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Scientific Modernity, Imperial Governance and Institutionalisation of Indian Meteorology

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Abstract

The Indian Meteorological Department (IMD) has been central to all the modern weather forecasting that is in place today. It replaced the traditional weather forecasting that was used by the communities to understand the weather, monsoon and storms till the eighteenth century. The new forecasting methods were born out of the urgent need of the British colonial government after many droughts, famines and cyclones hit the Bengal province, and they were not able to understand the sky. Surveying and mapping had been very common throughout Europe and the Atlantic world. The British too followed the suit in late nineteenth century as part of a grand project to consolidate their hold in India. Since India was at center of Indian Ocean empire, there was a lot of attention paid to appoint surveyors, cartographers and naturalists in India. They were tasked with the responsibility of retrieving existing historical accounts and rewriting them, demarcating spaces through cartographic survey and fixing the challenges through new scientific research. Meteorology, though less examined in recent writings on environmental history, was an emerging field of study in the nineteenth century and was being financed generously by the European companies, particularly Britain. One of the key questions raised in this paper is the kind of major leaps that were made in meteorological survey. The paper traces the gradual expansion and scientific standardization of weather forecasting, and highlights the real intent of the British government.

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Introduction

Traditional weather forecasting in Bengal and other parts of India till the eighteenth century was deeply rooted in observations of natural phenomena such as the colour of the sky, animal and bird behaviours, and other environmental signs (Singh, 2025). These indigenous meteorological practices were orally transmitted from one generation to the next and were closely tied to agricultural cycles and everyday life of the people. Changes in the colour of the sky, such as an orange hue during sunrise or sunset, were interpreted as signals of approaching rain

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or storms. Observation of halo effects around the sun were considered indicators of an impending rain or thunderstorms. Similarly, the movement and formation of clouds and the wind speed were used to understand the intensity of the rains. Behaviours of crows, sparrows and peacocks were keenly observed. For instance, crows nesting and flying low and restlessly were seen as an imminent rain, or Indian cuckoo's sudden increase in singing early morning were seen as sign of very good monsoon. Even tree behaviours were good indicators of weather. For instance, when neem trees flowered fully had good number of fruits, it was seen as indication of very good monsoon. On the contrary, if the neem leaves dried up early without flowering or fruits on its branches, it was a warning of an imminent drought and bad monsoon. Each village or sometimes one in a cluster of villages used to have an astrologer, who would also study the Panchang (Indian calendar) to predict the monsoons, rainfall and calamities. These predictions were vital for agricultural planning and determining the sowing and harvesting times for the communities.

The British replaced the traditional weather forecasting systems in India in the nineteenth century (Singh, 2023). They regarded these indigenous methods as unscientific and steeped in superstition. At the same time, European meteorological theories had advanced significantly during the nineteenth century, grounded in systematic, instrument-based observation, data collection, and analysis that followed empirical and quantitative principles. These scientific advancements, including the use of instruments such as barometers and thermometers, promised more precise and standardized forecasting that could better serve the economic and administrative needs of the British Empire (Achbari 2017; Williamson 2015; Naylor 2006). There was a rapid proliferation of networks of observation stations across Europe and later these observation stations were established in its colonial territories. These stations would collect reliable data on temperature, air pressure, precipitation, and other meteorological variables (Anderson, 2005). The expansion was paralleled by significant technological advancements in scientific instruments such as, psychrometers, sunshine meters, hygrometers, and rain gauges, which were engineered to achieve unprecedented levels of precision and comparability (Middleton, 1969). By the 1860s and 1870s, British and European meteorologists, apart from achieving accuracy also began to look for observational uniformity. For this, standardized equipment such as the Stevenson screen was used at all observation stations. This thermometer shelter minimized local environmental influences and ensured data consistency across stations (Golinski, 2007).

This shift toward technology-driven, data-centric meteorology marginalized traditional, localized, and experiential weather knowledge (Janković, 2000). Indigenous weather wisdom were seen as unreliable. The data-driven science facilitated more precise and standardized weather forecasts, which proved critical for the economic and administrative demands of the British Empire and other European powers. Such data supported navigation, agriculture, public health, and governance across expansive colonial territories (Cohn, 1996).

