

## CYCLONIC HAZARDS IN THE RECENT PAST IN PENINSULAR INDIA

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**Abstract:** Cyclonic storms happen to be a major event in the coastal peninsular of India emerging from the Bay of Bengal and the Arabian Sea in recent times. Cyclones generally devastated Odisha and the Indian and Bangladesh coastal region including Sunderbans, and their adjacent areas along the coastal tract of the Bay of Bengal, but on 3 June 2020, Mumbai along with other districts of Maharashtra faced the lashes of cyclonic storms after a gap of 100 years. As a result of rising sea level due to global warming and climate change, the Indian Meteorological Department, after computation of the yearly occurrences of the storms, states that the numbers of severe cyclones increased by 11 percent in the last decades in the Bay of Bengal and Arabian Sea. Further, the Indian Meteorological Department alerts the inhabitants living in the coastal stretch across the Indian peninsula for frequent occurrences of severe cyclones with 32 percent rise in the last five years duration in the Bay of Bengal and Arabian Sea.

**Keywords:** Climate Change, Cyclonic hazards, Bulbul, Amphan, Nisarga, Nivar, Burevi, El Niño-La Niña phenomena

### 1. INTRODUCTION

Almost all the scientists agreed that the cyclonic hazards are the consequences of climate change, global warming, and sea level rise. World-wide or regional available data for sea level rise is in contradiction with what different agencies and organizations published officially, yet sea level is rising and alarming. Of late, data on sea level rise along the coastal stretch of peninsular India, released by the Ministry of Earth Sciences, Government of India (2019), shows that the sea levels have risen by 8.5 cm during the past 50 years at the rate of 1.7 mm per year. The data of 10 major port areas across the country averages 1.7 mm a year, though this

long-term data collected is in different duration for different locations such as 28 years for Okha and 128 years for Mumbai. The scientists of the Ministry of Earth Sciences, Government of India collected data from different locations like Kandla (Gujarat), Okha (Gujarat), Mumbai (Maharashtra), Kochi (Kerala), Chennai (Tamil Nadu), Vizag (Andhra Pradesh), Port Blair (Andaman and Nicobar Islands), Paradeep (Orissa), Haldia (West Bengal) and Diamond Harbour (West Bengal). Such data on sea level change indicates the highest of annual average rise at Diamond Harbour at the rate of 5.16 mm per year and

the lowest at Chennai at the rate of 0.33 a year (Table 1). As the data have not been collected for all locations in the same duration, the researchers of the Ministry of Earth Sciences, Government of India considers the computation of data for sea level rise requires a greater accuracy, yet the officials of the ministry like to give an idea on sea level rise around peninsular India in the report (1). Climate change and global warming are the most appropriate reasons raised for such sea level rise as stated by the team of the central agency under Government of India. Simultaneously almost all the agencies working together with the United Nations, an international body, are all agreed on the rise of sea level in accelerating manner and published the data of sea level rise at the rate of 3.6 mm per year globally in their latest report of UN's Intergovernmental Panel on Climate Change (2, 3 & 4).

On contrary to this data published by Ministry of Earth Sciences, Government of India,

researchers like P K Bhaskaran, NNV Sudha Rani and ANV Satyanarayana of Ocean Energy and Naval Architecture Department, IIT, Kharagpur indicate comparatively slower rate of sea level rise in their publication titled 'Assessment of Climatological Trend of Sea Level over the Indian Coast' published very recently in the journal 'Pure and Applied Geophysics' (5). In their paper, they have shown that the Bay of Bengal is rising 3.6 times faster than Arabian Sea mentioning Kolkata faces bigger flooding risk than Mumbai (Table 2). The authors carried out their study on sea level rise in 2017 using 30 years' tidal gauge data from Kandla, Mumbai and Cochin in the west coast of India and Diamond Harbour, Haldia, Visakhapatnam and Chennai in the east coast of India. The authors indicate that the sea level in the Bay of Bengal is rising at 1.35 mm per year against the rise by 0.37 mm a year in the Arabian Sea showing the eastern coast of India is much more vulnerable than that of the western coast due to rising sea level.

**Table 1:** Data on sea level rise at 10 locations along the coastal stretch of India

Sl. No.	Locations	State	Rate of Change of sea level (mm/year)	Duration of data used (years)
1	Kandla	Gujarat	3.18	1950-2005
2	Okha	Gujarat	1.50	1964-1991
3	Mumbai	Maharashtra	0.74	1878-2005
4	Kochi	Kerala	1.30	1939-2005
5	Chennai	Tamil Nadu	0.33	1916-2005
6	Port Blair	A & N Islands	2.20	1916-1964
7	Vizag	Andhra Pradesh	0.97	1937-2005
8	Paradeep	Orissa	1.03	1966-2005
9	Haldia	West Bengal	2.89	1972-2005
10	Diamond Harbour	West Bengal	5.16	1948-2005

(Source: Ministry of Earth Sciences Report, Government of India, 2019)

