Navnath Mali – the rest is rain-fed. In Solapur district, government data show, of the total irrigation potential of 774,315 hectares, only 39.49 per cent was irrigated in 2015.

And the loss of crop cover (due to the switch to shorter-duration crops as a way to cope with the decreasing rain) as well as the growing heat, the farmers say, has further dried up the soil. The moisture in the soil now “is not even six-inches deep,” says Hausabai.

Groundwater levels are dropping too. The *Probable Water Scarcity Report* of the Groundwater Surveys and Development Agency shows that in 2018, in all 102 villages of Sangole, groundwater fell by more than a metre. “I tried drilling a borewell, but even at 750 feet, there is no water. The land is completely dry,” says Jotiram Khandagale, who owns around four acres and also runs a hair-cutting stall in Goudwadi. “Since the last few years, there is no guarantee of a good yield in both *kharif* and *rabi* seasons,” he adds. Mali estimates that in just Goudwadi, there are 150 private borewells, of which at least 130 have dried up – and people are digging even up to 1,000 feet to reach water.

The massive shift to sugarcane has also added to the move away from food crops. In the 2018-19 *rabi* season, Solapur district recorded only 41 per cent of *jowar* and 46 per cent of maize cultivation, says the Department of Agriculture. Across Maharashtra, the area on which *jowar* is cultivated has reduced by 57 per cent, and maize by 65 per cent, says the state’s *Economic Survey 2018-19*. And the yields of both crops have dropped by around 70 per cent.

Navnath Mali estimates that in just Goudwadi, there are 150 private borewells, of which at least 130 have dried up

Both crops are a critical source of foodgrain for humans and fodder for livestock. The scarcity of fodder has compelled the government (and others) to start cattle camps in the dry months in Sangole – as many as 105 camps with close to 50,000 cattle so far in 2019, estimates Popat Gadade. He is the director of a milk cooperative and the man who started the cattle camp in Goudwadi. And what do the cattle eat in these camps? The same sugarcane that guzzles (as estimates show) 29.7 million litres of water per hectare.

So, many intertwined shifts are underway in Sangole, those that are part of ‘nature’, but more so, those set in motion by humans. Among these are decreasing rainfall, fewer rain days, rising temperatures, more days of extreme heat, near-absent pre and post monsoon showers, and moisture loss in soil. As well as changes in cropping patterns – more shorter duration varieties and the resultant

loss of crop cover, fewer *desi* varieties, cultivation of fewer food crops such as *jowar* and more cash crops like sugarcane – along with poor irrigation, depleted groundwater levels – and more.

When asked what's causing all these changes, Tatyia at the Goudwadi cattle camp, smiles and says, "If only we could read the mind of the rain god! When man has become greedy, how will it rain? When human beings have changed their ways, how will nature follow its own?"

The old barrage on the dried up Man river just outside Sangole city

The author would like to thank activists Shahaji Gadahire and Datta Gulig for their time and valuable inputs.

Cover photo: Sanket Jain/PARI

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Villagers in Maharashtra's Latur district are baffled by the heavy and intense hailstorms in summer that have hit them this past decade. Some farmers are giving up on orchards altogether.



Hailstorms at 43°C wreck farming in Latur

Villagers in Maharashtra's Latur district are baffled by the heavy and intense hailstorms in summer that have hit them this past decade. Some farmers are giving up on orchards altogether

His roof didn't quite come down on him, but it did chase Gunwant around his farm. That image remains vividly etched in his mind. "The tin-roof of the shed on the edge of our land was torn off and came flying towards me," he recalls. "I hid under a pile of hay and managed to come out injury-free."

It isn't every day you get chased by a roof. The one Gunwant Hulsulkar was running from in Ambulga village had been ripped off by deadly winds accompanying a hailstorm there this April.

Emerging from under the hay-pile, Gunwant, 36, could barely recognise his own farm in Nilanga *taluka*. "It couldn't have lasted more than 18-20 minutes. But the trees had fallen off, dead birds were scattered around, and our livestock was badly injured," he says, pointing to the damage-marks left by the hailstorm on the trees.

“There is a hailstorm or unseasonal rain every 16-18 months,” says his mother Dhondabai, 60, sitting on the steps outside her two-room stone and mortar house in Ambulga. In 2001, her family shifted from cultivating pulses (*urad* and *moong*) to nurturing mango and guava orchards across their 11 acres. “We need to look after the trees through the year, but an extreme weather event of just a few minutes destroys our entire investment.”

It wasn't a one-off phenomenon that occurred this year. Extreme weather episodes, including torrential rainfall and even hailstorms, have showed up in this part of Maharashtra's Latur district for over a decade now. Uddhav Biradar's small one-acre mango orchard, also in Ambulga, collapsed in a 2014 hailstorm. “I had 10-15 trees. They died with that storm. I made no effort to revive them,” he says.

“The hailstorms continue,” 37-year-old Biradar adds. “It was painful to see the trees after the storm of 2014. You plant them, take care of them, and then they are blown away in minutes. I do not think I could go through all this again.”



Gunwant Hulsulkar (top left), his mother Dhondabai (top right) and father Madhukar (bottom right) are considering giving up on orchards because of the inevitable hailstorms, while Subhash Shinde (bottom left) says he might stay away from the kharif season altogether this time

Hailstorms? In Latur district of the Marathwada region? This is a place where, for well over half the year, the mercury is at or above 32 degrees Celsius. The latest hailstorm struck in the first week of April this year when temperatures ranged between 41 and 43 degrees.

But as almost every farmer here will tell you in exasperation, they can no longer figure out the behaviour of the *taapman*, *havaman* and *vatavaran* (temperature, weather and climate).

What they do comprehend is that the number of rainy days annually has dropped, while the count of hotter days has risen. In 1960, the year Dhondabai was born, Latur could expect at least 147 days annually that would see temperatures of 32 degrees or above, as data from an app on climate change and global warming posted by the *New York Times* shows. This year, that would be 188 days. When Dhondabai turns 80, there could be 211 of these very hot days.

“It’s hard to believe we are approaching the end of July,” Subash Shinde told me when I visited his 15-acre farm in Ambulga last month. The farm looks barren, the soil is brown and bears not a hint of green buds. Shinde, 63, takes out a handkerchief from his white *kurta* and soaks off the sweat from his forehead. “I usually sow soybean by mid-June. This time around, I might stay away from the *kharif* season altogether.”

Farmers like Shinde, in this 150-kilometre stretch linking southern Latur to Hyderabad in Telangana, mainly cultivate soybean. Till around 1998, Shinde says, *jowar*, *urad* and *moong* were the primary *kharif* crops here. “Those required consistent rainfall. We needed a timely monsoon for a decent harvest.”

Shinde and most others here shifted to soybean around the year 2000 because, he says, “it is a flexible crop. If the weather patterns change a bit, it does not collapse. It was attractive in the international market as well. We ended up saving money at the end of the season. Plus, the post-harvest leftovers of soybean could serve as animal fodder. But over the past 10-15 years, even soybean has not been able to deal with the erratic monsoons.”



Latur's widespread casualties of recent hailstorms: Wrecked safflower (top left; photo: Narayan Pawale); a field after the hailstorm (top right; photo: Nishant Bhadreshwar); destroyed watermelon (bottom left; photo: Nishant Bhadreshwar); wilting jowar (bottom right; photo: Manoj Aakhade)

And this year, “those who have sown their crops are now regretting it,” says G. Sreekanth, collector, Latur district. “Because the initial showers have been followed by a dry spell.” There has been only 64 per cent sowing (all crops) across the district. In Nilanga *taluka* , 66 per cent. Obviously, soybean, which accounts for over 50 per cent of total cropped area in the district, has taken a big hit.

Latur is in the agricultural region of Marathwada and has a normal annual average rainfall of 700 mm. The monsoon arrived on June 25 this year and has been erratic since. At the end of July, Sreekanth told me that there had been a 47 per cent shortfall below the normal rainfall for that period.

In the early 2000s, says Subash Shinde, an acre of soybean yielded 10-12 quintals on an investment of around Rs. 4,000. Nearly two decades later, the price of soybean may have doubled from Rs. 1,500 to Rs. 3,000 a quintal, but, he says, cultivation costs have tripled and per acre output has halved.

The data of the State Agricultural Marketing Board support Shinde’s observations. In 2010-11, soybean acreage was 1.94 lakh hectares, and production was 4.31 lakh tonnes, says the Board’s website . In 2016, soybean covered 3.67 lakh hectares, but production was just 3.08 lakh tonnes. An 89 per cent increase in acreage, but a 28.5 per cent fall in production.

Madhukar Hulsulkar, 63, Dhondabai's husband, points to another feature of the present decade. "Since 2012, our use of pesticides has increased a lot. Just this year, we have had to spray 5-7 times," he says.

Dhondabai chips in with more insights on the changing landscape. "We used to come across kites, vultures and sparrows regularly earlier," she says. "But for the past 10 years or so, they have become rarer and rarer."



Madhukar Hulsulkar under his mango tree: ' Since 2012, our use of pesticides has increased a lot. Just this year, we have had to spray 5-7 times'

"Pesticide use in India is still below one kilogram per hectare," says Atul Deulgaonkar, Latur-based environmental journalist. "The US, Japan and other advanced industrial nations use 8 to 10 times as much. But they regulate their pesticides, we do not. Ours contain cancerous elements, which affect the birds around the farm. It kills them."

Shinde blames critical changes in climate patterns for the productivity drop. "We used to have 70-75 rainy days in the four-month monsoon period [June-September]," he says. "It would drizzle, consistently and gently. In the past 15 years, the number of rainy days has halved. When it does rain, it pours maddeningly. And that is followed by a 20-day dry spell. It is impossible to farm in this weather."

The India Meteorological Department's data for Latur support his observations. In 2014, rainfall in the four monsoon months was 430 mm. The next year, 317 mm. In 2016, the district got 1,010 mm in those four months. In 2017, that was 760 mm. Last

year, Latur got 530 mm in the monsoon season, of which 252 mm came in the single month of June. Even in the years where the district receives its 'normal' rainfall, the spread and dispersal have been most uneven.

As Chandrakant Bhojar, senior geologist with the Groundwater Surveys and Development Agency, points out: "Torrential rainfall in a limited time results in soil erosion. When, instead, it drizzles consistently, that helps the groundwater recharge."

Shinde can no longer depend on groundwater because his four borewells are, more often than not, dry. "We used to strike water at 50 feet, but now even borewells 500 feet deep are dry."

That throws up other problems. "If we do not sow enough, there is no fodder for the animals," says Shinde. "Without water and fodder, farmers are unable to maintain their livestock. I had 20 head of cattle until 2009. Today, just nine. "

This is in Latur district of Marathwada, where for more than six months it's above 32 degrees Celsius. The latest hailstorm struck in April this year when temperatures ranged between 41 and 43 degrees

Shinde's mother, Kaveribai, still sharp and alert at 95, says "Latur was a hub of cotton since Lokmanya Tilak introduced it here in 1905." She sits on the floor with folded legs and needs no help to get up. "We used to have ample rainfall to cultivate it. Today, soybean has taken its place."

Shinde is happy his mother gave up active cultivation around two decades ago – before the hailstorms began. "They devastate the farmland within a few minutes. The biggest sufferers are those who own orchards."

In this relatively better-off southern belt, orchard-growers have indeed been particularly hit. "The last hailstorm came in April this year," says Madhukar Hulsulkar, taking me into the orchard where many yellow spots are visible on the tree trunks. "I lost fruit worth Rs. 1.5 lakhs. We are down to 50 trees from the 90 we began with in 2000." Now he's considering giving up on orchards as "the hailstorms are becoming inevitable."

Latur has, over a century, seen many shifts in cropping patterns. Once dominated by *jowar* (sorghum) and other millets, and to a lesser extent maize, it took to cotton in a big way from 1905.

Then came sugarcane from 1970, sunflower briefly, and large-scale soybean cultivation from 2000. The spread of cane and soybean was quite spectacular. In 2018-19, cane covered 67,000 hectares (say data from the Vasantdada Sugar Institute, Pune). And from one sugar factory in 1982, Latur now has 11. With the cash crops came the inescapable borewell explosion – there is no count of how many have been drilled – and intense groundwater exploitation. Over a 100 years of cash cropping in a soil historically attuned to millets has had its inevitable impacts on water, soil, moisture and vegetation.

Also, forest cover in Latur is just 0.54 per cent, says the state government website. Below even the pathetic Marathwada-wide average of 0.9 per cent.

Left: Kaveribai Shinde, 95, recalls, 'Latur was a hub of cotton... We used to have ample rainfall to cultivate it'. Right: Madhukar Hulsulkar and his son Gunwant – walking away from farming altogether due to the climate?

“It would be wrong to make a narrow causal equation between all these processes and climate change,” says Atul Deulgaonkar. “And difficult to support with hard evidence. Also, such change occurs across large regions and not within the human-drawn boundaries of a district. Marathwada, of which Latur is a small part, is experiencing profound changes in some ways linked to growing agro-ecological imbalances.

“But some correlation between the multiple processes does seem to exist across the larger region. And it is intriguing that extreme weather episodes and hailstorms really arrived and surged a decade after the last big crop shift and major changes in land use and technologies. Even if human activity cannot be condemned as the cause, it certainly contributes in significant measure to the climatic imbalances we’re seeing.”

Meanwhile, people are bewildered by the rising number of extreme weather episodes.

“Every agricultural cycle puts farmers under greater stress,” says Gunwant Hulsulkar. “That’s one of the reasons behind farmers suicides. My kids would be better off working as clerks at a government office.” His perspective on farming

has changed with the climate.

“Agriculture increasingly seems a waste of time, energy and money,” says Subash Shinde. It was different in his mother’s time. “Farming was our natural choice,” says the effusive Kaveribai.

When I bid Kaveribai farewell with a *namaste*, she offers me a handshake instead. “Last year, my grandson saved money and made me travel on a plane,” she says with a proud grin. “This is how someone greeted me on the flight. The weather is changing, I thought our greeting habits should also change.”

Cover photo (hailstorm damage in Latur): Nishant Bhadreshwar.

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In the high mountains of the eastern Himalayas in Arunachal Pradesh, the nomadic Brokpa community is recognising climate change and devising coping strategies based on traditional knowledge.



‘The happy days are now just nostalgia’

In the high mountains of the eastern Himalayas in Arunachal Pradesh, the nomadic Brokpa community is recognising climate change and devising coping strategies based on traditional knowledge

“Dzomo are very popular among us now,” says Pempa Tsuring, 35, a nomadic herder from Lagam village in West Kameng district.

Dzomo? What’s that? And what makes them popular here at 9,000 feet and above in the mountains of Arunachal Pradesh?

The *dzomo* are a hybrid of yak and *kot*, a type of highland cattle. The male hybrid, called *dzo*, is sterile, so the herders prefer the female, the *dzomo*. While this is not a new breed, the Brokpa, a semi-nomadic pastoral community, have been adding more of these animals to their herds in recent times – to adapt to the changing climate in the eastern Himalayas.

Pempa, whose herd of 45 animals includes both yaks and *dzomos*, says these yak-cattle hybrids “are more heat-resistant and can adapt better to lower altitudes and rising temperatures.”

In these high-altitude grazing grounds, heat or ‘warming’ are both very real and relative. Here there are no 32 degree Celsius days in the year. But yak, which can withstand minus-35 degrees with ease, struggle if the temperature rises beyond 12 or 13 degrees. Indeed, the entire ecosystem struggles when these changes occur – as they have in recent years in these mountains.

The Brokpa, the nomadic herders within the larger Monpa tribe (of around 60,000 in Arunachal notes Census 2011), have for centuries reared yak and tend them at mountainous grazing grounds. During the harsh winters, they live in the lower regions, and in summer they migrate to higher altitudes – moving between 9,000 and 15,000 feet.

But like the Changpa in the Changthang region of Ladakh, the Brokpa too have been severely hit by an ever-more erratic climate. For centuries, their livelihoods, their very societies, have been based on rearing and herding yak, cattle, goat, and sheep. Of these, they depend the most on the yak – at economic, social, and even spiritual levels. That bond is now severely undermined.

