



## Adapting to the Monsoon's New Normal

*This editorial is based on “[Learning to live with shifts in monsoon](#)” which was published in Hindustan Times on 25/06/2024. The article brings into picture the erratic monsoon patterns affecting agricultural cycles, exacerbated by climate crisis-induced delays and variable rainfall, necessitating urgent adaptation in water management and agricultural practices.*

**For Prelims:** [India's monsoon pattern](#), [Western disturbances](#), [Arctic Sea ice melting](#), [El Niño and La Niña](#), [Kharif Crops](#), [Irrigation](#), [Vector-borne diseases](#), [CRISPR technology](#).

**For Mains:** Significance of Monsoon for India, Implications of Changing Monsoon Patterns for India.

[India's monsoon pattern](#) is undergoing a significant shift, characterized by **delayed onset, below-normal rainfall in June, proper commencement only in July, and extended heavy rainfall into September**. This year's monsoon exemplifies this trend, arriving late in most regions and progressing slowly. While the exact causes are not fully understood, climate change factors such as **delayed western disturbances and Arctic Sea ice melting** are believed to play a role. The new pattern brings **erratic rainfall distribution, more dry days, and unusually high night temperatures**, posing substantial challenges for agriculture and water management across the country.

This evolving scenario necessitates both **immediate mitigation measures to protect farmers from economic losses and long-term adaptation strategies for water management**, especially for reservoirs that supply drinking water to the plains during summer months. The climate crisis underscores the urgent need for policies at national and local levels to address these emerging threats effectively.

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# MONSOON

Monsoons are seasonal winds that reverse their direction with the change of season.

## Origin of Monsoon

- Thermal Concept
- Dynamic Concept

## Thermal Concept by Halley

- Monsoon result of:
  - Heterogenous character of globe (Unequal distribution of land and water)
  - Differential seasonal heating and cooling of continents and oceans

## South-West (Summer) Monsoon

- Sun shines over Tropic of Cancer
- Brings low-pressure centres (Near Baykal Lake and Peshawar) due to High temperature

## Dynamic Concept by Flohn

- Monsoon originated due to shifting of pressure and wind belts
- Intertropical Convergence (ITC) formed due to convergence of NE and SE trade winds near equator
- Northern and Southern branches of the ITC, known as NITC and SITC respectively, create a belt of doldrums marked by equatorial westerlies

## South-West (Summer) Monsoon

- Sun shines over Tropic of Cancer
- NITC extended up to 30° N latitude covering south and SE-Asia and establishes Equatorial westerlies
- It brings atmospheric depressions (cyclones) with heavy rainfall

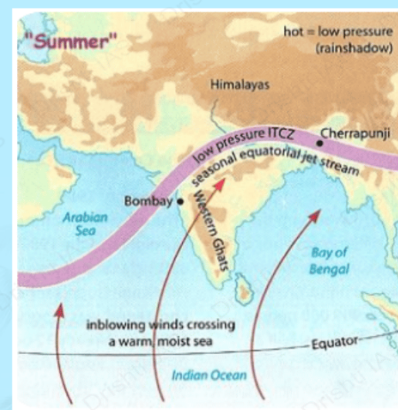
## North-East (Winter) Monsoon

- Sun shines over Tropic of Capricorn
- Due to Southward shifting of Sun, pressure and wind belts also shifts
- Western cyclonic disturbances (from Mediterranean Sea) enter India from west in winter due to Westerly Jet stream
- Northeast trade winds reestablished over south and SE Asia
- These NE trades become winter monsoons called Retreating Monsoon and rains in Andhra and Tamil Region

- Low temperature in Southern hemisphere brings High pressure centre over Australia and Indian Ocean
- Winds Blow from high (ocean) to low pressure in Asia (Land)
- Ferrel's law and Coriolis force turn these wind in south-westerly (SW) direction
- They bring moisture from Indian oceans to Indian subcontinent yielding heavy rainfall

## North-East (Winter) Monsoon

- Sun shines over Tropic of Capricorn
- Brings High Pressure centers (near Baykal Lake and Peshawar) due to low temperatures
- High temperature in Southern hemisphere brings Low pressure centre over Australia and Indian Ocean
- Winds Blow from high (land) to low pressure (ocean) in north-easterly (NE) direction called Retreating Monsoon



