**UNIVERSITY OF BARISHAL**



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**Introduction:**

Cyclones are one of the most powerful natural phenomena, and their intensity and impact have been increasingly influenced by climate change. In the case of Cyclone Remal, when compared with the previous two major cyclones in the region, there have been notable changes in storm patterns, intensity, and consequences. These variations provide significant evidence of how climate change is playing a central role in transforming the characteristics of tropical cyclones. This introduction delves into the observable changes between Cyclone Remal and its predecessors, focusing on wind speed, rainfall, storm tracks, and the broader role of climate change in driving these changes. Observing Cyclone Ramel’s Changes Cyclone Remal, when analyzed alongside the two cyclones that occurred before it, showcases an alarming increase in intensity. The wind speeds associated with Remal were higher than what was recorded in previous cyclones, indicating that these storms are becoming more powerful over time. This increase in wind intensity is directly correlated with rising sea surface temperatures, which serve as the primary energy source for cyclones. As the ocean heats up, more energy is available to fuel cyclonic systems, leading to faster wind speeds and more destructive potential. Additionally, Cyclone Remal produced significantly more rainfall than earlier cyclones, resulting in widespread flooding. This increase in precipitation is consistent with the effects of a warmer atmosphere, which can hold more moisture. When cyclones form, they draw in this moisture-laden air, leading to heavier downpours and more severe flooding. The regions affected by Remal experienced unprecedented levels of rainfall, causing both urban and rural infrastructure to suffer significant damage. Another observable change in Cyclone Remal was its trajectory. Historically, cyclones in the region followed more predictable paths, making it easier for governments and communities to prepare. However, Remal’s movement was more erratic and impacted areas that had not previously been as vulnerable to such storms. This shift in cyclone tracks is part of a broader trend observed globally, where changing wind patterns and ocean currents, influenced by climate change, are causing cyclones to deviate from their traditional routes. Climate Change and Cyclone Behavior, The role of climate change in driving these changes cannot be overstated. One of the most significant ways in which climate change affects cyclones is through the warming of the oceans. Cyclones draw their energy from warm ocean waters, and as sea surface temperatures rise due to global warming, the intensity of storms increases. In the case of Cyclone Remal, higher sea temperatures likely contributed to the storm's rapid intensification, making it far more destructive than earlier cyclones. In addition to warmer oceans, climate change is altering atmospheric circulation patterns. Cyclones are steered by large-scale wind currents, and as climate change shifts these currents, the paths that cyclones take become less predictable. This unpredictability, as seen in Cyclone Remal’s unexpected track, puts previously less affected areas at higher risk. Moreover, cyclones are moving more slowly, which means they linger longer over affected regions, dumping more rain and causing greater damage.

**Cyclone:**

In meteorology, the term cyclone is defined as

A system of winds that are rotating inwards to an area of low barometric pressure, such that in the Northern Hemisphere it is anticlockwise and in the Southern Hemisphere it is clockwise circulation.

**Cyclones Formed:** The formation of cyclones takes place in low-pressure areas. The vulnerability of the place where the cyclone strikes depend on the topography, intensity and frequency of the cyclone.

There are 6 factors that can be held responsible for the formation of the cyclone:

* Ample amount of warm temperature at the surface of the sea.
* Instability in the atmosphere.
* How the Coriolis force is impacting the area so that low-pressure area can be created.
* When the humidity is high in the lower to middle levels of the troposphere.
* Disturbance in the pre-existing low-level area.
* When the vertical wind shear is low.

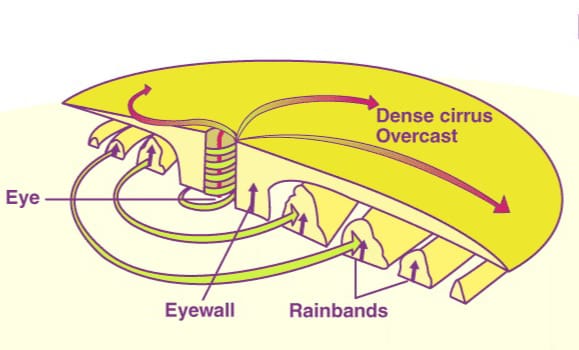


Figure: Cyclone formatione

In the above diagram, we see how cyclones are formed. The rising of warm air is shown using the green lines while the cool air sinking is shown using the red arrows.

* A cyclone is formed when the warm, moist air rises upward over the ocean. As this air moves up, there is a formation of a low-pressure area below.
* Now the low-pressure area is filled with the high-pressure air from the surroundings. Again, the next batch of cool air gets warm and moist over the ocean moving upward. This once again results in the formation of a low-pressure area. The cycle continues.
* This continuous cycle results in the formation of clouds in the air. More clouds are formed as the water from the ocean evaporates.

There are 4 types of cyclones and they are:

* Tropical cyclone
* Polar cyclone
* Mesocyclone
* Extratropical cyclone

**Tropical Cyclone**

The regions where the tropical cyclone occurs are over the tropical ocean. Hurricanes and typhoons are the two types of tropical cyclone. Atlantic and Northeast Pacific are the regions where hurricanes are found. Whereas, in the Northwest Pacific, typhoons are found. A tropical cyclone is divided into 5 categories depending on the intensity and the wind speed.

