Information:

The Climate Hazard & Vulnerability Atlas of India has been prepared for the thirteen most hazardous meteorological events, which cause extensive damages, economic, human, and animal losses. For a visual display of the Climate Vulnerability maps, we have used Geographic Information System (GIS) tools at the office of Climate Research and Services, India Meteorological Department Pune. The primary purpose of the Climate Vulnerability maps is for the users of disaster management sectors to identify the vulnerable districts for taking preventive and adaptive measures. Thus, in vulnerability maps, vulnerability assessment was focused at the district levels.

Since the Atlas is presented in WebGIS, the information on the values of the parameter and other information can be seen by keeping the cursor on the district. The facility of identifying the location and search option for the desired district to get the value of the parameter are made available on the top left side of the panel of each map. Total 640 maps are available in this web version of Climate Vulnerability Atlas.

For the analysis, we have considered the following data:

i. Disaster data from IMD publication "Annual Disastrous Weather Event" for the period 1967 – 2019. This publication provides information on the disaster events and their casualties in terms of human loss as per media reports and other official reports from various government agencies.
ii. IMD Climatological Normal for various meteorological parameters for the period 1981-2010.
iii. Hourly autographic data and three hourly synoptic hours data of surface meteorological stations of IMD. (http://dsp.imdpune.gov.in/)
iv. IMD Best Track Cyclone data for the period 1981-2020 (http://www.rsmcnewdelhi.imd.gov.in/index.php?option=com_content&view=article&id=48&Itemid=194&lang=en)
v. IMD digital Cyclone track data from Cyclone e Atlas for the period 1871-2020 provided by RMC Chennai. (http://www.imdchennai.gov.in/)
vi. Daily District rainfall data of IMD for the period 1901-2020.
vii. Daily rainfall data for more than 9000 rain gauge stations for the period 1901-2020.
viii. Census data of population density and housing density for cyclone vulnerability (https://censusindia.gov.in/2011-common/censusdata2011.html)
ix. Storm surge data from reports of RSMC, New Delhi (http://www.rsmcnewdelhi.imd.gov.in/index.php?option=com_content&view=article&id=177&Itemid=175&lang=en)

Computation of Normalized Vulnerability Index (NVI)

To compute the Normalized Vulnerability index (NVI) corresponding to each indicator for the i^{th} district, we have normalized the indicator values, which standardizes the disaster values to the range between 0.0 to 1.0 (Ref. Wu et al. 2002, Karmakar et al. 2010, Raskar-Phule and Choudhury, 2015, O'Brien et al. 2004, Leichenko, R. et al. 2004 etc.).

$$Normalized\ Value = \frac{\text{Actual Indicator Value} - \text{Minimum Indicator Value}}{Maximum\ Indicator\ Value - Minimum\ Indicator\ Value} \quad \dots (1)$$

A similar index has also been used in the report on "Climate Vulnerability Assessment for the Indian Himalayan Region," National Mission of Sustaining the Himalayan Ecosystem, 2018-19 (https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf)

Normalized values are categorized in four parts by using four quartiles and are given below:

Normalized Vulnerability Index value	Category
0.0	NIL
0.0 <VI ≤ 0.25	Low
0.25 <VI ≤ 0.50	Moderate
0.50 <VI ≤ 0.75	High
0.75 < VI ≤ 1	Very High

United Nations Office for Disaster Risk Reduction (UNDRR) and the International Science Council (ISC) launched an ambitious science project to identify the full scope of all hazards relevant to the Sendai Framework and the scientific definitions of these hazards. UNDRR-ISC, "Hazard Definition & Classification Review", Technical Report, published on October 4, 2021, has provided a clear definition of the hazard and vulnerability. This publication along with its supplement gives very useful information and identification of hazard events. The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.The Atlas gives for Hazard events and vulnerability separately. After the selection of Climate Hazard it will highlight the events related to it. These maps are prepared based on the climatological information and using different statistical and mathematical methods like computation of extreme wind speed of 50 years return period from the past long period data, climatological averages etc. No data on mortality or human casualties are considered for the preparation of these maps. The detailed information on these parameters are given below:

Climate Hazard Maps

1. Dust storm: Dust storms are common meteorological hazards in arid and semi-arid regions. It is usually caused by thunderstorms or strong pressure gradients associated with cyclones which increase wind speed over a wide area. These strong winds lift large amounts of sand and dust from bare, dry soils into the atmosphere, transporting them hundreds to thousands of kilometers away. Some 40% of aerosols in the troposphere (the lowest layer of the earth's atmosphere) are dust particles from wind erosion. Airborne dust presents serious risks for human health. Dust particle size is a key determinant of the potential hazard to human health. Particles larger than 10 µm are not breathable, thus can only damage external organs – mostly causing skin and eye irritations, conjunctivitis, and enhanced susceptibility to ocular infection. Inhalable particles, those smaller than 10 µm, often get trapped in the nose, mouth, and upper respiratory tract, and thus can be associated with respiratory disorders such as asthma, tracheitis, pneumonia, allergic rhinitis, and silicosis. However, finer particles may penetrate the lower respiratory tract and enter the bloodstream, affecting all internal organs and being responsible for cardiovascular disorders.