“The yak start feeling exhausted as early as late February because of the heat,” Leki Suzuk, a herder in Chandar (locally also spelt Chander) village, told me. I stayed with her family during my visit in May to Dirang block of West Kameng. “The summer is prolonged in the past several years, the temperature has risen. The yak have weakened,” adds Leki, who is in her late 40s.



The dzomo are a hybrid of the yak and kot , a type of highland cattle. The Brokpa, a nomadic pastoral community, have been adding more of these animals to their herds to adapt to the changing climate in the eastern Himalayas

Along with the temperatures, the Brokpa say, the entire weather pattern has become increasingly unpredictable in the past two decades in the mountains of Arunachal Pradesh, which border the Tibet Autonomous Region of China, Bhutan and Myanmar.

“Everything is delayed,” says Pema Wange. “The arrival of summer is delayed. The arrival of snowfall is delayed. The seasonal migrations are delayed. The Brokpa go to their higher grazing locations to find them still covered in snow. That means even the melting of the snows is delayed.” Pema, in his late 30s, is not a Brokpa, but a conservationist from Thembang village who belongs to the Monpa tribe and works for the World Wildlife Fund.

This time, I’m speaking to him on the phone, since much of the region which I normally traverse there has become inaccessible after heavy rains. But I was there in May this year, standing on a cliff with Naguli Tsopa, a Brokpa yak herder from Chandar village, looking down at the rich forests of West Kameng district. Most of his community is concentrated here and in Tawang district.

“It’s a long journey from here to Mago, our summer grazing ground,” said Naguli, who is in his late 40s. “We have to walk through the jungles for 3-4 nights to reach there. Previously [10-15 years ago], we used to leave [for the upward migration] by

May or June. But now we must start earlier, by February or March and return later, by up to 2-3 months.”

Naguli, who I accompanied on one of his long journeys into heavily misted woods to collect the best quality of bamboo that grows in these parts, pointed to more problems: “Because of the extended summers,” he said, “some of the local medicinal herbs we use to treat the yaks – they don’t seem to grow any more. How do we tend to their ailments?”

Arunachal is normally a rainfall-rich state, which averages over 3,000 millimetres of rain annually. But it has suffered rainfall deficits for several years in the past decade, with the shortfall ranging, suggests India Meteorological Department data, between 25 and 30 per cent in at least four of those years. Though in July this year, the state saw torrential downpours washing away or sinking quite a few roads. Amid these fluctuations, the constant in the mountains is rising temperatures.



Naguli Tsopa, taking a tea break while grazing his animals at the high-altitude grasslands of West Kameng district, says, ‘Because of the extended summers, some of the local medicinal herbs we use to treat the yaks don’t seem to grow any more. How do we tend to their ailments?’

In 2014, a study by the University of Wisconsin-Madison, recorded changes in temperatures in the eastern Tibetan Plateau (the larger geographical zone in which Arunachal is located). Daily low temperatures had “increased greatly over the last 24 years” (between 1984 and 2008). Daily high temperatures had increased at a rate of 5 degrees Celsius in 100 years.

“We are trying to deal with the issues of erratic weather,” says Tsering Dondup, another herder, in his early 30s, who we ran into. “We have extended our migration time by two or three months. We are using pasture more scientifically [through more patterned rather than random grazing].”

Like him, the majority of the Brokpa are aware of climate change. They don't speak much of why this might be happening, but understand the damage it is doing. And here's something encouraging: they're figuring out various adaptation strategies, say several researchers. One group that surveyed the community pointed to this in 2014 in the *Indian Journal of Traditional Knowledge*. Their research concluded that 78.3 per cent of Brokpas in West Kameng and 85 per cent of those in Tawang – that's 81.6 per cent of this nomadic community in Arunachal – “were aware [of]... the changing climatic scenario.” And of these, over 75 per cent “stated that they have adopted at least one adaptation strategy to cope up with climate change.” The researchers note other strategies too – ‘herd-diversification’, migration to higher altitudes, changes in the migrations calendar. Their paper speaks of “10 coping mechanisms” to counter “the negative impacts of climate change.” The other strategies include changes in pasture use, rejuvenation of degraded high-altitude grazing grounds, revised herding practices, and cattle-yak hybridisation. Also, supplementing feed with other items where grass is scarce, adopting new livestock healthcare methods, and seeking additional sources of income such as road construction labour, small businesses, and fruit collection.

There is no way to know if any or all these will work and not be overwhelmed by larger processes. But they're doing *something* – and have to. The herders tell me the average family has lost 20-30 per cent of its annual income from the decline of the yak economy. A fall in milk yields also means a drop in the amount of homemade ghee and *chhurpi* (cheese from fermented yak milk). The *dzomo* may be sturdier but do not necessarily match the yak in milk and cheese quality, or even in religious importance.

“As the yak herds are shrinking or suffering degradation, so too the incomes of the Brokpa are dwindling,” Pema Wange said during that May trip. “Now [commercially processed] packaged cheese is easily available in the local market. So *chhurpi* sales are falling. The Brokpa are hurt both ways.”

Shortly before I left for home that time, I ran into 11-year-old Norbu Thupten. He was with his herd in the isolated hamlet of Thumri along the Brokpa migration route. “My grandfather's time was the best,” he asserted confidently. And added,

perhaps reflecting the talk of his elders: "More pasture and fewer people. The elders say we had neither border restrictions nor climate difficulties. But the happy days are now just nostalgia."



The Brokpa of West Kameng and Tawang districts in Arunachal Pradesh , a community of reclusive herders of the Monpa tribe , live in the mountains at altitudes ranging from 9,000 to 15,000 feet . They say their migration patterns are changing with the increasingly unpredictable weather patterns



A young brigade packs the rations while the senior herders prepare to migrate. 'Everything is delayed', says Pema Wange. 'The arrival of summer is delayed. The arrival of snowfall is delayed. The seasonal migrations are delayed'



Outside Chandar village, a group of Brokpa herders talks about the migration route. Because the snow at higher altitudes clears late, they now often have to change their route or wait along the way with their herds



A group of Brokpa herders going to the grazing ground at Mago, along a route that crosses three high-altitude passes: 'Previously, we used to leave by May or June. But now we must start earlier, by February or March and return later, by up to 2-3 months'



Tashi Tsering milking dzomo in the forests near Lagam village. The dzomo may be more heat-resistant and can adapt better to lower altitudes, but don't necessarily match yaks in milk and cheese quality, or even in religious importance; they are smaller too, and more disease-prone, and this is impacting the Brokpa economy



Back from collecting fruits in the jungle: To cope with the changes, Brokpa herders are turning to other sources of income such as road construction labour, small businesses, and fruit collection – which involves many hours of walking on muddy roads



Returning after collecting bamboos from the jungle: Bamboos are central to the Brokpa's daily life, and are used to build makeshift kitchens and household items. But these rhythms are all slowly changing



A Brokpa herder with a dzo that died while descending from the mountains. Since food is scarce in these high-altitude villages, nothing is wasted



A fire is always lit in the Brokpa kitchen. It helps them – and their animals – stay warm during the harsh winters. A 2014 study notes that daily low temperatures in the region ‘increased greatly’ between 1984 and 2008, and daily high temperatures increased at a rate of 5 degrees Celsius in 100 years



Naguli Tsopa at home with chhurpi, the traditional cheese. This important source of income for the Brokpa herders is dwindling with the falling yak population and the availability of packaged cheese in nearby markets



At home in Chandar: Leki Suzuk and Naguli Tsopa. When a Brokpa couple moves in together, they club their herd to optimise grazing resources



Little Norbu, Leki Suzuk and Naguli Tsopa's youngest son, struggling with an umbrella in a gusty wind

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People in the Sundarbans of West Bengal, for long living on the edge, are now facing climate change – recurring cyclones, erratic rain, growing salinity, rising heat, depleting mangroves and more.



Sundarbans: ‘Not a blade of grass grew...’

People in the Sundarbans of West Bengal, for long living on the edge, are now facing climate change – recurring cyclones, erratic rain, growing salinity, rising heat, depleting mangroves and more

Kajal Lata Biswas is still haunted by memories of the cyclone. Though it's been 10 years since Aila hit the Sundarbans, she still clearly recalls May 25, 2009.

It was just before noon. “The [Kalindi] river water rushed into the village and flooded all the houses,” says Kajal Lata. She was at a relative’s house in Kumirmari village that day, around seven kilometres from her own village, Gobindakati.

“Some 40-50 of us took shelter in a boat where we stayed the whole day and night. We watched trees, boats, cattle and paddy being swept away. At night, we could not see a thing. Even the matchsticks were soaked. We could see only when lightning flashed across the sky.”

Sitting outside her house and cleaning fish for lunch, 48-year-old Kajal Lata, a farmer, continues, “That night can never be forgotten. There wasn’t a drop of drinking water. Somehow, I collected a few raindrops in a plastic bag, which I used to wet the lips of my two daughters and niece, who were very thirsty.” Her voice shakes with the memory.

The next morning, they used a boat to reach their village. Then waded through flood water to reach home. “Tanushree, my elder daughter, then 17, almost drowned where the water was very high. Luckily, she grabbed her aunt’s saree *pallu* which had come loose,” Kajal Lata says, her eyes relaying the fear she felt. In May 2019, her fear returned with cyclone Fani, its arrival coinciding with the wedding of her younger daughter, 25-year-old Anushree.

Kajal Lata Biswas, cleaning fish outside her house in Gobindakati village, recalls the terror of approaching cyclones; paddy is stored in these huts (right) in her village, and the crop has taken a hit

The wedding was fixed for May 6. Loudspeaker announcements about Fani by the *panchayat* and on radio by the government had started a few days earlier.

“Imagine our plight and fear,” Kajal Lata says. “We were terrified that winds and rain would destroy all the preparations. There was some rain in the days before the wedding. But thankfully, the cyclone did not affect our village,” she adds, clearly relieved.

On May 2, the India Meteorological Department had issued a warning about Fani hitting Andhra Pradesh, Odisha (which turned out to be the worst affected) and West Bengal. Talking about Fani, Prafulla Mondal, an 80-year-old farmer and former teacher in Rajat Jubilee village, raises his voice a few notches: “Fani missed the Sundarbans very narrowly. The winds whistled by us. If it had hit our village, we would have been destroyed, along with our houses and land...”

As both Mondal and Kajal Lata know only too well, cyclones are common in the Sundarbans. The Disaster Management and Civil Defence Department of the West Bengal government categorises both South and 24 North Parganas districts as ‘very high damage risk zones’ due to cyclones.

Mondal’s village is in Gosaba block of South 24 Parganas district, and Kajal Lata’s village is in North 24 Parganas district’s Hingalganj block. Both are among the 19 blocks which comprise the Indian Sundarbans in West Bengal – 6 blocks in North

24 Parganas and 13 in South 24 Parganas.

Spread across India and Bangladesh, the Sundarbans is a vast delta with perhaps the largest contiguous mangrove forest in the world – covering around 10,200 square kilometres. “The Sundarbans region is one of the richest ecosystems in the world...” says a 2014 report by the World Bank titled *Building Resilience for the Sustainable Development of the Sundarbans*. “The entire mangrove forest region is known for its exceptional biodiversity, including numerous threatened species such as the Royal Bengal tiger, estuarine crocodile, Indian python, and several species of river dolphin. It is home to more than 10 per cent of mammal and 25 percent of bird species found in India.”

The Indian Sundarbans – roughly 4,200 square kilometres – is also home to nearly 4.5 million people, many of whom live on the edge, struggling with meagre livelihoods, a harsh terrain and weather extremes.

Though the region has not seen a major cyclone after Aila, it remains severely vulnerable. A 2006 report by the Indian Institute of Technology, Kharagpur, done for the West Bengal government’s Department of Disaster Management, notes that the state experienced 71 cyclonic storms from the years 1891 to 2004. In that period, South 24 Pargana district’s Gosaba was the most affected block, with six severe cyclones and 19 cyclones.

In Rajat Jubilee village, 80-year-old Prafulla Mondal has weathered many storms, but his family is now struggling with erratic weather changes

Prafulla can thus recall cyclones even before Aila. “I cannot forget the 1998 cyclone [described as West Bengal’s ‘most intense storm’ since Independence, stronger even than Aila, which was a ‘severe cyclonic storm’] with its strong and violent winds. Before that too, I can remember the cyclone of 1988,” he says.

But even given this stormy past, cyclonic depressions (a tropical weather disturbance at sea, in the range of 31- 60 kilometres an hour, below the range of a cyclonic storm of 62-82 kilometres) have increased 2.5 times in the last 10 years in the lower Gangetic delta (where the Sundarbans are located), notes Dr. Abhijit Mitra, a Kolkata-based oceanographer, in a 2019 book titled *Mangrove Forests in India. Exploring Ecosystem Services*. “This means that cyclones occur more frequently,” he says.

Various other studies show that the incidence of cyclones has increased in the Bay of Bengal, alongside the Sundarbans. One study published in 2015 in the *Diversity* journal puts the increase at 26 per cent between 1881 and 2001. And using available data from 1877 to 2005 on cyclones in the Bay of Bengal during May, October and November, a 2007 study shows that the frequency of severe cyclonic storms here has registered significant increasing trends in past 129 years during these intense cyclonic months

In part, this is attributed to the increase in sea surface temperature (notes, among others, a paper in the *Journal of Earth Science & Climate Change*). These temperatures rose in the Indian Sundarbans at 0.5 degrees Celsius per decade from 1980 through 2007 – higher than the globally observed warming rate of 0.06° C per decade.

There have been several catastrophic fallouts. “While the Sundarbans last experienced a major cyclone in 2009,” says Prof. Sugata Hazra of the School of Oceanographic Studies at Jadavpur University, Kolkata, “the region has suffered because of repeated inundation and embankment failure owing to subsequent cyclones in the northern Bay of Bengal.”

Rising sea levels and sea surface temperatures, among several other shifts, are threatening the Sundarbans

Embankments, the World Bank report notes, “play a key role in the Sundarbans as systems of defense against cyclonic storms and sea level rise. The people and the productivity of their holdings are under increased threat from deltaic subsidence, sea level rise, and increased cyclone intensity as climate change and the decay of a 19th century 3,500-kilometer system of embankments take their toll...”

A 2011 World Wildlife Fund paper says that the relative mean sea level for 2002-2009 measured at the Sagar island observatory, Sundarbans, rose at the rate of 12 mm per year or at the rate of 8 mm per year for 25 years.

The warming and related sea level rise is also adverse affecting mangroves. These forests help protect coastal areas from cyclones and erosion, act as breeding ground for fish and other species, and are also the habitat of the Bengal Tiger. A 2010 paper by Jadavpur University’s School of Oceanographic Studies, titled

Temporal Change Detection (2001-2008) Study of Sundarban notes that the rise in sea level and cyclones seriously affect the health of Sundarban's mangrove forests by reducing the forest cover.

Arjun Mondal a fisherman from Rajat Jubilee village, was acutely aware of the importance of mangroves to the Sundarbans. He worked with an NGO, the Sundarbans Rural Development Society. "Everyone has heard of climate change, but how is it affecting us? We need to know more about this," he told me in May 2019.

On June 29, 2019, Arjun was carried away by a tiger while hunting for crabs in the Pirkhali forest. While humans have for long been attacked by tigers in the Sundarbans, the increasing reports of attacks are at least partially due to the erosion of forest land caused by rising sea levels, bringing tigers in closer contact with inhabited villages.

With the battering of the region by cyclones, water salinity levels have also risen, especially in the central Sundarbans, where Gosaba is located. "...the ecosystem is being adversely impacted by significant increases in salinity due, in part, to sea level rise as well as reductions in freshwater flows to the delta," notes the World Bank report.

The extensive embankments in the Sundarbans, crucial to farming and controlling soil salinity, are steadily being eroded by the rising sea levels

A research paper co-authored by Dr. Mitra describes the Sundarbans as 'hypersaline'. "Water salinity has increased due to rising sea levels in the central part of Sundarbans. This is clearly linked to climate change," says Dr Mitra.

Other researchers have noted that the siltation of the Bidyadhari river, which prevents fresh water flows from the Himalayas to the central and eastern Sundarbans. Researchers have attributed the siltation in part to land reclamation, cultivation, dumping of sewage sludge and fisheries waste. The building of the Farakka Barrage in 1975 (on the Ganga, in West Bengal's Murshidabad district) also contributed to the increasing salinity of the central Sundarbans.

