Turning into a Desert

Time is Running Out to Fix Haryana and Punjab's Groundwater Crisis

By Fazil Khan, M.S. Data Journalism '21

In April this year, Yashbir Singh, a paddy farmer from Karnal in Haryana, found the two tubewells he uses to irrigate his fields had gone dry only after a few years of operation.

Like most other farmers in Punjab and Haryana, Singh mainly grows wheat and paddy (rice) on his 35 acres of land. Almost all of his agricultural income comes from these two crops and he largely depends on natural underground water reserves to irrigate his fields. So, the dry tubewells needed to be replaced.

The 38-year-old business school graduate turned farmer had to shell out more than $4,000 (INR 300,000) to install two new wells that went deeper into the ground to pump out water for his thirsty crop. While the new pumps lift groundwater from a depth of 130 ft., his new wells reach down 350 ft. The water table is declining rapidly in this part of the country, and farmers typically prepare by digging their wells as deep as they can to delay another such overhead expenditure in the near future, which has become more frequent in recent years for the same reason.

"I have no idea how long these new ones will work for," said Singh over a phone call in early July as he stood in his dry fields lamenting over the delayed annual monsoon season. "Groundwater levels are declining every year. They have dwindled almost 20-30 ft in just a couple of years and you either need to dig deeper or use more powerful pumps to make existing tubewells work."

At the time of this conversation, Singh's farmlands stood dry as the southwest monsoon did not arrive even a week after its normal arrival date, further highlighting the importance of the tubewells. "We've not received even a single drop so far."

With a population of close to 1.5 billion, India holds only a fraction of the world's fresh groundwater resources but accounts for more than a quarter of the total groundwater extracted globally every year – more than any other country on the

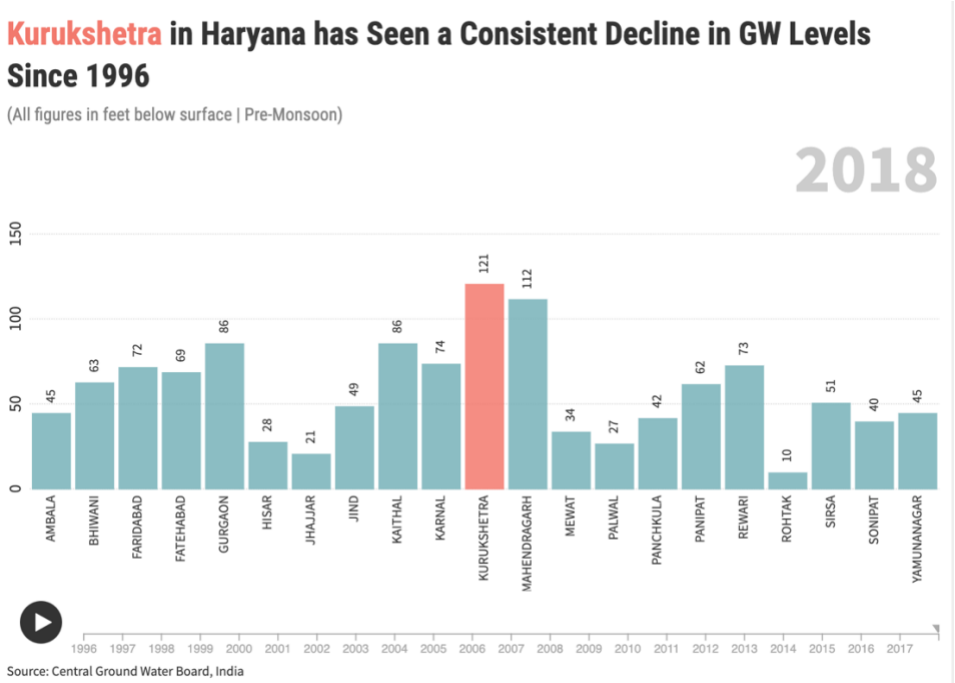
planet. Over 90 percent of this is used in agriculture. This extraction in some regions significantly overshoots the annual groundwater “recharge” accentuating India’s severe water crisis. Nowhere is this crisis more alarming than in the northwestern states of Punjab and Haryana.

To Keep the Pumps Running

Groundwater levels in Punjab and Haryana have depleted rapidly in the past couple of decades owing to over extraction and climate change. According to official data from the Central Ground Water Board (CGWB), the average depth at which water is found in both Haryana and Punjab has nearly doubled between 1996 and 2018. But there are wide variations in depth levels across districts be it the current depth of groundwater or its change over time.

For instance, the Rohtak district in Haryana has had the shallowest pre-monsoon (in May) levels of groundwater at an average of about 10 ft in 2018 which has remained virtually unchanged over two decades. Kurukshetra district, on the

other hand, had average groundwater levels at just over 48 ft. below the ground in 1996 which increased to 121 ft. in 2018 – the deepest for any district in the state. The deepest single well was in Bhiwani at 265 ft. in 2018.