## What is the Significance of Monsoon for India?

- Agricultural Backbone:** The monsoon is the lifeblood of Indian agriculture. With 61% of Indian farmers dependent on rainfall for agriculture, the monsoon directly impacts food

## security and rural livelihoods.

- A well-distributed monsoon is crucial for the **55% of India's [net sown area \(139.42 million hectares\)](#) that is rain-fed**, supporting 34 of the country's 40 major crops.
  - This heavy reliance on monsoon rains makes it a key determinant of agricultural productivity and, by extension, the nation's economic health.
- **Water Resource Management:** India receives **70-90% of its annual rainfall** during the four monsoon months (June to September).
    - This concentrated period of precipitation is critical for replenishing water bodies, including rivers, lakes, and groundwater aquifers.
    - The monsoon plays a vital role in **water resource management, influencing irrigation capabilities, drinking water availability, and hydroelectric power** generation throughout the year.
  - **Economic Ripple Effects:** The monsoon's impact extends far beyond agriculture. A good monsoon year typically boosts rural incomes, leading to increased demand for consumer goods, automobiles, and services.
    - Conversely, a poor monsoon can lead to inflation, particularly in food prices, affecting the entire economy.
    - The monsoon's performance often influences monetary policy decisions and government spending priorities.
      - **Monsoon is the real Finance Minister of India** - Pranab Mukherjee
  - **Ecological Balance:** The monsoon is crucial for maintaining India's diverse ecosystems. It supports the country's biodiversity by nurturing forests, [wetlands](#), and other natural habitats.
    - The timing and intensity of the monsoon **influence [wildlife migration patterns](#), breeding cycles, and overall ecosystem health.**
    - Any significant alteration in monsoon patterns can have far-reaching consequences on India's flora and fauna.
  - **Climate Regulation:** The Indian monsoon system is a key component of global climate regulation. It affects atmospheric circulation patterns far beyond the Indian subcontinent.
    - The monsoon's interaction with phenomena like [El Niño and La Niña](#) has implications for **weather patterns across Asia** and even globally.
  - **Cultural and Social Significance:** Beyond its environmental and economic importance, the monsoon holds deep cultural significance in India.
    - It influences festivals (like **Pongal, Baisakhi**), traditions, and even **folk music** (like Purvaiya ) and literature.
    - The arrival of monsoon has been celebrated in Indian culture for millennia, shaping social practices and community rituals.

## What are the Implications of Changing Monsoon Patterns for India?

- **Agricultural Disruption:** Changing monsoon patterns disrupt traditional cropping cycles, potentially decreasing yields and increasing crop failures.
  - For instance, in 2018, **Kharif sowing was 9.7% lower** as monsoon delay over Central and North India.
  - These changes could significantly **impact food security and the livelihoods** of millions of farmers across India.
- **Water Scarcity and Management Challenges: Irregular monsoons intensify water scarcity issues, straining both surface and groundwater resources.**
  - In 2019, Chennai faced a severe water crisis when its four main reservoirs dried up due to monsoon failure.
  - The **2023 monsoon** ended with live water storage at **74%** of the capacity of India's 150 major reservoirs.
- **Economic Impact: Climate change due to rising temperature and changing patterns of monsoon rainfall in India could cost the Indian economy 2.8 % of its GDP.**
  - Increased costs for farmers (**irrigation, crop insurance**) could lead to higher rural debt and potential shifts in rural-urban migration patterns.
- **Public Health Concerns: Altered monsoon patterns can change the distribution of [vector-borne diseases](#) like malaria and dengue. Increased flooding risk may lead to more water-borne diseases, while food insecurity could affect nutrition levels.**
  - Mental health impacts due to climate-related stress and economic uncertainties are likely to increase.
- **Biodiversity and Ecosystem Changes:** Shifting monsoon patterns can alter habitats, affecting flora and fauna distribution.
  - The **Western Ghats**, a biodiversity hotspot, has seen a decline in rainfall over the last century, affecting its unique ecosystem.
  - In the **Sundarbans**, changing rainfall patterns and rising sea levels have led to increased salinity, threatening **mangrove forests and the endangered Bengal tiger population.**
- **Impact on Monsoon-Dependent Energy Production: India's hydroelectric power generation, which contributes about 12% of the total electricity production, faces unpredictability due to changing monsoon patterns.**
  - Fluctuations in reservoir levels **impact not just power generation but also the grid stability**, challenging India's renewable energy goals and necessitating a re-evaluation of the energy mix.
  - For instance, in the southern region of India, which contributes approximately **22% of the total hydro energy generated**, low rainfall has indeed played a role in decreased hydropower capacity in 2023-24.
- **Impact on Traditional Knowledge Systems:** Indigenous and local knowledge systems, which have long guided agricultural and water management practices based on predictable monsoon patterns, are **becoming less reliable.**
  - This erosion of traditional ecological knowledge presents a challenge of cultural erosion and reduced sustainable resource management practices.