   Dust storm climatological values for the period 1981-2010 have been used for the preparation of theses maps. Since it is a part of weather phenomena, we are producing two types of district maps in our Atlas for this event, viz. monthly and annual climatology of frequencies of event. In addition, the Normalized Vulnerability index is being calculated for each district as per the formula mentioned in equation 1. Total twenty-six maps are presented.

2. Hail storm: Typically, hail is a cascading effect of a thunderstorm event. A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with the rain. Extreme temperature changes from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Hailstorms are usually considered "severe" when hail is larger than 1" and accompanied by winds greater than 58 miles per hour. The severity of hail events range based on the size of hail, winds, and structures in the path of a hailstorm. Storms that produce high winds in addition to hail are most damaging and can result in numerous broken windows and damaged siding. Hailstorms can cause extensive property damage affecting both urban and rural landscapes. These can cause damage to crops, livestock, and wildlife and can cause extensive damage to buildings, including roofs, windows, and outside walls. Vehicles can be total losses. When hail breaks windows, water damage from accompanying rains can also be significant.

   Hail storm climatological values for the period 1981-2010 have been used for the preparation of theses maps. Since it is a part of weather phenomena, we are producing two types of district maps in our Vulnerability Atlas for this event, viz. monthly and annual climatology of frequencies of the event for each district. In addition, the Normalized Vulnerability Index is being calculated for each district as per the formula mentioned in equation 1. Total twenty-six maps are presented.

3. Thunderstorm: A thunderstorm is a type of storm with lightning and thunder. They are caused by an updraft, which occurs when warm, moist air rises vertically into the atmosphere. The updraft creates a cumulus cloud, which will eventually be the thunderstorm cloud. The basic factors that form a thunderstorm are moisture, unstable air, and a Lifting mechanism. Every thunderstorm produces lightning, which kills more people each year than tornadoes. Heavy rain from thunderstorms can lead to flash flooding, strong winds, hail, and tornadoes are also dangers associated with thunderstorms.

   Thunderstorm climatological values for the period 1981-2010 have been used for the preparation of theses maps. Since it is a part of weather phenomena, we are producing two types of district maps in our Vulnerability Atlas for this event, viz. monthly and annual climatology of frequencies of the event for each district. In addition, the Normalized Vulnerability Index is being calculated for each district as per formula mentioned in equation 1. Total twenty-six maps are presented.

4. Fog: Fog is a visible aerosol comprising tiny water droplets or ice crystals suspended in the air at or near the earth's surface. Nearby bodies of water, topography, and weather conditions are three factors that influence fog. Fog formation starts when the air near the earth's surface becomes saturated. Air in this area becomes saturated by any of these three processes: cooling, the addition of moisture, and mixing with another air parcel. Depending on the concentration of the droplets, visibility in fog can range from the appearance of haze to almost zero. Many lives are lost each year worldwide from accidents involving fog conditions on the highways, including multiple-vehicle collisions. The aviation travel industry is affected by the severity of fog conditions. Fog is also having an impact on health. Vapor in the fog impacts breathing adversely. But generally, smog which is a combination of fog and smoke has a dangerous effect on health.

   Fog climatological values for the period 1981-2010 have been used for the preparation of theses maps. Since it is a part of weather phenomena, we are producing two types of district maps in our Vulnerability Atlas for this event, viz. monthly and annual climatology of frequencies of the event for each district. In addition, the Normalized Vulnerability Index is being calculated for each district as per the formula mentioned in equation 1. Total twenty-six maps are presented.

5. Lightning: Lightning is an electrical discharge caused by imbalances between storm clouds and the ground or within the clouds themselves. Most lightning

occurs within the clouds. In the early stages of development, air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges build up enough, this insulating capacity of the air breaks down and there is a rapid discharge of electricity that we know as lightning. The flash of lightning temporarily equalizes the charged regions in the atmosphere until the opposite charges build up again. Lightning can set off building or farm fires, damage electrical equipment, and electrocute humans and livestock. Lightning can enter your home by following wires and pipes that go into the ground; it can also travel through metal reinforcing wire or bars in concrete and explode. Lightning often knocks out power lines and sends powerful electrical surges through electrical and phone lines. Once in your home, they can burn out appliances and other electronics.