**Table 2:** List of tropical cyclones occurred in the year 2019 that affected India and its neighbourhoods

Cyclone Names	Sea-Coast	Category	Date of Occurrences	Affected Areas	Wind Speed	Damage	Fatalities
Pabuk	Bay of Bengal	Cyclonic Storm	31 December 2018 - 8 January, 2019	Vietnam Thailand Myanmar	95 km/h	\$157.2 million	10
Fani	Bay of Bengal	Extremely Severe Cyclonic Storm	26 April - 5 May, 2019	Bangladesh Orissa Sri Lanka Eastern India	250 km/h	\$8.1 billion	89
Vayu	Arabian Sea	Very Severe Cyclonic Storm	10- 19 June, 2019	Maldives India Pakistan Oman	150 km/h	\$140,000	8
Hikka	Arabian Sea	Very Severe Cyclonic Storm	15 - 25 September, 2019	Gujarat Oman Saudi Arabia	157 km/h	Minor	None
Kyarr	Arabian Sea	Super Cyclone	24 October - 3 November, 2019	Western India Oman UAE Socotra Somalia	240 km/h	Minor	None
Maha	Arabian Sea	Extremely Severe Cyclonic Storm	29 October - 7 November, 2019	Gujarat Daman Diu	170 km/h	Minor	None
Bulbul	Bay of Bengal	Very Severe Cyclonic Storm	6-12 November, 2019	Myanmar A&N Islands Eastern India Bangladesh	140 km/h	\$6 billion	38
Amphan	Bay of Bengal	Super Cyclone	14-20 May, 2020	India Bangladesh Sri Lanka Bhutan	165-185 km/h	\$13.35 billion	118
Nisarga	Arabian Sea	Severe Cyclonic Storm	1-3 June, 2020	Maharashtra (India)	100-110 km/h	\$665 million	6
Gati	Arabian Sea	Cyclonic Storm	21-24 November, 2020	Somalia	45-55 km/h	-	9
Nivar	Bay of Bengal	Severe Cyclonic Storm	23-27 November, 2020	Tamil Nadu, Puducherry	80-90 km/h	-	33
Burevi	Bay of Bengal	Severe Cyclonic Storm	1-4 December, 2020	Sri Lanka, India	100-110 km/h	-	11

## 2. LANDFALL OF BULBUL – A RAVAGER CYCLONE

The warning system for cyclone-forecasts was so poor even only 10 years back. But of late, the alert system has gradually been improving and the common people, come to know, even about each progress of ensuing cyclone from its generation in the deep ocean to landfall on the coastal areas well in

advance. The United Nations highlights such importance of investing in early warning systems to reduce the damage caused by natural disasters by campaigning if one knows how to make a society resilient, a hazard does not necessarily have to become a disaster (6). The warning systems help both the disaster managers and the concerned administrations to take proper steps for remedial measures well before the

occurrence of cyclone Bulbul this time that touched the land at night on the 9 November 2019. By 8.30 pm IMD issues notice that the landfall process of Bulbul has started and warns that the landfall is a two hour process. And thus, the wall cloud region is entering into land. It is likely to move north-eastwards, weaken gradually. By midnight, the department states that the current intensity near the center is 105 – 115 km/h gusting to 125 km/hr. Eye lies over South 24 Parganas close to the east of the Sunderban's Dhanchi forest which is located about 30 km southwest of Sunderbans National Park, 100 km southeast of Kolkata, 60 km east of Sagar Island, 165 km west southwest of Khepupara (7). By 11.30 pm, the landfall process ends and at 9.30 am in the next day morning (10 November 2019), the threat for West Bengal is over as the cyclone has weakened and will become a deep depression, moving towards Northeast India (8).

In coastal areas of the Indian and Bangladesh Sunderbans, Bulbul is accompanied with torrential rains and high velocity winds to the tune of 110-120 km/hr. gusting up to 130 km/hr. The coastal areas of West Bengal such as Digha, Howrah, Hooghly, North and South 24 Parganas, Purba Medinipur are witnessing winds of more than 100 km/hr. during the period when the storm is tracking West Bengal. The City of Joy Kolkata has received a whopping 104 mm of rain along with winds gusting up to 50–70 km/hr. The amount of rainfall received in 24 hours during cyclonic storm Bulbul is as following –

Rainfall Data of the Coastal Stretch of West Bengal  
 Contai – 166 mm

Dum Dum – 103 mm  
 Alipur – 91.7 mm  
 Digha – 96.6 mm  
 Diamond Harbour – 91 cm

Rainfall Data of the Coastal Stretch of Bangladesh  
 Khepupara – 105 mm  
 Bhola – 99 mm  
 Barishal – 139.5 mm  
 Jessore – 52 mm

Despite such improved warning systems, frequent alert and utmost efforts from the district administrations and their management team, the deadly cyclone Bulbul has taken the lives of people while displaced two million others and affected 2.73 lakh families after hitting the coast of India and Bangladesh on Saturday night (9 November 2019). Persistence of the landfall process about 3 hours instead of its usual 2 hours duration for a cyclonic storm causes huge destruction as Bulbul releases its energy through gusty winds for more than an hour over the entire areas of the Sunderbans. Bulbul, the severe cyclonic storm, alerts the people as well as the states to think again – why resilient infrastructure matters in an era of severe cyclones and storm surges and lay out for building houses and educational institutions safer and stronger. In an era of very severe cyclonic storms the people must build to last with the assistance from the concerned government sectors as the number of cyclones rose 32% in the past 5 years in the Arabian Sea and Bay of Bengal.