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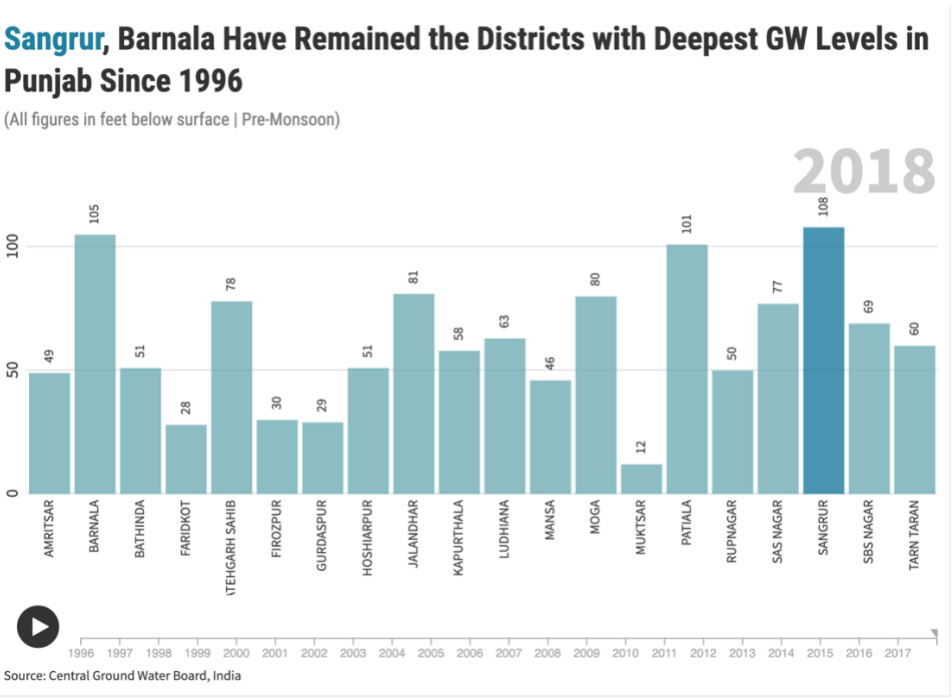
In neighboring Punjab, Sangrur, which is considered one of the worst-affected districts in the state, official numbers put the pre-monsoon groundwater depth at 108 ft in 2018. Barnala district saw levels go from an average of 35 ft. a couple of decades to over 100 ft. in 2018.



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“The rate of extraction [in Punjab and Haryana] is alarming,” said Naresh Devineni, assistant professor at The City College of New York, who has extensively studied groundwater behavior in the region. Devineni said that while shallow aquifers of groundwater are already overexploited, farmers, with these tubewells, have also been mining deeper reserves of groundwater that take “hundreds of years to recharge”.

“The recharge will not happen at the same rate. So, the long-term sustainability of the water resource in that area is in jeopardy,” he said.

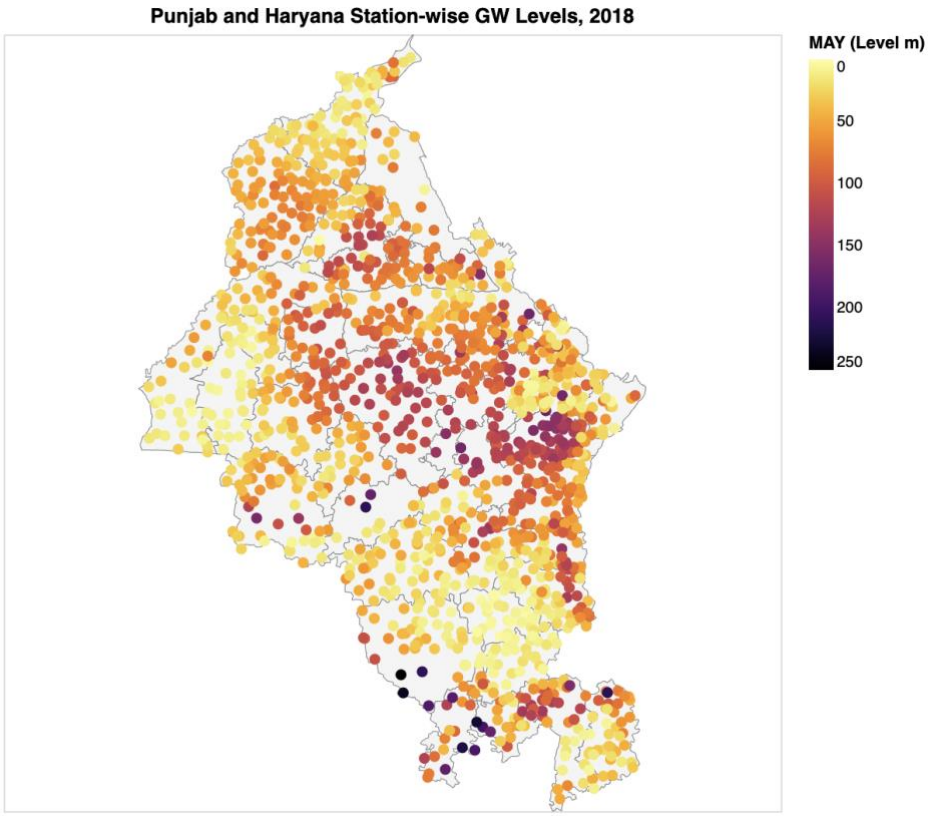
The presence of river valleys – that create alluvial plains, a flat landform created by the deposition of sediment over a long period of time – and the distance from them, dictate the spread or extent of an aquifer. A wider spread means a gradual observed decline in groundwater levels whereas a narrower extent results in the inverse. A simpler demonstration of this would be removing the same amount of water from a swimming pool and a bucket of water. The change in the water levels in both the cases would be starkly different.

