



## Arctic Sea Ice Impact on Indian Monsoon

**For Prelims:** [India's monsoon pattern](#), [Western disturbances](#), [Arctic Sea ice melting](#), [El Niño and La Niña](#)

**For Mains:** Significance of Monsoon for India, Impact of Arctic Sea Ice on Indian Monsoon Implications of Changing Monsoon Patterns for India.

[Source: TH](#)

Recently research revealed that the **decline in Arctic sea ice levels**, driven by [climate change](#) is influencing the [Indian summer monsoon rainfall \(ISMR\)](#) leading to increased **variability and unpredictability**.

- It involved researchers from [India's National Centre for Polar and Ocean Research \(NCPOR\)](#), under the Ministry of Earth Sciences, and **South Korea's Korea Polar Research Institute**.
- Another study attributes the **significant rain surplus in northwestern India this monsoon season** to long-term trends driven by the climate crisis

### How Arctic Sea Ice Influences the Indian Monsoon?

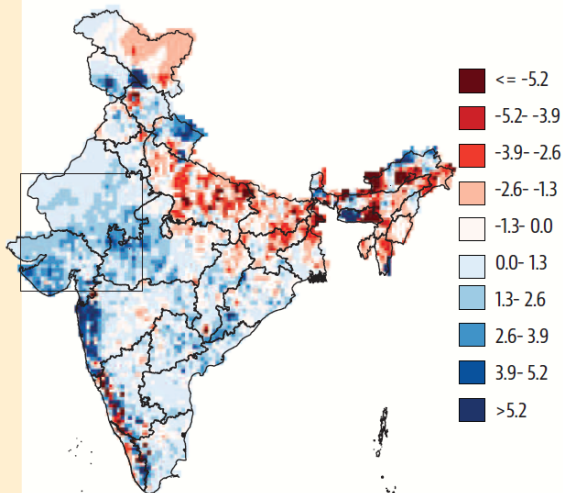
- **Central Arctic Sea Ice Decline: Less Arctic Sea** (sea ice cover of the Arctic Ocean and its vicinity) leads to **reduced rainfall in western and peninsular India**, but **increased rainfall in central and northern India**.
  - This is due to **increased heat transfer from the ocean to the atmosphere**, strengthening [Rossby waves](#), which alter global weather patterns.
  - **Enhanced Rossby waves cause high pressure over northwest India and low pressure over the Mediterranean, shifting the subtropical [easterly jet](#) northward**, resulting in more rain over western and peninsular India.
- **Low Sea Ice in the Barents-Kara Sea Region:** Low sea ice in the Barents-Kara Sea leads to **higher pressure over southwest China** and a **positive Arctic Oscillation**, which affects global weather patterns.
  - Reduced sea ice causes **heat to rise, creating calm, clear skies** over northwest Europe.
  - This disruption **impacts upper atmospheric conditions in subtropical Asia and India**, resulting in **high rainfall over northeastern India**, while central and northwest regions experience less rain.
- **Climate Change's Role:** The warming Arabian Sea and moisture from surrounding water bodies further destabilise weather patterns, exacerbating the variability in monsoon rainfall.

### What are the Findings of the Study Related to Surplus Rain in North-Western (NW) India?

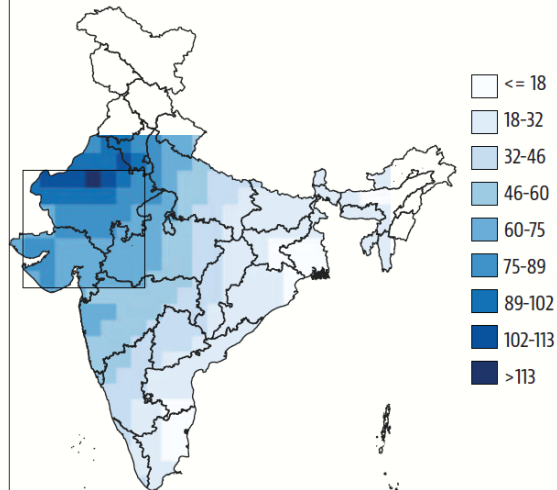
- **Increased Moisture from the Arabian Sea:** NW India is experiencing a wetter monsoon season due to **increased moisture inflow from the Arabian Sea**. This trend is expected to continue, particularly under high emissions scenarios.



