



Monsoon: Our finance minister

- **Every year we wait to exhale** – journey from sea to land; across lands; across fields and cities
- **Nature's way:** small temperature difference to carry 40,000 billion tonnes of water from ocean to land
- **Nature's lesson:** use weak forces rather than concentrated forces – solar instead of oil and gas; rainwater instead of dams
- But how much do we know about monsoon? Its science? Its changing character? Its scientists?



Tragedy: our making

- Today we cry when it does not rain
- Today we cry when it does rain
- Go from cycle of crippling drought to back-breaking flood
- Double whammy
- Mismanagement of water resources + changing character of rainfall
- Must know this change

Monsoon is globalised Indian – connected to ocean currents and winds from the Pacific, Arctic, Tibetan Plateau. Most under-studied, complex, confounding and capricious. Now climate change is making it even more variable and **more extreme. We need to know it better**

Which way the wind blows?

Excessive rainfall and the dip in temperature this March have been attributed to western disturbances. Scientists say weather phenomena in areas as far as the Pacific or the Arctic could be impacting winter rain in India

WESTERLIES

Westerlies are planetary winds that blow from west to east between 30 to 60 latitude. Western disturbances which hit India come with the Westerlies

Pacific Decadal Oscillation

PDO is the alternate cooling and warming of the waters of the Pacific Ocean off the western coast of North America in areas above 20 North. This change in sea surface temperature impacts air currents in Northern Hemisphere affecting Westerlies and western disturbances

Jet streams

Jet streams are narrow bands of strong wind flowing in the upper troposphere. They impact western disturbances which are present in the mid-troposphere and can amplify their impact

Arctic warming

The jet streams in the northern hemisphere are maintained due to the heat difference between the cool Arctic and warm equator. But heating up of the Arctic in the past 20 years has weakened the jet streams. The changes in jet stream patterns have also impacted western disturbances

Heating of the Tibetan plateau

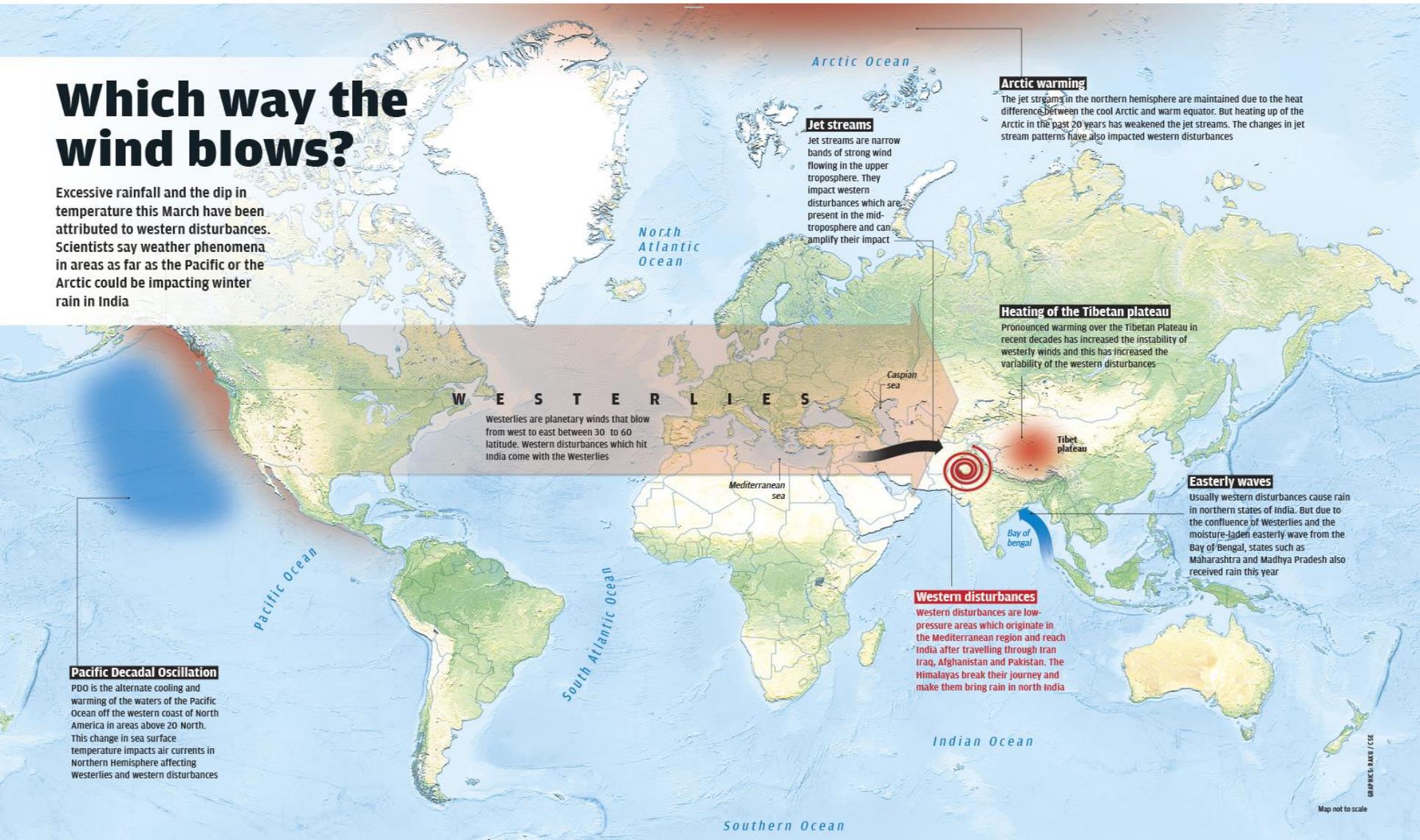
Pronounced warming over the Tibetan Plateau in recent decades has increased the instability of westerly winds and this has increased the variability of the western disturbances