The Indian Meteorological Department (IMD), established in 1875, has a very complex history rooted in the colonial ideology that intertwined with the British government's political economy. After the British established themselves firmly in the east coast of India, Calcutta (modern day Kolkata) and Madras (modern day Chennai) became the most important entrepots. They began systematic weather data collection in these two locations in 1785 and 1796, as a large number of European ships would make voyage from Europe to Calcutta and Madras (IMD, 2025). One of the major challenges for the British ships was the unpredictable strong winds and storms that often wrecked the moving ships in the Indian Ocean. When it comes to understanding oceans and weather, marine cartography and navigational charts provided some solutions. It had well evolved in the seventeenth century. British navigators were greatly helped by these early Spanish and Portuguese voyages and they also started keeping records of winds in their voyages of late sixteenth century. The ships' logs began to be maintained by the captains of the ships to record the direction of trade winds, which were important for sailing. Monsoon winds were, however, still the least understood winds and their origin and character remained obscure for a very long time.

In the latter half of the eighteenth century and subsequently in the early decades of the nineteenth century, as the sea voyages of European trading

companies increased into the Indian Ocean, they decided to develop a proper understanding of monsoon. A British navigator Edmond Halley had theorized monsoon patterns to seasonal wind reversals in the seventeenth century. This was possibly the first scientific theorization to understand the sky. He wrote a detailed account of his experience with the trade winds and monsoon (Halley,1686). Halley is credited with the drawing of the earliest meteorological chart of trade winds in the Atlantic and Indian Oceans. Halley was of the view that the variation of winds is 'better expressed' through the map than in words. While showing the trade winds, he also explained the monsoon and its causation in the summer months due to the movement of winds from high pressure to low pressure 'to bring it to an Equilibrium'. James Capper conceptualized the existence of different monsoon winds and called them Northeast and Southwest monsoon. James Capper's Observations on the Winds and Monsoons, written in 1801, validated the work of Edmund Halley by arguing that monsoon winds changed their direction in the Indian subcontinent due to the changing position of the Sun vis-à-vis position of Earth. In 1817 an India sailing directory was published by James Horsburgh. The directory contained account of different winds and different dangers that were to be encountered by British officers travelling to India by Sea (Horsburgh,1817). It gives a very detailed account of hurricane and storm-prone regions that need to be avoided. It also mentions dangerous coral reefs and dangerous shoals. The directory also mentions the proper seasons and the different winds to be used for sailing in and out of India.

By the beginning of the nineteenth century, wind theory had firmly been established. Later in 1855, Charles Wilkes also stressed on the persistent character of the southwest monsoon (Horsburgh,1860). He drew the sailing direction map based on the theory of the winds. Monsoon in the Indian Ocean was studied with a lot of interest because it was connected with East India Company's ship routes and their movement was mainly dependent on wind directions. In 1855, an American navigator, Matthew Fontaine Maury, identified ways to figure out the dominant wind patterns, what he termed 'the wings of the wind'. This allowed the ships to travel the same distance in a shorter time span (Maury,1855). He also wrote about the southwest and northeast monsoons and wind directions in the Indian Ocean- 'monsoons of the Indian Ocean prevail really for about five months each way (Maury,1855). On the basis of observation charts of more than a hundred ships in the Indian Ocean, Maurey was able to write Monsoon & Trade Wind Chart of the Indian Ocean on the request of the East India Company (Maury, et. al.1860). The Company believed that after drawing up monsoon and wind charts the distance of the British fleet would be reduced, which in turn would cut the transportation cost of goods.

Research Methodology

This study is mainly a historical analysis of the development of meteorological science related to cyclone mapping in the nineteenth century British Indian Ocean empire. It combines archival research with textual analysis to explore the transition from amateur meteorological record keeping to systematic analysis of records retrieved from ship logs and weather observatories. Primary data were gathered from archival sources of the British East India Company and scientific reports published under aegis of the British government. These sources include meteorological journals and correspondence between colonial administrators, surveyors, cartographers, and naturalists. Secondary sources, such as historical accounts and scholarly works on environmental history and colonial science, were also consulted to contextualize the primary data and identify gaps in existing literature on nineteenth century meteorology. Particular attention was paid to the technologies and instruments used, the role of European funding, and the integration of meteorological data into broader environmental projects. Discourse analysis was employed to examine the intent behind British meteorological investments, assessing whether these efforts were driven by scientific curiosity, economic interests, or imperial control. Comparative analysis was used to contrast early amateur meteorological practices with later systematic approaches in data collection methods and storm documentation. One of the challenges faced during the research was the lack of indigenous knowledge in colonial documentation. To mitigate this, the study cross-references multiple archival sources and incorporates secondary literature to ensure a comprehensive understanding.