The climatology of lightning observation obtained from the Global Hydrometeorology Resource Centre (GHRC) of National Aeronautics and Space Administration (NASA). It provides a comprehensive active archive of both data and knowledge augmentation services with a focus on hazardous weather. GHRC focuses on lightning, tropical cyclones and storm-induced hazards through integrated collections of satellite, airborne, and in-situ data sets.
The TRMM LIS 0.1 Degree Very High Resolution Gridded Climatology data collection consists of a set of gridded climatologies constructed from individual observations made by the Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission (TRMM) satellite (data also at GHRC). Complex algorithms are used to estimate total flash rate density (number of flashes per square kilometer per year) based on the flashes observed by the instrument and the amount of time it viewed a given area.

This Very High Resolution (VHR) Gridded Lightning Climatology Collection consists of lightning climatology for Annual and monthly for the period 1998-2013.
The data set is freely available to download from the following link;
https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_vhr-climatology.html

Reference : Cecil, Daniel J. 2006. LIS/OTD 0.5 Degree High Resolution Annual Climatology (HRAC) [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. DOI: http://dx.doi.org/10.5067/LIS/LIS-OTD/DATA301

6. Wind Hazard: Extreme wind that may be associated with any weather systems like thunderstorms, cyclones etc is one of the major hazards to the society as the extreme wind can damage any structure, including the building of various types, electrical infrastructure, telecom industry, agriculture, and forest as well as transport and other sectors.

We have initially used hourly wind data from 39 IMD autographic stations with 15 years or more data to compute extreme wind. This hourly data also report the daily maximum gusty wind speed. Since the number of autographic data stations is very small, we have also considered daily synoptic hour data of 490 stations with 15 years or more data. From these 490 stations data, we have prepared month-wise annual maximum wind series data for computation of 50 years return period extreme values. Since these 490 synoptic stations are not reporting gusty wind speed, 50 years of extreme return values were first extracted to represent extreme gusty wind speed. Then the relation between hourly extreme values and maximum gust wind speed for 39 autographic stations were obtained and average over all the 39 stations to establish the relationship between maximum wind and gusty wind over India. We have then multiplied this factor to 50 years return period extreme values obtained from annual maximum series to obtain 50 years return period extreme values of maximum gusty wind speed of 490 stations. Using QGIS raster statistics, finally, monthly wind hazard maps are prepared for 12 months and for annual. In addition, the Normalized Vulnerability Index is being calculated for each district as per the formula mentioned in equation 1.

7. Extreme rainfall Events: Rainfall events of high intensities are in most cases cause by floods, waterlogging, landslides and many other disasters. information of maximum probable frequencies (number of days) of extreme rainfall events (heavy, very heavy, or extremely heavy) of each district from the past record of more than 100 years can identify the districts vulnerable to extreme events. In order to view the climate change impact on extreme rainfall events in various decades, the extreme rainfall information is made available for different decades and periods viz. 1951-60, 1961-70, 1971-80, 1981-1990, 1991-2000, 2001-2010, 2011-2019, 1901-2019 and 1951-2019. The user has to select the period from the drop-down menu available while clicking on Extreme Rainfall. After selecting the desired period/decade, one can get the vulnerability maps for four seasons, annual and for the monsoon months viz. June, July, August, and September. For any season/month or annual, there are three events viz. maximum probable frequency of Heavy rainfall event, maximum probable frequency of Very Heavy & Extremely Heavy rainfall events, and maximum probable frequency of Heavy, Very Heavy & Extremely Heavy rainfall events. For extracting maximum probable frequency, we have considered the maximum frequency among all the raingauge stations in the district for the selected period. The hazard caused by the extreme rainfall event is generally not limited to a point station where the observation is made but may spread wider areas of the district and cause an impact on increasing flood events, water quality, health, and other societal problems. Thus the climatology of the frequency of extreme rainfall events is helpful to identify the districts vulnerable to frequent extreme rainfall events. Followings are the terminologies used by the India Meteorological Department for different extreme rainfall events and have been used in our analysis:

Terminology	Rainfall range in mm
Heavy Rainfall	64.5- 115.5
Very Heavy Rainfall	115.6-204.4
Extremely Heavy rainfall	Greater or equal to 204.5