Easterly waves

Usually western disturbances cause rain in northern states of India. But due to the confluence of Westerlies and the moisture-laden easterly wave from the Bay of Bengal, states such as Maharashtra and Madhya Pradesh also received rain this year

Western disturbances

Western disturbances are low-pressure areas which originate in the Mediterranean region and reach India after travelling through Iran, Iraq, Afghanistan and Pakistan. The Himalayas break their journey and make them bring rain in north India



Already difficult to predict...

What it takes to predict monsoon

More than 1,000 scientists, six institutions, thousands of weather sensors on land and sea, and seven satellites collate and analyse trillions of megabytes of weather-related data every moment

4 IMD head office uses this data to forecast monsoons and to monitor developing weather systems in real time. IMD also disseminates this information to various climate services

5 The weather data is used by various institutes, including defence establishments, for research and forecasting

2 Two satellites immediately relay weather data back to regional centres for processing. At least five other satellites provide round-the-clock observations from space

3 Six regional centres, including INCOIS at Hyderabad, process the data from satellites on relevant parameters. INCOIS provides customised data to IMD and other research institutes for forecasting models

1 More than 3,600 weather observation stations and instruments over land, sea and sky send real-time data on temperatures, atmospheric pressure, humidity, wind velocities and radiations to satellites

- Argo floats
- Ships
- Pilot balloons
- Buoy
- Upper air observatory
- Doppler radar



Now more variable, extreme

- Weird weather has become the 'new normal'
- Unseasonal rain
- Abnormally high rain that comes in short periods
- Unseasonal and deadly hailstorms; cold and heat spells
- **2016: Flood in the time of drought**



