

CYCLONIC STORM AND HEAVY RAIN FALL DRIVE TO COASTAL FLOODS:

Frequency Increasing Every Year Globally



Dr. Bharat Raj Singh
Director General (Technical),
School of Management
Sciences, Lucknow Mob: 9415025825;
email: bsringshko@yahoo.com

USA & UK northern region may get affected with cold waves, disasters, intense storms, heavy snow falls and living life may not become conducive. The cold waves, extreme temperature drop may force living population in North American and Europeans to find new places for their living. Asian region especially India surrounded by three sides from sea and fourth side from Himalayan hills, may also be affected badly with cold waves, disastrous intense storms, heavy snow falls nearby Himalayan glacier region; may cause heavy loss to the livelihood.

Climate change is something that happens very slowly on a human scale, but very quickly on a geological scale. According to satellite images from the NASA Earth Observatory, the Okjokull glacier in western Iceland appeared as a solid-white patch in 1986, but in an image from August 01, 2019, only small dashes of white ice remained.

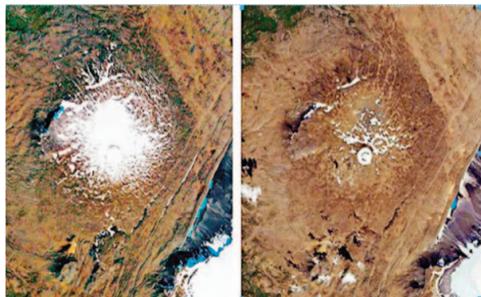


Figure 1: Scientists see the shrinking of glaciers as one of many warning signs that the earth's climate is stumbling toward dangerous tipping points (Source: The NASA Earth Observatory)

It is quite possible that flooding in coastal areas can happen in two main ways: from sustained heavy rain that doesn't drain away, or from storm surges, when storms drag the sea up and over the coastline. But when they occur together, or in close succession, the consequences can be even more severe.

We look at how heavy rainfall and high water levels combine to cause "compound flooding". The results show the risk of compound floods has increased for many major US cities in the last century starting from Dec 2013. Thereafter it is noticed that entire world's coastal areas is badly affected due to flooding. Thus we have to find out how it effects, creates increased risk for people lives and other losses in those areas due to ecological imbalances.

•Compound flooding

Compound flooding occurs when a storm weather system is passing over the sea, its low pressure centre pulls up the surface of the water and on other hand, as the storm blows onto the land; the wind pushes the sea towards the coast, creating even higher sea levels and battering the coastline with large waves. This is known as a storm surge, which can breach coastal defences and cause flooding. Heavy rainfall can combine with a storm surge to cause a "compound flood". Recent compound floods have caused substantial damages and loss of human life. Flooding caused by Typhoon Haiyan in Thailand in 2013 is one example, which left more than 6,300 people dead. Another is flooding in the UK during the winter of 2013-14, which was a result of high tides, strong winds and persistent rain.

•Increased flood risk

We assembled historical records of rainfall, tide gauge readings, and hurricane tracks to see how often compound floods have occurred at 30 sites around the US coast. The length of the record differs for each site, but two-thirds have a record at least 65 years long. It is found that the number of compound events has increased for many sites, including major cities such as Boston, New York City, Tampa, Houston, San Diego, Los Angeles, and San Francisco. These changes in the risk of compound flooding are likely to be exacerbated by ongoing sea level rise, which has been identified in other studies as the main driver for changing coastal flood risk.



Figure 2: Flooding in Plaquemine Parish, Louisiana, following Hurricane Isaac. (Credit: US Coast Guard)

•The Gulf and Atlantic coast

Similar weather patterns are found behind the arrival of storm surges and heavy rainfall in the US coastline. The particularly such cases are found along the Gulf and Atlantic coast where tropical cyclones and hurricanes often produce large storm surges and also bring significant amounts of precipitation. The New York climate during 1940s, occurred after 105 years accounting the linkage between storm surges and rainfall. In the present day, these links are now stronger, so the return period reduces again to 42 years - in total, a 5.8-fold increase in the risk of an extreme flood.