The Mondal family in Rajat Jubilee knows the effects of the high salinity – they had no rice to sell for three years after Aila. Their annual income of Rs. 10, 000- 12,000 from selling rice was wiped out. "With rice cultivation gone, entire villages emptied

out as men left to hunt for work, to Tamil Nadu, Karnataka, Gujarat and Maharashtra, where they joined factories or construction sites as labourers,” Prafulla recalls.

Across the state, Aila affected more than 2 lakh hectares of cropped area and over 6 million people, and it killed 137 and destroyed over 1 million houses . “There was nobody in my village who did not suffer losses,” Prafulla says. “My house and crops were destroyed. I lost 14 goats and could not cultivate paddy for three years. Everything had to be rebuilt from scratch. Those were hard years. I took up carpentry and odd jobs to make a living.”

After Aila intensified salinity, Kajal Lata’s family too had to sell six *bighas* of their 23 *bighas* (7.6 acres) of land. “Not a blade of grass grew for two years because the soil was so salty. Not even rice could grow. Slowly, vegetables like mustard, cabbage, cauliflower and gourds are growing again, enough for our consumption, but not enough to sell,” she says. “We also had a pond which produced different fish like *shol* , *magur* , *ruí* and we could earn Rs. 25,000-30,000 a year by selling these. But after Aila, the water became entirely salty, so there is barely any fish.”

Mangroves are critical to the ecosystem of the Sundarbans, but they too are slowly thinning out

The soil degradation – including high salinity and high alkalinity – caused by Aila resulted in poor paddy growth across much of North and South 24 Pargana, notes a 2016 paper in the *Journal of Experimental Biology and Agricultural Sciences*. A study in the journal shows that to grow paddy again, phosphate and potash-based fertiliser had to be used above the recommended levels.

“After Aila, fertiliser use has increased. Only then we are able to get the required yield,” says Prabir Mondal, Prafulla’s 48-year-old son. “It isn’t healthy to eat, but we still need to eat it. I remember the rice we ate as children. You could eat it as it is. Now, even when eaten with vegetables, something feels amiss.”

His father owns 13 *bighas* (4.29 acres) of land which produces 8-9 *bastas* of rice per *bigha* – one *basta* equals 60 kilos. “The cost of planting, cutting and lifting the rice plus fertiliser costs means that we earn very little over what we have spent,” says Prabir.

Paddy production across the Sundarbans, a 2018 research article observes, fell by half after Aila – from 64-80 quintal to 32-40 quintals per 1.6 hectares. Though paddy production has now stabilised to pre-Aila levels, says Prabir, his family and

others in his village remain completely dependent on rainfall from June to September.

And that rainfall has become unreliable. “The accelerated sea level rise,” says Prof. Hazra, “and the delayed arrival and deficiency of monsoon, are impacts of climate change in the long run.”

High rainfall exceeding 100 millimetres a day is occurring more often in the last two decades over the northern Bay of Bengal (where the Sundarbans is located), says ongoing research at the School of Oceanographic Studies, Kolkata. At the same time, in the sowing season, Prof. Hazra says, the monsoon has often fallen short, as it did this year – till September 4, around 307 millimetres short in South 24 Parganas and nearly 157 mm less in North 24 Parganas.

It's not just this year – a shortfall or excess rain has been recurring in the Sundarbans for some years. The normal June to September monsoon rain in South 24 Parganas is 1552.6 mm. The monsoon data for 2012-2017 the district indicates that rainfall was deficient in four out of six years, with major lows in 2017 (1173.3 mm) and 2012 (1130.4 mm).

In the North 24 Parganas, the opposite has happened: excess rainfall. The normal June to September rainfall here is 1172.8 mm. The monsoon data for 2012-2017 shows that rainfall was excess in four out of these six years with the highest in 2015 – 1428 mm.

“The real trouble is the untimely rain,” says Kajal Lata. “In February this year, there was plenty of rain, almost like monsoon. Even the elders said they could not recall a time when it rained so much in February.” Her family depends on paddy for an income, sown in June-July and harvested in November-December. “The paddy growth depends entirely on rainfall. If there is no rain, the rice will not grow.”

Since the last four or five years, she says, it's been raining in her village in November-December, in addition to the monsoon months. While some showers during these months usually occur here, their intensity can harm the paddy harvest. “Either there is no rain when required or it rains excessively out of season. This is destroying the harvest. Every year we think this time there won't be excessive [unseasonal] rain. But it rains so much and the crop is completely destroyed. That is why we have the saying, ‘*Aashay morey chaasa*’ [‘Hope kills the farmer’].”

‘The paddy growth depends entirely on rainfall. If there is no rain, the rice will not grow’

In Rajat Jubilee village, Prabir Mondal is also worried. “Through June and July, there was no rainfall [in my village]. Some paddy leaves dried up. Thankfully, rain has arrived [in August]. But will it be enough? What if it rains too much and the crop drowns?”

As a healthcare practitioner (he has a BA degree in alternative medicine), Prabir says his patients also increasingly complain of the heat. “Many now suffer from heat stroke. It can hit at any time and can be fatal,” he explains.

Land temperatures in the Sundarbans are also increasing, besides the rising sea surface temperatures. From 180 days in a year when the temperature was 32 degrees Celsius or higher here in 1960, the number of such days increased to 188 in 2017, show data on an interactive portal of the *New York Times* on climate and global warming. This could become 213 to 258 days by the end of the century.

Buffeted repeatedly by the growing heat, cyclones, erratic rain, salinity, vanishing mangroves and more, the residents of the Sundarbans live in a near-constant state of uncertainty. Prafulla Mondal, witness of several storms and cyclones,

wonders: "Who knows what will come next?"

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Pastoralists from Kachchh walk great distances in search of grazing lands for their sheep in Gujarat, even as pastures disappear or become inaccessible, and climate patterns get ever more erratic.



Counting sheep as grasslands shrink in Gujarat

Pastoralists from Kachchh walk great distances in search of grazing lands for their sheep in Gujarat, even as pastures disappear or become inaccessible, and climate patterns get ever more erratic

“Is there rain in your village?” It was Karabhai Aal on the phone from Banaskantha district in North Gujarat. “There is none here.” That was in the last week of July this year. “If it rains, we will go home,” he had declared with half a hope.

That he was speaking to a non-farmer in very urban Pune city, 900 kilometres away, didn’t seem to matter to him, so great was his anxiety. Karabhai’s complete focus on the rains arises from the centrality of the monsoons to the survival game he and his family play out each year.

Twelve months had gone by since the 75-year-old pastoralist had left his village on his annual migration with his son, daughter-in-law, two grandsons, and a brother and his family. The 14-member group moved with their flock of over 300 sheep,

three camels and the night guardian of their herd – a dog named Vichhio. And in those 12 months they had traversed – with their animals – over 800 kilometres across Kachchh, Surendranagar, Patan and Banaskantha districts.

The 800-kilometre route that Karabhai Aal's family traverses annually, across three regions of Gujarat. Source: Google Maps

Karabhai's wife Dosibai and their youngest school-going grandchildren had remained at home in Jatavada village in Rapar *taluka* of Kachchh, Gujarat. The clan belongs to the Rabari community (listed as OBCs in that district), and leave their village each year for 8 to 10 months in search of pastures for their sheep. In a normal year, these nomadic pastoralists set out soon after Diwali (October-November) and return just as the next monsoon is set to break.

This means they are on the move all year round, except during the rainy season. Even when they return, some family members remain outside their homes, taking the sheep to feed on the outskirts of Jatavada. The animals cannot reside within the village, needing their space and grazing grounds.

"I thought the village *patel* had sent you to drive us away from here." That was how Karabhai had greeted us in early March when we traced him to a parched field in Gavana village of Surendranagar district. That's about 150 kilometres from Ahmedabad city.

His suspicions had a basis. When times get tough, as they do during a prolonged drought, landowners drive pastoralists and their herds off their territory – they want to save the grass and crop stubble for their own cattle.

"The *dushkaal* [drought] is very bad this time," Karabhai had told us. "That is why we left from Rapar in the month of Akhaad [June-July] last year, because there was simply no rain." The ongoing drought in their arid home district had forced an early start to their annual migration.

"We wander with our sheep until the monsoon starts. If it doesn't rain, we don't go home! This is the life of a *maldhari*," he told us. The term *maldhari* is derived from the Gujarati words *mal* (livestock) and *dhari* (guardian).

"The 2018-19 drought in Gujarat's arid and semi-arid regions has been so severe that even some of those pastoralists who had become sedentarised in their village almost 25 years ago, began migrating again in search of grazing lands, fodder and

livelihoods,” says Neeta Pandya. She is the founder of the Maldhari Rural Action Group (MARAG), Ahmedabad, a non-profit active among pastoralists since 1994.

As the Aal family's 300 sheep spread out on a barren stretch that was once a field of jeera (cumin), Karabhai (right) speaks to a friend in his village Jatavada checking if all is well back home

In 2018, rainfall in Kachchh, home to this *maldhari* family, plummeted to a mere 131 millimetres. The ‘normal’ annual average for Kachchh is 356 mm. But this was not a wayward year. The monsoon in the district has been increasingly erratic for over a decade now. Data of the India Meteorological Department (IMD) show that rainfall in the district fell to 291 millimetres in 2014, to 294 in 2016, but went up to 493 mm in 2017. A similar five-year period four decades ago – 1974-78 – shows one disastrous year (88 mm in 1974) and four successive years in which the rainfall is above the ‘normal’ average.

In a 2018 report titled *Gujarat's water crisis rooted in years of misplaced priorities*, Himanshu Thakkar of the South Asia Network on Dams, Rivers and People writes that over the last three decades, successive governments in the state have pushed the Narmada dam as a lifeline for the drought-prone areas of Kachchh, Saurashtra and North Gujarat. In practice, however, these regions are given the lowest priority. They receive only the residual water after the requirements of urban areas, industries, and farmers in central Gujarat are met.

“The water in the Narmada should be used for farmers and pastoralists in these areas,” Thakkar told us on phone. “The programmes of well-charging and check dams adopted in the past must be revived.”

The *maldharis* are dependent on common grazing lands and village pastures for their herds to feed. Most of them do not own land and those who do, grow rain-fed crops like *bajra* – food for them and fodder for the animals.

“We came here two days ago and today we are leaving. There is not much [for us] here,” said Karabhai in March, pointing to an empty field of *jeera* (cumin). It was also dry and very hot. In 1960, when Karabhai was a teenager, Surendranagar district would have seen temperatures crossing 32 degrees Celsius around 225 days a year. Today, that would be 274 days or more, an increase of at least 49 hotter days across 59 years, according to a calculation from an interactive tool on climate and global warming posted online by the *New York Times* this July.

Source: IMD's Customised Rainfall Information System and DownToEarth - Envi Stats India-2018

Over 63 per cent of working people in Surendranagar, where we met the pastoralists, are involved in agriculture. The figure for all of Gujarat is 49.61 per cent. The major crops grown here are cotton, cumin, wheat, millets, pulses, groundnut and castor. When harvested, their crop stubble is good fodder for the sheep.

Of a total sheep population of 1.7 million in Gujarat's 33 districts, Kachchh alone is home to 570,000, or over a third of them, according to the 2012 Livestock Census of India. In the Wagad sub-region of the district, where Karabhai comes from, there are about 200 Rabari families like his own, travelling those 800 kilometres each year with a total of 30,000 sheep, according to the non-profit MARAG working with the community. They invariably move within a 200-kilometre radius from their homes.

Traditionally, the herds provided post-harvest manure for the fields with their dung and urine. In return, the farmers gave the pastoralists *bajra*, sugar and tea. Like the climate, this centuries-old mutually beneficial relationship is undergoing serious change.

“Is the harvesting done in your village?” Karabhai asks Govind Bharwad of Patan district. “Can we halt in those fields?”

“Is the harvesting done in your village?” Karabhai asks Govind Bharwad, who was also with us. “Can we halt in those fields?”

“They will harvest after two days,” says Govind, a member of the MARAG team and an agro-pastoralist from Dhanora village in Sami *taluka* of Patan district. “This time, *maldharis* can pass through the fields but they can’t stay. It is our panchayat’s decision, because of the acute shortage of water and fodder.”

That is where Karabhai and his family were headed next – towards Patan. By the time they’re home they will have traversed three major regions: Kachchh, Saurashtra and North Gujarat.

Amidst changing weather and climate conditions, the one constant is their hospitality – even in their temporary homes en route. Hiraben Aal, Karabhai’s daughter-in-law, had patted out a tall stack of *bajra rotla* for the family, and made hot tea for everyone. “How much have you studied? I’ve never been to school myself,” she said, and began to wash the utensils. Every time she stood up, she pulled her black *chunari* over her face due to the presence of older men in the family, and drew it back whenever she crouched to the ground to work.

The family’s sheep are of the Marwari breed, native to Gujarat and Rajasthan. In a year, they sell 25 to 30 rams for around Rs. 2,000 to Rs. 3,000 each. Sheep milk is another source of income for them, though this herd’s yields are relatively low. Karabhai says 25-30 sheep give them about 9-10 litres of milk daily. Each litre fetches about Rs. 30 from small local dairies. The family turn the unsold milk into buttermilk and make ghee from the butter it yields.

“Ghee *pet ma chhe!* [The ghee is in the stomach!]” Karabhai chuckled. “The feet burn while walking in this heat, so eating it helps.”

What about selling the wool? “Until two years ago, people would buy the wool for Rs. 2 per animal. Now no one wants to buy it. The wool is like gold to us, but we have to throw it away,” said Karabhai, wistfully. For him and millions of other pastoralists, landless, small and marginal farmers, sheep (and goats) are their wealth and central to their livelihoods . Now that wealth is shrinking.



Prabhuvala Aal, 13, readies the camel for the next stretch while his father Valabhai (right) begins rounding up the sheep. Meanwhile, Prabhuvala's mother Hiraben (bottom left) takes a tea-break while Karabhai (extreme right) gets the men ready for the long walk ahead

The number of sheep in India declined by over 6 million in five years between the 2007 and 2012 Livestock Censuses – from 71.6 million to 65.1 million. That's a fall of 9 per cent. In Gujarat too, the number declined sharply by nearly 300,000 to its present 1.7 million figure.

Kachchh too saw a decline, but the animal fared relatively better, thanks perhaps to the care of the *maldhari*s. Here there were just around 4,200 fewer sheep in 2012, compared to 2007.

The 2017 Livestock Census data won't be out for six months, but Karabhai says he sees a declining trend and lists a mix of reasons for the fall in sheep numbers.

“When I was in my 30s, there was so much more grass, trees, there were no problems in grazing the sheep. Now the forests and trees are cut down, and grasslands are shrinking, becoming smaller. There is more heat,” he says, asserting the role of human activity in spurring erratic weather and climate patterns.

“During drought years, just like we suffer, the sheep suffer too,” he adds. “The shrinking of the grasslands means they have to walk and wander more in search of grass and fodder. The number of sheep is also perhaps going down because people might be selling off more animals to earn something.”

He's right about the shrinking of the grasslands and grazing grounds for his flock. About 4.5 per cent of land in Gujarat is grazing land or pasture, according to Prof. Indira Hirway of the Centre For Development Alternatives, Ahmedabad. But the official data, as she points out, do not factor in the large-scale illegal encroachment on these lands. So the real picture remains hidden. In March 2018, the government admitted in reply to questions in the state assembly that 4,725 hectares of *gauchar* (grazing) land in 33 districts had been encroached upon. Even that figure was attacked by some legislators as a gross underestimate.

The government itself admitted that in 2018, there were 2,754 villages in the state with no grazing land at all.

There was also an increase in the land – some of it acquired by the state – handed over to industry by the Gujarat Industrial Development Corporation. For SEZs alone, it handed over to industries 4,620 hectares between 1990 and 2001. By the end of the period 2001-2011 that had risen to 21,308 hectares .