### 3. AMPHAN - MAIDEN SUPER CYCLONE OF THE CENTURY

In the ultimate fact of nature, this time too, Sunderbans is lulled with the sweetest tragic melody of devastating strike composed of the tunes of the Super Cyclonic Storm Amphan (pronounced as Um-Pun). Super Cyclonic Storm Amphan batters over North & South 24 Parganas districts and Kolkata on 20 May 2020 barreling in from the Bay of Bengal with the wind speed of up to 185km/h where it claimed 80 lives in West Bengal and 16 killed as storm hits Bangladesh coast causing heavy rains and tidal surges (9). In Kolkata metropolis, it is tall trees that are first assailed by the storm. Huge damage of properties, houses and households, large trees, bamboo groves, communication and electric poles etc. as reported due to the Super Cyclonic Storm Amphan leads to a severe natural disaster. In the morning of 21 May, Super Cyclonic Storm Amphan lies as a well-marked low over North Bangladesh and adjoining area. Weather office hopes that there will be no further threat for the Gangetic West Bengal including severely damaged and destroyed North & South 24 Parganas and Kolkata. The cyclonic storm Amphan has strengthened to the massive storm to hit India and Bangladesh in modern history. Its 2201 km across, with an eye 20 km in size, a steady wind of 165 km/h gusting at 185 km/h is equivalent to a Hurricane Cat 5 generated on 13 May in the east Bay of Bengal. The deep depression in the Bay of Bengal has intensified into cyclone Amphan, which is

centered around 10.50N and 86.40E, about 650 km of Chennai and on 17 May, Indian Meteorological Department (IMD) confirms Cyclone Amphan, the first cyclone in North Indian Ocean for 2020, heading towards West Bengal and Bangladesh and then it is official as the Cyclone Amphan is declared by IMD. The Amphan cyclone is so massive, its moisture plume covers all the stretch of West Bengal including Digha, Shankarpur, Tajpur and Mandarmani. Naturally, Cyclone Amphan will have catastrophic damaging potential with extremely heavy rains and high-velocity winds, along with and off the coast of Odisha and West Bengal. Further, IMD forecasts the landfall of Amphan is still a suspense. Impact of Cyclone Amphan on coastal West Bengal and Bangladesh will be mostly on 19 or 20 May 2020. IMD Authority, on 17 May, advises fishermen in sea to return to the coast by 18 May positively. Not only to the fishermen, but IMD advises the Government of West Bengal to combat cyclone Amphan by taking immediate measures to save domestic households and government properties. Meanwhile, Amphan qualifies to be the first Super Cyclone of this century in the Bay of Bengal as the winds in the inner periphery of the storm are more than 200 km/h and likely to build up further to be more than 225 km/h. The Super Cyclone continues to retain and refine its eye as a sharp pin-hole round structure with a diameter of 20 km clearly seen in the satellite image published and displayed by the IMD in the storm that has moved nearly northward with a speed of 12 km/h on 17 & 18 May, 17



km/h on 19 May and 22 km/h on 20 May respectively. On 20 May, the landfall process commenced at 2.30 pm and continued for about 4 hours. The forward sector of the wall cloud region is entering into land in West Bengal. Ultimately, in their Bulletin No. 13 dated 20.05.2020, issued at 1830 hours IST, IMD declared that Super Cyclonic Storm Amphan crossed West Bengal-Bangladesh coasts as a Very Severe Cyclonic Storm with the speed of 155-165 km/h gusting to 185

km/h across Sunderbans (Table 3) near Lat 21.650N and 88.30E between 1530 & 1730 hours IST of 20th May nearby Dakshin Chandanpiri of Namkhana Block under South 24 Parganas District of West Bengal. Passage of gradual progress of the Super Cyclonic Storm Amphan is prepared that weakened into a well-marked low pressure area over north Bangladesh based on the data released by IMD (Fig 1).