Our reports : weird, variable and devastating

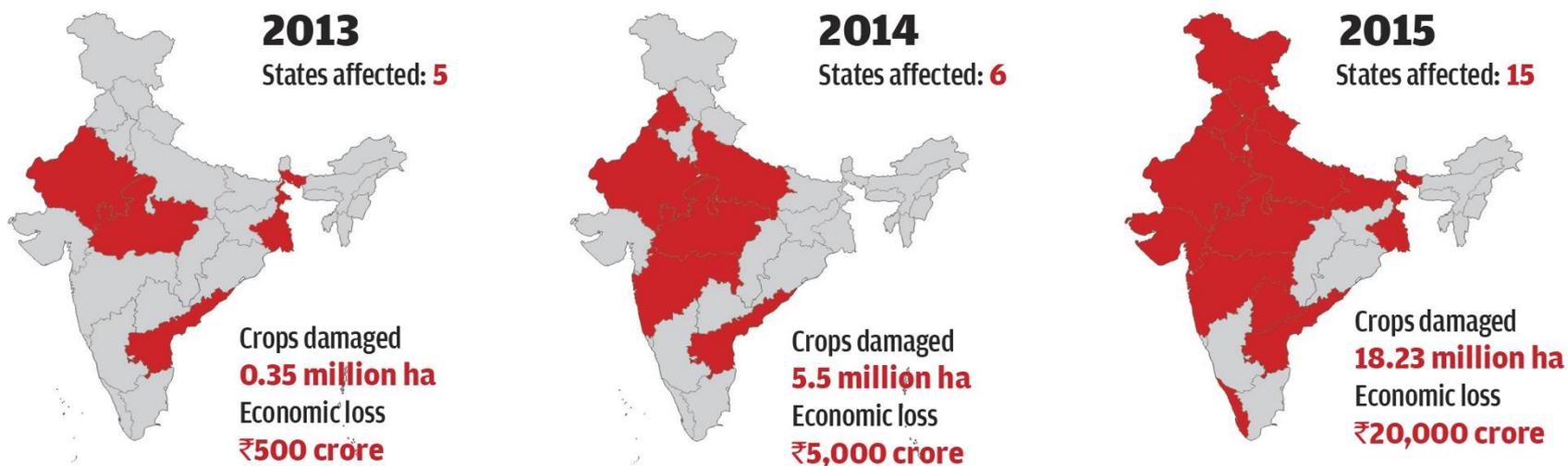




Killing fields: Season of despair for farmers

When freak becomes norm

When hailstorms and unseasonal rains destroyed large swathes of rabi crops in 2013, they were thought to be freak weather events. But they hit again in 2014, and then this year, each time with more intensity, and causing more damage