•Multiplier effect

So why is compound flooding such a threat to coastal areas in the US? The joint impacts of storm surges and heavy rainfall has a multiplier effect on coastal infrastructure and compounds the threat to coastal areas in the US - caused damage to infrastructure, such as washing-out bridges and overwhelming sewer systems, which has knock-on risks to human safety and public health.

This shows that as sea levels rise and extreme rainfall events become more frequent as global temperature rise, confirms that glaciers melting from Arctic, Antarctica and islands are major source and the risks of compound flooding are likely to increase through this century. By understanding how these risks have changed in the past, we can hope to

make better predictions of how they may change in the years ahead.

Prof. Bharat Raj Singh, School of management Sciences, Lucknow, who is editor of the book: **Climate Change - Realities, Impacts Over Ice Cap, Sea Level and Risks**, ISBN 978-953-51-0934-1, Published in January 2013 by InTech, Rijeka, Croatia Page 63, had already predicted long back in the said book and reproduced as under:

"The studies and reports show that the potential for runaway greenhouse warming due to release of carbon dioxide and other gases in the atmosphere which is the cause of potential increase of the global temperature, and subsequent melting of ice cap, rise in sea level, and it triggers the disasters and major issues are noticed as: i). Emissions from human activities are increasing the frequency of extreme weather events, ii). Due to climate change there are likely to be many more heat waves, droughts and changes in rainfall patterns, iii). By 2050, sea-rise could reach 2.5ft and more than 4.5ft by 2080 under the same conditions, iv). Global warming threatens the planet in a new and unexpected way - by triggering earthquakes, tsunamis, avalanches and volcanic eruptions, v). Severe storms of the future would put a third of New York City streets under water and flood many of the tunnels leading into Manhattan in under an hour because of climate change and vi). Climate changes may still be avoided if we transform our hydrocarbon based energy systems and if we initiate rational and adequately financed adaptation programmes to forestall disasters and migrations at unprecedented scales."

In the another book of Prof. Singh: **Global Warming - Causes, Impacts and Remedies**, ISBN 978-953-51-0934-1, Published in April 2015 by InTech, Rijeka, Croatia Page 39-40, Chapter Title: Study of Impacts on Continues Shrinkage of Arctic Sea & Sea Level Rise had specifically predicted about Asian region especially India which is three sides surrounded from sea and fourth side from Himalayan hills may cause heavy loss to the livelihood and reproduced as under:

There are very strong signs already been seen in the rate of sea ice change for the last one decade and happening by 2020 or 2030 is not unrealistic while most of the ocean basin will remain ice free through the summer from the North America map. Only a small amount of sea ice will remain along the north coasts of Greenland, USA and Canada by 2040. There are possibilities to grow glacier near north coast's due to heavy ice sheets meeting in the Atlantic sea that may not convert into water quickly and create pressure drop, snow fall, extreme temperature drop to minus (-) 60-70 degree centigrade. Northern region of USA & UK may get affected with cold waves, disasters, intense storms, heavy snow falls and living life may not become conducive. This disaster climatic effect may force living population of North American and Europeans to find new places for their living. Asian region especially India which is surrounded by three sides from sea and fourth side from Himalayan hills, may also get badly affected with cold waves, disastrous intense storms, heavy snow falls nearby Himalayan glacier region; may cause heavy loss to the livelihood. It is also expected that the situation may go bad to worst every year and will continue in till next decade. During winter, New York, Britain and Canada i.e., northern belt, may suffer with extreme weather conditions such as: intense storm, heavy snow fall and power disruption. Thus it is need of the hour to act very fast to help in stopping Climate Change due to Global warming by adopting means of "Save Earth and Save Life" for happy living.

Why heavy rainfall expected up to 150 mm in coastal area of India?

India is surrounded by three sides from coastal and fourth side from Himalayan hills. About 560 million against total population of 128 billion about 43.7% of Indian population lives in coastal States and Union Territories and 171 million (14.2% of population lives in coastal area and Coastal districts of India. These are often low-lying and a densely-populated area, which means flooding, can have devastating impacts. As per above predictions, we are this year facing multifold divesting impact of flooding in the coastal area and landslides in Himalaya regions.