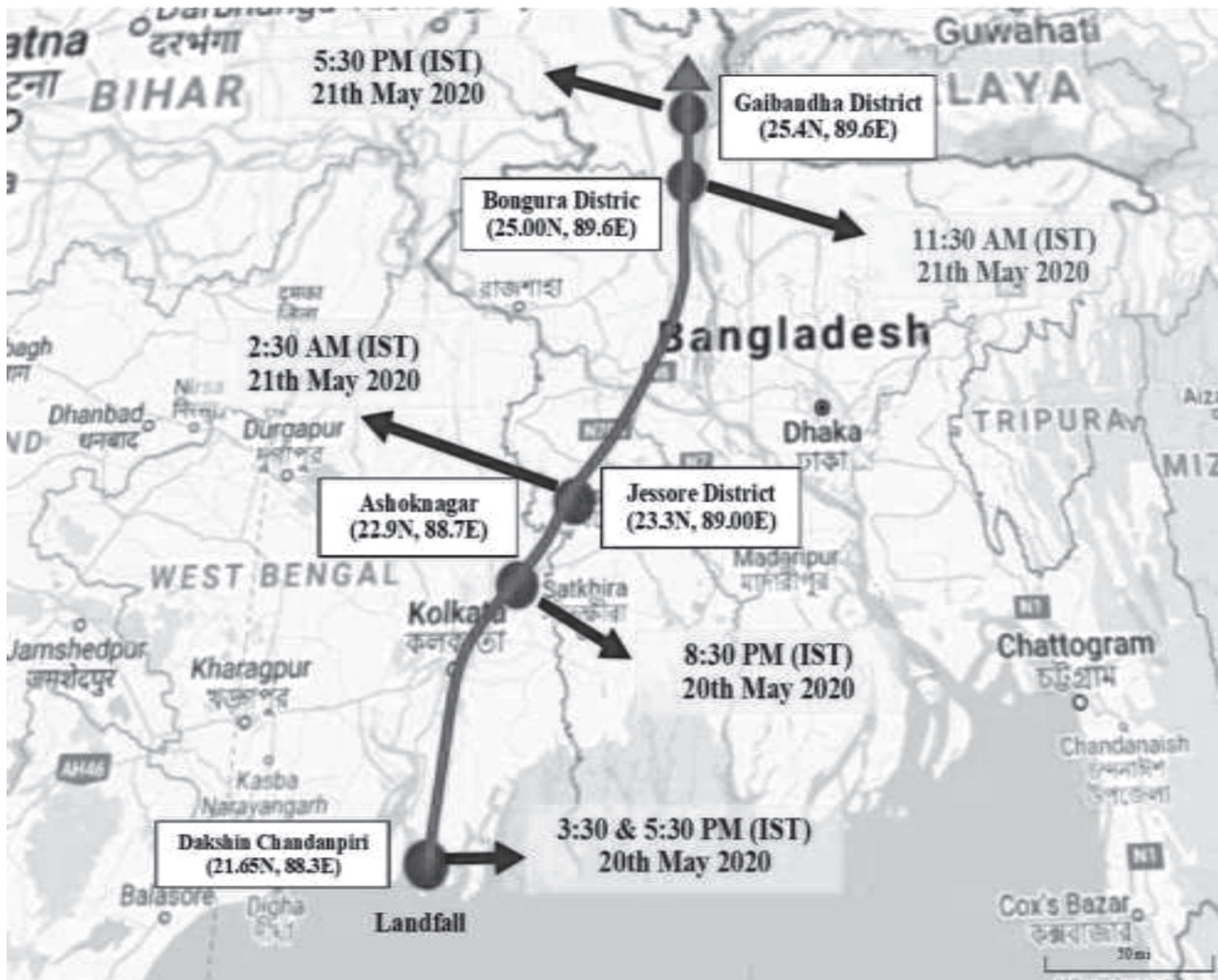


Fig. 1. Passage of gradual progress of the Super Cyclonic Storm Amphan

Amphan is another crisis during an unprecedented crisis in the country among corona lock down, floods, earthquakes, and heavy rain. To combat this crisis, both the State alerted the local people of the coastal areas repeatedly and Central Governments deployed several teams of National Disaster Response Force. But with all measures on behalf of both state and central governments, Super Cyclonic Storm Amphan devastated almost the entire areas of North & South 24 Parganas districts almost entirely including Kolkata and other districts of the South Bengal partially, though the storm is likely to retain the status of Super Cyclonic Storm for 12 hours before it downgrades in the open

wind speed and rainfall at South 24 Parganas district in the wake of cyclone Amphan up to 2 pm on 20 May, the day of striking, are recorded by the IMD (Table 3).

IMD warns even after the landfall process that the North & South 24 Parganas districts including the Kolkata metropolis are to witness lull as the eye of the Super Cyclone Amphan passes through, but heavy rains, strong winds will resume in 30 minutes and that strong winds will resume in 30 minutes and that strong winds lashing over 2 hours destroy the said areas. Anyway, by the way of playing destruction with havoc devastation, maiden cyclone of this pre-monsoon season

**Table 3:** Wind speed and Rainfall data on the day of Amphan

Sl No	Place	Wind Speed (km/h) Gale	Wind Speed (km/h) Gusts	Rainfall (mm)
1	Sagar	91	130	15.3
2	Mousuni Island	94	141	14.0
3	Bakkhali	106	146	14.0
4	G Plot (Pathar Pratima)	94	128	13.0
5	Kultali	65	107	10.0
6	Basanti	48	84	5.6
7	Gosaba	39	80	3.7
8	Joynagar	38	82	5.9
9	Diamond Harbour	38	83	7.3
10	Budge Budge	34	74	5.8

Source: Indian Meteorological Department (IMD)

waters itself to Extremely Severe Cyclonic Storm. This will happen because of relatively cool water and vertical wind shear is a change in wind speed or direction with change in altitude, it inhibits tropical cyclones. Anyway, West Bengal faces a drastic damage overall amounting to about thousands crore Rupees. Amphan, qualified as the first Super Cyclone of the century in the Bay of Bengal damages almost the entire South 24 Parganas district due to its huge wind speed and heavy rainfall. Readings of

Amphan grabs the distinction of becoming the only Super Cyclone in the Bay of Bengal since the year 2000. Because of such ravager Super Cyclone Amphan, huge loss of wildlife including Royal Bengal tiger is reported from the Sunderbans. At least 80 people killed, 10000 homes destroyed, and millions remain without power as the cyclone batters West Bengal. It devastated coastal villages, hampered by torn down power lines and flooding over large tracts of land and trees uprooted by stormy winds.