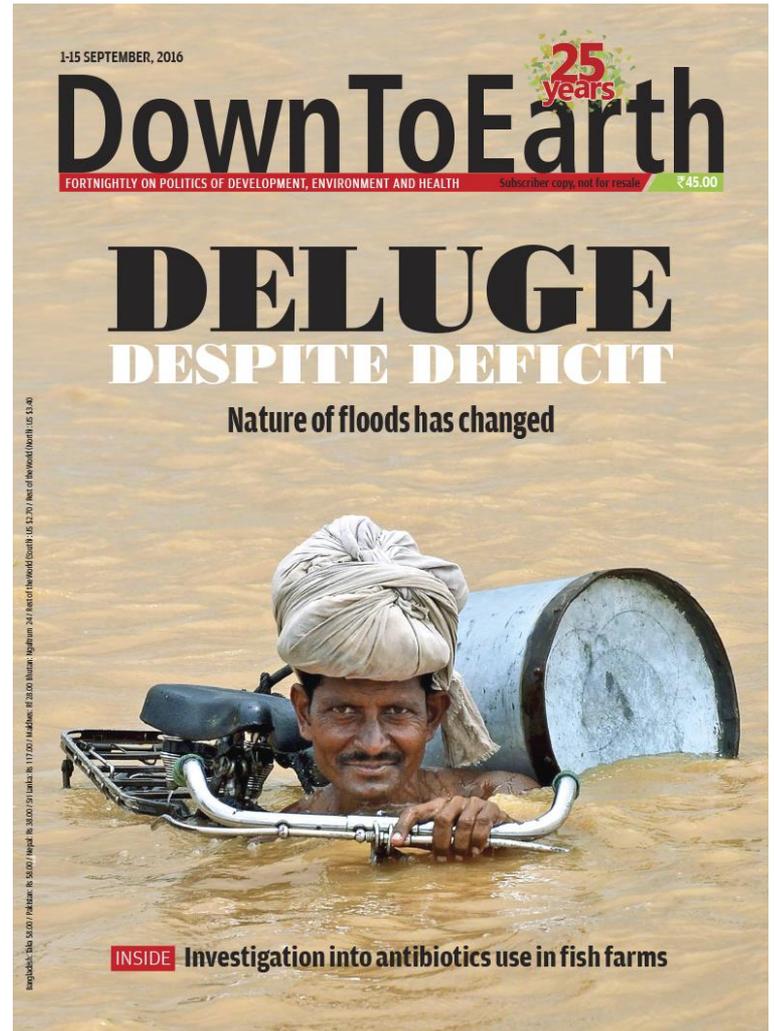
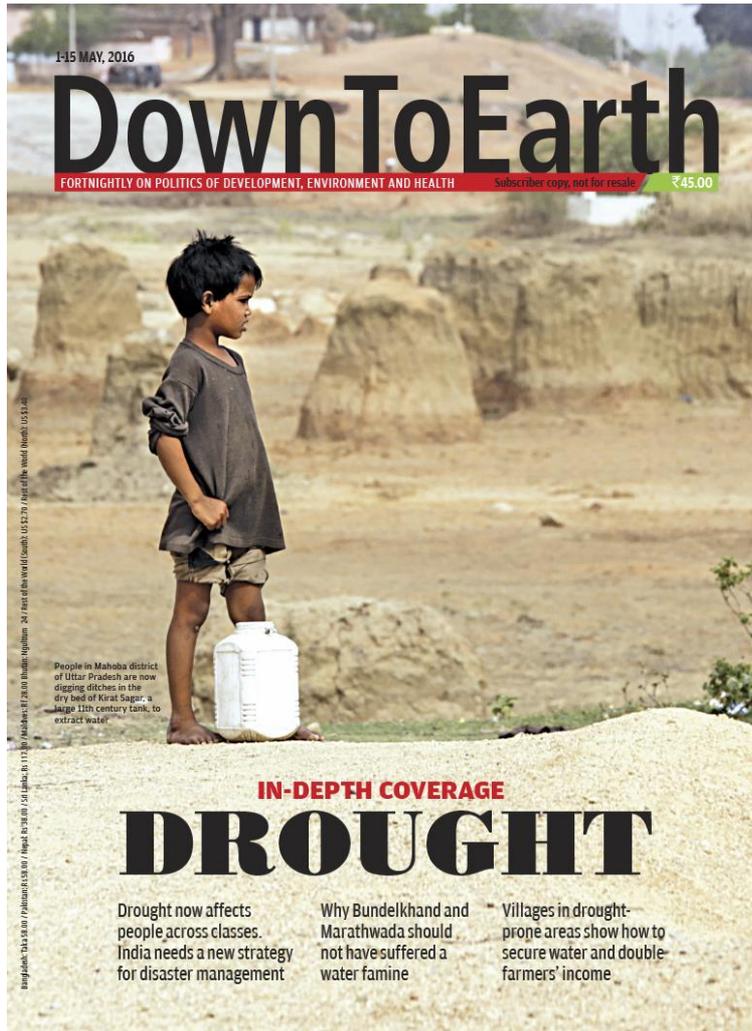
Source: Based on state estimates