This, coupled with the wide variations in extraction levels across different regions, means that individual tubewells at hyperlocal levels go much deeper to pump usable water. In some cases, farmers claim their tubewells go as deep as

1,200 ft. For reference, this is more than three times the height of the Statue of Liberty in New York from the base of its foundation to the torch.

“Shallower groundwater is not as clean as deeper groundwater because it's just been exposed to more contamination,” said Balsher Singh, a PhD candidate at the University of British Columbia studying agriculture practices, groundwater depletion, and climate change. The other reason why farmers go deeper even when water is found at shallower depths is the “future-proofing” of these wells to save money in digging the well even deeper a few years down the line.

“If you are digging a tubewell and water is at 100 ft., you don't want to be digging a tubewell again ten years from now. You know that water is going down so you want to dig a deep tubewell at one go,” he said.



Link to Interactive: https://fazilkhan.github.io/Groundwater-stationlevels/

One particular cause for this over-extraction of groundwater and consequent decline in groundwater levels is the farming of paddy in the region. Both Punjab and Haryana are amongst the top food grain producers in the country. Wheat and rice are the two major crops grown in the region. In the 2019 fiscal year, two-

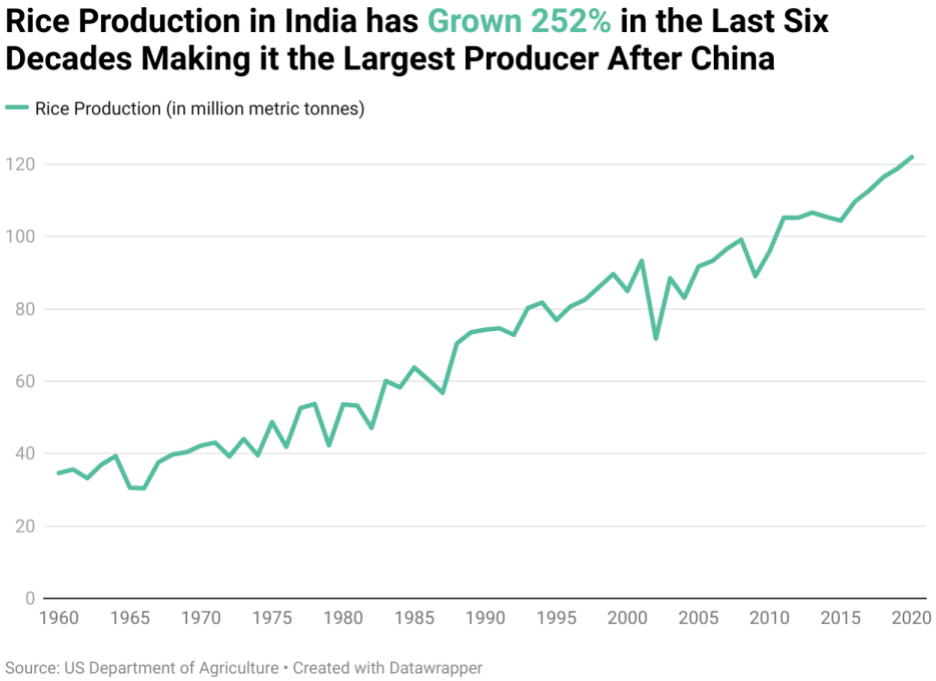
thirds in Punjab and 45 percent of the total farm output in Haryana was just rice and wheat. Paddy was grown on three-fourths of the net sown area in Punjab in the same year. For Haryana it was 40 percent.

But paddy is a water-intensive crop. According to estimates, it takes 4,000-5,000 liters of water to grow a kilogram of rice. Decades of dependence on groundwater to fulfill this demand is why levels have fallen to critical levels in the region.

The Seeds of the Crisis

The Indian government in the 1970s made a massive push to scale up the production of food grains, especially the staple crops of rice and wheat, in order to make the country self-sufficient in food production. Use of fertilizers and other technologies was promoted and policies such as at minimum fixed prices (MSP), where the government assured procurement of the produce at set prices, protecting the farmers from market fluctuations.

These measures were introduced to encourage the farmers to turn things around for a country that had witnessed food shortages in the recent past. It was called the “green revolution” and, within years, it showed promising results.