### 3.1 Post-Amphan Scenario

Nature is just and will revenge the cause, having a desire of revenge up to the plunderer of the planet for centuries. Perhaps the decision is finally decided by nature and that is why nature will kill people biologically with the corona viruses, chemically with gas leakage, physically by the devastation for Amphan cyclone, geographically by inundation and flood, psychologically by quarantine and economically by lock down, and the rest will work out the number of deaths and loss statistically. For instance, the death toll due to cyclone Amphan in West Bengal has risen to 86. Flying objects due to havoc gusty winds during the storm because of the Super Cyclone Amphan hit and killed a man in the street, though Indian Meteorological Department (IMD) alarmed all about such cyclone-hit incidents well before the storm lashed into its landfall process. Apart from these fatalities, thousands of trees and electric poles are uprooted disrupting communication and power supply. Entire South Bengal inclusive Kolkata metropolis is devastated after the hit of the Amphan cyclone. In the history of Kolkata city, this kind of calamity is unheard of, but the Kolkata Municipal authorities assured that they will work round the clock to get the city back to its previous spirit.

Super Cyclone Amphan has become the costliest on record in the North Indian Ocean having damage of approx. \$13.35 billion (2020 USD) with the total fatalities of 118 persons that affected India, Bangladesh, Sri Lanka, and Bhutan. Amphan started from low pressure in the southeast Bay of Bengal on 13 May and became a cyclonic storm on 16,

centered around 1100 km south of Paradip, Odisha and after becoming a Super Cyclonic Storm on 18, made landfall on 20 May in between 3.30 pm and 5.30 pm at Dakshin Chandanpiri near Bakkhali, South 24 Parganas district, West Bengal as Very Severe Cyclonic Storm (VSCS) having highest wind speed 260 km/h (1-minute sustained) and 240 km/h (3-minute sustained) and lowest pressure with 925 hPa (mbar), 27.32 in Hg. Super Cyclone Amphan affected the areas of Sri Lanka, India (Andaman Islands, Odisha, and West Bengal), Bangladesh and Bhutan, though number of fatalities are less due to accurate forecasts and warnings for cyclone Amphan by the IMD that saved precious lives and managing crisis by the central and state governments of India that helped the states in making required preparations to face the calamity for the cyclone Amphan.

Cyclone Amphan will go down in history as the most ferocious storm leaving a trail of destruction for Kolkata metropolis having rainfall 159 mm for only 6 hours in between 5.30 pm and 11.30 pm on 20 May. Havoc wind speed with gale of 130 km/h gusting to 150 km/h snapped power lines, uprooted more than 10000 trees and 4000 electric poles. IMD reported that the chief amounts of rainfall (in cm) released on 20 May are: Alipore - 24, Dum Dum - 20 in Kolkata and Haldia - 8 in Purba Medinipur district. Maximum sustained wind speed is recorded at Dum Dum reported 130 km/h at 6.55 pm and at Alipore 112 km/h at 5.52 pm on 20 May 2020.



### 3.2 Kolkata on Amphan

Following data related to effect of Amphan on Kolkata are received from Indian Meteorological Department, Kolkata.

#### Rainfall

Alipore - 240 mm  
Dum Dum - 200 mm  
Salt Lake - 183 mm

#### Maximum Sustained Wind Speed

Dum Dum at 6.55 pm - 130 km/h  
Alipore at 5.52 pm - 112 km/h

**Trees uprooted - 10000+**

**Electric Poles Uprooted - 4000+**

Not only in West Bengal, heavy rainfall leaves Meghalaya and Assam water logged for cyclone Amphan, though Tripura gets light and moderate rainfall. Jamshedpur records 23 mm rains in Amphan hit. In West Bengal, South 24 Parganas district received maximum rainfall and faced the gusty winds as the landfall of the Super Cyclone has been processed here. Being a resident of a village in the extreme southern portion of the South 24 Parganas district adjacent to the coastal areas of the Bay of Bengal, the author had never witnessed such a fierce cyclone and destruction in his life where almost all the green cover comprising with the large and medium size trees are uprooted and roof of the thatched houses are blown with the winds for Amphan, the first ever Super Cyclone of the century.

### 4. NISARGA - A DEBUTANT CYCLONE

Climate change and global warming have changed the nature and behaviour of the Bay of Bengal, Arabian Sea and North Indian

Ocean a lot, as witnessed from the series of cyclones with tremendous intensity, havoc wind speed and huge rainfall since the last decade of the century. IPCC predicted long ago that cyclones are more powerful by increasing the potential energy available to them for warming of seas, effectively enhancing their power ceiling or speed limit. Cyclonic storm Nisarga, emerging from the Arabian Sea, is a result of such changing climatic condition and as per forecasts of the Indian Meteorological Department (IMD), Cyclone Nisarga has made landfall close to Alibag of Raigad district of Maharashtra near Lat 18.40N and Long 73.00E and 80 km south southeast of Mumbai.

Series of alarms for Cyclone Nisarga through bulletin have been issued on a regular basis by the Indian Meteorological Department (IMD) to alert the administration and the people. At 11.30 am, IMD issued such a bulletin stating Severe Cyclonic Storm Nisarga lay centered at 60 km south of Alibag, 110 km south of Mumbai, close to Raigad district. Current intensity near the centre is 100-110 km/h wind speed gusting to 120 km/h. Observations from the coastal stations by 8.30 am in the morning on 3 June by the Indian Meteorological Department (IMD) are as following (Table 4).