Recurring Tropical Cyclones

Tropical Cyclones, specially those occurring in the Bay of Bengal, were a big worry for the British sailing fleet. Despite various early studies on wind theories, cyclones were still unpredictable. Cyclones came with very high-intensity winds with torrential rain and storm-surge that led to floods and damage to standing crops in eastern provinces of India. Various strong and destructive cyclones have been reported in the British accounts (Blanford,1877). Two of the most reported cyclone were that of 1864 and 1876. Detailed reports of the two cyclones were published to suggest that the cyclone led to widespread destruction of houses, trees and livestock. It flooded the cropping fields with salt water (Special Narrative,1865). In 1864 cyclone alone, approximately 200 British ships and boats were wrecked, which caused a huge financial loss to the trading company ships. In all these cyclone reports there were details of the destruction caused to the government buildings, death of people and cattle. These cyclones also led to the spill over of the salt water into the agricultural fields of the coastal area. It is intriguing that despite the fact that storms were quite common in the Indian Ocean since time immemorial, it is only from the nineteenth century these storms began to be seen as calamitous bringing disaster and destruction. Meteorological science were then seen as a solution to the problems. The 'history of meteorological science' in that sense was 'colonial efforts to consolidate territorial power' (Morgan, 2020). The recurrent cyclonic storms that struck the eastern coast of India during the nineteenth century served as a critical force for the institutionalization and advancement of modern meteorological science (Singh, 2025). These unpredictable weather events not only revealed the vulnerability of colonial infrastructures, trade networks, and agrarian systems, but also necessitated the need for systematic observation, data collection, and predictive modelling. Colonial administration began to view meteorology as an indispensable science that could mitigate risks to governance, commerce, and human life by transforming atmospheric uncertainty into calculable and manageable knowledge. The British observers began thinking in terms of forecasting so that they were in a position to send the warning of an imminent storm.

Imperial Meteorology in the Bay of Bengal

The development of meteorology in nineteenth century India was significantly influenced by earlier and contemporary meteorological theories and practices from the Atlantic Ocean region and broader Western scientific thought. The early British meteorologists recognized the interconnectedness of global weather systems, which spurred the exchange of climatological data not only within India but also internationally. This was crucial because weather and climate do not adhere to geographical boundaries, and phenomena such as the Atlantic oscillations, which was later more formally identified by British meteorologists like Sir Gilbert Walker, provided important frameworks for understanding monsoon variability and cyclonic activity in the Indian Ocean region. The Atlantic Ocean meteorological theories concerning atmospheric circulation and cyclones helped shape the methodologies used in India. The concept of teleconnections, which emerged from studies in the Atlantic and Pacific regions, guided Indian meteorologists in their attempts to correlate climatic variations across vast distances, such as the linkages between El Nino-Southern Oscillation (ENSO), Atlantic sea surface temperatures, and the Indian monsoon. This integration of Atlantic and Indian Ocean meteorological knowledge created a scientific basis for empirical forecasting systems and early storm warning mechanisms, which became central to the IMD's mission.

In India, the British East India Company had already started establishing observatories in the coastal areas of Madras, Bombay and Calcutta by the last decade of the eighteenth century itself. The first astronomical Observatory in India with a telescope was established in Madras in 1792 by the British East India Company for promoting the knowledge of astronomy, geography and navigation in India. This became possible because some of the officials of the British East India Company posted in India, were imbued with scientific curiosity. They realised that India has a climate very different from their home country, and therefore, they began doing amateur meteorological observations and recording. One such officer was Col. Pearse who lived in Calcutta in 1785 (Hundred Years,1976). In 1793, Goldingham prepared a meteorological register that allowed

