Challenges in cyclone forecasting

Why in news?

Though meteorologists had forecast a historic hurricane season for 2024 based on the expectation that a strong La Niña would emerge this winter, 2024 has evolved to be a year with a summer with no major hurricanes.

What was the 2024 hurricane projection?

- **2023 Hurricane season** - It was history's fourth-most active despite the strong El Niño that year.
- **2024 Hurricane Forecast** - Meteorologists had forecast a historic hurricane season for 2024 based on the expectation that a strong La Niña would emerge this winter.

  Usually, subdued hurricane season emerge during an El Niño and an earnest one during a La Niña.

- **Failure of projection** - 2024 has evolved to be a year with a summer with no major hurricanes.
- **Truant La Nina** - One important reason for the failure of forecast was the weakness of La Niña.

Cyclone

• **Cyclone** – As per National Disaster Management Authority (NDMA), cyclones result from atmospheric disturbances surrounding a low-pressure area characterized by rapid and often destructive air circulation.
• **Air circulation**- The air circulates inward in an anticlockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere.
• **Occurrence**- Cyclonic winds move across nearly all regions of the Earth except the equatorial belt.
• **Warm ocean waters -** Cyclones require sea surface temperatures of at least 26.5°C to form.
• **Low-pressure system -** As warm, moist air rises from the ocean, it creates a low-pressure area.
- The rising air cools and condenses, forming clouds and thunderstorms.
• **Coriolis Effect -** The rotation of the Earth causes the air to spiral, contributing to the cyclone's circular motion.
- Cyclones rotate counterclockwise in the Northern Hemisphere, and they rotate clockwise in the Southern Hemisphere.
• **Intensification of cyclone -** As the storm gathers strength, it draws more warm air from the ocean.
- The ***cyclone's eye*** forms at the center, surrounded by a ring of thunderstorms called the eyewall, which houses the strongest winds.
To know more about cyclones, click here.

What are the components of forecasting cyclones?

- **Satellites -** By monitoring sea surface temperatures, cloud formations and wind patterns to detect the early formation of cyclones.
- **Doppler radar -** It provides detailed information about wind speeds and precipitation patterns.
- **Weather buoys -** These floating devices gives real-time data of atmospheric pressure and sea surface temperatures.
- **Climate models -** They estimate the likelihood and intensity of cyclonic activity by using broader atmospheric and oceanic metrics.
- **Numerical weather prediction model -** Post-processing techniques to improve forecasts of tropical cyclone track, intensity, and wind structure.
- Statistical and machine learning methods for predicting tropical cyclone intensity change.

What are the challenges in cyclone forecasting?

- **Limitation of climate models** – They forecast cyclones not explicitly but indirectly, based on metrics that indicate cyclonic activity and its potential intensity
- **Global warming** - Rising Ocean temperatures are increasing the frequency of stronger cyclones, making it harder for traditional forecasting methods to keep pace.
- **Link between hurricanes and ENSO -** Climate change is starting to affect the traditional relationship between ENSO and hurricane intensity.
- **Rapid intensification** - Warming of upper oceans in all cyclone-producing regions of the planet led to many instances of rapid intensification that affects cyclone forecast.

Rapid intensification is when the maximum cyclone wind speed increases

by 55 km/hr or more within a 24-hour period.

- **Post landfall behavior -** Predicting the storm's behavior after landfall, such as rainfall, flooding, and wind damage, is also complex.
    - The terrain, local weather patterns, and storm structure can significantly influence the cyclone's impact after it hits land.
- **Impacting preparedness** - These challenges are critical, as it directly affects how governments and communities prepare for and respond to cyclones

What are factors influencing cyclone in Indian ocean?

- **Ocean stretch** – The typical stretch of ocean limits cyclone intensification, over both the Arabian Sea and the Bay of Bengal, thus limiting the size and strength of the cyclones.
- **Movement of cyclone** - Most cyclones over the Arabian Sea tend to be steered northwestward, away from India.
- **Chronic stressors** – India is vulnerable to chronic stressors such as ocean warming, rising sea levels, and the increasing incidence of rainfall extremes and dry spells.
- **Acute stressors -** These acute stressors exacerbate the chronic ones, leading to more damaging events like heavy rainfall events, flooding, and flash drought.
- **Combination of acute and chronic stressor** - Cyclone induced flooding worsens as sea levels rise or heatwaves during droughts devastate crops and reduce water availability.
- **Monsoon Change** - Warming in the Indian Ocean, especially the Bay of Bengal, has been extending the southwest monsoon into the northeast monsoon and delivering both excess and extreme rainfall.

What are the needs of effective forecasting?

- **Disaster management** – Accurate forecasting is essential to plan for cyclone mitigation and adaptation measures.
- **Resource management** - India remains an economically developing country, and any increments in its ability to manage its financial and human resources will be critical for the foreseeable future.
- **Sustainability** - India's dream of sustained economic development need the resilience of entire subcontinent.
- **Security** - India's vulnerabilities to chronic and acute climate stressors aren't only India's socio-economic vulnerabilities, but also India's national security issues.

What India needs to do?

- **Hyperlocal risk projections** - India must focus on local predictions for cyclones that will help allocate resources more efficiently and enhance disaster preparedness.
- **Infrastructure enhancement** - Infrastructure upgradation is required in the installation of ocean observation systems and in high-resolution earth observation satellites.
- **Developing India-specific weather models -** That are able to understand and

simulate Indian conditions more accurately.

- **Mitigation and adaptation** - By investing in renewable energy, weather forecasting, early warning systems, and disaster management.
- **Regional cooperation** – Establishing subcontinent-wide weather and climate networks and improving forecasts and projections for all parts of India's wider neighbourhood.
- **Gathering more weather data** - To make accurate forecasts of cyclones and generate useful early warnings in a particular region.

Reference

The Hindu| The challenge of forecasting cyclones