**Table 4:** Wind Speed and Rainfall data on the day of Cyclone Nisarga

Sl. No.	Places	Wind Speed (km/h)	Rainfall (mm)
1	Ratnagiri	55	30
2	Colaba	09	37
3	Santacruz	15	21
4	Dahanu	11	04
5	Goa	30	74

Source: Indian Meteorological Department (IMD)

IMD (Indian Meteorological Department) alarms that wind is picking up along the coast. Ratnagiri recorded 55 km/h at 8.30 am in the morning. During the landfall process, Alibag, the nearest place of landfall, reported 93 km/h wind speed at 1330 hours IST as reported by IMD.

Severe Cyclonic Storm Nisarga has been considered as the first tropical cyclone since 1891 that hit Maharashtra coast on 3 June 2020. Only two depressions, in 1948 and 1980, have come close but never turned into tropical cyclones during June, as per available records. And for India, this is the second cyclone in the season and first in the Arabian Sea as the depression intensified into a Severe Cyclonic Storm Nisarga (10). At present sea conditions are favourable as the sea surface temperature is around 31-32°C, and the vertical wind shear is high around 25-30 knots for the formation of deep depression and cyclones thereon.

## 5. CYCLONE NIVAR

The rapid rhythm of the cyclonic storm suggests an ecstatic mood which is the rhythm of seasons, rhythm of tides and waves, wind speed and rainfall and this rhythm may not be denied. Such rhythmic appearance and disappearance of the very severe cyclonic storm Nivar of the oceanic bodies of Indian Ocean and Bay of Bengal lasted for 48 hours duration and ravaged the coastal stretch of Tamil Nadu and Puducherry on 26 November 2020. Very Severe Cyclonic Storm (VSCS) Nivar was barreling towards Tamil Nadu and Puducherry on 24 and 25 November 2020, though it was generated on 21 November 2020 over the Equatorial Indian Ocean and adjoining central parts of the Bay of Bengal starting its movement initially with a formation of low pressure and

associated rainfall over South Peninsular India during 23 – 25 November 2020 as per the series of bulletin issued by the Indian Meteorological Department (IMD). IMD's forecast on 22 November 2020 of a low pressure area with the gradual intensification into a cyclonic storm ultimately formed as a very severe cyclonic storm Nivar on 24 November 2020 and the storm moved northwestwards with a speed of 13 kmph at 1730 hours IST of 25 November over Southwest Bay of Bengal (BOB) near Latitude 11.4°N and Longitude 80.7°E, about 110 km east southeast Cuddalore, about 115 km east southeast of Puducherry, and 185 km south southeast of Chennai. The landfall process of Nivar commenced at 1130 hours IST and Very Severe Cyclonic Storm Nivar lies about 50 km east southeast of Cuddalore, and about 40 km east southeast of Puducherry. Centre of the cyclone is likely to cross near Puducherry within the next 3 hours with wind speed of 120-130 kmph gusting to 145 kmph. Landfall process continues at 01.30 hours IST in the midnight and the center of the cyclone moved northwestwards with a speed of 16 kmph during past six hours on 26 November 2020. The very intense convection formed over Puducherry is weakening that leads to the decrease of intensity of the rainfall gradually, though the rainfall has been continuing. Convective clouds and squall lines in association with the feeder band of the cyclone Nivar are moving across Chennai in a regular interval that causes the intermittent rainfall precipitation – reported the Indian Meteorological Department. As Southern India is bracing for the Very Severe Cyclonic Storm Nivar, heavy rainfall is recorded in Tamil Nadu and Puducherry for the period from 24 to 26 November 2020 accordingly (Table 5).

**Table 5** Rainfall data from 0830 hours IST of 24 November to 0830 hours IST of 25 November and from 0830 hours IST of 25 November to 0230 hours IST of 26 November 2020 for the Very Severe Cyclonic Storm Nivar

Name of the place	Rainfall (mm)	
	24-25 November 2020	25-26 November 2020
Numgabakkam	106	98
Minabakkam	120	106
Chennai	128	113
Nagpatnam	87	63
Karaikal	77	96
Cuddalore	156	270
Puducherry	209	300

(source: IMD)

Ultimately the cyclone Nivar crossed Tamil Nadu and Puducherry coastal stretch near Puducherry near Latitude 12.1°N and Longitude 79.9°E at 2330 hours IST of 25 November to 0230 hours IST of 26 November 2020 as a very severe cyclonic storm with the wind speed of 100-110 kmph gusting to 120 kmph at 0230 hours IST of 26 November 2020. The entire landfall process of the very severe cyclonic storm Nivar took about 3 hours for its completion. Cyclone Nivar crossed the land exactly at the area of Marakkanam in Tamil Nadu with a peak gusty wind speed of 130 kmph and dumped over 300 mm rain in Puducherry in the wee hours of 26 November 2020. Very Severe Cyclonic Storm Nivar crossed the coast of Tamil Nadu and Puducherry as severe cyclonic storm due to gradual decrease of its intensity and is to be weakened further into a cyclonic storm during the next hours, and usually the winds with higher speed of 100 – 110 kmph will be decreased to 65 – 75 kmph when it enters farther into the lands as a storm in the northeast part of Puducherry and coastal tract of Tamil Nadu.