the daily recording of observations. The Calcutta Observatory was founded in 1829. All these early observatories lacked trained meteorologists. They were equipped with old instruments, and this hampered the systematic data collection. By 1848, however, hourly meteorological observation began at all major observatories at Madras, Bombay, Calcutta, Shimla and Trivandrum. While these observatories were intended to understand the weather patterns in India, the colonial government was still uncertain about unravelling the mystery of cyclones in the Indian Ocean, where most of its trading activities depended. The British were already having a fair knowledge of trade winds ever since their early contacts with the Indian rulers in the sixteenth century. E. Halley was able to put together the nature of different trade winds in various parts of the globe in 1686 (Halley,1686). James Kyd tried to record the day and night tides to understand the oceanic behaviour and prepared the register of tidal observations in the Hooghly river for the years 1805-1828, but he was not able to connect these observations to ocean storms. Henry Piddington began the recording of ocean storms in the Indian Ocean in 1839 and was able to link it to the 'cyclone', a term that he coined inspired by a Greek word meaning coils of snake. His book Sailor's Handbook of Storms was an outcome of his observation of the ocean storms between 1839 and 1851. But his meteorological observations were not accurate enough to do any kind of modelling and forecast.

The only way that could have reduced the damage to the British buildings and vessels was an early warning of the cyclone. The government of Bengal appointed Henry F. Blanford as a Meteorological Reporter. He began his work by collecting data recorded by various meteorological stations and observatories of Calcutta and Madras. Blanford and his co-meteorologist, J.E.Gastrell after doing a comprehensive study concluded that most of the cyclones in the Bay of Bengal arose along a line parallel to, and immediately to the west of the Andaman and Nicobar Islands (Blanford, 1868-69). Later, M. V. Portman writing about a cyclone that he experienced in 1891 during his inchargeship of the Andamans mentions that when the cyclone of 2nd November 1891 came 'great surprise was exhibited', as it was earlier assumed that 'the Andamans only formed the cyclones' and were thus away from its ferocity (Portman, 1899). The climatic characteristics of tropical cyclones have been worked out by scientists on the basis of study of data of tracks of storms and depressions in the Bay of Bengal available with Indian Meteorological Department. The analysis indicates that the peak incidence of cyclonic storms occurs during the post-monsoon period, particularly in October and November. Drawing on compiled data pertaining to storm and depression tracks over the past 120 years, geographers have mapped the trajectories of severe cyclonic formations within a grid encompassing latitudes 5° to 15° N and longitudes 90° to 95° E. The preponderance of these cyclones manifests during the transitional inter-monsoon months of October, November, and December, a phase characterized by the attenuation of the southwest monsoon and the activation of the retreating monsoon across the Bay of Bengal. The scientists obtained information from ships' logs of the days preceding different cyclones when they actually hit the Bengal coast. The logbooks of Royal Navy vessels are preserved in The National Archives at Kew, where Admiralty records including 'captains', 'masters', and 'lieutenants' logs can be accessed, detailing voyages, weather, and ship activities from the seventeenth century onward (The National Archives, 2022). Meanwhile, the logbooks of East India Company ships are housed in the British Library within the India Office Records, containing detailed accounts of voyages, weather observations, and ship operations from the eighteenth and nineteenth centuries (British Library, n.d.). These records contain valuable observations on tides, ocean currents, winds, and weather conditions in the Indian Ocean. If studied carefully, the factors that directly influenced the nature and intensity of the Indian monsoon could be understood. Their significance is particularly evident in the case of India, since numerous East India Company ships sailed regularly to the Indian Ocean, and each of these ships maintained detailed logbooks. These logs provide a first-hand, day-to-day account of sailing activities, recording information such as wind force, wind direction, and prevailing weather. Detailed analysis of ships' logbooks can be found in Dennis Wheeler (Wheeler, 2004).

By the mid nineteenth century the barometric data from different locations were very scant for any conclusive study. However, after 1864 cyclone Blanford had observed through the records that after the cyclone, low pressure prevailed near the

Andamans for some days previous to the occurrence of the cyclone. Blanford therefore advised the British government in Calcutta to establish meteorological stations in Bengal and Bihar so that early observation of cyclone's relation to low atmospheric pressure could be studied. Barometric pressure from these locations and the observatories of Calcutta and Madras gave a lot of observational inputs which was used by Henry Blanford to unfold the possible causes for origin of the cyclone that came afterwards.