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However, the turning point as far as groundwater irrigation is concerned came in the 1990s when the state governments started to offer subsidies to farmers on power used in agriculture. Farmers largely relied on the canal system to water their crops until this point since the use of private tubewells was an expensive affair. Subsidized electricity made groundwater cheaper and significantly more accessible.

Power subsidies have led to a sharp increase in the number of tubewells in the country. In Punjab, there were about 1.5 million tubewells in 2017-18. – nearly a 700 percent increase from what the figure looked like in 1980. The state has 34 tubewells per sq. km of net sown area and about three-fourths of the total land is irrigated through groundwater.

This extra drilling has had a direct impact on groundwater reserves in the region. A paper published in the Journal of Hydrology earlier this year found that the overall groundwater storage for the total area of the region remained stable between 1974 and 2001. However, It lost about 32 cubic kilometers of water between 2001 and 2010.

“Government assured procurement from the farmer. Essentially the idea was that you produce and we buy it from you at a good price, incentivizing higher production,” said Balsher. “The farmers took up the challenge really well. They bought new machinery and took up loans to dig deeper wells. They changed their whole farming structure or their farming techniques to cater to this program.”

The national push to scale up production of food grain created a demand for a staple crop like paddy. Assured procurement by the government at an MSP made paddy a safer crop for farmers with guaranteed returns even when it is not native to the region. But it’s also this safety net that created farmers’ dependence on paddy. Now, farmers find it difficult to move away from it even when they know what damage it’s causing to the groundwater table.

“We know it’s a problem but no other crop other than rice guarantees a good price,” said Hoshiyar Singh, 33, a resident of Lehel Kalan village in Sangrur, Punjab. “At the end of the day, a farmer needs to make an income and feed their family.”

Hoshiyar Singh is pursuing a PhD in political science at the Chandigarh University but said that he helps out his father who is involved in agriculture. The entire family income depends on the 20-acres of land that they own and farm on. He said that he has witnessed tubewell depths at least double in just the past 8-10 years. While he understands that it is of utmost importance to diversify crops in order to arrest the rapid decline in groundwater table, he said the government needs to provide price guarantees for alternative crops too, incentivizing a much-needed shift from paddy.

"Government spending on agriculture has anyway been very low. Unless they make an arrangement to fetch similar prices from other crops, diversification is difficult," he said.

Is there a Solution?

There have been initiatives from both the state governments to encourage farmers to move away from paddy or even limit the use of groundwater but none that have caused any major change so far. The Punjab government in 2009 barred the transplanting of paddy, the process of sowing rice seedling grown in a nursery, before Jun 15 to limit groundwater extraction in peak summer. But that created a whole new problem.

Delayed planting pushed the harvesting of the crop to the end of October. This meant that farmers were now left with a small window to sow wheat before the November 15 deadline – sowing wheat after this would decrease the yield and push the harvesting further into the Summer season. To meet that deadline, farmers have no option but to burn the stubble left behind after the harvesting of paddy, causing severe air pollution in the national capital to its south.

State governments are also trying to replace the species of rice to one that saves water but farmers have only just begun to shift to those. Moreover, proposals to roll back MSPs to reduce dependence on paddy or power subsidies, as advised by experts, are too bold of a political move for any governments to dare to make as recent farmers' protests have shown.

In the case of Haryana, the most recent attempt has been to provide monetary incentives to farmers if they cultivate a crop other than paddy. Launched last season in May, the program called *Mera Paani, Meri Virasat* (My water, my heritage), promises to offer INR 7,000 per acre of land to farmers who diversify more than 50 percent of their total paddy area. These crops could include maize,

cotton, pulses or vegetables. The farmers who register for the scheme and grow an alternative to paddy on more than half of their land will be able to sell their produce at a minimum support price, the scheme says.

“We’ve gotten a good response from the farmers to the scheme,” said Girish Nagpal, deputy director of agriculture, Haryana. “Honorable chief minister is himself monitoring the scheme and I think INR 7,000 is a significant amount.”

But questions have been raised on the implementation of the scheme after its first run last year. According to the scheme, a quarter of the total incentive is given to the farmer after the first physical inspection by the agriculture department at the time of sowing while the remaining 75 percent is disbursed after the second verification at the time of harvesting. Discrepancies were found in the total identified area where paddy was not cultivated after the first and second rounds of verification.

A report in the Hindustan Times in November of last year said that while 39,000 hectares of such land was identified during the first stage of verification, only about 5,000 hectares was identified for the same in the second as per compiled data until October 29, 2020. Authorities, however, said at the time that the data was still being tabulated. Nagpal denied any discrepancy in the numbers.

But the promised incentive is either delayed or not paid at all, farmers say.

“I have not found a single farmer who said that they registered for the scheme and their crop was procured at a minimum support price,” said Ramandeep Singh Mann, an engineer-turned farmer activist who has been working for farmers’ rights for over a decade. “When there is no proper implementation of such initiatives, it also discourages farmers to trust any future schemes from the government.”

“I don’t think the government is serious about this issue. It only goes as far as central government publishing reports once a while and journalists reporting about it and that’s it,” added Mann.