Strong wind speed of the Cyclone Nivar tears down the power lines, several trees are uprooted and a total of 101 huts are

damaged, though Nivar means light in Persian. The Greater Chennai Corporation cleared 223 roads after uprooted trees disrupted traffic due to Cyclone Nivar. The airport operations, metro rail, and bus transport have resumed in Tamil Nadu after Cyclone Nivar made landfall near Puducherry, while the metro and the bus resumed in the afternoon, the flight operations started at 9 am, the authorities said on 26 November 2020. Heavy rainfall causes waterlogging in several areas of Tamil Nadu and Puducherry following landfall made by Cyclone Nivar last night on 25 November. At least 33 people were killed, and several others injured in Tamil Nadu and Puducherry (11).

## 6. CYCLONE BUREVI

Cyclones sometimes doubled the roles for stormy devastation and the executioner for performing double landfall processes. The recently formed Cyclone Burevi, emerged from the Bay of Bengal and Indian Ocean, doubled up with the uncontrollable fury of nature with the double-acting landfall process in two countries consecutively striking first over Sri Lanka at Mullaittivu, north of Trincomalee on 2 December 2020,

and second yet to strike Indian coast at Tuticorin in between Kanyakumari and Pamban of Tamil Nadu scheduled on 4 December 2020 as per forecast by the Indian Meteorological Department (IMD), but the second landfall not yet happened. Cyclone Burevi is the 5th cyclonic storm in the peninsular India in 2020, and the third cyclonic event formed over the Bay of Bengal (12).

The year 2020 is a world-wide remarkable year for the corona pandemic due to the pathogenic contamination of Covid 19 and for the several severe cyclonic disturbances in coastal peninsular India. Again, the first day of December, the last month of this year 2020 starts with a cyclonic note for India as the cyclone Burevi formed over the Bay of Bengal and the adjacent ocean on 28 November and hit Sri Lanka on 2 December and the peninsular India likely on 4 December. Cyclone Burevi is generated with the formation of a low pressure area over the South Andaman Sea, and the adjoining areas of southeast Bay of Bengal, and Equatorial Indian Ocean on 28 November 2020. The low pressure area has formed a depression over the southeast Bay of Bengal on 30 November 2020 and a deep depression at 0530 hours IST on 1 December 2020, respectively. That deep depression is intensified into a cyclonic storm Burevi at 1730 hours IST on 1 December 2020 and is further intensified into a severe cyclonic storm at 1930 hour IST on 2 December 2020 as reported by the Indian Meteorological Department (IMD). Deep depression has become a cyclonic storm over the Bay of Bengal when its maximum sustained wind speed (MST) ranges from 34 to 47 knot/kmph. Cyclone Burevi is the 4th

named storm in the new list (April 2020) for the Tropical cyclonic names of the North Indian Ocean and the 5th storm in the Indian Ocean for 2020 and 3rd in the Bay of Bengal in 2020. For the influence of the cyclonic storm Burevi, coastal areas of Tamil Nadu, Puducherry, Kerala, and Maharashtra have received heavy to very heavy rainfall along with high-velocity winds, though the speed of the cyclonic movement of the cyclone Burevi is fluctuating in nature when it advances towards the coastal region (Table 6). Huge rainfall has been continuing in the coastal areas of three states for the occurrence of the Cyclone Burevi. Extreme southern districts of Tamil Nadu have received continuous heavy rainfall for the cyclonic storm (Table 7).

**Table 6** Speed of progress of Cyclone Burevi over the Bay of Bengal

Date	Time (hours IST)	Speed (kmph)
30.11.2020	1730	7
01.12.2020	0830	11
02.12.2020	0830	15
02.12.2020	1430	18
03.12.2020	0530	12
03.12.2020	1130	11
04.12.2020	0830	0 (stationary)

(Source: IMD)

Landfall process of a cyclone creates the most chaotic situations in the surrounding environments that leads to the worst weather conditions. Cyclone Burevi started its first landfall process near the north of Trincomalee in Sri Lanka by 2230 hours of IST on 2 December 2020 and it takes about three hours to complete the landfall process before entering the Gulf of Mannar in the morning of 3 December 2020. Cyclonic storm Burevi crossed the coastal areas of Sri Lanka close to north Trincomalee near Latitude 8.85°N



**Table 7** Rainfall precipitation during the advancement of Cyclone Burevi

Name of the Areas	Name of the Districts	Rainfall (cm)	
		2 – 3 December 2020	4 – 5 December 2020
Vedaranyam	Nagapattinam	20	7
Karaikal	Karaikal	16	16
Thalaignayiru	Nagapattinam	15	9
Thirupoondi	Nagapattinam	15	11
Nagapattinam	Nagapattinam	14	16
Thiruthuraiipoondi	Tiruvarur	13	7
Rameswaram	Ramanathapuram	12	11
Mudukulathur	Ramanathapuram	11	7
Sirkali	Nagapattinam	10	12
Kodavasal	Tiruvarur	10	15
Adirampattinam	Thanjavur	10	7
Manjalaru	Tiruvarur	10	7
Tiruvarur	Tiruvarur	10	7
Aduthurai Aws	Thanjavur	10	7
Tambaram	Chengalpattu	9	7
Pattukottai	Thanjavur	9	7