Table 1: Population

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S.No.	Total Population of India	1.28 billion (Census 2014, Source: www.indiaonlinepages.com)
1.	Population of Coastal States and Union Territories	560 million against total population of 128 billion
2.	Population of Island Territories	0.44 million
3.	Total Population of coastal districts	171 million
4.	Percentage of population in coastal area and Coastal districts of India	14.2%

For the last 5 years India faced Hurricanes and Divesting Impact in Himalayan Region

India is facing major cyclonic storms and caused high wind storm, heavy rain falls and its frequency is increasing every year as few mentioned below:

Kedarnath Disaster June 16-17, 2013

The Kedarnath valley, along with other parts of the state of Uttarakhand, was hit with unprecedented flash floods on 16 and 17 June 2013. On 16 June, at about 7:30 p.m. a landslide and mudslides occurred near Kedarnath Temple with loud peals of thunder. Prof. Singh was the only Scientist who declared it is not cloud burst but it happened due to hair crack into the thick glacier sheets on account of global warming at high altitude of Himalayan. The heavy glacier sheets gone down during first rain and created havoc. Such landslides and mudslides frequency will increase in future every year all over the Himalayan with more intensity and will disrupt the life of this region.



Figure 3: Disastrous Flooding at Kedarnath Temple

Cyclonic Storm Phailin in Odisha, October 12, 2013

The severe cyclone storm "Phailin" that hit the coast of Odisha on October 12, 2013, brought with it very high speed winds and heavy rainfall that caused extensive damages particularly to houses, standing crops, power and

communication infrastructure in the coastal districts of the state. The need to immediately start recovery and reconstruction work after Cyclone Phailin, especially in the affected districts, has prompted the state government, in collaboration with the World Bank and the Asian Development Bank, to initiate an assessment of the recovery needs in order to draw up a comprehensive recovery framework. This rapid damage and needs assessment report details the damage caused due to the storm, and the action taken for effective recovery after the impact. It provides a detailed analysis of the affected sectors, the extent of damages sustained, the reconstruction and recovery needs, and the recovery strategy.



Figure 4: Cyclonic Storm Phailin

Cyclonic Storm Hudhud in Andhra Pradesh, October 12, 2014

On October 11, Hudhud underwent rapid intensification and developed an eye at its center. In the following hours, the storm reached its peak intensity with a minimum central pressure of 950 mbar (28.05 in Hg) and three-minute average wind speeds of 185 km/h (115 mph). Maintaining intensity, it made landfall over Visakhapatnam, Andhra Pradesh at noon of October 12, near 17.7°N 83.3°E. The maximum wind gust recorded by the High Wind Speed Recorder (HWSR) instrument of the Cyclone Warning Center in Visakhapatnam was 260 km/h (160 mph). Measured by the Doppler weather radar stationed in the city, the storm's eye was 66 km (41 mi) in diameter. The strength of the winds disrupted telecommunication lines and damaged the radar, inhibiting further observations. Bringing extensive damage to the coastal districts of Andhra Pradesh, Hudhud gradually weakened as it curved northwards over land. The storm continued its weakening trend and was last noted as a well-marked low pressure area over east Uttar Pradesh on October 14. Unlike most BoB storms that dissipate quickly over land, Hudhud has been the only TC whose remnant ever reached as far north as the Himalayas.

Cyclonic Storm Nilofar in Gujarat, October 31, 2014

The third-strongest cyclone in the Arabian Sea, in late October 2014, reached peak maximum sustained winds estimated between 205 km/h (125 mph) and 215 km/h (130 mph). The India Meteorological Department (IMD) named it Nilofar; the name refers to the water lily, and was suggested by Pakistan. The western fringes of the storm caused flash flooding in northeastern Oman, killing four people.

Nilofar originated from a low pressure area between India and the Arabian Peninsula. It developed into a depression on October 25 and moved generally northward through an area of favorable conditions. The system intensified into a cyclonic storm on October 26. Quickly organizing due to the conditions, Nilofar developed a well-defined eye and structure, attaining its peak intensity on October 28. At the time, Nilofar was expected to make landfall in western India, prompting evacuations and preparations. However, high shear caused the storm to rapidly weaken, and Nilofar degraded into a remnant low pressure area on October 31 off the Indian state of Gujarat.