## Change in June-September daily rain in the 1979-2022 period (mm/day in 44 years)



## % change in June-September rain between 2081-2100 and 1850-1900 under SSP5-8.5

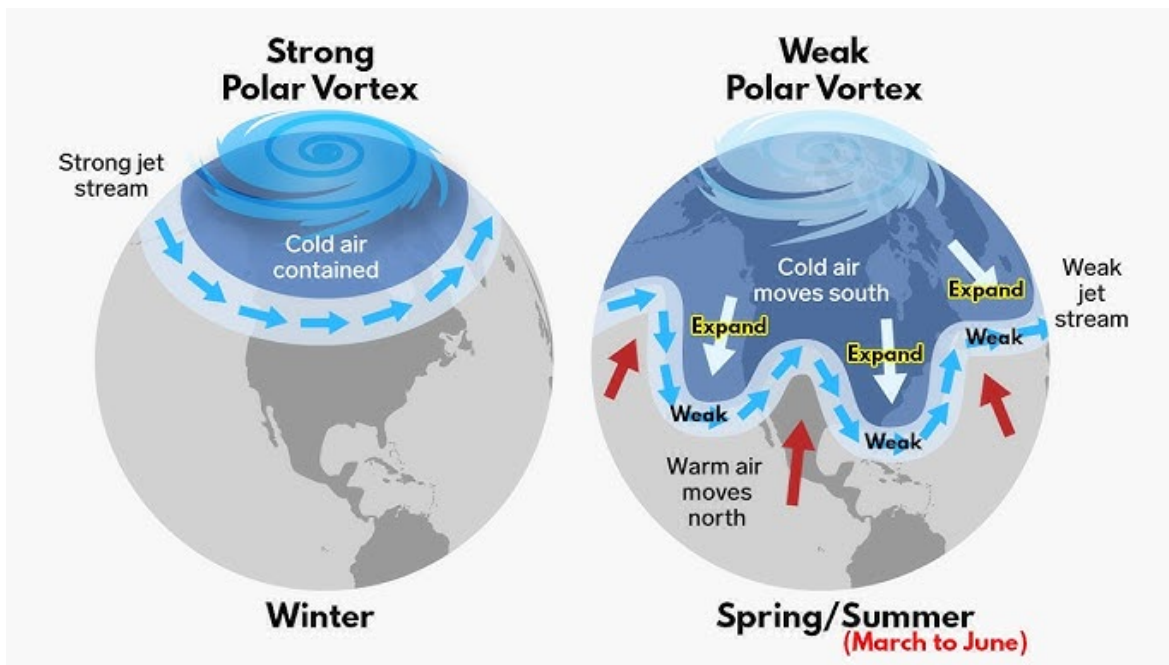


Source: Increased Summer Monsoon Rainfall Over Northwest India Caused by Hadley Cell Expansion and Indian Ocean Warming

- **Changes in Wind Patterns:** The region's increased rainfall is linked to altered wind patterns. **Faster winds over the Arabian Sea** and **slower winds over northern India trap moisture in northwestern India.**
  - Enhanced evaporation from the Arabian Sea, driven by these winds, also contributes to the region's increased precipitation.
- **Shifts in Pressure Gradients:** Changes in wind patterns are attributed to shifts in pressure gradients.
  - Increased pressure around the **Mascarene Islands** (Indian Ocean) and decreased pressure in the **equatorial Indian Ocean** have **strengthened the monsoon winds** that bring rain to northwestern India.
- **Amplified Winds from East-West Pressure Gradient:** An increased east-west pressure gradient, influenced by higher pressure over the eastern Pacific, further amplifies these winds. This could potentially **lead to even wetter monsoons in the future.**