Karabhai on the road to Jatavada and (right) with his wife Dosibai Aal and neighbour Ratnabhai Dhagal outside the Aal family home in that village

Back in Surendranagar in March, as the day temperature had risen, Karabhai urged the men, "it's almost afternoon, come on, start moving!" The men walked ahead and the sheep followed. His grandson Prabhuvala, 13, the only member of Karabhai's group who has been to school – up to Class 7 – scoured the bushes along the field's boundary and drove the few animals lingering there back to the flock.

The three women packed their load of rope cots, steel milk cans and other belongings. Prabhuvala untied a camel from a distant tree and brought it closer to where Hiraben, his mother, had gathered their travelling home and kitchen, to put it all up on the animal's back .

We met Karabhai again, five months after, in mid-August, on the road in Rapar *taluka* and visited his home in Jatavada village. "I too travelled with the family until 10 years ago," his wife Dosibai Aal, 70, told us as she made tea for everyone. "The sheep and the children are our wealth. They must be well cared for, that is all I want."

Bhaiyabhai Makwana, a neighbour, grumbled that droughts were occurring too often. "If there's no water, we can't return home. In the last six years, I came home only twice."

Ratnabhai Dhagal, another neighbour, spoke of other challenges, "I returned home after two years of drought and found that the government had fenced off our *gauchar* land. We wander all day but our *mal* cannot find enough grass. What do we do? Take them grazing or cage them? Pashupalan [animal rearing/ pastoralism] is the only work we know and live by."

"There is so much suffering from these droughts," says Karabhai, tired of the increasingly erratic weather and climate patterns. "There is nothing to eat and no water for the animals, or even for the birds."

The rains in August brought them a little relief. The extended Aal family jointly owns about eight acres of rain-fed land on which they have sown *bajra* .

A combination of many factors has impacted the grazing of animals and migration patterns of the pastoralists. Failing or inadequate monsoons, recurrent drought, shrinking grasslands, rapid industrialisation and urbanisation in the state, deforestation and reduced availability of fodder and water. The lived experience of the *maldharis* suggests several of those factors both result from, and feed into, shifts in weather and climate. Ultimately, the movement of these communities is seriously affected, reshaping schedules they've followed for centuries.

"Write about all our difficulties," Karabhai says as we leave, "and we will see if it brings any change. If not, there's god."

The writer would like to thank the Maldhari Rural Action Group (MARAG) team in Ahmedabad and Bhuj for their support and field assistance in reporting this story.

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In Rayagada, Bt cotton acreage has risen by 5,200 per cent in 16 years. The result: this biodiversity hotspot, rich in indigenous millets, rice varieties and forest foods, is seeing an alarming ecological shift.



Sowing the seeds of climate crisis in Odisha

In Rayagada, Bt cotton acreage has risen by 5,200 per cent in 16 years. The result: this biodiversity hotspot, rich in indigenous millets, rice varieties and forest foods, is seeing an alarming ecological shift

“Everybody is doing it. So we are too,” said Rupa Pirikaka, somewhat uncertainly.

‘It’ is genetically modified (GM) Bt cotton seeds, now easily bought at the local market, or even in one’s own village. ‘Everybody’ is countless other farmers like her in the village of and across the rest of south-western Odisha’s Rayagada district.

“They are getting money in their hands,” she says.

Pirikaka is a Kondh Adivasi farmer in her 40s. Every year, for over two decades, she would prepare a hill slope for *dongar chaas* – literally, ‘mountain farming’ (shifting cultivation). Following traditions honed by the region’s farmers over centuries, Pirikaka would sow mixed plots of heirloom seeds which she had saved from family harvests the previous year. These would yield a basket of food crops: millets like *mandia* and *kangu*, pulses like pigeon pea and black gram, as well as traditional varieties of long beans, niger seeds and sesame.

This July, for the first time, Pirikaka switched to Bt cotton. That was the time we met her, sowing the dark pink, chemical-doused seeds on a hill slope at her village in Bishamakatak block. The penetration of cotton into the shifting cultivation practices of the Adivasis was striking, making us ask her about this switch.

“Other crops like turmeric also give money,” admits Pirikaka. “But nobody is doing that. Everyone is leaving *mandia* [millet]... and going after cotton.”

The area under cotton in Rayagada district has risen by over 5,200 per cent in barely 16 years. Official data show just 1,631 acres under cotton in 2002-03. In 2018-19 that was 86,907 acres, according to the district agriculture office.

Rayagada, with close to 1 million people, is a part of the Koraput region, one of the world’s great biodiversity hotspots, and a historical area of rice diversification. A 1959 survey of the Central Rice Research Institute showed the region still had over 1,700 rice varieties at the time. It’s down to around 200 now. Some researchers believe it to be a birthplace of rice cultivation.

In the Niyamgiri mountains, Adivasi farmers (left) are taking to GM cotton (its pink seeds are in the box on the right), though many are reluctant to abandon indigenous food crops such as pigeon pea (seeds in the white bowl). These are sown interspersed with cotton, and agricultural chemicals for the cotton plants seep into the entire farm

The Kondh Adivasis here, largely subsistence farmers, are known for their sophisticated practices of agro-forestry. Even today, many Kondh families across the region’s emerald-green terraced fields and mountainside farms, cultivate a dizzying array of paddy and millet varieties, pulses and vegetables. Surveys by Living Farms, a non-profit in Rayagada, have recently documented 36 millet varieties and 250 forest foods.

Most Adivasi farmers here work on individual or common property farms ranging from 1 to 5 acres in size.

Their seeds are largely nurtured and shared within the community, using almost no synthetic fertilisers or other agri-chemicals (also called agro-chemicals).

Yet, cotton has become the second-most cultivated crop in Rayagada after paddy, overtaking millets – the premier traditional food crops of the region. It covers a fifth of the 428,947 acres under cultivation in this district. Cotton's swift expansion is reshaping this land and people steeped in agro-ecological knowledge.

Cotton occupies roughly 5 per cent of India's gross cropped area, but consumes 36 to 50 per cent of the total quantum of insecticides, herbicides and fungicides applied nationally. It is also a crop with the greatest correlation to indebtedness and farmer suicides across India.

The scenario here is reminiscent of Vidarbha between 1998 and 2002 – initial excitement over the new miracle (and then illegal) seeds and dreams of great profits, followed by the effects of their water-guzzling nature, the huge spike in expenses and debt, and various ecological pressures. Vidarbha subsequently ended up as the epicentre of farmer suicides in the country for over a decade. Those farmers were overwhelmingly Bt cotton growers.

The shop we're standing in is owned by Chandra Kudruka (name changed), a 24-year-old Kondh youth. Returning from Bhubaneswar with a degree in hotel management, he started this store in his village of Rukaguda (name changed) in the Niyamgiri mountains this June. Potatoes, onions, deep-fried snacks, sweets – it seemed like any other village shop.

Except for his hot-selling product – stacked under the counter. A large sack of glossy, multi-coloured packets of cotton seeds, many featuring images of happy farmers and Rs. 2,000 notes.

A bulk of the seed packets in Kudruka's shop were illegal and unauthorised. Some packets were not labelled at all. Several were not approved for sale in Odisha. Nor was his shop licensed to sell seeds and agri-chemicals.

Also in stock, to be sold with the seeds, were cartons of green and red bottles of the controversial herbicide glyphosate. A World Health Organisation report in 2015 (later contradicted by the WHO under industry pressure) termed glyphosate as 'probably carcinogenic to humans'. It is banned in states like Punjab and Kerala, restricted in neighbouring Andhra Pradesh, and is currently at the centre of multi-million dollar lawsuits brought by cancer patients in its country of origin, America.

In Kaliponga village, farmers Ramdas and his wife Ratnamani sow BT and HT cotton just days after dousing their lands with glyphosate, a broad spectrum herbicide

All this is unknown to farmers in Rayagada. Glyphosate, referred to as 'ghaasa maraa' – literally 'grass killer' – is marketed to them to destroy weedplants on their fields swiftly. But it is a broad spectrum herbicide, which kills all plants other than those which have been genetically modified to resist it. Kudruka also breezily showed us seeds of cotton, which he said will survive the spraying of glyphosate. Such 'herbicide tolerant' or 'HT seeds' are prohibited in India.

Kudruka had already sold 150 seed packets to farmers in the past fortnight, he said, adding. "I have ordered more. They will be here by tomorrow."

Business seems to be roaring.

"About 99.9 per cent of the cotton in Rayagada today is Bt cotton – non-Bt seeds are just not available," an officer observing the crop's cultivation in the district told us off the record. "Officially, Bt cotton is at a standstill in Odisha. It is neither approved, nor banned."

We found no authorisation from the central government agency responsible for allowing release of Bt cotton in the state of Odisha. The Ministry of Agriculture's cotton status report of 2016 in fact shows figures for Bt cotton in Odisha, year upon year, as nil, suggesting that governments would rather not acknowledge its existence. "I don't have information on HT cotton," state agriculture secretary Dr. Saurabh Garg told us on the phone. "On Bt cotton, whatever is the government of India policy is our policy. We do not have anything separate for Odisha."

That attitude has serious consequences. Trade in unauthorised Bt and illegal HT seeds, as well as in agri-chemicals, is thriving and fast penetrating new areas of Rayagada, as was evident in Kudruka's shop in the Niyamgiri mountains.

Globally, agri-chemicals have destroyed soil microbes, eroded fertility and harmed "countless habitats of plants and animals, both on land and in water," as Prof. Shahid Naeem recently said. Naeem, who heads the department of ecology, evolution and environmental biology at Columbia University, New York, says, "All these organisms are important, because collectively they make up healthy ecosystems that remove pollutants from our water and air, enrich our soil, nourish our crops and regulate our climate systems."

“It did not come easy, I had to work very hard to get them (Adivasi farmers) to switch to cotton,” said Prasad Chandra Panda.

‘Kappa Panda’ – literally ‘Cotton Panda’ – as he is called by his clients and others, was speaking to us at his seed and chemical inputs shop, Kamakhya Traders, in the *tehsil* town of Bishamakatak in Rayagada.

Panda opened the shop 25 years ago, all the while holding his job as an extension officer in the district’s agriculture department. He retired after 37 years there, in 2017. As a government officer, he pushed villagers to abandon their “backward agriculture” for cotton, while his shop, licensed in his son Suman Panda’s name, sold them seeds and associated agri-chemicals.

GM cotton seed packets marketed to Adivasi farmers in Rayagada lack mandatory labelling, are sold at prices above official caps, can be illegal herbicide-tolerant seeds, and usually don’t list Odisha as a recommended state for cultivation. Bottom right: P. C. Panda says he does not sell unauthorised seeds. The recently retired agriculture officer has run a seeds and inputs shop in Bishamakatak for 25 years

Panda saw no conflict of interest in this, saying, “Government policies introduced cotton as a cash crop for farmers. The crop needed market inputs, so I established a shop.”

Through the two-hour conversation we had in Panda’s shop, farmers kept dropping in to purchase seeds and chemicals, seeking his counsel on what to buy, when to sow, how much to spray and so on. He answered each one with an air of infallible authority. For them, he was the scientific expert, the extension officer, their advisor, all rolled into one. Their ‘choice’ was his command.

The scenes of dependence we witnessed at Panda’s shop played out across the cotton-growing villages we toured. The coming of ‘the market’ has had an impact way beyond the cotton crop.

“As the farm land is entirely allocated for cotton, farmers have to buy all their household necessities from the market,” Debal Deb, scientist and barefoot conservationist, told us. Based in Rayagada since 2011, Deb runs a remarkable in-situ rice conservation project and conducts farmer trainings.

“The traditional knowledge of farm-related as well as non-farm occupations are rapidly disappearing,” he said. In village after village, there is no potter, no carpenter, no weaver. All household goods are bought from the market, and most of these – from the pitcher to the mat – are made of plastics, imported from faraway towns. Bamboos have disappeared from most villages, and with them bamboo crafts. They are now substituted by wood from the forest and expensive concrete. Even for erecting a pole or making a fence, villagers have to cut trees from the forest. The more people depend on the market due to the lure of profit, the more the environment degrades.”

“The shopkeeper said these were good,” Ramdas (he only uses his first name) told us sheepishly, of the three Bt cotton seed packets he had bought on credit from Kudruka’s shop. We had met the Kondh Adivasi farmer at the foothills of the Niyamgiri as he was walking back to his village, Kalipanga, in Bishamakatak block. The shopkeeper’s advice was the sole reason he gave us for choosing those seed packets.

What had he paid for them? “If I had paid just now, Rs. 800 each. But I do not have Rs. 2,400, so the shopkeeper will take Rs. 3,000 from me at harvest time.” But even if he were paying Rs. 800 per packet and not the Rs. 1,000 he eventually will, that would still be costlier than the mandated price of Rs. 730 for the most expensive cotton seed: Bollgard II Bt cotton.

Pirikaka, Ramdas, Suna and other farmers told us that cotton was unlike anything they had planted before:

‘Our traditional crops do not require anything to grow
...’

None of the packets Ramdas had purchased displayed a printed price, a manufacturing or expiry date, name or contact details of the company. They featured a huge red ‘X’ overlaid on an image of a bollworm, but were not labelled as Bt seeds. Although the packets did not specify ‘HT’, Ramdas believed the crop “can be sprayed with *ghaasa maraa* [herbicide]” since the shopkeeper had told him so.

Like every farmer we interviewed over a fortnight in July, Ramdas was unaware that herbicide-tolerant seeds are disallowed in India. He did not know that companies cannot sell unlabelled seeds, or that there are price caps on cotton seeds. Given that none of the writing on seed packets and agri-chemical bottles was in Odia, farmers here would not know what claims manufacturers were making, even if they could read.

Yet, the prospect of money was drawing them to cotton.

“If we grow this, I might make some money I need this year for my son’s fees in a private English-medium school” – that was the hope of Shyamsundar Suna, a Dalit tenant farmer speaking to us in Kerandiguda village of Bishamakatak block. We found him, his Kondh Adivasi wife Kamala, and their two children Elizabeth and Ashish, hard at work sowing cotton seeds. Suna had applied all kinds of agri-chemicals, of which he knew little, to his seeds. “The retailer told me the cotton will come out well,” he explained.

Pirikaka, Ramdas, Suna and other farmers told us that cotton was unlike anything they had planted before. “Our traditional crops do not require anything to grow – no fertiliser, no pesticide,” said Pirikaka. But with cotton, Ramdas said, “each packet demands further expenses of 10,000 rupees. Only if you can spend on these seeds, fertilisers and pesticides, might you get some return at harvest time. If you can’t do this... you will lose all your money. If you can, and things turn out good [with] stable weather – then you might sell it [his harvest] for Rs. 30,000- Rs. 40,000.”

Even as farmers were taking to cotton in the hope of making money, most were hard-pressed to say how much they earned through it.

Come January-February, farmers will have to sell their produce back via the input retailer, who would recoup his costs with exorbitant interest, passing on what remained to them. “I have just ordered 100 packets from the trader in Gunpur on credit,” Chandra Kudruka told us. “I will repay him at the time of harvest, and we will split the interest paid by the farmers.”



Top row: In mid-July, for the first time, Kondh Adivasi farmer Rupa Pirikaka sowed GM cotton seeds from the market in her mountainside plot in Karanjaguda village. Bottom left: Nanda Sarka and her family sowed four packets of Bt cotton on their two acres in Kaliponga village. Bottom right: Shyamsundar Suna and Kamala are tenant farmers in Kerandiguda. They recently started cultivating Bt cotton, and are hoping to make more money to meet their children's education costs

What if the farmers' crops fail and they cannot pay him back for the packets he has sold them on credit? Isn't that a big risk?

"What risk?" asked the young man, laughing. "Where will farmers go? Their cotton is sold to the trader through me. If they harvest just 1-2 quintals each, I will recover my dues from that."

What went unsaid was that the farmers might be left with nothing.

Rayagada will also be left shorn of its precious biodiversity. As Prof. Naeem puts it, globally, eliminating crop diversity means jeopardising food security and reducing the ability to adapt to global warming. He also warned that climate change and biodiversity loss are deeply linked: "a planet that's less green and less biologically diverse is likely to be hotter and drier."

And as Rayagada's Adivasi farmers abandon that biodiversity for a monoculture of Bt cotton, Odisha is undergoing a far-reaching shift in ecology and economy, sparking crises at both, the level of the individual household and at that of climate impact. Pirikaka, Kudruka, Ramdas and 'Cotton Panda' are among the unlikely cast of characters caught up in this shift.

