

IMPACT OF TROPICAL CYCLONES IN OMAN: A CONCISE OVERVIEW

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Abstract: Tropical cyclones, with their powerful winds, heavy rains, and devastating storm surges, have significantly impacted Oman over the years. This overview examines the nature of tropical cyclones, their formation, and their effects in Oman. The study details notable cyclones, including Cyclone Gonu (2007), Cyclone Mekunu (2018), Cyclone Shaheen (2021), and Cyclone Tej (2023), highlighting their impacts on infrastructure, communities, and the environment. The response and preparedness measures undertaken by Oman to mitigate the damage from these natural disasters are also discussed. This historical perspective underscores the importance of continuous improvement in disaster management and resilient infrastructure to safeguard the nation against future cyclones.

Keywords: Oman, Tropical cyclones, Impact, Preparedness.

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INTRODUCTION:

A tropical cyclone is a rapidly rotating storm system characterized by a low-pressure center, closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms producing heavy rain and squalls [1]. These systems are known by different names depending on their location and strength: hurricanes in the Atlantic Ocean or northeastern Pacific Ocean, typhoons in the northwestern Pacific Ocean, and tropical cyclones, severe cyclonic storms, or simply cyclones in the Indian Ocean and South Pacific.

The term tropical indicates the geographical origin of these systems, which form exclusively over tropical seas. Cyclone refers to the circular movement of their winds around a central clear eye, with surface winds blowing counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere due to the Coriolis effect. Tropical cyclones generally form over large bodies of warm water, deriving their energy from the evaporation of ocean water, which condenses into clouds and rain as moist air rises and cools. This contrasts with mid-latitude cyclonic storms like nor'easters and European windstorms, which are powered mainly by horizontal temperature differences [2].

Tropical cyclones typically span 100 to 2,000 km in diameter and impact regions worldwide, including the Gulf Coast of North America, Australia, India, and Bangladesh [3]. The strong rotating winds are a result of the conservation of angular momentum from the Earth's rotation as air moves inward toward the axis of rotation, making these storms rare within 5° of the equator. In the South Atlantic, tropical cyclones are uncommon due to strong wind shear and a weak Intertropical Convergence Zone, while the African easterly jet and atmospheric instability promote cyclone formation in the Atlantic Ocean and Caribbean Sea. Near Australia, cyclones are influenced by the Asian monsoon and the Western Pacific Warm Pool.

Warm ocean waters are the primary energy source for tropical cyclones, which are strongest over or near water and weaken rapidly over land. Consequently, coastal regions are more vulnerable to these storms than inland areas. Coastal damage may result from high winds, rain, high waves, storm surges, and the potential for tornadoes [4]. Tropical cyclones draw in air from a large area and concentrate moisture into heavy precipitation over a smaller area, potentially causing river flooding, overland flooding, and overwhelming local water control structures. While their effects can be devastating, tropical cyclones may help alleviate drought conditions and play a role in regulating global climate by transporting heat and energy from the tropics to temperate latitudes.

A tropical cyclone is a warm-cored, non-frontal synoptic-scale low-pressure system over tropical or subtropical waters with a well-defined center, deep atmospheric convection, and a closed wind circulation at the surface. Historically, tropical cyclones have occurred worldwide for thousands of years, with one of the earliest recorded events estimated to have occurred in Western Australia around 4000 BC [5]. Before the advent of satellite imagery in the 20th century, detecting tropical cyclones was only possible when they impacted land or were encountered by ships.

Currently, about 80 to 90 named tropical cyclones form annually worldwide, with over half developing hurricane-force winds of 120 km/h or more. A tropical cyclone is considered to have formed when mean surface winds exceed 65 km/h, indicating it has become self-sustaining and capable of further intensification [6]. A 2021 review article in *Nature Geoscience* concluded that the geographic range of tropical cyclones is expected to expand poleward in response to climate-induced changes in the Hadley circulation [7].

Despite significant advancements in understanding and mitigating the impacts of tropical cyclones on Oman, there remains a need for comprehensive, updated research on the long-term effectiveness of current disaster preparedness and response strategies. Additionally, the potential impact of climate change on the frequency, intensity, and geographical distribution of cyclones affecting Oman is not fully understood. There is also a lack of localized studies focusing on the socio-economic impacts of cyclones on different regions within Oman, which can help tailor more effective regional response strategies.