Nagpal, on the other hand, said there have been no delays in the payment of these incentives. “The payment is made within the same financial year,” he said.

Another initiative that has been taken in the past few years, in many instances by the farmers themselves and recently with a push from the government, is a different technique to sow paddy that helps reduce water consumption. Traditionally, rice is sprouted in a nursery and then planted into standing water. In this recently adopted technique called direct seeding of rice or DSR, the seed is directly sown and sprouted into the soil with the help of machines. Paddy grown through DSR uses up to 30 percent less water compared to the traditional method, according to various estimates.

Governments in both the states have been trying to encourage farmers to shift more and more to DSR, setting annual targets for local authorities in terms of land cultivated with this technique.

Progress has been made on this front. While Punjab brought a record 20 percent of the total targeted rice area under DSR last year, Haryana has doubled its target earlier this month of covering 20,000 hectares under DSR. But here again, promised incentives, which have been marked by long delays especially in Haryana, need to come through to make the shift smoother for farmers.

Even this, however, is too little for a meaningful change in the overall reversal of the crisis, experts say.

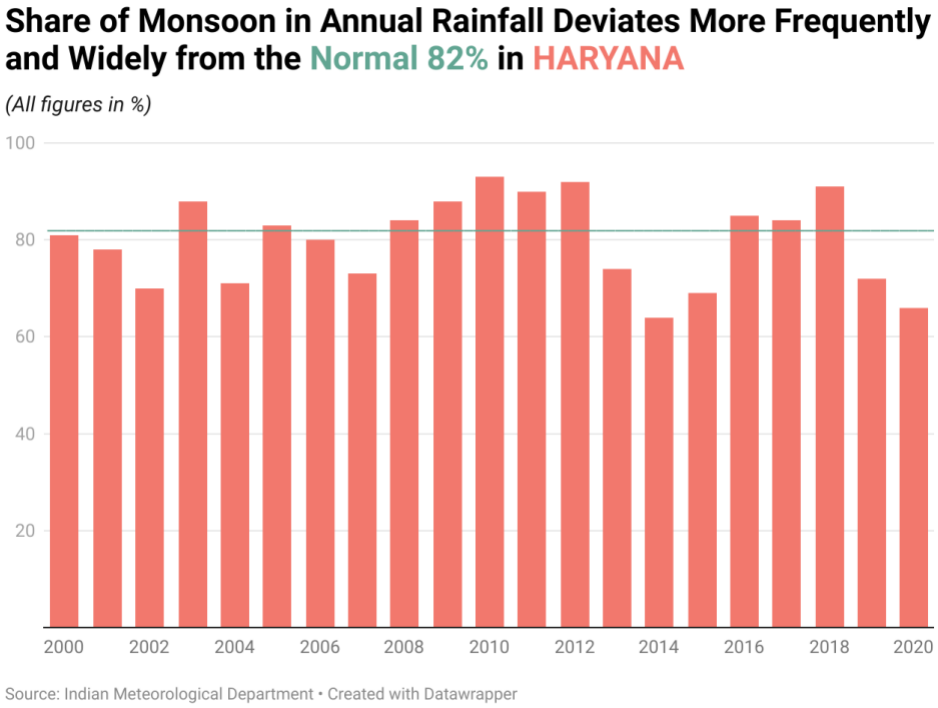
Water used up in the region for growing paddy is three times the average annual rainfall, said Devineni, adding that even saving up to 30 percent of water via DSR can only provide temporary relief and would not ensure long-term sustainability. Not growing paddy, at least at the scale it's being grown at present, is the only sustainable solution to the groundwater crisis in his opinion.

Enters Climate Change

Like most aspects of life on Earth, climate change is expected to exacerbate the groundwater problem in the region. Some say it is already happening. As rainfall continues to become more erratic and temperatures rise, groundwater extraction is most likely to increase in these states.

"Paddy can withstand high temperatures as long as there's enough water. If the temperatures rise, then you need even more water and so on," said Balsher.

Rainfall has indeed become more inconsistent in the two states. Annual rainfall has frequent deviations from normal and these deviations, especially during the monsoon months of June, July, August, and September. Both Punjab and Haryana receive close to 80 percent of their annual rainfall during monsoon months but wide variations have been witnessed in this figure over the past couple of decades.