“Southern Odisha was never a traditional cotton-growing area. Its strength lay in multiple cropping,” said Debal Deb “This commercial cotton monoculture has altered the crop diversity, soil structure, household income stability, farmers' independence, and ultimately, food security.” It sounds like an infallible recipe for agrarian distress.

But these factors, especially those relating to changes in land use, plus what all this implies for water and the rivers, and loss of biodiversity – could also be playing themselves into another long-term, large-scale process. We are witnessing the sowing of the seeds of climate change in this region.

Cover photo: In Kaliponga village, farmer Ramdas sows Bt and HT cotton a few days after dousing the land with glyphosate, a broad spectrum herbicide. (Photo: Chitragada Choudhury)

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A chemical-intensive Bt cotton monoculture is spreading through Odisha's Rayagada district – harming health, deepening debt, irreversibly eroding indigenous knowledge, and sowing the seeds of a climate crisis.



‘Cotton has now become a headache’

A chemical-intensive Bt cotton monoculture is spreading through Odisha's Rayagada district – harming health, deepening debt, irreversibly eroding indigenous knowledge, and sowing the seeds of a climate crisis

“The more we buy, the more we are in debt.” That’s Kunari Sabari, a farmer in her 40s, speaking to us in Khaira, a village mainly of her own Saora Adivasi community.

“The *gobarakhatachaasa, halaachasaa* [farming with cow dung and ploughs], which was ours, nobody is doing that anymore,” she said. “Now we run to the market for everything. Seeds, pesticides, fertiliser. Unlike before, even what we eat, we have to buy.”

Kunari’s account reflects a dependence brought about by cotton cultivation that is taking root across the ecologically sensitive highland tracts of Odisha’s Rayagada district, with deep implications for its rich store of biodiversity, farmers’ distress

and food security (See *Sowing the seeds of climate crisis in Odisha*). This was clearly visible as we descended south-east to the plains of Rayagada's Gunupur block, where cotton first arrived. Bordering Andhra Pradesh, the landscape here is one of monocrop fields of cotton as far as the eye could see. Also visible – deep distress.

“We took to cotton 10-12 years ago. We do it now because we have no other choice.” That's what many people in Khaira, which is in Gunupur block, told us. Several farmers in the area said that as they shifted towards a capital-intensive cotton, they had progressively lost their own seeds and traditional methods of multi-cropping.

“We had our own crops and our own agriculture,” rued Khetra Sabara, a young Saora cultivator. “Andhra *wallas* came and told us to grow cotton, and taught us everything.” Santosh Kumar Dandasena, another farmer here, added that the prospect of making profit drew villagers to *kappa*, or cotton. “Initially it gave happiness, we made money. But now, it is only misery and loss,” he said. “We have got destroyed and the *sahucars* [moneylenders] are happy.”

Dark green John Deere tractors rumbled up and down the village road as we spoke. The walls of the local temple were plastered with seed company posters in Odia advertising Bt cotton. Tilling and sowing equipment for that crop lay around the village square.



Top left: In Gunupur block, monocultures of GM cotton stretch into the horizon. Top right: In Khaira village, farmers say they are deep in debt since shifting to cotton 10-15 years ago, and cannot access fresh credit from moneylenders unless they sow cotton. Bottom row: Odia advertisements for cotton seeds are nailed onto trees, and the village temple walls are plastered with yet more posters advertising cotton seeds

“Most of the cotton farmers are indebted, because the seed and input costs are increasing while the sale price of the produce fluctuates; and the middlemen take away the profit,” Debal Deb, a conservationist working in the region, explains. “In Rayagada, many farmers get as little as 20 per cent of the market price [for their produce].”

Why persist with cotton in the face of mounting losses? “We are tied in debt to the *sahucar*,” said Sabara. “If we do not sow cotton, he will not lend to us anymore.” Dandasena added, “If we grow say, rice, we will not get any loans. Only cotton.”

“Farmers don’t understand this crop they are growing,” Deb’s colleague, Debdulal Bhattacharya, tells us. “They are completely dependent on the market at every step... from sowing to harvest, and can’t take their own decisions [though]... they own the land. Should we call them farmers or labourers on their own farms?”

Perhaps the most devastating impact of cotton’s spread, Deb and his colleagues point out, is the erosion of local biodiversity, and with it the knowledge of communities who work in, and sustain, this ecologically rich landscape. Both are critical to an agriculture that is climate-resilient – with the capacity to withstand the increasing uncertainties and extremities of weather.

“Climate change,” Deb says, “is inducing abrupt vagaries of the local weather. Prolonged spells of drought, too much untimely rain, and more frequent droughts are already [being] experienced by Odisha farmers.” Cotton as well as modern varieties of rice and vegetables, which are replacing heirloom varieties, “are inherently incapable of surviving the sudden changes in local environmental conditions. This means a severe uncertainty of crop plant survival, pollination, productivity, and finally, food security.”

Rainfall data for the region, and the accounts of farmers, all point to increasingly erratic weather. Average annual rainfall for the district in the period 2014-18 was 1,385 mm. That was 34 per cent higher than the 1,034 mm for the five years of 1996-2000 (show data of the India Meteorological Department and the central Ministry of Environment, Forest and Climate Change). Also, as a 2019 study by researchers from the Indian Institute of Technology, Bhubaneswar, found: “The heavy-to-extreme rainfall days, as well as dry days, are notably increasing while light-to-moderate rainfall days and wet days are decreasing in Odisha.”

Farmers like Kunuji Kulusika (centre) worry about the impact of the spread of Bt cotton and its associated agri-chemicals on their indigenous seed varieties (left), and on their soil and other life forms on the farm (right)

“For the past three years... the rains have been coming in late,” Sharanya Nayak, a farmer and activist based in neighbouring Koraput district, tells us. “There has been less rainfall in the initial monsoon period, followed by extreme rainfall in mid-season, and then heavy rainfall” towards the end of the season. This means sowing gets delayed, extreme rains mean no sun in the crucial mid-season, and heavy downpours at the end damage the harvest.

Debjeet Sarangi, from Living Farms, an NGO which works on food and agriculture in the region, concurs: “The monsoon season in this region used to go from mid-June until October. In the last few years, however, it has become erratic.” Both Sarangi and Nayak argue that Odisha's multi-cropping systems, with an emphasis on indigenous food crops, are better suited than cotton to cope with these vagaries. “It is our experience that multi-crop farmers are better able to cope with such erratic weather patterns,” Sarangi says. “Farmers who are linked to the market through a single crop of Bt cotton are sitting on a time bomb.”

Several farmers sense the dangers to food security and autonomy of cultivation under the new GM monoculture dispensation – even as they are taking to the new practices. But many others, in particular women, insist that they should not abandon their traditional agriculture. In Kerandiguda village, against the backdrop of the Niyamgiri, we came across Kunuji Kulusika, a Kondh Adivasi woman dissuading her son Surendra from growing cotton this year.

She was hard at work, barefoot in a mountainside plot of shifting cultivation. In her knee-length saree worn without a blouse, and hair pulled back in a side knot, Kunuji looked the archetype of the Adivasi woman who features in ads by governments, corporations and NGOs, promising to uplift her from ‘backwardness’. Yet, as Deb suggests, the erosion of the advanced knowledge and skills of people like Kunuji will be devastating for a world grappling with climate change.

“If we abandon our [own] crops even for a year,” Kunuji said, explaining why she feared shifting to cotton, “how will we replenish the seeds? We will run the danger of losing them. Last year, Surendra grew some cotton where we would plant *makka* [maize]. If we continue like this, we will be left with no maize seeds of our own to sow in the future.”

‘If we abandon our [own] crops even for a year’, Kunuji said, explaining why she feared shifting to cotton, ‘how will we replenish the seeds? We will run the danger of losing them’

Kunuji became visibly excited when we mentioned heirloom seeds. She raced into her house and emerged with different varieties of crops grown by the family, which she had stored in bamboo baskets, plastic jars or cloth bags. First: two varieties of pigeon pea, “to be sown depending on the incline of the land.” Next: an upland paddy, mustard, *moong* or green gram, *biri* or black gram, and two types of beans. Then: two varieties of finger millets, maize, niger seeds. Lastly: a sack of *siali* seeds (a forest food). “If it rains too much, and we have to stay home-bound, we roast these and eat,” she said, and roasted a handful for us.

“The agro-ecological knowledge of the Kondhs and other tribes here was so sophisticated that families were able to grow 70-80 crops over the year in one plot – cereals, pulses, roots, tubers, millets,” says Pradeep Patra of Living Farms. “It still exists in a few patches, but overall, the coming of cotton and its spread in the past 20 years has proven devastating for this seed diversity.”

Kunuji also fears the impacts of the chemical inputs. These are indispensable to growing cotton, while hardly ever used by Adivasi families for their traditional crops. “All those pesticides, those fertilisers – Surendra will put all that on the cotton [plants]. Won’t that spoil our soil, kill everything else in it? I saw with my own eyes on a farm next to mine – when they went back to planting *mandia* [finger millets], it did not do well, it was stunted.”

Herbicide-tolerant cotton seeds are not permitted in India, but are spreading like wildfire through Rayagada, along with associated chemicals like glyphosate, a “probably carcinogenic” herbicide. “Owing to regular use of herbicides,” says Debal Deb, “companion flora, including several hedge plants and grasses, have disappeared from the fields. That has led to the decline in butterflies and moth populations, which depend on non-crop plants.

“The ecological knowledge base of this region [and its biodiversity] has eroded alarmingly. More and more farmers are abandoning their traditional multi-cropping and agroforestry systems in favour of monocultures, which demand high amounts of pesticides. Cotton farmers are also using herbicides. Most of them... don't know which insects are actually pests and which are not. So they spray to eliminate all insects.”

With the shift to cotton, says Sharanya Nayak, “every insect, bird, animal is seen through just one lens – as an enemy of the crop. This then is the perfect alibi for indiscriminate use of agri-chemical inputs.”

Kunuji recognises that people were seeing its ill-effects, yet taking to cotton. “They see this much money at one time,” she said, spreading her hands out. “And they get lured.”



Bt cotton monocropping (top row) and associated agri-chemicals (bottom row) are spreading through Rayagada, posing an irreversible threat to the region's rich biodiversity

“Community systems of seed-sharing and exchange, pooling of livestock and labour for work on the farm,” says Patra, were also getting eroded as cotton edged out traditional crops. “Now farmers look to the moneylender and the trader.”

An agriculture officer in the district (who did not want to be identified) concurred with Patra. He admitted that it was the state that had introduced and promoted cotton in villages here in the 1990s. The aggressive push from private seed and agri-chemical input dealers from neighbouring Andhra Pradesh, followed. While the government is worried, the officer admitted that there was little being done to address the explosion of fake and illegal seeds, and the growing consumption of agri-chemicals. “Cotton has now become a headache,” he said.

Yet, the lure of money is powerful, especially for young farmers. With aspirations of English education for their children, smartphones and motorbikes, and impatience with their parents' ways of farming, cotton seems worth the risk. If markets are down one year, they may be up the next.

Ecology, however, is less forgiving.

“There is an undocumented increase in the frequency of hospitalisation and in the types of diseases. The number of people suffering from various nerve and kidney diseases is quite high,” says Deb. “I suspect these are from exposure to organophosphate pesticides and glyphosate herbicide, which are in wide use in the district.”

Dr. John Oommen, who practices at the 54-year-old Christian Hospital, Bissamcuttack, says that such causal links are hard to make in the absence of dedicated investigations. “The focus of the state is still on communicable diseases like malaria. But the fastest growing diseases which we are seeing among tribals here are heart and kidney ailments... chronic kidney diseases in fact, and the numbers are huge.”

He points out that “all private hospitals in the area have started dialysis centres, and it is a fantastic business. We will have to investigate the question – what is causing kidney failure on this scale?” Oommen expresses concern that communities which had sustained themselves for hundreds of years were being exposed or bulldozed into changes they were little prepared for.

Back in the Niyamgiri mountains that week, on a warm morning, we met Obi Nag, a middle-aged Kondh Adivasi farmer walking toward his plot of land with a metal pot and a one-litre bottle of Glycel, a liquid formulation of glyphosate, manufactured by the Maharashtra-based Excel Crop Care Limited.

Nag was carrying a blue hand-operated sprayer on his bare back. He stopped by a small mountainside stream beside his plot, and set his load down. Using the pot, he filled the sprayer with water. Then he added two capfuls of glyphosate “as per the shopkeeper’s directions.” He stirred it vigorously, strapped on the sprayer again and began spraying the vegetation on his plot. “All this will be dead in three days, and the farm will be ready for sowing cotton,” he said.



On a July morning, in the Niyamgiri mountains, a bare-bodied Obi Nag opens a bottle of glyphosate, a herbicide and probable carcinogen. He dilutes it with water from the stream flowing by his farm, and sprays it over the land, preparing to sow Bt cotton (left and middle). Three days later, much of the vegetation on the land has wilted (right)

The warnings on the glyphosate bottle, in English, Hindi and Gujarati, included these: Keep away from foodstuffs, empty foodstuff containers, and animal food; Avoid contact with mouth, eyes and skin; Avoid inhalation [of] the spray mist. Spray in direction of [the] wind; Wash thoroughly the contaminated clothes and parts of the body after spraying; Wear full protective clothing while mixing and spraying.

Nag was bare-bodied except for a small garment around his waist. As he sprayed, droplets fell on his feet and legs, while the wind carried the mist of herbicide over to us, to the tree standing in the middle of his plot, and to adjoining fields. As well as into the stream flowing by his farm, which gushed down to other fields and skirted by a cluster of some 10 houses and their hand pump.

Three days later we came by Nag's plot again, and found a small boy grazing cows close by. We asked Nag if the glyphosate he had sprayed could imperil the cows, and he said confidently: "No, it's been three days. Had they grazed the day I had sprayed, they would have fallen ill and maybe died."

We asked the boy how he knew which fields were freshly sprayed with glyphosate to avoid taking his livestock into. He shrugged and said "farmers tell us if they have sprayed herbicides." The boy's father told us that a neighbouring village had seen some cattle deaths last year after the animals grazed on a freshly-sprayed plot.

Meanwhile most of the grass on Nag's plot had wilted. It was ready for sowing cotton.

Cover photo: Mohini Sabara, a Saora Adivasi tenant farmer in Rayagada's Gunupur block, says they grew food crops until some years ago, and now only grow Bt cotton. (Photo: Chitragada Choudhury)

PARI's nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.

This district in Vidarbha, which for long had adequate water resources, is seeing new rainfall patterns. Now listed as a 'climate hotspot', the changes in Bhandara are bringing uncertainty and losses for paddy farmers.



Belated rains, beleaguered farmers in Bhandara

This district in Vidarbha, which for long had adequate water resources, is seeing new rainfall patterns. Now listed as a 'climate hotspot', the changes in Bhandara are bringing uncertainty and losses for paddy farmers

Inside a tiny hole on the hardened soil lies a dead crab, its legs severed from its body. "They are dying of the heat," says Devendra Bhongade, pointing at holes all over his five-acre paddy farm.

If it had rained, you'd see crabs swarming in the water on the farm, incubating, he adds, standing amid the drying yellowish-green paddy. "My tillers won't survive," is the anxious refrain of this farmer in his early 30s.

In Rawanwadi, his village of 542 people (Census 2011), farmers sow seeds in nurseries – small plots on their land -- in the first half of June, for the arrival of the monsoon. After a few heavy showers, when the furrows bordered by bunds

have accumulated muddy water, they transplant the 3 to 4 week-old shoots into their fields.

But even six weeks after the usual start of the monsoon, as late as July 20 this year, it hadn't rained in Rawanwadi. Twice it drizzled, Bhongade says, but not enough. Farmers who have wells were managing to water the paddy shoots. With work drying up on most of the farms, landless labourers had left the village in search of daily wages.

Around 20 kilometres away, in Garada Jangli village, Laxman Bante too has been witnessing this scarcity for some time. June and July go by without any rain, he says, while the other farmers gathered nod in agreement. And once in 2 to 3 years they almost lose their *kharif* crop.