This study provides a detailed historical overview of tropical cyclones that have affected Oman, highlighting both well-documented and less-known events. By integrating recent data on Cyclone Tej and analysing the evolving patterns of cyclonic activity, this research offers a fresh perspective on the challenges and responses related to tropical cyclones in Oman. The study aims to bridge the gap in existing literature by combining historical data

with contemporary insights, offering a holistic view of the impacts and adaptive measures taken by Oman.

The aim of this study is to provide a comprehensive historical overview of tropical cyclones that have affected Oman, analyse their impacts on infrastructure and communities, and evaluate the effectiveness of disaster preparedness and response measures implemented by the Omani government. The objectives are framed from aim as follows: (i) To document and analyse the major tropical cyclones that have affected Oman; (ii) To assess the socio-economic and environmental impacts of these cyclones on different regions within Oman; (iii) To examine the potential influence of climate change on the frequency, intensity, and geographical distribution of cyclones affecting Oman; and (iv) To evaluate the effectiveness of current disaster preparedness and response strategies implemented by the Omani government and identify areas for improvement.

HISTORICAL TROPICAL CYCLONES:

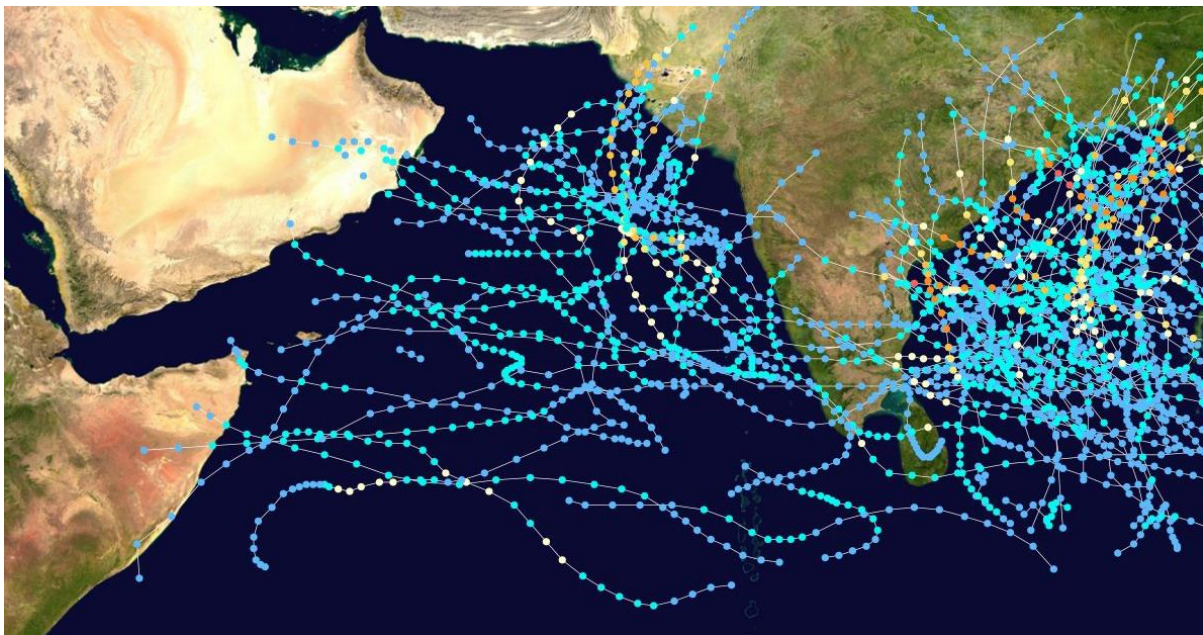


Figure 1. Global tropical cyclone tracks

Figure 1 is adopted from Wikipedia - Global tropical cyclone tracks by Nilfanion in 2005. The paths of tropical cyclones over the northern Arabian Sea and Bay of Bengal from 1985 to 2005 are shown [8]. During this 20-year period, some cyclones that developed over the Arabian Sea entered Oman, such as the 2002 cyclone that affected Salalah and its surroundings.

Tropical storms and cyclones are confined to two cyclone seasons: the pre-monsoonal period (May-June) and the post-monsoonal period (October-November) [9]. Most storms originate over the southeastern Arabian Sea near the Laccadive Islands, but some late-season storms start over the southeastern Bay of Bengal and move westward across southern India, regenerating as they pass over the warm waters of the Arabian Sea.

Once a storm or cyclone forms over the southeastern Arabian Sea, it typically moves northwest towards the Arabian Peninsula, sometimes curving northwest towards Gujarat and Pakistan, and other times curving west towards the Gulf of Aden. Pedgley (1969) has detailed the characteristics of these coastal storms [10].