**The face of India's farmer
Grief, despair, desperation**



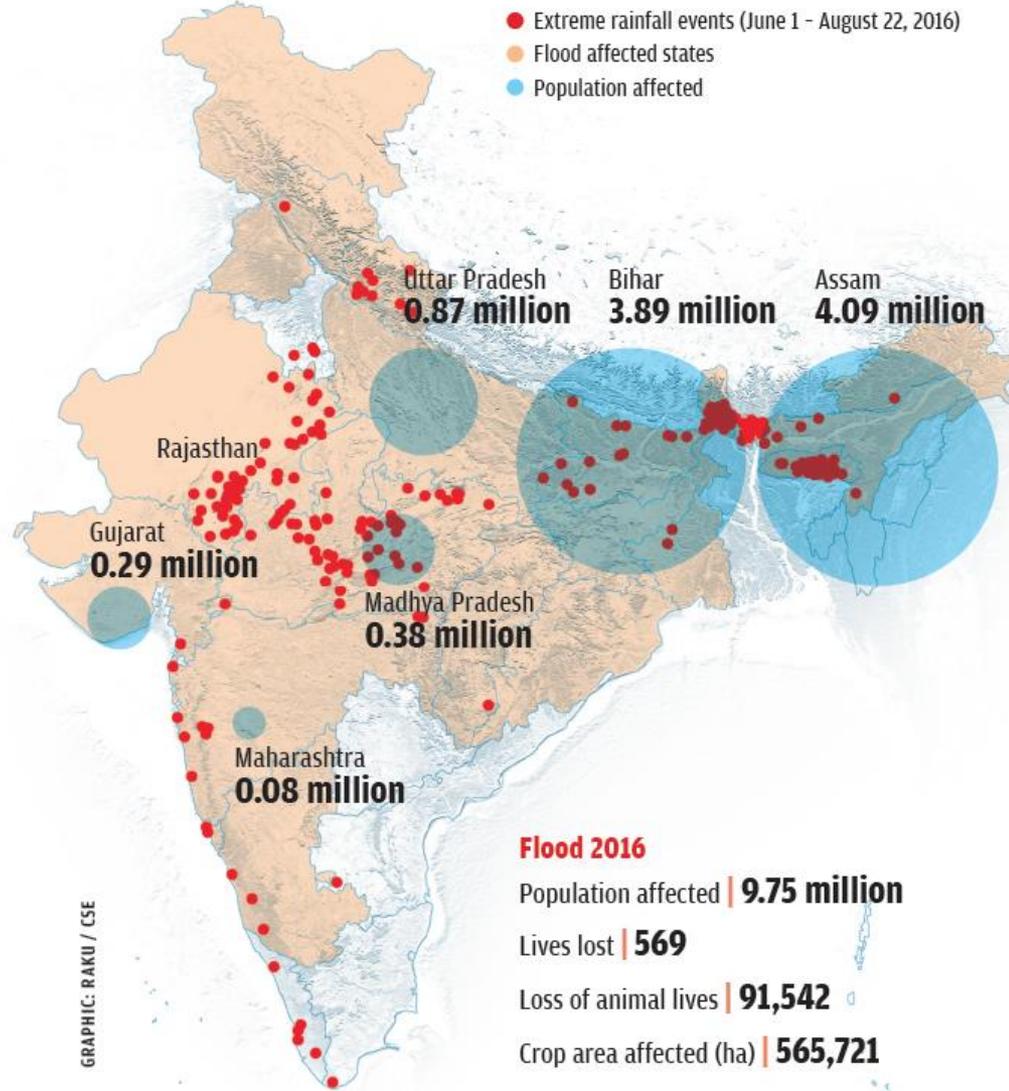
From crippling drought to deluge: double-triple whammy





Under water

Most of the floods in 2016 were preceded by extreme rainfall events—a precipitation of 124.5 mm or more in a day





Change that will destroy us

- Unless
- We learn, and learn fast
- **Become water-waste wise**
- Deliberately plan for every drop of water
- See land for water, and not just for buildings
- Harvest rain everywhere/every possible way
- Recycle and reuse every drop
- Make this our obsession. **National obsession**