**Polar Cyclone**

The polar cyclone is also known as the “Arctic hurricane” in the Northern Hemisphere. This is due to their energy sources.The forecast of the polar cyclone is difficult as they take less than 24 hours, and they are formed quickly.

**Mesocyclone**

The mesocyclone is considered to be one of the strong thunderstorms. The mesocyclone is found within the convective storm in the form of a vortex of air. The air rises and rotates along the vertical axis. The direction of this air and the low-pressure system are the same in the given hemisphere

**Extratropical Cyclone**

The cyclones that are formed in the middle latitudes along the frontal boundaries are either known as extratropical cyclones or mid-latitude cyclones. The winds of the extratropical cyclone are weaker however, the temperature gradients are sharp.

**Tropical cyclones are classified by their maximum wind speed.**

According to Bangladesh meteorological department:

|  |  |
| --- | --- |
| Depression | 28-31mph |
| Deep Depression | 32-31mph |
| Cyclonic storm | 39-54mph |
| Severe cyclonic storm | 55-73mph |
| Severe cyclonic storm of hurricane intensity | 74mph |

Observation of changes in cyclone remal with previous two cyclone changes:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Remal | Amphan | Mocha |
| Intensity | Severe cyclonic storm | Super cyclonic storm | Extremely sever cyclonic storm |
| Region | Bay of bengle | Bay of bengle | Bay of bengle |
| Affected area | Firozpur, Khulna, Bagerhat, Satkhira, Patuakhali, Barguna, Bhola and Barisal | Khulna, Jashore, Satkhira, Bagerhat, Pirojpur, Barguna, Patuakhali, Bhola and Noakhali | Cox's Bazar, Saint Martin's Island, tecnaf and parts of the Chattogram Division. |
| Wind speed | 100 to 135 km per hour (60 to 85 mph) |  | 190 to 215kmh (130mph) |
| Air pressure | Below 978mbar | Below 920 mbar | Below 478 mbar |
| Affected people | According to the Government preliminary assessment (SoS Form) 3.75 million people were affected across 19 districts (107 sub-districts, 914 unions). Around 150,475 houses have been damaged (114,992 partially and 35,433 fully damaged) and additionally, 10 deaths are officially recorded. | The Government undertook a massive evacuation of 2.4 million people in 12,078 cyclone shelters, and 26 people died. | At least 463 people including three deaths in Bangladesh. The storm also injured 719 affected approximately 2.3 million people, destroyed over 2,000 houses, and damaged more than 10,000 houses |

**Changes in cyclone due to climate change:**

Climate change has significantly impacted cyclones in Bangladesh, leading to changes in their frequency, intensity, and overall effects. The following are key changes observed:

1. Increased Frequency of Severe Cyclones

While the total number of cyclones may not have significantly increased, intense cyclones (Category 4 and 5) are becoming more frequent. Warmer ocean temperatures due to climate change provide more energy for cyclones, leading to stronger storms when they do occur.

2. Increased Intensity

Warmer sea surface temperatures in the Bay of Bengal contribute to cyclones becoming more intense, with higher wind speeds, more rainfall, and stronger storm surges. This results in greater destruction to coastal regions.

3. Shifting Cyclone Seasons

The typical timing of cyclone seasons is also changing, with cyclones occurring outside the traditional pre-monsoon (April to June) and post-monsoon (October to November) periods.

4. Higher Storm Surges

Sea level rise has led to higher storm surges during cyclones, worsening flooding in coastal areas. The increased height of storm surges makes them more destructive, especially in low-lying areas of Bangladesh such as the Sundarbans and the southern delta region.

5. Increased Rainfall

Cyclones are bringing heavier rainfall due to increased atmospheric moisture levels. This raises the risk of inland flooding even in areas that may not directly experience storm surges

**Conclusion**

In conclusion, the "remal" or desertification aspect of climate change in Bangladesh adds a significant challenge to a country already grappling with a wide range of environmental issues. The growing threat of desertification, combined with rising sea levels and extreme weather events, is undermining food and water security, livelihoods, and overall development. Addressing these challenges requires a multi-faceted approach, combining local adaptation efforts with global cooperation to ensure that vulnerable communities can survive and thrive in the face of ongoing climate change. The analysis highlighted the vulnerability of coastal communities and the need for improved disaster preparedness and response measures. The study also underscored the importance of addressing climate change, infrastructure development, and ecosystem management to reduce the risk of future cyclones. Improved early warning systems and evacuation plans are crucial; infrastructure development should prioritize climate resilience; ecosystem restoration and conservation are essential; and community-based initiatives and international cooperation are vital. The lessons learned from these cyclones can inform future disaster management strategies, contributing to the overall resilience of vulnerable coastal communities. By understanding these past events, Bangladesh can continue to improve its preparedness and resilience-building strategies to better face future cyclones. Bangladesh is one of the most disaster-prone areas in the world. In this study, we have reviewed the cyclonic storm Remal, which furiously hit the south-western region of Bangladesh. The study suggests that research and development activities focused on cyclone mitigation, including short- and long-term measures like a proper warning system based on an accurate forecasting model, afforestation, and embankment establishment, should receive priority attention from the academic community in developing societies. The future of Bangladesh’s battle against climate change will depend not only on its ability to adapt internally but also on the commitment of the global community to reduce greenhouse gas emissions and provide support to those countries that are most at risk.