Bante, who is around 50, recalls that in his childhood this was not the pattern. The rain was consistent, paddy was steady.

But 2019 has been another year of loss, part of the new pattern. The farmers are anxious. "My land will go fallow in *kharif*," says a fearful Narayan Uikey (*sitting on the floor: see the cover photo*). He is in his 70s and has farmed for over five decades on 1.5 acres, and also worked as a labourer most of his life. "It stayed fallow in 2017, in 2015..." he recalls. "Even last year, my sowing was delayed because of the late rain." The delay, Uikey says, reduces yields and incomes. Agricultural wage work becomes scarce too when farmers cannot engage labourers for the sowing.



Devendra Bhongade (top left), on his drying farm of dying paddy tillers in Rawanwadi, pointing to crab-holes (top right). Narayan Uikey (bottom left) says, 'If the rains fail, the farms fail'. Laxman

Bante, farmer and former sarpanch of Garada Jangli, waiting by his village's arid farmlands

Garada Jangli is a small village of 496 people in Bhandara *taluka* and district, around 20 kilometres from Bhandara city. Like in Rawanwadi, most of the farmers here have small plots of land – between one and four acres – and depend on the rains for irrigation. If the rains fail, the farms fail, says Uikey, a Gond Adivasi.

By July 20 this year, the sowing on almost all the farms in his village remained suspended, while the saplings in the nurseries began drying up.

But on Durgabai Dighore's farm, there was a desperate rush to transplant the half-grown tillers. There is a borewell on her family's land. Only four or five farmers in Garada have that luxury. After their 80-foot dug-well dried up, the Dighores sank a borewell within the well two years ago, going 150 feet down. When it too became dry in 2018, they got a new one.

Bante says borewells are a new sight here, largely unseen in these parts until some years ago. "In the past, there was no need to bring in a bore [well]," he says. "Now water is difficult to find, the rain is unreliable, so people are getting them [borewells]."

Two small *malgujari* tanks around the village are also dry since March 2019, adds Bante. Usually, they retain some water even through the drier months. He surmises that the growing number of borewells is drawing away groundwater from the tanks.

These conservation tanks were constructed in the late 17th to mid-18th centuries in the eastern paddy-growing districts of Vidarbha under the supervision of local kings. After the creation of Maharashtra, the state irrigation department took over the maintenance and operation of the big tanks, while the *zilla parishads* took over the smaller tanks. These water bodies are meant to be managed by the local communities and used for fisheries and irrigation. Bhandara, Chandrapur, Gadchiroli, Gondia and Nagpur districts have around 7,000 such tanks, but a majority have for long been neglected and are in a state of disrepair.

After their dug-well dried up (left), Durgabai Dighore's family sank a borewell within the well two years ago. Borewells, people here say, are a new phenomenon in these parts. Workers on the the Dighores' farm (right) could transplant the paddy in July because of the borewell water

Many young men, says Bante, have migrated – to Bhandara city, Nagpur, Mumbai, Pune, Hyderabad, Raipur and other places – to work as cleaners on trucks, itinerant labourers, for farm labour, or to do whatever work they might find.

This growing migration is reflected in population numbers: while Maharashtra's population grew by 15.99 per cent from Census 2001 to 2011, Bhandara's grew just 5.66 per cent in that period. The main reason that comes up repeatedly in conversations here is that people are leaving due to the growing unpredictability of agriculture, declining farm work, and an inability to meet increasing household expenses.

Bhandara is a largely paddy-growing district, farmland interwoven with forests. The average annual here ranges from from 1,250 mm to 1,500 mm (notes a report of the Central Ground Water Board). The perennial Wainganga river flows through this district of seven *talukas*. Bhandara also has seasonal rivers and around 1,500 *malgujari* water tanks, notes the Vidarbha Irrigation Development Corporation. While it has a long history of seasonal migration, Bhandara has not reported extensive farmers' suicides – unlike some districts of western Vidarbha.

With only 19.48 per cent urbanisation , it's an agrarian district of small and marginal farmers, who draw an income from their own land and from farm labour. But without robust irrigation systems, the farming here remains largely rain-fed; tank water is adequate only for some farmlands after October, with the end of the monsoon.

Several reports suggest that central India, where Bhandara is located, is witnessing a weakening of the June to September monsoon and increasing events of heavy to extreme rainfall. A 2009 study by the Indian Institute of Tropical Meteorology, Pune, speaks of this trend. A 2018 World Bank study finds Bhandara district to be in the top 10 climate hotspots in India, the other nine being contiguous districts in Vidarbha, Chhattisgarh and Madhya Pradesh, all in central India. A 'climate hotspot', the study says, is a location where changes in average weather will have a negative effect on living standards. The study warns of the huge economic shocks that people in these hotspots could face if the present scenario continues. In 2018, the Revitalising Rainfed Agriculture Network compiled a fact-sheet on Maharashtra, based on rainfall data of the India Meteorological Department. It explains: One, the frequency and gravity of dry spells increased in almost all the districts of Vidarbha from 2000 to 2017. Two: the rainy days shrank though the long-term annual average rainfall has remained almost constant. This means that the region is getting the same amount of rain in a fewer number of days – and this affects the growth of crops.

Many of Bhandara's farms, where paddy is usually transplanted by July, remained barren during that month this year

Another study, done in 2014 by The Energy and Resources Institute (TERI), notes: "Rainfall data from the period 1901-2003 shows that the share of monsoon rain in July has been decreasing [across the state], while August rainfall has been increasing... Moreover, there has been an increase in the contribution to extreme rainfall events to monsoon rainfall, especially during the first half of the season (June and July)."

For Vidarbha, the study, titled *Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change*, highlights the main vulnerabilities as "long dry spells, recent increase in rainfall variability and decrease in amount [of rainfall]."

Bhandara, it says, is in the group of districts where extreme rainfall could increase by 14 to 18 per cent (relative to baseline), and the dry days during the monsoon are projected to also increase. The study also notes that there will be an average increase (over the annual mean temperature of 27.19 degrees) for Nagpur division

(where Bhandara is located) by 1.18 to 1.4 degrees (by 2030), 1.95 to 2.2 degrees (by 2050) and 2.88 to 3.16 degrees (by 2070). This is the highest for any region in the state.

Bhandara agriculture officials too have noticed these incipient changes in their largely rain-dependent district that still gets categorised in government literature and district plans as a 'better-irrigated' region due to its traditional tanks, rivers and sufficient rainfall. "We are seeing a steady trend of delayed onset of rains over the district, which hurts sowing and yields," says the divisional superintending agriculture officer in Bhandara, Milind Lad. "We used to have 60-65 rainy days, but in the last decade or so, this is down to 40-45 in the June-September period."

Some circles – clusters of 20 revenue villages – of Bhandara have got barely 6 or 7 days of rains this year in June and July, he observes.

"You can't grow fine quality rice if the monsoon is delayed," adds Lad. "Production drops by 10 kilos per day per hectare if the paddy transplantation is delayed after the 21-day period of the nursery."

The traditional method of broadcasting seeds – throwing the seeds into the soil rather than planting a nursery first and then transplanting the tillers – is steadily returning to the district. But broadcasting can bring poor yields due to a low rate of germination, unlike the transplantation method. Still, instead of losing the entire crop if the tillers don't grow in the nursery without the first rains, with broadcasting the farmers could face only a partial loss.

Paddy occupies most of Bhandara's farms in the kharif season

“Paddy needs good rains in June-July for the nursery and transplantation,” says Avil Borkar, chairman of the Gramin Yuva Pragatik Mandal, Bhandara, a voluntary organisation that works with paddy farmers in eastern Vidarbha on the conservation of native seeds. And the monsoon is altering, he notes. Small variations, people can deal with. “But a failure of the monsoon – they can’t.”

By the end of July, the rains have started to pick up in Bhandara. But by then the *kharif* sowing of paddy has been hit – only 12 per cent of sowing was done by the end of July in the district, says Milind Lad, the divisional superintending agriculture officer. Paddy occupies almost all of Bhandara’s 1.25 lakhs hectare cultivable land in *kharif*, he adds.

Many *malgujari* tanks that sustain fishing communities are also dry. The only talk among villagers is of water. Farms are the only avenue of employment now. In the first two monsoon months, people here say, Bhandara has not yielded any work for the landless, and even if it rains now, the *kharif* planting has been irreparably hit.

For acres upon acres, you see empty patches of land – brown, ploughed soil, hardened by heat and a lack of moisture, interspersed with the burning yellow-green beds of the nursery, where the shoots are wilting. Some nurseries that look green are invariably helped by a desperate splash of fertiliser that aids a momentary growth spurt.

Besides Garada and Rawanwadi, some 20 villages in the Dhargaon circle of Bhandara, says Lad, haven’t received good rains this year – and in the past few years too. Rainfall data show that Bhandara faced an overall deficit of 20 per cent from June till August 15, 2019, and a bulk of the 736 mm rain it registered (of the 852 mm long-term average for that period) was after July 25. That is, in the first fortnight of August, the district overcame a big deficit.

Besides, even this rainfall has been uneven, circle-wise data of the India Meteorological Department show. Tumsar, in the north, got good rains; Dhargaon, in the centre, saw a deficit; and Pauni, in the south, received a few good showers.

Maroti and Nirmala Mhaske (left) speak of the changing monsoon trends in their village, Wakeshwar. Maroti working on the plot where he has planted a nursery of indigenous rice varieties

However, the meta data don't reflect the micro-observations of the people on the ground: that the rains come in spurts and in a very short duration, sometime in a few minutes, though the rainfall gets registered for a full day at a rain-gauge station. There are no village-level data on relative temperature, heat or humidity. On August 14, the district collector, Dr. Naresh Gite, instructed the insurance company to compensate all farmers who had not sown on 75 per cent of their land this year. Initial estimates said such farmers would number 1.67 lakh, with a cumulative unsown area of 75,440 hectares.

By September, Bhandara had recorded 1,237.4 millimetres of rain (starting from June) or 96.7 per cent of its long-term annual average for this period (of 1,280.2 mm). Most of this rain came in August and September, after the June-July rain-dependent *kharif* sowing was already hit. The rain filled the malgajari tanks in Rawanwadi, Garada Jangli, and Wakeshwar. Many of the farmers attempted a re-sowing in the first week of August, some of it by broadcasting seeds of the early yielding varieties. Yields may be reduced though, and the harvest season may be pushed by a month to late November.

Back in July, Maroti, 66, and Nirmala Mhaske, 62, are troubled. Living with unpredictable rains is difficult, they say. The earlier patterns of prolonged periods of rain – lasting 4 or 5 or even 7 days at a stretch, no longer exist. Now, they say, it rains in spurts – heavy showers for a couple of hours, interspersed with long dry spells and heat.

For around a decade, they haven't experienced good rains in the *Mrig nakshatra*, or the period from early June to early July. This was when they would sow their paddy nursery and transplant the 21-day tillers onto the water-drenched plots between bunds. By the end of October, their paddy would be ready to harvest. Now, they wait until November and sometimes even December to harvest the crop. The delayed rains affect per-acre yields and limit their options of cultivating long-duration fine-quality rice varieties.

“By this time [July end],” says Nirmala, when I visited their village, Wakeshwar, “we would be through with our transplantation.” Like numerous other farmers, the Mhaskes are awaiting the showers so that the tillers can be spread out on their farm. For two months, there has practically been no work for the seven labourers who work on their land, they say.

The Mhaskes’ old house looks out to a two-acre farm on which they grow vegetables and local varieties of paddy. The family owns 15 acres. In his village, Maroti Mhaske is known for his meticulous crop planning and high yields. But the changes in rainfall pattern, its growing unpredictability, its uneven spread, has put them in a bind, he says: “How do you plan your crop if you don’t know when and how much it will rain?”

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An unusual activity of the fisherwomen of Bharathinagar in Tamil Nadu keeps them more in the water than on boats. But climate change and overexploitation of marine resources are eroding their livelihoods.



Tamil Nadu's seaweed harvesters in rough seas

An unusual activity of the fisherwomen of Bharathinagar in Tamil Nadu keeps them more in the water than on boats. But climate change and overexploitation of marine resources are eroding their livelihoods

They're up by 3 each morning. They've got to be at work by 5 a.m. and need to complete all their household tasks before that. The commute to their vast, wet workplace is a short walk. They just step out of their homes, stride up to the sea – and dive in.

Sometimes they take a boat to nearby islands – and dive in around those. They will do this repeatedly for the next 7-10 hours, surfacing from each dive clutching a bundle of seaweed as if their lives depended on it – as indeed they do. Diving into the waters to collect those marine plants and algae is the main source of earning for these women from the fishing hamlet of Bharathinagar in Tamil Nadu's Ramanathapuram district.

On a working day, they carry 'protective gear', along with clothes and net bags. While boatmen ferry them to the islands with waters rich in seaweed, the women tie their sarees dhoti-style between their legs, attach the net bags around their waists, and wear t-shirts atop their sarees. The 'protection' consists of goggles for their eyes, strips of cloth wound around their fingers or surgical gloves for some, and rubber slippers to prevent their feet from being cut on sharp rocks. These they use, whether just offshore or around the islands.

Seaweed harvesting is a traditional occupation passed on from mother to daughter through the generations in this region. For some single and destitute women, it is the only source of income.

An income that is dwindling as the seaweed gets less and less, a fallout of warming, rising sea levels, changing weather and climate, and overexploitation of this resource.

"The growth of seaweed has drastically fallen," says P. Rakkamma, 42. Like the other women harvesters at work here, she is from Bharathinagar, which is near Mayakulam village of Thiruppullani block. "We do not find the same amount of it as we used to earlier. It now sometimes gives us work for only 10 days in a month." Given that there are only five months in a year when there is systematic harvesting by the women, that's a blow. Rakkamma feels the "waves have become stronger and sea levels have risen from after the tsunami" of December 2004.



Seaweed harvesting is a traditional occupation passed on from mother to daughter in this region; here, U. Panchavaram is collecting seaweed from the reefs

The changes are hurting harvesters like A. Mookupori, who has been diving for seaweed since she was eight years old. Her parents died when she was very young, and she was married off by relatives to an alcoholic man. Now 35, Mookupori has three daughters and still lives with him, but he is in no condition to earn anything and support the family.

The sole earning member in their household, she says the “earnings from harvesting seaweed are now insufficient” to support her three daughters in studying further. Her eldest child is working towards a B. Com degree. The second one is awaiting admission to a college. The youngest is in Class VI. Mookupori fears things “are not going to improve” soon.

She and her fellow harvesters are Muthuraiyars, categorised in Tamil Nadu as a Most Backward Community (MBC). A. Palsamy, president of the Ramanathapuram Fish Workers’ Union, estimates there are no more than 600 women seaweed harvesters across Tamil Nadu’s 940-kilometre coastline. But the work they do, serves a much larger population not confined to the state.

“The seaweed we harvest,” P. Raniamma, 42, explains, “goes into the manufacture of *agar*.” That is a gelatinous substance which is used as a thickener in foods.

The seaweed from here is also used in the food industry, as an element in some fertilisers, by pharma companies in medicinal preparations, and for other purposes too. The women harvest and dry the seaweed that is later sent to factories in Madurai district to be processed. This region has two major varieties – *mattakorai* (*gracilaria*) and *marikozhunthu* (*gelidium amansii*). Gelidium is sometimes served as a part of salads, puddings and jams. It is believed to be helpful to those who are dieting and is sometimes used to treat constipation.

Mattakorai (*graciliaria*) is used in fabric dyeing, among other industrial purposes. But the popularity of seaweed in such a wide array of industries has also led to its overexploitation. The Central Salt and Marine Chemicals Research Institute (Mandapam Camp, Ramanathapuram) has pointed out that unregulated harvesting has led to a drastic fall in its availability.



P. Raniamma with her harvest of marikozhunthu , a small edible seaweed variety

The yields reflect that fall. “Five years ago, we used to harvest at least 10 kilograms of *marikozhunthu* in seven hours,” says S. Amritham, 45. “But now, no more 3 to 4 kilos in a day. Also, the size of the seaweed has reduced over the years.”