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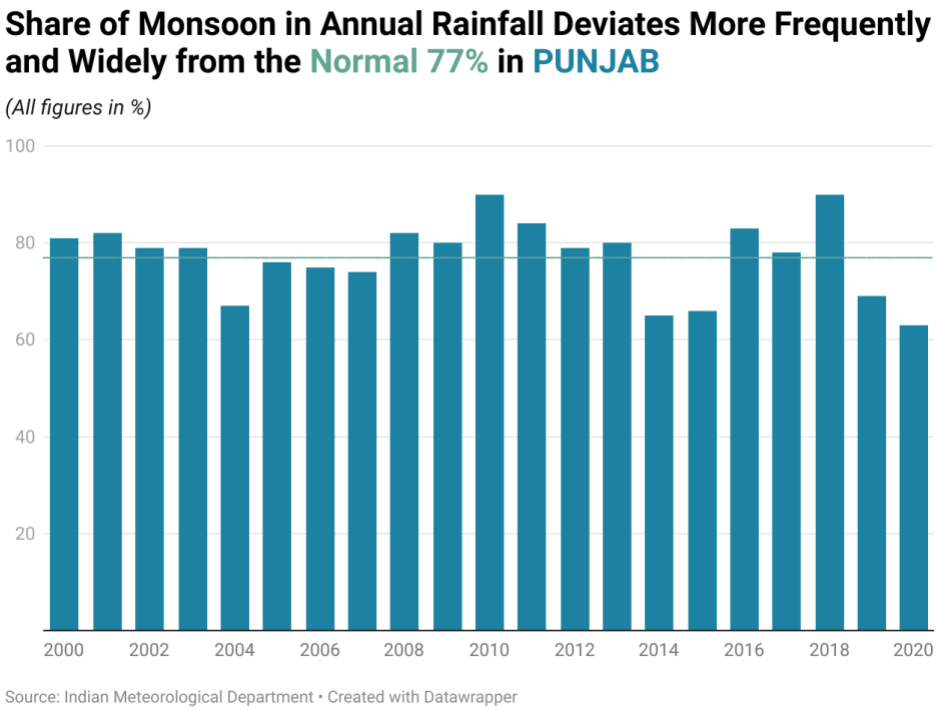

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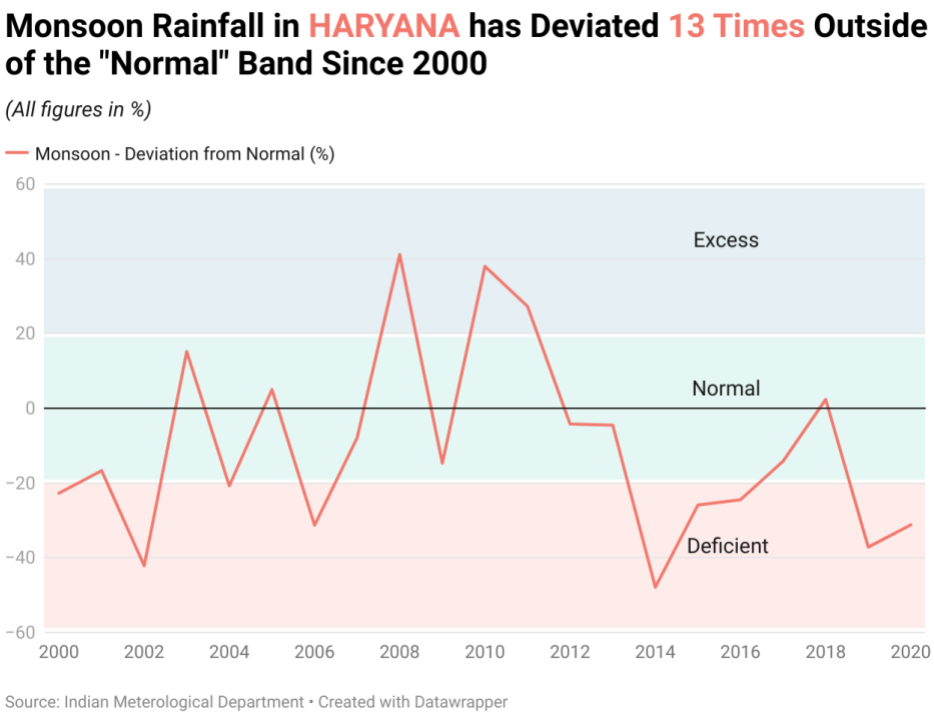
The Indian Meteorological Department (IMD) categorizes deviations of +/- 19 percent in rainfall as “normal” for the purposes of its analysis. Deviations of more than 20 percent, positive and negative, from this normal are considered “excess” and “deficient” rainfall, respectively.

Since 2000, monsoon rainfall in Haryana has been outside of the “normal” band 13 times, deviating more than 40 percent at least once on either side. There have been nine instances when rainfall has either fallen into the “excess” or “deficient” categories in Punjab during the same time frame. At least twice in the last two decades, monsoon rainfall in Punjab was over 55 percent more than the “normal”. Anything over 59 percent is categorized as “large excess” by IMD.