Severe Cyclonic Storm Chapala, October 28, 2015

The third named storm of the 2015 North Indian Ocean cyclone season, it developed on 28 October off western India from the monsoon trough. Fueled by record warm water temperatures, the system quickly intensified and was named Chapala by the India Meteorological Department (IMD). By 30 October, the storm developed an eye in the center of a well-defined circular area of deep convection. That day, the IMD estimated peak three-minute sustained winds of 215 km/h (130 mph), and the JTWC estimated one-minute winds of 240 km/h (150 mph); only Cyclone Gonu in 2007 was stronger in the Arabian Sea.

After peak intensity, Chapala skirted the Yemeni island of Socotra on 1 November. Drier air and increased wind shear weakened the cyclone, although it maintained much of its intensity upon entering the Gulf of Aden on 2 November, becoming the strongest known cyclone in that body of water. After bypassing northern Somalia, Chapala weakened further and turned to the west-northwest. Early on 3 November, the storm made landfall near Mukalla, Yemen, as a very severe cyclonic storm, making it the strongest storm on record to strike the nation. The storm dissipated the next day.

Cyclone Titi in Odisha, Oct 11, 2018

Cyclone Titi killed at least eight people in Andhra Pradesh and left a trail of destruction in Odisha after making landfall early today morning. Titi made landfall as a very severe cyclonic storm with wind speeds of 130-140 kmph. Shortly after crossing the coast of southern Odisha and northern Andhra Pradesh, Titi weakened to a severe cyclonic storm with wind speeds of 90-100 kmph. Through the day, Titi continued to weaken in intensity and the India Meteorological Department has predicted that by tonight, Titi will become a deep depression. A red alert (the highest category of warning for rain) remains in effect for parts of Odisha. The IMD has predicted heavy to very heavy rain in Odisha and the risk of flooding in the state persists. While there was widespread damage in Odisha, the state achieved its 'zero casualties' target with Cyclone Titi passing by without any loss life. A total of eight districts in Odisha -- Ganjam, Gajapati, Khurda, Puri, Jagatsinghpur, Kendrapara, Bhubaneswar and Balasore -- were affected by Cyclone Titi.

Phethai Dust storms to floods, Kerala, Dec 19, 2018

Cyclone Phethai made landfall in Andhra Pradesh, displacing thousands of people. It comes just about a month after Cyclone Gaja devastated neighbouring Tamil Nadu, Kerala, and Puducherry. That cyclone, which caused wind speeds to surge to 120kmph, claimed the lives of at least 45 people and caused extensive damage to houses, crops, and infrastructure.

Cyclonic Storm Fani in Odisha May 03, 2019

An enormous tropical cyclone made landfall in eastern India Friday near the coastal city of Puri, impacting an area that's home to tens of millions of people. It's believed the storm, called Cyclone Fani (pronounced "Foni"), struck the coast with winds in excess of 115 miles per hour (equivalent to a Category 3 hurricane). That makes it the strongest storm to hit India in 20 years. CycloneFani made landfall close to Puri in Odisha, with max wind speeds 180-190 km/h (Cat 3 equivalent), and forecast to move NNE and weaken as it moves towards West Bengal and then on to Bangladesh. The

storm has since weakened but will remain a dangerous system as it moves up India's east coast toward Bangladesh, where 2.1 million people were evacuated. Flash flooding and potentially deadly landslides may occur. Overall, the United Nations warns that 28 million people live in the path of the storm.



Figure 5: Cyclonic Storm Fani

Cyclonic Storm Vayu in Gujarat, June 12, 2019

Six million people could be affected by hurricane-strength Tropical Cyclone Vayu, which is barreling toward northwest India and will skirt the coastline of Gujarat beginning Thursday morning. Almost 300,000 people are set to be evacuated to 700 shelter homes, a spokesperson for India's Home Ministry said Wednesday. Schools and colleges in the area are closed until Friday, officials said. With winds of 170 kmph (100 mph), Tropical Cyclone Vayu could become the strongest cyclone to strike northwestern India in decades. It comes a month after powerful Tropical Cyclone Fani slammed into India's northeastern coast.