## Rosby Waves

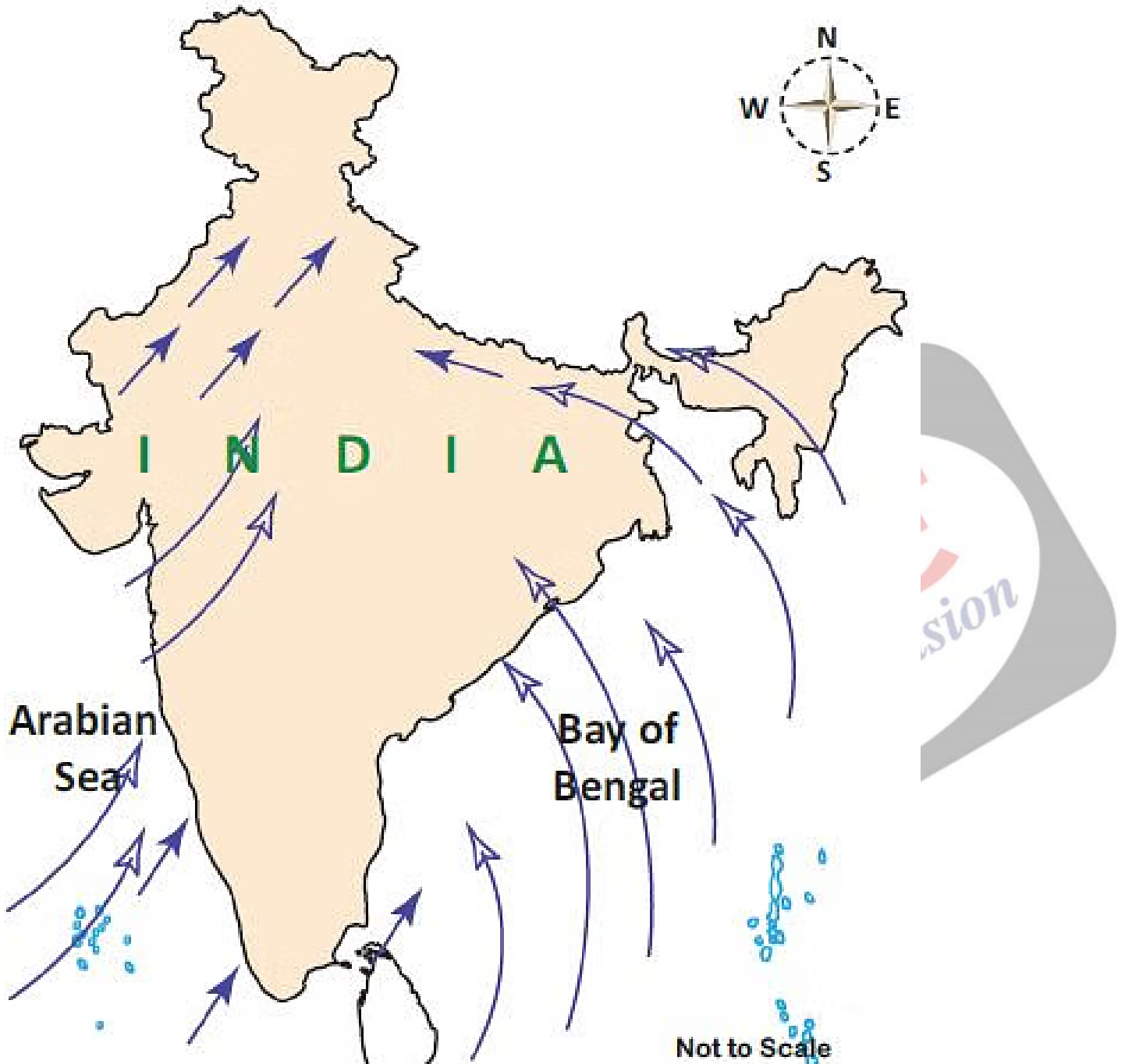
- These are **large-scale atmospheric waves**, also called **planetary waves**, that occur primarily in the **mid-latitudes** of the Earth's atmosphere.
- They form in **jet streams with high-altitude** air currents **flowing from west to east** and have a **meandering pattern** that influences weather across the Northern and Southern Hemispheres.
- These waves are **most prominent where there is a large temperature contrast between the equator and the poles.**
- They play a **key role in shaping global weather patterns**, affecting temperature extremes and precipitation levels.
- Rossby waves **help balance global heat distribution, preventing polar regions from becoming too cold** and **equatorial regions from overheating.**