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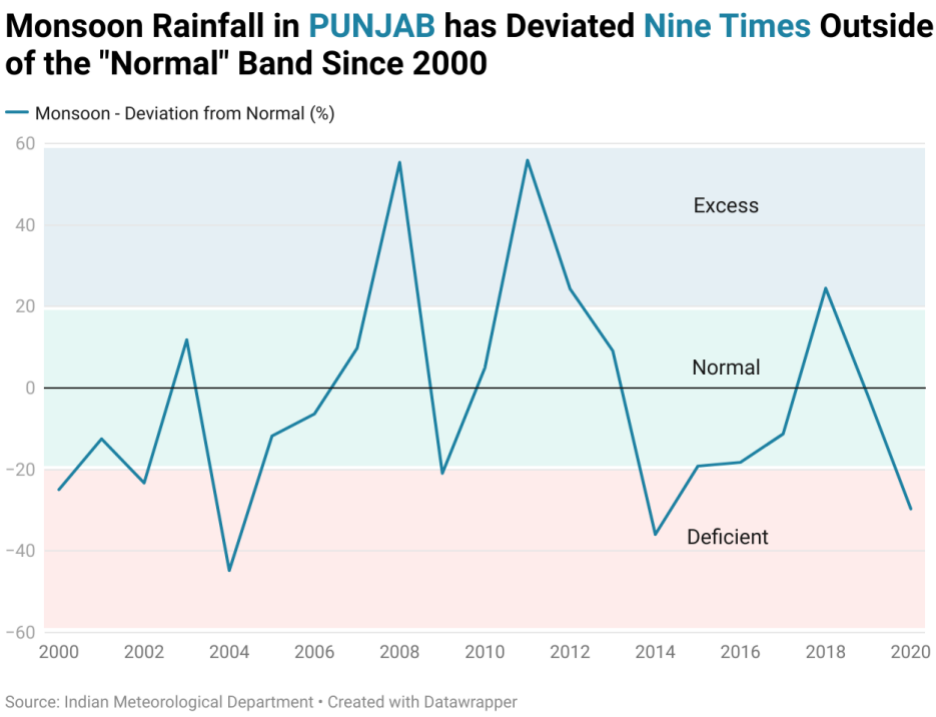
“Monsoon is no longer how it used to be,” said Malak Singh, a 36-year-old farmer from Pabana Hassanpur village in Haryana. “There used to be a time 10-15 years ago when it used to rain continuously. That doesn’t happen anymore.”



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While monsoon deficits push farmers to double down on tubewell irrigation further straining groundwater reserves, shorter concentrated spells of excess rainfall flood the fields, destroying the crop.

“If the rainfall basically translates into floods and you have higher temperature, then goodbye to agriculture both ways,” said Upmanu Lall, director of the Columbia Water Center at Columbia University. Things only work well when the increase in rainfall is spread out over months and we don’t know how rainfall is going to behave in the coming years, he said.

In addition to flooding the fields, the excess does not necessarily help the groundwater situation as well.

“You cannot change the infiltration rate of [water seeping into the ground],” said Rajiv Sinha, professor at the India Institute of Technology, Kanpur, adding that there’s a capacity beyond which groundwater cannot be recharged in a given year and the rest of the water just drains away.

“It’s not a pipe that you keep putting in water. If you have these kinds of extreme rainfall events which are distributed over time, it will have a serious impact on the groundwater recharge system,” he said.

Rainfall is considered to be the single most important source of water recharge across India. However, groundwater extraction in both Punjab and Haryana significantly exceeds the annual recharge. According to a 2017 government report, Punjab annually extracts 166 percent of its annual extractable groundwater resource – the highest in the country. Haryana, on the other hand, extracts 137 percent extractable groundwater resource annually. Rajasthan and Delhi, both neighboring states of Haryana, are the only other states to have extraction that exceeds annual recharge. Rajasthan is a desert state. The report, which analyzed groundwater levels and the rate of extraction at a block level, identified a majority of the blocks in all these states as “over-exploited”.

The impact of this overexploitation in the case of Haryana and Punjab is visible in post-monsoon groundwater levels, the measurements for which are taken by the CGWB in either October or November. While the October numbers have gaps, November’s data is available for each year from 1996 to 2017 and are, therefore, compared in the analysis.

Although most of the recharge in the two states happens during monsoon months, these are also the months when paddy irrigation and constant discharge takes place. Therefore, a look at post-monsoon data provides a peek into how paddy might directly affect groundwater levels. And the depletion in post-monsoon levels too has been as rapid as pre-monsoon levels if not worse. As with pre-monsoon levels, post-monsoon groundwater levels too have nearly doubled in depth in both Haryana and Punjab. Moreover, the post-monsoon levels across most districts also do not show any improvement over pre-monsoon levels in a given year as would be expected.

“Essentially, the extraction is so high that the [monsoon] recharge is just not enough to sustain the system. That is why there is a net decline,” said Sinha.

Fewer Districts Show Any Improvement in GW Levels Over Pre-Monsoon Levels Across Both States