Figure 2 shows the frequency of tropical storms and cyclones (wind speeds of Beaufort force 10 or more) affecting the Arabian Sea, 1801-2000. One additional cyclone that affected Salalah coast on 10 May 2002 has added to the figure.

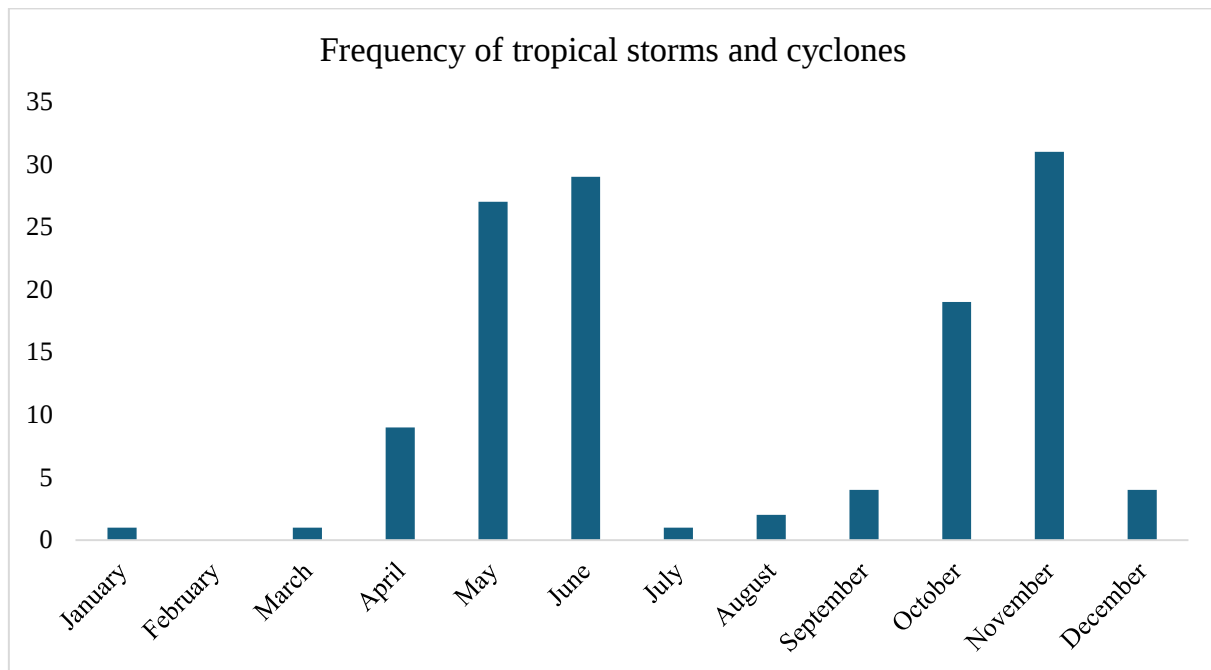


Figure 2. Tropical storms and cyclones (wind speeds of Beaufort force 10 or more) affecting the Arabian Sea, 1801-2002 [11].

Cyclones have occasionally entered the Gulf of Aden and, more rarely, the Gulf of Oman. According to Membrey (2001, 2002), a tropical cyclone on June 4, 1980, brought 24 hours of torrential rain to the Batinah and Muscat regions, causing severe flooding and widespread property damage [11,12]. Nearly 300 mm of rain fell on Muscat city, resulting in the deaths of at least 700 people due to the destruction that followed. Severe cyclones have also affected the Salalah area in May 1959, May 1963, and November 1966. In June 1977, a severe cyclone crossed Masirah Island with a central pressure of about 976 hPa; maximum sustained winds were around 90 knots, with gusts up to 120 knots. The 24-hour rainfall was 430.6 mm. In June 1996, a tropical storm crossed the Omani coast near Ras Madraka (south of Masirah Island), bringing more than 200 mm of rain to the eastern Hajar Mountains and over 150 mm to the Dhofar mountains in the south. In June 2002, a tropical storm affected Salalah city, with 58.6 mm of rain reported in Salalah plain and 250.6 mm in the adjoining mountains. Additionally, Membrey (2001) noted that the Hajar Mountains received up to 300 mm of rainfall in July 1995 due to a monsoon depression [11].