## What is the Indian Summer Monsoon Rainfall (ISMR)?

- **About:** The **Indian Summer Monsoon Rainfall (ISMR)** is a **major climatic phenomenon** that occurs when **moist air from the Indian Ocean** moves towards the **Indian subcontinent**.
  - It occurs over the Indian subcontinent from **July to September** with most of the rains recorded in **July and August**.
- **Factors Influencing ISMR:** ISMR is influenced by the **surface temperatures of the Indian, Atlantic, and Pacific Oceans**, as well as the **circum-global teleconnection (CGT)**, a large-scale **atmospheric wave** flowing at the **mid-latitudes**.
- **Formation:**
  - Sunlight warms the **Central Asian and Indian landmass** more **rapidly** than the surrounding ocean, creating a **low-pressure band** known as the **Intertropical Convergence Zone (ITCZ)**.
  - **Trade winds** blowing **from the southeast** are **deflected toward the Indian landmass** due to the **Coriolis force**.
    - As these winds cross the equator and move over the Arabian Sea, they gather moisture and release it as rainfall over India
  - The **southwest monsoon splits into two arms**. One bringing rain to the **west coast (Arabian Sea arm)** and the other to **India's eastern and northeastern parts (Bay of Bengal arm)**.
    - These arms **converge** over **Punjab and Himachal Pradesh**.

## South West Monsoon In India



- **India Winter Monsoon Rainfall:** The northeast monsoons is the **reversal phase of monsoon during the winters** (due to the high-pressure cells that are formed over the Siberian and Tibetan plateaus).
  - **It occurs during October to December.**

## North East Monsoon In India



# 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:
  - Heterogeneous 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

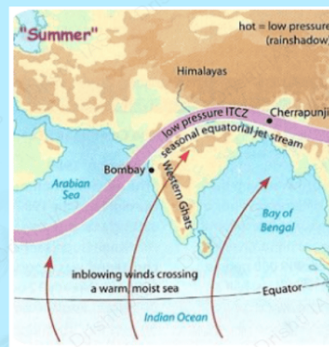
## North-East (Winter) Monsoon

- 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 the Monsoon for India?