Vayu passed about 300 kilometers (185 miles) west of Mumbai on Wednesday, moving north toward the Gujarat coastline. The forecast calls for the storm to turn west, which could keep the center of the storm just offshore over the next 48 hours as it moves parallel to the Saurashtra Peninsula and Kutch district of Gujarat. But even if the storm does not make an official landfall -- meaning the center, or eye, of the storm moves onshore -- at least half the storm will be over land, so the coastal region will be hit directly by rain, wind and storm surge. India has deployed 39 National Disaster Response Force teams -- each with about 45 people -- to help local authorities with evacuation, search, rescue and relief operations. The army has 34 teams on standby.

Extreme Rainfall and Landslides in India during 2019

While the monsoon is eagerly awaited in India, where rain dependent agriculture accounts for a significant proportion of employment and GDP, this year's downpour wreaked havoc across several states. In July-August 2019, heavy rainfall caused landslides in the northern states of Uttarakhand, Himachal Pradesh and Jammu & Kashmir Haryana, while flooding cities such as: coastal Karnataka, Kerala; Pune and Mumbai in Maharashtra, Baroda, Ahmedabad in Gujarat, Rajasthan, Madhya Pradesh and in the north east & west portion of West Bengal up to Aug 05, 2019-Most westerly winds from the Arabian Sea will impact the Konkan region. Total rainfall of 100 mm will be common along coastal Maharashtra, Karnataka and Kerala. Locally heavy rain up to 150 mm is possible. Southerly winds from Bay of Bengal will keep Northeastern India drenched. Here is the regional rainfall breakup by intensity: i). Heavy to very heavy rain and thunderstorms: Coastal Maharashtra, Goa, and coastal Karnataka, ii). Heavy rain and thunderstorms: Gujarat, east Rajasthan, Uttarakhand, Chhattisgarh, Madhya Pradesh, Kerala, and Andaman & Nicobar Islands, iii). Fairly widespread rain and thunderstorms: Haryana, Chandigarh, Punjab, Delhi, Uttar Pradesh, Himachal Pradesh, Sikkim, West Bengal, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, Bihar, Jharkhand, Odisha, interior Maharashtra, Telangana, interior Karnataka, and Andhra Pradesh, iv). Scattered rain and thunderstorms: Jammu & Kashmir and west Rajasthan and v). Isolated rain and thunderstorms: Tamil Nadu. Max temperatures of 40°C or more are likely over a part of west Rajasthan.

Aug 06, 2019 and beyond-A part of inland Gujarat Rajasthan, and Madhya Pradesh may receive 50 mm rainfall until Wednesday morning due to wind convergence of westerly winds and northwesterly winds. Intense and prolonged rain may cause flash flooding. A Cyclonic Circulation over North Bay of Bengal will slowly move westward, forming a low pressure area along the monsoon trough and bringing locally heavy rain and thunderstorms. The circulation will be over Eastern India, Central India on Thursday, and the Northern plain. A trough over Northern plain, a feeble Western Disturbance at upper level, and a feeble Cyclonic Circulation over western Uttar Pradesh will trigger rainfall and thunderstorms mainly over the Northern Plain. The intensity is expected to increase as we head into the weekend. Rough sea conditions are likely in Central Arabian Sea and the Bay of Bengal. Strong winds reaching 40-50 kmph are expected off the coast of Konkan region, Odisha, and Andhra Pradesh, and over Andaman & Nicobar Islands this weekend and into next week.

From above, we found that extreme havoc, dusty storm, cyclonic storm and landslides in hilly area started from USA since 2014 and now its frequency has gone in multi-fold throughout the world. The most affected areas are USA, Canada, UK, India, China, Japan, Thailand, Australia, and Neausiland etc. where risk of casualty, damage to infrastructure like: homes, flushing away the bridges, power stations is going higher every year. This is only because of manmade problem of global warming that has badly put ecological system un-predictive. The GDP of developed and developing countries are going down due to heavy expenditure over disaster management control. We have look back to control environmental damage and put back our nature with 60% greenery by planting trees, recharging our urban and rural regions with water reservoirs, using renewable energy as much as possible. The weight shift of melting ice from polar (Northern / Southern coast) to sea, might create change in the spinning angle of the Earth from 23.43 degree to further (+) or (-). The day may be a dark day on the beautiful planet when the entire living creatures may face dire consequences of their end up, provided things are checked and not to go beyond our control today. Thus it is need of the hour to act very fast to help in stopping Climate Change due to Global Warming by adopting means to Save Earth and Save Life for happy living.