TROPICAL CYCLONES IN OMAN:

Oman, located on the southeastern coast of the Arabian Peninsula, was affected by cyclones, particularly during the monsoon season and the cyclone season. Cyclones in this region are referred to as tropical cyclones or cyclonic storms [13-16]. Also, Oman has experienced several significant cyclones over the years. These cyclones have varied in intensity and impact, affecting different regions of the country [17-19]. Some notable cyclones that have impacted Oman are listed as follows:

1. Cyclone Gonu (2007)

Cyclone Gonu, which occurred in early June 2007, was one of the most devastating cyclones to affect Oman in recent history [20]. It reached Category 5 status, the highest on the Saffir-Simpson Hurricane Wind Scale, and made landfall in northern Oman, near the capital city, Muscat. Gonu brought heavy rainfall, intense

winds, and severe flooding to the region, causing considerable damage to infrastructure, homes, and agriculture. It was responsible for several fatalities and extensive economic losses.

2. Cyclone Phet (2010)

In June 2010, Cyclone Phet struck the southern coast of Oman and neighbouring areas of Pakistan. Although it was not as destructive as Gonu, it brought heavy rainfall and flooding to the Dhofar region of Oman, resulting in the displacement of residents and damage to infrastructure, resulting in property damage. It still had a considerable impact on the affected areas.

3. Cyclone Keila (2011)

In November 2011, Cyclone Keila affected the southern parts of Oman, bringing heavy rains and flash floods. The storm caused damage to infrastructure and agriculture, particularly in the Dhofar and Al Wusta regions.

4. Cyclone Nanauk (2014)

In June 2014, Cyclone Nanauk formed in the Arabian Sea and brought moderate rainfall to the coastal areas of Oman. It dissipated before making a significant landfall, resulting in minimal impact compared to other cyclones.

5. Cyclone Ashobaa (2015)

Cyclone Ashobaa, which occurred in June 2015, brought heavy rain and gusty winds to the coast of Oman. While it did not cause extensive damage, it served as a reminder of the cyclone risk in the region. Also, it caused localized flooding and minor damage to infrastructure but was less severe than many other cyclones.

6. Cyclone Mekunu (2018)

Cyclone Mekunu made landfall in the Dhofar region of southern Oman in May 2018, particularly affecting the city of Salalah. It was classified as a Category 3 storm and brought heavy rainfall, high winds, and significant storm surge, leading to flooding and destruction of property in the Dhofar region. Mekunu caused

fatalities and severe damage to infrastructure, agriculture, and properties.

7. Cyclone Luban (2018)

Cyclone Luban, which occurred in October 2018, affected the southern coast of Oman, particularly the Dhofar and Al Wusta regions. It caused heavy rains and flooding, leading to displacement of residents and damage to infrastructure.

8. Cyclone Hikaa (2019)

In September 2019, Cyclone Hikaa made landfall in Oman near the coastal city of Duqm. It caused heavy rainfall, flash floods, and property damage in the affected areas. While it was not as destructive as some previous cyclones, it highlighted the continued cyclone risk in the region. Also, the impact was significant in the affected coastal areas.

9. Cyclone Shaheen (2021)

In October 2021, Cyclone Shaheen made landfall near the northern coast of Oman [21]. It brought heavy rainfall, strong winds, and flooding, particularly affecting the regions of Muscat and Al Batinah. The cyclone caused fatalities and considerable damage to infrastructure and properties.

10. Cyclone Tej (2023):

In October 2023, Cyclone Tej was a powerful cyclone that affected Oman, particularly the southern regions including Dhofar and Al Wusta. The cyclone brought extremely heavy rainfall, intense winds, and significant storm surges. The impact included widespread flooding, extensive damage to infrastructure such as roads and buildings, and disruption to local communities.

PREPAREDNESS AND RESPONSE:

Oman is susceptible to cyclones during the southwest monsoon season, and the cyclone season in the Arabian Sea. Oman has been improving its disaster preparedness and response mechanisms to mitigate the impact of cyclones. This includes early warning systems, evacuation plans, and infrastructure improvements. The government's efforts have helped reduce the loss of life and property in recent years, but cyclones remain a significant natural hazard for the country.

CONCLUSION:

Tropical cyclones have posed a significant threat to Oman, causing substantial damage and disruption over the years. The country's experiences with major cyclones such as Gonu, Mekunu, Shaheen, and Tej illustrate the severe impacts these storms can have on infrastructure, communities, and the environment. Despite advancements in disaster preparedness and response, the increasing frequency and intensity of cyclones necessitate ongoing efforts to enhance resilience and mitigate risks. Investment in early warning systems, evacuation plans, and infrastructure improvements is crucial. Oman's proactive measures have helped reduce casualties and property damage, but continuous adaptation and preparedness are essential to face the evolving challenges posed by tropical cyclones.

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