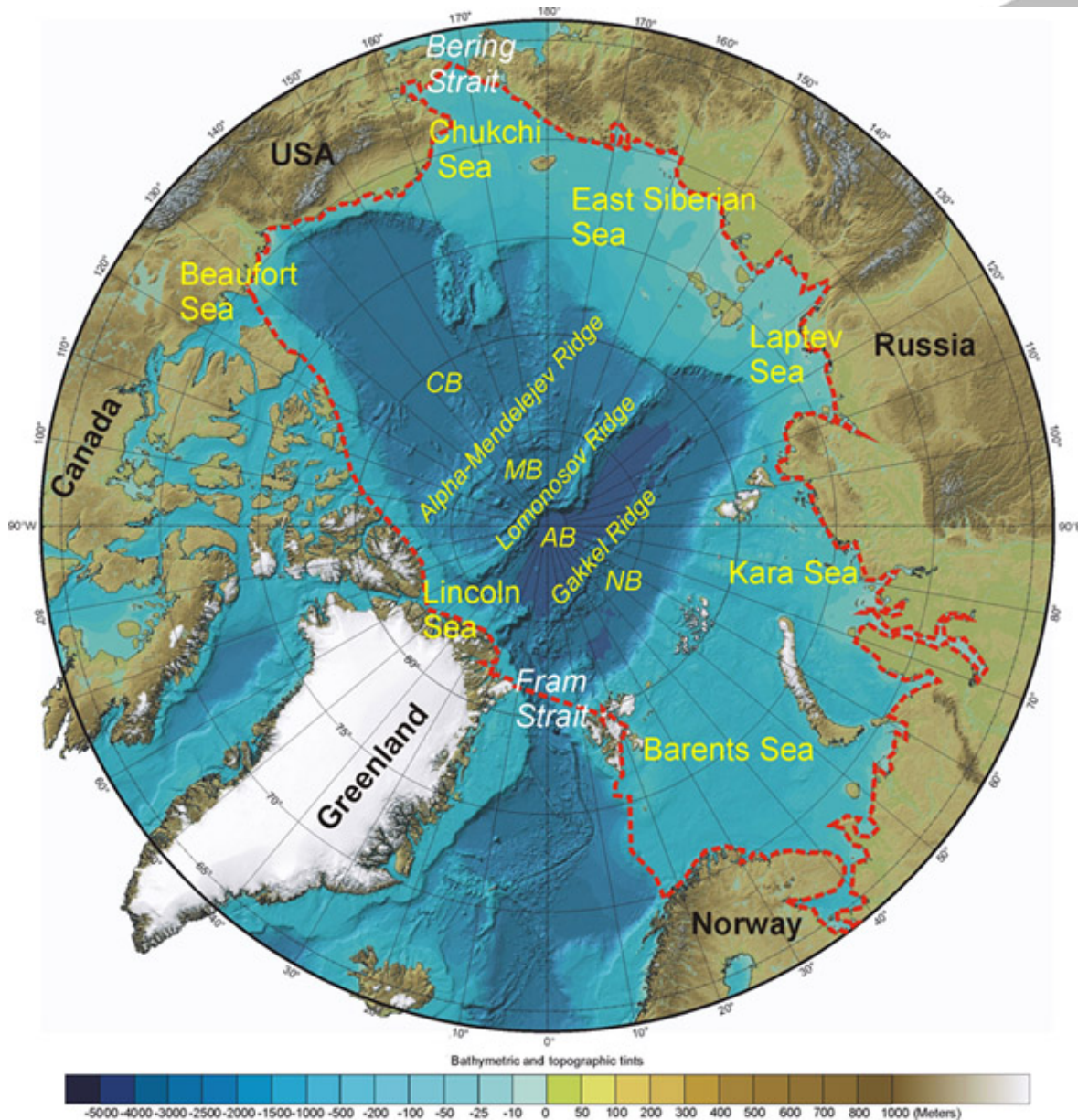
- Agricultural Backbone:** The monsoon is crucial for Indian agriculture, impacting food security and rural livelihoods. With **61% of farmers reliant on rainfall**, a well-distributed monsoon **supports 55% of India's rain-fed crops** and influences agricultural productivity and the economy.
- Water Resource Management:** India receives **70-90% of its annual rainfall during the monsoon season** (June to September), essential for replenishing rivers, lakes, and groundwater.
  - This period is vital for irrigation, drinking water, and hydroelectric power.
- Economic Ripple Effects:** A good monsoon **boosts rural incomes and consumer demand**, while a poor monsoon can cause [food price inflation](#) and impact the overall economy, influencing monetary policy and government spending.
- Ecological Balance:** The monsoon **supports India's diverse ecosystems**, affecting

biodiversity, wildlife migration, and habitat health. Changes in monsoon patterns can disrupt flora and fauna.

- **Climate Regulation:** The Indian monsoon plays a key role in global climate regulation, influencing atmospheric patterns and interacting with phenomena like [El Niño](#) and [La Niña](#).

## Arctic Ocean

- It is the smallest of the world's oceans, centering approximately on the North Pole.
- It is bordered by Canada, Greenland, Iceland, Norway, Sweden, Finland, Russia, and the United States.
- **Key Seas:** Includes the Barents, Kara, Laptev, East Siberian, and Beaufort Seas.
- **Ice Coverage:** Predominantly covered by sea ice, with patterns of seasonal melting and freezing.
- **Climate Change:** Rapid warming has diminished ice cover, leading to new shipping routes (e.g., Northern Sea Route) and increased access to resources.
- **Resources:** Home to an estimated 13% of the world's undiscovered oil and 30% of its natural gas reserves.



**Drishti Mains Question:**

Discuss the impact of shifting monsoon patterns on agricultural productivity in India. How do these changes affect food security and rural livelihoods?

**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)**

PDF Refernece URL: <https://www.drishtias.com/printpdf/arctic-sea-ice-impact-on-indian-monsoon>