On the basis of the atmospheric data collected from the main cyclone track and other affected regions Gastrell and Blanford hypothesised that the cyclone in the Bay of Bengal occur mainly at the periods of changing monsoon. Most of these occur at the close of the south-west monsoon in October and November. These did not occur before that. The cyclones originating in the north of the Bay of Bengal usually travel towards north-west. Those originating near the Andaman islands travel towards north-west, and the ones originating in the south of the Bay travel usually to west (Blanford,1868-69). They also recommend certain early conditions before the occurrence of cyclone. It was always preceded by a strong damp stormy wind from south-west of their place of origin, and the barometer ranges lower than usual. They also recommended that in the coastal Bengal if the wind blew from south-east and move towards north-east with falling barometer, bad weather was certain, and therefore, warning ought to be sent to the interiors.

Blanford also gathered information from the people of Bengal about their traditional knowledge on cyclones. Bengal natives had their traditional warning signs which was based on their years of everyday experiences. Few of the signs included dogs howling, leaves of the silk-cotton trees turning upside down, and ants moving to the higher grounds (Kingsbury, 2019). People also used to hear a roaring sound coming from the Bay of Bengal for two or three days before the arrival of a cyclone. Because of major decreases in air pressure and water pressure animals quickly sense these changes. Birds and bees are the first living beings to sense this drop in barometric pressure and would instinctively seek cover of their nests or hives (Acharya, 2011). Another indicator that the local people observed was that birds tended to fly lower to the ground when a cyclone was approaching the coast. Further, in the cyclone year there was ripening and early rotting of fruits, unusual flowering of plants. The publication of Henry F. Blanford's Indian Metrologist's Vade-Mecum in 1876-77 changed the way observation were being read. It introduced the idea of causes of climate events such as monsoons and cyclones (Blanford,1877).

Telegraph Lines and Weather Forecasting

Telegraph lines were in place in India well before Henry Blanford wrote his masterpiece Indian Meteorologist's Vade-Mecum. The first telegraph line in India was established experimentally between Calcutta and Diamond Harbour in 1850, and by 1854 telegraph services had expanded significantly. It was opened to the public and quickly covered major routes and administrative centers across India. International telegraph communication between India and England began via the Persian Gulf line in 1865, and a direct telegraph line from Britain to India was completed and operational by 1870. During those years the idea of utilising the telegraph for forecasting had not yet been conceived, although meteorologists like Blanford were proposing that the telegraph could prove to be an important tool for collection weather data and subsequent early warning to Bengal government. He recommended that Meteorological Telegraph Stations in Ceylon and Port Blair be set up and they should be connected with stations in mainland India. Blanford advocated for the improvement of daily weather reports by increasing the number of stations sending daily telegrams, aiding early detection and warning of cyclonic activity. This integration of telegraphy into meteorological science meant that information could outrun the weather. It could provide critical lead time for anticipating and preparing for cyclonic storms, especially in vulnerable coastal areas of the Indian Ocean, specially Calcutta.

By the late 1870s, daily telegrams of weather from all parts of India were introduced. It enabled the timely publication of daily weather reports across the region. The presence of telegraph lines played a significant role in advancing meteorological observations and early cyclone warning systems. Telegraph lines allowed meteorological observatories and coastal stations to send weather observations and barometric readings rapidly across long distances. This real-time sharing of data was critical for identifying the development and movement of

cyclonic systems, which could form and intensify rapidly over the Indian Ocean. With telegrams, meteorologists could communicate imminent cyclone threats to port authorities, shipping companies, and coastal communities hours before a storm's arrival. This was a significant advancement providing time for ships to avoid danger and for preparations on land (Anderson, 2005).