Rise in GW Levels Decline in GW Levels

Search in table

	1996		2017	
District	Pre-Monsoon (May)	Post-Monsoon (Nov)	Pre-Monsoon (May)	Post-Monsoon (Nov)
Ambala	32.55	30.28	74.02	70.38
Amritsar	25.53	18.28	45.44	46.62
Barnala	32.48	35.66	99.91	102.96
Bathinda	26.02	25.66	50.13	51.61
Bhiwani	44.69	40.23	60.44	34.88
Faridabad	14.93	11.32	47.71	39.11
Faridkot	14.67	14.17	26.94	28.32
Fatehabad	32.65	30.71	64.83	68.34
Fategarh Sahib	33.20	31.04	76.05	75.63
Firozpur	16.83	15.49	25.56	29.92
Gurdaspur	22.18	14.53	28.09	24.28
Gurgaon	35.99	31.10	74.77	76.22
Hisar	26.77	25.62	29.04	24.67
Hoshiarpur	34.25	29.04	54.43	47.84
Jalandhar	35.57	33.20	82.16	80.12
Jhajjar	17.75	15.39	17.32	17.52
Jind	19.72	20.57	44.03	41.83
Kaithal	25.03	25.76	85.93	87.67
Kapurthala	26.15	29.63	63.91	59.09
Karnal	30.94	22.05	72.58	76.32
Kurukshetra	48.33	48.39	116.93	121.30
Ludhiana	37.11	33.07	67.62	65.69
Mahendragarh	75.53	60.47	95.02	104.99
Mansa	11.98	12.21	45.18	45.64
Mewat	14.31	12.21	23.23	24.61
Moga	31.50	31.46	82.25	82.06
Muktsar	12.17	12.99	12.34	11.12
Palwal	14.40	12.27	25.92	23.49
Panchkula	50.53	42.95	27.33	30.28
Panipat	26.58	22.25	56.86	54.60
Patiala	32.61	36.88	92.59	101.22
Rewari	49.12	42.42	79.50	64.67
Rohtak	10.27	8.92	15.03	12.21
Rupnagar	24.28	18.08	40.23	40.45
SAS Nagar	26.28	20.83	47.51	72.18
Sangrur	88.13	89.41	103.35	108.83
SBS Nagar	36.19	32.97	66.70	67.56
Sirsa	35.27	33.66	43.24	51.12
Sonipat	18.01	11.06	41.11	35.57
Tarn Taran	27.43	26.44	56.99	60.17
Yamunanagar	30.91	22.02	43.24	35.99

Note: Consistent post-monsoon measurements were only available until 2017. Hence, only that data is used for this table.

Source: Central Ground Water Control Board • Created with Datawrapper

Link to Interactive: https://www.datawrapper.de/_/Npddh/

What Lies Ahead?

A draft report by the Central Ground Water Board in 2019 warned that Punjab is on its way to turn into a desert in the next 20-25 years if the extraction of the groundwater continues at the current pace. Haryana faces a similar crisis. Although experts believe that it's complicated to make such a bold prediction that far into the future, the crisis will indeed grow in severity if no urgent steps are taken to alter the current state of affairs.

Groundwater depletion is also expected to lead to other crises. A recent study, analyzing satellite imagery and census data, estimated that groundwater depletion may reduce cropping intensity by up to 20 percent across India and by up to two-thirds in the regions projected to have low future groundwater availability in 2025. "These large projected losses are of concern given that India is one of the largest agricultural producers worldwide, and over 600 million farmers depend on Indian agriculture as a primary source of livelihood," the study noted.

Farmers, although aware of the seriousness of the matter, continue to ask for price guarantees on alternative crops if they are to give up cultivating paddy. And these guarantees are important. For over eight months now, farmers from across the country but mostly from Punjab and Haryana have been protesting along the borders of the national capital against new farm laws that farmers believe will do away with these support prices – even on paddy and wheat.

"If the government were to offer him [the farmer] the same guaranteed price for crops like corn, pulses or other things, and these were the crops that they were growing before they grew paddy, the guy is happy to do it," said Lall.

Farmers are also willing to let go of the electricity subsidy if reliable 24/7 supply is ensured. Currently, only about four to six hours of electricity is provided which sometimes may not also come by at a fixed time of the day, farmers say. This unreliability of power supply, Devineni said, forces farmers to keep the tubewells running and pumping out water that may be more than their fields require.

Everyone, from the farmer to the political leadership, knows that the groundwater situation in the region is alarming but no visible progress has been made in solving the problem, experts say. All the stakeholders know that crop-

diversification is the only sustainable solution to the crisis but they fail to meet at a common ground. Farmers won't switch paddy for anything without a guaranteed minimum selling price and government efforts to incentivize the switch through other means haven't taken off.

With every paddy season, the crisis gets even more severe. Even changes in extraction rates would only show improvement in groundwater levels years or decades.

"It's a continuous process. It's not like a scheme is implemented and suddenly water levels will rise," said Girish Nagpal, the deputy director of agriculture development authority in Haryana. "We will need to change the mindset of the farmer through incentives that there's good income outside of paddy too."

The growing influence of climate change on agriculture on the ground means that there's no time left to take this issue head on. Yashbir Singh, the farmer from Karnal for instance, saw his fields go from bone dry due to a delayed monsoon to being flooded within a span of two weeks after incessant rains in mid-July, incurring losses of more than $8,000. It's because of these uncertainties that farmers, he said, wouldn't experiment without a promise of at least partially guaranteed returns, even if it means further stressing the groundwater reserves.

"There is just no choice for the farmers but to continue with this. There's no other secure source of income," he said. "We're 100 percent ready to switch if given a guaranteed selling price."

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