(Source: IMD)

and Longitude 81.0°E with a wind speed of 80-90 kmph gusting to 100 kmph with heavy to very heavy rainfall. After making landfall over northeast Sri Lanka the cyclonic storm Burevi moved west northwestwards with a speed of 12 kmph during the past 6 hours – reported by the Indian Meteorological Department (IMD). Cyclone Burevi earlier made its first landfall at night on 2nd December near the north of Trincomalee district between Thiriyaya and Kuchchaveli villages and moved near Mannar by 3 December early morning. The maximum rainfall of 279.8 mm on 2-3 December is recorded in Kilinochchi of Sri Lanka. North Sri Lanka witnessed heavy downpour with Trincomalee recording 167 mm rainfall, Jaffna 245 mm and Mannar 190 mm in 2-3 December 2020. Cyclone Burevi was no more in the status of a cyclone at 1730 hours IST of 3 December before its arrival to the Indian coast and is weakened into a deep depression as it moved over the shallow water of the Gulf of Mannar and has crossed

a longer passage over the ocean-land-ocean. The storm might lose its intensity partially because of the movement of the storm in the shallow waters of the Gulf of Mannar and ultimately the Cyclone Burevi disappeared within the ocean.

## 7. DISCUSSIONS

### 7.1 Climate Change and Cyclonic Storms

Cyclonic storms with severe devastating forms are the result of very recent phenomenon of global warming and climate change as interpreted by the meteorologists and climate change researchers, though the weather is an extraordinarily complex system for its dynamic nature and changing parameters of sensitivity. For gradual rising of sea level along the vulnerable coastal land of peninsular India due to climate change due to global warming is one of the major causes for such consecutive occurrences of cyclonic storms in recent times because of the formation of weather system over the higher sea surface temperature (SST) which is

strengthened by the sufficient energy in the form of heat and moisture in the North Indian Ocean peak cyclone season during October – December and April – June round the year respectively. Intensification of cyclonic storms over the Bay of Bengal (BOB) is directly correlated to that sea surface temperature. Even in the huge rainfall precipitation during the landfall processes of the cyclonic storms, the sea surface temperature over the Bay of Bengal is recorded 29 – 30°C for major cyclonic events in peninsular India. That sea surface temperature over the Bay of Bengal favoured and strengthened the weather system for the formation of the recent past cyclonic storms of Nivar and Burevi, though cyclone Burevi has not become a very severe cyclonic storm to the peninsular India for its physical nature of two consecutive landfall processes and the cyclonic weather system linger for a much longer duration. The weather systems come across a long distance over the warmer water of the Bay of Bengal before its strike upon the coastal region.

## **7.2 El Niño - La Niña Phenomena and the Cyclonic Storms**

Cyclonic storms sometimes accelerate the events of monsoon arrival and this happened for the year 2020 with the strike of the Super Cyclone Amphan. The probable date of arrival of south-west monsoon was advanced to 1 June 2020. Further, the El Niño and La Niña, both appear in alternate years causing reverse events of warming and cooling, sometimes drought and flooding, though La Niña favours the southwest monsoon rain in India. La Niña phenomenon is associated with sea surface temperatures and weather

phenomena opposite to those of El Niño. Indian Ocean monsoon, for instance, are typically drier than usual in El Niño years but wetter than usual in the La Niña year. Naturally, El Niño and La Niña have also major impacts on the weather systems of the Indian Ocean and the causes for the formation of cyclonic storms thereon (13 & 14). Due to such causes including the impact of climate change, series of cyclonic storms strike the peninsular India, for e.g., only after a week of devastation by the very severe cyclonic storm Nivar (26 November 2020), southern peninsular coastal stretch of India is to be ravaged again by the Cyclone Burevi. Before the occurrences of the cyclones Burevi and Nivar, Cyclone Gati hit Somalia coast on 23 November and Cyclone Nisarga destroyed Maharashtra coastal region on 6 June 2020 emerging from the Arabian Sea. Before the formation of these cyclones, Amphan, the maiden Super Cyclone of the century ravaged the south districts of Bengal of both India and Bangladesh on 20 May 2020 emerging from the Bay of Bengal. Thus, the Cyclone Burevi is the 5th cyclonic storms in peninsular India in 2020, and the third cyclonic event formed over the Bay of Bengal.

## **8. CONCLUSIONS**

The most vulnerable coastal land of peninsular India is of late considered as unsafe for living, as on average, four cyclones ravaged coastal India each year during the period from 2009 to 2020 for gradual rising of sea level. Though the coastal stretch is considered a cyclone-hit area, living closer to the sea is good for mental health as a protective zone for

psychological wellbeing where 'Blue Health' should be the only link between health and the natural environment (15). Researchers suggest living close to the sea could help to reduce mental health disorder particularly for those who live less than a kilometer from the coastal zone. Keeping all these merits and demerits with alertness, in fact, the concerned local government involves responsibility with the approaches towards appropriate disaster management due to cyclonic hazards and trains tolerance practices as the coastal population at risk is increasing annually.

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