The telegraph laid the foundation for a more 'synoptic weather forecasting' and coordinated observation and analysis of weather patterns over a vast region (Bergman, 2016). This was crucial for understanding the behaviours of cyclones, especially their paths and intensity changes. Telegraph was thus not just being used as a communication tool, but also as an effective tool for data collection. The entire ambit of data analysis for cyclone prediction changed from isolated observations to coordinated, science-driven early warning systems across India and the wider Indian Ocean area. In 1876 the telegraph regulations were introduced that later became the basis of the Indian Telegraph Act of 1885 (The Indian Telegraph Act, 1885). It had significant impacts, particularly on meteorology and cyclone prediction in India. The regulations gave the British colonial government exclusive rights to establish, maintain, and operate telegraph lines. It ensured a consistent, reliable network that could be used for public and official communication, including meteorological data sharing crucial for cyclone warnings. Meteorologists could use the telegraph lines to quickly transmit weather observations from multiple stations. This also enabled the IMD with Henry Blanford appointed as the first Meteorological Reporter, to collect weather data in near real-time, which was essential for issuing early cyclone warnings and coordinating response efforts (Evolution of IMD, 2025). Gradually, there was expansion of telegraphic services to more regions and government departments, including railways, irrigation, and military services. It ensured that cyclone warnings and flood alerts were communicated promptly to officials who could take preventive actions. The 1885 Act legalized the placement of telegraph lines over both public and private land. It further helped in building a comprehensive communication infrastructure that improved the reach and efficacy of cyclone prediction and warnings across India. These legislative and institutional measures laid the groundwork for India to establish one of the earliest large-scale meteorological networks in the world. Calcutta became the hub of cyclone detection and warning issuance center across the Indian Ocean.

By the nineteenth century, the British government had begun to realize that meteorological models were essential for the political economy, since weather patterns directly affected agriculture, trade, and revenue. It believed that devastations caused by cyclones could be controlled through the warning of an imminent cyclone. Its early prediction would enable them to govern Bengal more effectively, which was not only high revenue generating region but also an important hub of international trade. Marine cartography like landscape cartography were also developed to serve the purpose of the British colonial control in the Indian Ocean. While topographical survey was done to facilitate revenue extraction agenda of the Company, monsoon and wind charts were developed to suit the trade and ship movements in the seas. These maps were represented in a particular way to suit the requirements of the colonial power. In that sense nature was seen as material as if it could be produced. Very soon the colonial government realised that the nature of storm and weather was completely different in the Indian Ocean. The unpredictable character of the tropical cyclones was studied to make it more predictable through new scientific methods, using navigational techniques and charts. The later decades of the nineteenth century were quite vibrant in terms of meteorology. Its rapid evolution combined with telegram enabled the colonial government to understand that meteorological models could be highly useful for the political economy of their Indian Ocean empire. After the IMD was established, it would publish daily, weekly and monthly weather reports along with annual rainfall summaries and cyclone warnings. These information were vital for disaster preparedness and allowed the British government to reduce the damage to the huge and costly ships.

Conclusion

The historical trajectory of IMD reflects the transformation of weather science as a colonial necessity. The British had begun to establish weather observation stations all across Europe and its colonies including India. The British colonial government's concern with protecting its ships from unpredictable storms in the early 19th century

certainly spurred advancements in meteorological science in India. From the very coining of the term cyclone by Henry Piddington to the publication of Sailor's Handbook of Storms and Henry Blanford's Indian Metrologist's Vade-Mecum facilitated the dissemination of research findings, while the developments in tropical meteorology and storm signal warnings, enhanced weather forecasting. The integration of provincial meteorological systems into a subcontinental framework under the Indian Meteorological Department further strengthened organized weather monitoring. The scientific understanding of cyclones in the Bay of Bengal proved particularly valuable, especially after telegraph lines connected weather stations, enabling faster and more accurate predictions. These advancements allowed the British government to attribute societal difficulties to unpredictable natural forces, such as recurrent cyclones, rather than its own economic decisions. The advancement of meteorological science allowed the British government to argue that it was the unpredictable forces of nature, such as the recurrent cyclones, rather than its own economic decisions, that lay at the root of society's difficulties. It shifted attention away from the harmful effects of its exploitative economic policies and placed responsibility on environmental factors instead. At the same time, the IMD's colonial legacy was a decisive moment in the centralisation of knowledge production and it exemplifies how scientific modernity was integrated into imperial governance. This legacy continued to have lasting implications for environmental regulations in South Asia's colonial past.

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