## How India can Adapt to Changing Monsoon Patterns?

- **Decentralised Climate Adaptation:** There is a need to decentralize India's vast climate adaptation requiring each state and union territory to assess climate risks and develop mitigation

and adaptation strategies.

- All **766 districts should create plans based on microclimatic changes** and socio-economic data, addressing crop insurance, power supplies, and groundwater quality.
- The **CEEW's support for Thane, Maharashtra**, in developing a risk-informed heat action plan this year can serve as a model for others.
- **Adaptive Crop Genetics and Bioengineering: Developing climate-resilient crop varieties through advanced genetic engineering and [CRISPR technology](#).**
  - Create crops with improved **water-use efficiency, heat tolerance, and ability to thrive in shorter or longer growing seasons.**
  - Establish a **national seed bank** of adaptive varieties and promote decentralized, community-led seed preservation efforts to maintain agricultural biodiversity.
- **Precision Agriculture and AI-Driven Farming:** Implementing large-scale use of IoT sensors, drones, and satellite imaging for real-time crop and soil monitoring.
  - Utilize artificial intelligence to analyze this data alongside weather predictions to provide hyper-local, crop-specific recommendations to farmers.
  - Develop AI models that can predict optimal planting times and crop choices based on evolving monsoon patterns.
- **Leveraging Indian Monsoon Data Assimilation and Analysis Reanalysis:** While the IMD provides data at various administrative levels, the current network lacks the density for granular mapping.
  - Using **Indian Monsoon Data Assimilation and Analysis reanalysis data**, we can mapped monsoon variability for all tehsils in India for.
  - Local decision-makers can utilize these metrics to enhance disaster preparedness and response.
  - These plans should integrate tehsil-level climate data with socio-economic and sector-specific information for **detailed risk assessments in agriculture, water, and energy sectors.**
- **Urban Rainfall Harvesting and Water Banking: Transform cities into massive water catchment areas by mandating rain-harvesting systems for all buildings.**
  - Implement a "**water credit**" system where excess harvested water can be "**banked**" or traded, incentivizing conservation.
  - Developing Sponge cities and underground water storage facilities in urban areas to capture monsoon rains for year-round use.]
- **Floating Agriculture and Aquaponics:** Promote floating farms and gardens in flood-prone areas, **adapting techniques from places like Bangladesh.**
  - Integrate these with advanced aquaponics systems to create resilient food production units that can thrive in both excess water and drought conditions.
  - This can turn flood-prone areas from liabilities into productive assets.
- **Bioengineered Coastal Defense Systems:** Develop "living shorelines" using genetically modified mangroves and other coastal plants that can rapidly adapt to changing salinity and water levels.
  - Combine these with artificial reef structures to create dynamic, self-repairing [coastal defense systems](#) that can evolve with changing monsoon and sea-level patterns.

- **Decentralized Energy Micro-grids:** Develop a network of localized, renewable energy microgrids that can adapt to changing monsoon patterns.
  - These could combine solar, wind, and micro-hydro power sources, automatically adjusting to seasonal variations and ensuring energy security in the face of changing rainfall patterns.

**Drishti Mains Question:**

Discuss the implications of changing monsoon patterns on agricultural productivity and water management in India. How should policy frameworks adapt to mitigate these challenges effectively?

**UPSC Civil Services Examination, Previous Year Question (PYQ)**

**Prelims:**

**Q. With reference to 'Indian Ocean Dipole (IOD)' sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct? (2017)**

1. The IOD phenomenon is characterized by a difference in sea surface temperature between tropical Western Indian Ocean and tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

**Select the correct answer using the code given below:**

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

**Ans: (b)**

**Mains:**

**Q. How far do you agree that the behavior of the Indian monsoon has been changing due to humanizing landscape? Discuss. (2015)**