The industry around it has shrunk too. As late as 2014, there were 37 *agar* units in Madurai, says A. Bose who owns a seaweed processing company in that district. Today, he says, there are just about 7 – and those are functioning at 40 per cent of their capacity. Bose used to be president of the All-India Agar and Alginate Manufacturers Welfare Association – a body dysfunctional for the last two years because of a shortage of members.

“The number of days we get work has reduced,” says M. Mariamma, 55, who has been diving for seaweed for over four decades. “We do not have any other job opportunities during the off-season.”

When Mariamma was born, in 1964, Mayakulam village could expect 179 days in a year when temperatures would reach 38 degrees Celsius or higher. In 2019, that would be 271 such hotter days – an over 50 per cent increase. In the next 25 years, the region could see between 286 and 324 such days, according to a calculation from an interactive tool on climate and global warming posted online by the *New York Times* this July. There is little doubt that the seas, too, are warming.

All this has an impact on something beyond just the fisherwomen of Bharathinagar. The latest report of the Intergovernmental Panel on Climate Change (IPCC) mentions, without endorsing, studies that view seaweed as a potentially

important factor in mitigating climate stress. The report itself concedes that:
“Seaweed aquaculture warrants further research attention.”

Prof. Tuhin Ghosh of the School of Oceanographic Studies at Jadavpur University, Kolkata, was one of the lead authors of that report. His views seem to validate what the fisherwomen are saying about a decline in their yields. “It is not only seaweed, but a host of other processes that are declining or gaining pace [like migration],” he told PARI on the phone. “That would be true of fish yields , prawn seed yields, and several things connected to both seas and land, including crab collection, honey collection, migrations (as seen in the Sundarbans) and more.”



Sometimes, from here, the women take a boat to nearby islands to dive in from there

What the fishing communities are saying, Prof. Ghosh says, has substance.

“However, in the case of fish, it is not just a matter of changing climate – but also the severe overexploitation by trawlers and industrial-scale fishing. That has sharply depleted the catch in the normal channels of the traditional fisherfolk.”

While trawlers may not affect seaweed, industrial overexploitation undoubtedly does. The women of Bharathinagar and their fellow harvesters appear to have pondered their own important, if small, role in that process. Activists and researchers who have worked with them say that, worried by the shrinking yields, they held meetings among themselves and decided to restrict systematic harvesting to five months from July. Then for three months, they do not venture

out to sea at all – allowing the seaweed to revive. From March to June, they do harvest but only for very few days in a month. Simply put, the women have created their own self-regulatory regime.

That is a thoughtful approach – but comes at some cost to themselves.

“Fisherwomen are not given work under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA),” says Mariamma. “Even during the harvesting season, we hardly earn Rs.100-Rs.150 a day.” In season, each woman can collect up to 25 kilograms of seaweed a day, but the rates they get (also declining) vary according to the kind of seaweed they manage to bring back.

Changes in rules and laws have further complicated matters. Till 1980, they could go out to islands quite far off, such as Nallatheevu, Challi, Upputhanni – some of them nearly two days away by boat. They could spend up to a week on collecting seaweed before returning home. But that year, 21 of the islands they went to came under the Gulf of Mannar Marine National Park – and thereby under the jurisdiction of the Forest Department. The department denied them permission to stay on the islands and has increasingly shut off their access to these locations. Protests against that ban have not elicited any sympathetic response from government. Fearing fines that could range from Rs. 8,000-Rs. 10,000, they don’t go to the islands much anymore.



The net bags the women use to collect the seaweed; in the process, they often bruise and bleed, but a bag full means income to support their families

So incomes have shrunk further. “We earned at least Rs. 1,500 to Rs. 2,000 when we used to spend a week on the islands,” says S. Amritham, who has been harvesting seaweed since she was 12. “We used to get both *mattakorai* and *marikozhunthu* seaweed. Now it is hard to earn Rs. 1,000 in a week.”

The harvesters may not know of the debates around climate change, but they have experienced it and are aware of some of its impacts. They have understood that many changes are underway in their lives and occupation. They have observed and experienced the changes in the behaviour of the seas, and in temperatures, weather and climate. They have also realised something about the role of human activity (including their own) in the many changes taking place. At the same time, their only income is locked into the whole, complicated set of processes. And they know they are being given no alternatives – as Mariamma’s comment on being excluded from the MGNREGA shows.

The water levels begin to rise from noon, so they start winding up activity for the day. In a couple of hours, they’ve brought back their ‘catch’ on the boats they’ve gone out in and laid it out on shore in the net bags.

Their activity is anything but simple and not without risk. The seas are getting more difficult, and some weeks ago, four fishermen died in a storm in this region. Only three bodies were recovered, and locals believe the winds will get slower and the seas calmer only when the fourth is found as well.

As the locals would say, without the favour of the winds, all sea-related work is challenging. With changes in larger climatic conditions, too many days are unpredictable. Yet the women still venture out into the unquiet waters in search of their only source of livelihood – knowing that both figuratively and sometimes literally, they are adrift on rough seas.



Manoeuvring the boat into the sea to dive for seaweed: without the favour of the winds, all sea-related work is challenging. With changes in larger climatic conditions, too many days are unpredictable



A seaweed harvester with a torn glove – flimsy protection against the rocks and choppy waters



Preparing the nets: the women's protective gear includes goggles, strips of cloth or gloves for the hands, and rubber slippers to prevent their feet from being cut on sharp rocks



S. Amritham fighting against the strong waves, trying to reach the reefs



M. Mariamma tightening the rope of the net bag used for collecting the seaweed



Getting ready to dive in



And then the dive, propelling themselves towards the sea bed



Into the deep – the women's workplace, an opaque underwater world of fish and sea creatures



This long-leaf seaweed, mattakorai, is collected, dried and used for dyeing clothes



Raniamma collects marikozhunthu by controlling her breath for several seconds while suspended on the sea bed



Then it's back to the surface, amid the choppy waves, with their hard-earned harvest



The tide is starting to come in, but the women continue to labour till noon



A seaweed harvester cleaning her gear after a dive



On the way back to the shore, exhausted



Dragging the seaweed that they have collected, on to the shore



Others unloading the net bags full of day's dark green harvest



A small boat loaded with seaweed reaches the shore; a harvester guides the anchor



A group unloading the harvested seaweed



Weighing the day's collection



Preparing to dry the seaweed



Others carrying their collection amid a carpet of seaweed spread out to dry



And then it's back to their homes on land, after hours at the sea and under water

Cover photo: A. Mookupori pulling the net bag. Now 35, she has been diving for seaweed since she was eight years old. (Photo: M. Palani Kumar/PARI)

Many thanks to Senthair S. for her generous help with this story .

PARI's nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.

Many in Versova Koliwada have a story to tell of dwindling fish – the reasons range from local-level pollution to global-scale warming. Both have combined to bring the impact of climate change to the city’s shores.



The shrinking pomfret of suburban Mumbai

Many in Versova Koliwada have a story to tell of dwindling fish – the reasons range from local-level pollution to global-scale warming. Both have combined to bring the impact of climate change to the city’s shores

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At Versova jetty one morning some months ago, I asked Ramji *bhai*, who was sitting on a rock at the edge of the creek, what he was doing. “Timepass,” he replied. “I’ll take this home and eat it.” He pointed to a small *tengda* (a type of catfish) he’d just caught. I saw other fishermen cleaning nets they had floated in the creek the night before – they had caught loads of plastic but no fish.

“Fishing in the *khadi* [creek] today is barely possible,” says Bhagwan Namdev Bhanji, who has lived all his 70-plus years in Versova Koliwada, a fishing village in north Mumbai’s K-West ward. “When we were young, the coast here was like the

one in Mauritius. If you threw a coin into the water, you could still see it... The water was that clean."

The fish that do find their way into the nets of Bhagwan's neighbours – nets now cast deeper into the sea – are often smaller too. "Earlier, we used to get bigger pomfret, but now we're getting small ones. It's had a huge impact on our business," says 48-year-old Priya Bhanji, Bhagwan's daughter-in-law, who has been selling fish for 25 years.

Almost everyone here – the *koliwada* is home to 1,072 families or 4,943 people involved in fishing (2010 Marine Fisheries Census) – has a story to tell of the vanishing or shrunken fish. And the reasons they point to range from local-level pollution to global-scale warming – both have combined at Versova to bring the impact of climate change to the city's shores.

Bhagwan Bhanji in a yard where trawlers are repaired, at the southern end of Versova Koliwada

In the waters near the shore, in the Malad creek (that empties into the sea at Versova), the *bhing* (giant herring), *pala* (hilsa shad) and other fish that were easily caught by residents of this *koliwada* around two decades ago seem to have been decimated by immediate human intervention.

Untreated sewage from around 12 *nallahs* (open sewers) flowing from surrounding localities, industrial sludge, and effluents from two municipal wastewater treatment facilities in Versova and Malad West, now drain into the once-clear creek of Bhagwan's memory. "There is hardly any marine life. All this pollution goes 20 nautical miles into the sea. Because of everyone's sewage, dirt and garbage, a clear creek has become a gutter," says Bhagwan, who is known in the neighbourhood for his knowledge of Koli history, culture and local politics. Until some years ago, he managed the shore tasks – drying the fish, making nets, supervising repairs – for his late brother's two fishing boats.

The murky waters mean low levels of dissolved oxygen in the creek and near the shore, along with a large number of faecal bacteria – and fish cannot survive this. A 2010 paper by scientists at the National Environmental Engineering Research Institute (NEERI) says, "The condition of Malad creek is alarming as [there is] no DO [dissolved oxygen] in the creek during low tide... During high tide the condition was slightly better..."

Pollution of the oceans intersects with climate change to create long-lasting impacts. Increased development activities, coastal and marine pollution (more than 80 per cent originates from land-based sources) and climate change's impact on ocean currents will accelerate the spreading of marine dead zones (oxygen-dead areas), observes a 2008 book by the United Nations Environment Programme titled *In Dead Water: merging of climate change with pollution, over-harvest and infestation in the world's fishing grounds*. "... the effects of pollution," the book says, "are exacerbated by the destruction of mangroves and other habitats due to the rapid construction taking place on coastlines..."

Left: Struggling against a changing tide – fishermen at work at the koliwada. Right: With the fish all but gone from Malad creek and the nearby shorelines, the fishermen of Versova Koliwada have been forced to go deeper into the sea

In Mumbai too, over the years, vast tracks of mangroves have been cleared for roads, buildings and other projects. Mangroves are critical spawning grounds for fish. A 2005 paper in the *Indian Journal of Marine Sciences* notes, "Mangrove forests not only support coastal marine organisms, but also protect the coast from erosion and serve as breeding, feeding and nursery grounds for estuarine and marine organisms." In just 11 years from 1990 to 2001, the paper adds, a total of 36.54 square kilometres of mangroves was lost in just the Mumbai suburban region.

"The fish used to come to the coast to lay their eggs [in the mangroves], but that cannot happen now," Bhagwan says. "We have destroyed as many mangroves as we could. Very few are left. The buildings on the coastline in the suburbs and entire localities here, like Lokhandwala and Adarsh Nagar, were mangroves earlier." As a result, with the fish all but gone from Malad creek and the nearby shorelines, over the years, the fishermen of Versova Koliwada have been forced to go deeper into the sea. But in the deep seas too, rising sea temperatures, increasing cyclonic storms, and over-fishing by trawlers have hit their business.

"Earlier, they didn't have to go deep sea fishing [more than 20 kilometres from the shore] because the coastal ecology was so rich," says Ketaki Bhadgaonkar of Bombay 61, a group of architects studying the effects of coastal pollution and climate change in Versova Koliwada. "Deep sea fishing has made fishing

economically unviable because it involves a lot of investment in big boats, a crew and so on. And fishermen are not even certain they'll come back with a bigger fish catch."

Photos taken by Dinesh Dhanga, a Versova Koliwada fisherman, on August 3, 2019, when boats were thrashed by big waves. The yellow-ish sand is the silt from the creek that fishermen dredge out during the monsoon months, so that boats can move more easily towards the sea. The silt settles on the creek floor because of the waste flowing into it from nallahs and sewage treatment facilities

Deep sea fishing has become uncertain also due to the warming of the Arabian Sea – its surface temperature has risen by 0.13 degree Celsius per decade on average between 1992 and 2013, shows a paper in the journal *Geophysical Research Letters*. This has affected marine life, says Dr. Vinay Deshmukh, who was with the Mumbai centre of the Central Marine Fisheries Research Institute (CMFRI) for over four decades. "Sardines, one of the predominant fishes in the south [of India], started moving north [along the coast]. And mackerel, another fish from the south, started moving into deeper waters [below 20 metres]." The northern Arabian Sea waters and deep sea waters remain relatively cooler.

The warming of Mumbai's and Maharashtra's sea waters is part of an interconnected global pattern – in 2014, the Intergovernmental Panel on Climate Change (IPCC) estimated that the upper 75 metres of the world's oceans were warmed by 0.09 to 0.13 degree Celsius per decade between 1971 and 2010.

This rising sea temperature has altered the biology of some fish – a significant and "irreversible change" says Dr. Deshmukh. "When the waters were relatively cool and the temperature was around 27 degrees, fish matured late. As the waters become warmer, the fish started to mature early. That is, they started producing eggs and sperm early in their life cycles. When that happens, the body growth of the fish slows down. This we have clearly seen in bombay duck and pomfret." So a mature pomfret that was roughly 350-500 grams three decades ago, estimate Dr. Deshmukh and local fishermen, is typically just 200-280 grams today – shrunk in size due to warming and other forces.

A mature pomfret that was roughly 350-500 grams three decades ago, is typically just 200-280 grams today – shrunk in size due to warming and other forces

But, in Dr. Deshmukh's view, overfishing has been an even bigger culprit. The number of boats has increased and the time that trawlers (some owned by *koliwada* locals too) and other big boats spend at sea has gone up too. In the year 2000, he notes, these boats would spend 6-8 days at sea; this rose to 10-15 days and is now 16-20 days. This has added to the pressure on the existing fish stock in the sea. And, he says, the floor ecology has degraded due to trawling, "which scrapes the ground [sea floor], uproots plants and does not allow the organisms to grow naturally."

The total fish catch in Maharashtra, Deshmukh says, touched a high in 2003, when it was around 4.5 lakh tonnes, the highest in its documented history since 1950. With overfishing the catch went down every year after that – it was 3.81 lakh tonnes in 2017.

"Over-harvesting and bottom trawling are degrading fish habitats and threatening the entire production of ocean biodiversity hotspots," says the book *In Dead Water*, "making them more vulnerable to climate change." And, it says, the impacts of human activity (including pollution and mangrove-destruction) will be further compounded by sea level rise and increased frequency and intensity of storms. Both are in evidence in the Arabian Sea – and thereby in Versova Koliwada. "...anthropogenic forcing has increased the probability of late-season ECSCs [extremely severe cyclonic storms] over the Arabian Sea..." says a paper published in *Nature Climate Change* in 2017.

Extensive land reclamation and construction along the shore have decimated mangroves, altered water patterns and severely impacted Mumbai's fishing communities

These storms hit fishing communities the hardest, observes Prof. D. Parthasarathy, convenor of the Climate Studies department at the Indian Institute of Technology, Bombay. "Because of the decline in the fish catch, fishermen are forced to go

deeper into the sea. But [some of] their boats are quite small and they are not equipped for the deep sea. So when there are storms and cyclones, they get affected more. Fishing is becoming much more uncertain and much more risky.”

Rising sea levels is another linked problem. Along the Indian coast, the levels have risen by 8.5 centimetres during the past 50 years – or around 1.7 millimetres per year (said the government in the Rajya Sabha in November 2019, responding to a question raised in Parliament). Global sea levels have been rising at an even higher rate – around 3 to 3.6 mm every year over the past 25 years, say IPCC data and a 2018 paper in a journal titled *Proceedings of the National Academy of Sciences* (USA). At this rate, sea levels around the world could rise by around 65 centimetres by 2100 – though the rise varies regionally, depending on a complex interaction of tides, gravity, the Earth’s rotation and so on.

A rise in the sea level, Dr. Deshmukh warns, “is especially dangerous for Versova because it is situated at the mouth of the creek and wherever the fishermen keep their boats, they are vulnerable to stormy weather.”

Many in Versova Koliwada have observed these rising sea levels. Harsha Rajhans Tapke, who has been selling fish for 30 years, says, “Because the fish catch has become less, people [builders and locals] have reclaimed the land where we would dry our fish and started building houses there [on the sand].. With this reclamation, the water level in the creek is rising, and we can see that along the shore.”

Harsha Tapke (left), who has been selling fish for 30 years, speaks of the changes she has seen. With her is helper Yashoda Dhangar, from Kurnool district of Andhra Pradesh

And when very high rainfall too hits the city, the combined effect on fishing communities – of loss of mangroves, of land reclaimed for construction, of rising sea levels and more – is huge. On August 3, 2019, for example, Mumbai received 204 millimetres of rain – the third highest 24-hour August rainfall in a decade – and a high tide of 4.9 metres (around 16 feet). On that day, several small boats docked at Versova Koliwada were thrashed around by strong waves, and the fishing community suffered heavy losses.

“That side of *koliwada* [where the boats are kept] has been reclaimed, but for the last seven years, water had not risen as much as it did that day,” says Dinesh Dhanga, chairman of the Versova Mashemari Laghu Nauka Sanghatana, an

organisation of around 250 fishermen who work on 148 small boats. "The storm came during high tide, so the water level rose twice as high. Some boats drowned, some were broken. Fishermen lost their nets and water got into the engines of some boats." Each boat, Dinesh says, can cost up to Rs. 45,000. The nets cost up to Rs. 2,500 each.

All this has had a huge impact on the livelihoods of Versova's fishing community "We've seen a difference of 65-70 per cent in the catch," says Priya Bhanji. "If we're taking 10 *tokri*s [baskets] to the market now, we used to take 20 *tokri*s earlier [around two decades ago]. It's huge difference."

And while the size of the catch has decreased, the price at which the women buy the fish at the wholesale market near the dock has risen – so their profits have steadily fallen. "Earlier, we used to sell our biggest piece [of pomfret], about a foot long, for Rs. 500. Now for that price, we sell a six-inch pomfret. The size of pomfret has become smaller and the prices have gone up," adds Priya, who makes Rs. 500-600 a day on the three days she goes to sell fish.

Left: Dinesh Dhanga (on the right) heads an organisation of around 250 fishermen operating small boats; its members include Sunil Kapatil (left) and Rakesh Sukacha (centre). Dinesh and Sunil now have a Ganapati idol-making workshop to supplement their dwindling income from fishing

To tide over the reduced incomes, many in fishing families have sought other work. Priya's husband Vidyut worked in the accounts department of the central government office (until he took early retirement); his brother Gautam works with Air India as a store manager, while his wife sells fish in the Andheri market. "Now they are doing office jobs [because fishing is no longer viable]" Priya says. "But I can't do anything else because I am habituated to this."

Sunil Kapatil, 43, whose family owns a small boat, has also looked for other ways to earn an income. A few months ago, he has started a Ganapati idol-making business with his friend Dinesh Dhanga. "Earlier, we would go fishing in nearby areas, about an hour. Now, we have to travel 2-3 hours. We used to come back with 2-3 *peti*s [baskets] full of fish in a day. Now we're struggling to catch even one *peti* ..." Sunil says. "Sometimes, we make Rs. 1,000 [a day], sometimes we don't even make Rs. 50."

Still, many in Versova Koliwada remain full-time fishermen and fish sellers, struggling against the rising sea level, the rise in temperatures, overfishing, pollution, vanishing mangroves and more – along with a falling catch and smaller fish. Rakesh Sukacha, 28, who had to drop out of school after Class 8 to pitch in with his family's income, is among those who continue to depend only on fishing. He says: "Our grandfather used to tell us a story: if you see a lion in the jungle, you have to face it. If you run away, it will eat you up. If you win [against him], you are the brave one. In the same way, they told us to learn to face the ocean."

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City farmers? Yes, sort of – in the national capital, struggling as a choked Yamuna river and the destruction of its floodplains spur the region’s climate crisis and devastates their livelihoods.



Big city, small farmers, and a dying river

City farmers? Yes, sort of – in the national capital, struggling as a choked Yamuna river and the destruction of its floodplains spur the region’s climate crisis and devastates their livelihoods

*“Insaan ab na jhagde se marega na ragade se
marega tho bhook aur pyas se.”*

*“Humankind will now die not of conflict or stress
But of hunger and thirst.”*

So, it's not just science ringing alarm bells about climate change then. India’s literary epics had it nailed down ages ago, asserts 75-year-old Delhi farmer Shiv Shankar. He believes he is paraphrasing lines from the 16th century classic *Ramcharitamanas* (see video). Shankar may be a bit rusty in his reading of the classics, and you might find it difficult to locate those lines in the original Tulsidas poem. But the words of this farmer in the floodplains of the Yamuna river seem well suited to our own era.

Shankar, his family and many other cultivators describe, in painstaking detail, the many changes in temperature, weather and climate affecting what is one of the largest floodplains in an urban area anywhere. Just 22 of the 1,376 kilometres of the Yamuna flow through the National Capital Territory, and its 97 square kilometre floodplains account for barely 6.5 per cent of Delhi's area. But that seemingly small presence has a big impact in balancing the climate, also functioning like nature's thermostat for the capital.

Farmers here note the changes now underway in their own idiom. Till 25 years ago, says Shiv Shankar's son Vijender Singh, people here started using light blankets by September. "Now," says the 35-year-old, "winter doesn't start till December. Earlier Holi in March was marked by a very hot day. Now it's like celebrating the festival in winter."

Shiv Shankar, his son Vijender Singh (left) and other cultivators describe the many changes in temperature, weather and climate affecting the Yamuna floodplains. Vijender Singh with his wife and two sons, his mother Savitri Devi, and Shiv Shankar (right)

The lived experiences of Shankar's family reflect those of other farmers here. Varying estimates say between 5,000 and 7,000 farmers reside along the Delhi shores of the Yamuna – the longest tributary of the Ganga and second greatest (after the Ghaghara) in terms of volume. The agriculturists here cultivate some 24,000 acres, much reduced from a few decades ago, they say. These are farmers in a big city, not of some remote rural region. They live precariously, with 'development' all the time undermining their existence. The National Green Tribunal (NGT) has been inundated with petitions protesting rampant illegal construction on the floodplains. And it isn't just the cultivators who are worried.

"If the floodplains are concretised as has been happening," says retired Indian Forest Service officer Manoj Misra, "Delhiwallas will be forced to leave the city because temperatures in both summer and winter will become extreme and unbearable." Misra heads the Yamuna Jiye Abhiyan (Long Live Yamuna) movement founded in 2007. The YJA brought together seven of Delhi's leading environmental organisations and

concerned citizens, and works on saving the river and its ecosystem. “The city is becoming unliveable and will witness drastic migration. If it doesn't fix its air quality, (even) the embassies will move out.”

Back in the floodplains, the erratic rains in the past few decades torment farmers and fishermen alike.

The communities dependent on the Yamuna river do still welcome the rains each year. Fishermen, because the excess water cleans out the river and allows fish to multiply, and farmers for whom it brings a layer of fresh fertile soil. “*Zameen nayi bann jati hai, zameen palat jati hai* [the land is rejuvenated and transformed by the monsoon rains],” Shankar explains. “This happened almost every year till 2000. It rains less now. Earlier monsoon would start in June. This time June and July were dry. Rains were late, affecting our crops.”

“The *namak* [alkaline content, not salt] rises in the soil when rain is less,” Shankar had told us when showing us around his fields. Delhi's alluvial soil is a result of the deposits left by the river over its floodplains. That soil had long supported growing sugarcane, rice, wheat, several other crops and vegetables. Three varieties of sugarcane – *lalri*, *mirati*, *soratha* – were a pride of the city till the late 19th century, says the *Delhi Gazetteer*.

“*Zameen nayi bann jati hai, zameen palat jati hai* [the land is rejuvenated and transformed by the monsoon rains],”
Shankar explains.

The cane was used for making *gur* (jaggery) in *kolhus* (crushers). Till a decade ago, tiny makeshift shops and carts selling fresh sugarcane juice dotted Delhi's street corners. “Then governments stopped allowing us to sell sugarcane juice, so cultivation stopped,” says Shankar. There have been official bans on the cane juice sellers – and court cases challenging them – since the 1990s. “Everyone knows sugarcane juice fights illness, beats the heat by cooling our system,” he asserts. “The soft drink companies got us banned. Their people lobbied with ministers and we were thrown out of business.”

And sometimes, weather extremes combine with political-administrative decisions to wreak havoc. The flooding of the Yamuna this year – when Haryana released water from the Hathni Kund barrage in August, it coincided with the rains in Delhi – destroyed several crops. Vijender shows us the shrunken chillies, shrivelled brinjals, and puny radish plants that will not bloom this season in their five bigha (one acre) plot here in Bela Estate (located just behind the national memorials of Rajghat and Shantivan).

This capital city has for long had a semi-arid climate. It was a south-east division of the agricultural state of Punjab before it became the British capital in 1911, and is surrounded by the Rajasthan desert to the west, Himalayan mountains towards the north and Indo-Gangetic plains to the east. (All regions also grappling with climate change today). This meant cold winters and scorching summers, with the monsoon providing a 3 to 4 month reprieve.

Now it's more erratic. Delhi recorded a rainfall deficit of 38 per cent in the June-August season this year according to the India Meteorological Department. It received 404.1 mm rain against a normal of 648.9 mm. Simply put, Delhi saw its poorest monsoon in five years.

Monsoon patterns are changing and the rainfall is patchy, notes Himanshu Thakkar, coordinator, South Asia Network of Dams Rivers and People. "The number of rainy days has been depleting, though the quantum of rain may not go down. There is high intensity on the days it rains. Delhi has been changing and that will impact the Yamuna and its floodplains. Migrations, the number of vehicles on the road and air pollution – all have gone up, which has also sparked changes in surrounding areas of UP and Punjab. The micro climates [of a small area] impact the local climate."

The flooding of the Yamuna (left) this year – when Haryana released water from the Hathni Kund barrage in August – coincided with the rains in Delhi and destroyed several crops

'Jamna paar ke mattar le lo' ('Buy these peas from across the Yamuna') – the proud cry of vegetable sellers that once rang through the streets of Delhi fell silent somewhere in the 1980s. In the book *Narratives of the Environment of Delhi* (published by the Indian National Trust for Art and Cultural Heritage), old timers

recall that the melons available in the city were like the ' *Lukhnavi kharbuza* ' (Lucknow's watermelons). The juiciness of the fruit, grown on the sandy soils of the river, also depended on the prevailing air. The earlier melons were plain green and heavier (implying greater sweetness) and appeared once a season. Changes in cultivation practices have brought newer kinds of seeds. The melons are now smaller and striped – the new seeds give greater yields but smaller sizes.

The fresh mounds of water-chestnut – *singhara* – that vendors carted house to house two decades ago have all but vanished. They were grown around the Najafgarh jheel (lake). Today the Najafgarh Drain and the Delhi Gate Drain account for 63 per cent of the Yamuna's pollution, says the website of the National Green Tribunal (NGT). “ *Singhara* is grown in small water bodies,” says Baljeet Singh, 80, general secretary of the Delhi Peasants Cooperative Multipurpose Society. “People stopped cultivating it in Delhi because it needs the right amount of water – and plenty of patience.” The capital city today is rapidly running short on both – water and patience.

Farmers too want quicker yields from their lands, says Baljeet Singh. So they go for crops that take 2-3 months and can be grown 3-4 times a year like bhindi, beans, brinjal, radish, cauliflower. “New varieties of *mooli* (radish) seeds were developed two decades ago,” Vijender says. “Science has helped increase yields,” says Shankar. “We got some 45-50 quintals of *mooli* earlier [per acre]; now we can get four times as much. And we can grow it thrice a year.”

Vijender's one acre plot in Bela Estate (left), where he shows us the shrunken chillies and shrivelled brinjals (right) that will not bloom this season

Meanwhile, development of the concrete kind moves ahead rapidly in Delhi, not least in the floodplains. According to the *Economic Survey of Delhi 2018-19*, cropped area declined by almost 2 per cent each year between 2000 and 2018. Presently, 2.5 per cent of the city's population and nearly 25 per cent of its area (down from over 50 per cent in 1991) is rural. In the Master Plan 2021 for the capital, the Delhi Development Authority (DDA) plugs for complete urbanisation.

It's pace of urbanisation – mainly, rapid construction activity, legal and illegal – means Delhi could be the most populous city in the world by 2030, according to UN estimates. The capital, with 20 million people presently, will have overtaken Tokyo (now 37 million) by then. It will also be one of 21 Indian cities to run out of groundwater by next year, says the Niti Aayog.

“Concretisation of the city,” says Manoj Misra, “means more land gets paved, less water percolation, less greenery... paved spaces absorb and release heat.”

In 1960 – when Shankar was 16 – Delhi saw an average of 178 days when the temperature reached at least 32 Celsius, according to an interactive tool on climate and global warming of the New York Times. In 2019, that's 205 hotter days. By the end of this century, India's capital city could go from experiencing less than six months of 32 C heat to over eight months of it each year. Human activity has much to do with that.

Shiv Shankar and his son Praveen Kumar start the watering process on their field

Misra points to a difference of almost 4 degrees Celsius now in temperatures between Palam in south-west Delhi and the floodplains to its east. “If it's 45 Celsius in Palam, it can be around 40-41 C in the floodplain.” Within a megapolis, he says, “these floodplains are a gift.”

Since nearly 80 per cent of Yamuna's pollution comes from the capital, as the NGT acknowledges, what would happen if it 'left' Delhi – a logical step for the aggrieved party in a toxic relationship. “Delhi exists because of the Yamuna, not the other way around,” says Misra. “Over 60 per cent of the drinking water for Delhi comes from the upstream diversion of the river into a parallel canal. The monsoon rescues the river. In the first wave or first flood pulse, the pollution is taken away from the river, in the second and third flood pulse, it recharges the groundwater of the city. The 5-10 yearly basis recharge is done by the river, no other agency can do that job. When we had flood-like situations in 2008, 2010 and 2013, the water was recharged for the next five years. Most Delhiwallas don't appreciate this.”

Healthy floodplains are key – they give water the space to spread out and slow down. They store excess water during floods, releasing it slowly into groundwater aquifers. This eventually helps recharge the river. Delhi was ravaged by its last devastating flood in 1978 when the Yamuna rose six feet above its official safety level, scores of people died, lakhs were affected, quite a few rendered homeless – not to forget the damage done to crops and other water bodies. It last breached this danger mark in 2013. According to the 'Yamuna River Project: New Delhi Urban Ecology' (led by the University of Virginia), steady encroachment of the floodplain has severe consequences. “The embankments will fall during a 100-year flood event, wiping out structures built in low lying areas of the floodplain and inundating east Delhi with water.”

Shiv Shankar explaining the changes in his farmland (right) he has witnessed over the years

Farmers caution against further construction in the floodplains. “It will impact the water level tremendously,” says Shiv Shankar. “For every building, they will make basements for parking. They will plant fancy trees to get wood. If they put fruit trees – mango, guava, pomegranate, papaya – that will at least help people to eat and earn. And birds and animals get to eat too.”

Official figures show that since 1993, over Rs, 3,100 crores have been spent on cleaning the Yamuna. Why then, scoffs Baljeet Singh, “isn't the Yamuna clean today?”

It's all coming together in Delhi – in the wrong way: unrelenting concretisation of every available inch in the city; uncontrolled construction on, and misuse of, the Yamuna floodplains; the choking of a great river with toxic pollutants; the massive changes in land use and new seeds, practices and technologies bringing an impact their users may not see; the destruction of nature's thermostat; erratic monsoons, extraordinary levels of air pollution. It's a deadly brew.

Shankar and his fellow farmers recognise some of its ingredients. “How many roads will you build?” he asks. “The more you concretise, the more heat the ground absorbs. Nature's mountains – even they allow earth to get recharged during the rains. The mountains humans have built in concrete do not allow the earth to breathe or recharge or retain and use the rains. How will you grow food if there is no water?”

PARI's nationwide reporting project on climate change is part of a UNDP-supported initiative to capture that phenomenon through the voices and lived experience of ordinary people.