8. Drought: Drought occurs due to deficiency of rainfall for an extended period of time, resulting in meteorological drought and causing lack of soil moisture leading to extensive damage to crops, loss of yield, resulting in a water shortage causing adverse impacts on vegetation, animals, and people. There are various indicators for monitoring drought in different temporal scales. In our present analysis, we have considered the Standardized Precipitation Index (SPI) for identifying the drought. SPI is computed for the cumulative period of four months (June-September) southwest monsoon season. It is computed for each year for the period 1901-2020 for all the districts using monthly rainfall data of districts and frequency of droughts of each category viz. moderate, severe, extreme drought and combination of all categories are computed. Finally, the Normalized Vulnerability Index is calculated for each district as per the formula mentioned in equation 1 for each category separately.

9. Cyclone: It is one of the major meteorological disasters in coastal areas of India. Cyclones are intense low-pressure areas from the center of which pressure increases outwards. The amount of pressure drop in the center and the rate at which it increases outwards gives the intensity of the cyclones and the strength of winds. The criteria followed by the India Meteorological Department (IMD) to classify the low pressure systems in the Bay of Bengal and in the Arabian Sea as adopted by the World Meteorological Organisation (W.M.O.) are given in the following Table:

   Table : Criteria for classification of cyclonic disturbances over the North Indian Ocean

Type of disturbance	Associated maximum sustained wind (MSW)
1. Low Pressure Area	Not exceeding 17 knots (<31 kmph)
2. Depression(D)	17 to 27 knots (31-49 kmph)
3. Deep Depression(DD)	28 to 33 knots (50-61 kmph)
4. Cyclonic Storm(CS)	34 to 47 knots (62-88 kmph)
5. Severe Cyclonic Storm(SCS)	48 to 63 knots (89-117 kmph)
6. Very Severe Cyclonic Storm(VCS)	64 to 119 knots (118-221 kmph)
7. Super Cyclonic Storm	120 knots and above (≥222 kmph)

We have considered IMD Cyclone data from Cyclone e Atlas for the period 1961-2020 for computation of several parameters. Since in cyclone eAtlas information on cyclone is combined for SCS, VCS and Super Cyclonic Storm and termed as SCS, in all our maps we have produced the information on Cyclonic Storm (CS) and Severe

Cyclonic Storm(that combined SCS, VCS and Super Cyclonic Storm). In order view the climate vulnerability of cyclones in various decades, the information is made available for different decades and periods viz. 1961-70, 1971-80, 1981-1990, 1991-2000, 2001-2010, 2011-2020 and 1961-2020. The user has to select the period from the drop-down menu available while clicking on cyclone. After selecting the desired period/decade, one can get the vulnerability maps.

Cyclone return periods (CS, SCS, and combining CS and SCS) are computed in coastal districts for all the month and annual scale. The methodology is based on computing the Hurricane return period by NOAA. Cyclone return periods are the frequency at which a certain cyclone intensity can be expected within a given distance of a given location within a specified buffer zone around the district(we have considered 50 nm as a buffer zone). (Ref: NOAA Technical Memorandum NWS NHC 38). Cyclone return periods maps are given for CS, SCS and ALL categories

The maximum probable precipitation of each district corresponding to cyclone days is computed from the daily station rainfall data for the period. Considering the horizontal scales of the cyclone and their effect in producing rainfall in the broader area, a buffer zone of 2.5° around each district is used. Also, to identify the rainfall related to cyclone activity only, we have considered the rainfall of all the stations for the cyclone days and within 500 km of the cyclone location. These maps are made on a monthly and annual scale.

Cyclone Landfall Count for each district gives the total number of cyclone (of any intensities) made landfall over the district during the period. These maps are made for all the months and on an annual scale.

For the computation of Maximum sustained wind in each district IMD Best Track Cyclone data for the period 1981-2020 is used, and the same buffer zone of 2.5° is considered. This map is made for an annual scale.

Maximum Storm surge heights map in annual scale gives the maximum storm surge heights in meter each of the coastal district experienced so far associated with cyclone.

We have also considered population density data and housing density data from Census data. The Normalized vulnerability index is calculated as described by equation 1 for each parameter viz. maximum probable precipitation, cyclone return period, maximum sustained wind, storm surge height, housing, and population density. Finally weighted average Normalized Cyclone Vulnerability index is computed with suitable weights. These maps are made on an annual scale.

Climate Vulnerability Maps

India Meteorological Department publishes Annual Disaster Weather Report every year for the climate hazardous events that cause casualties in terms of death and other losses. This publication is available since the year 1969. Only those events that resulted in human death are being considered from these reports for the preparation of climate vulnerability maps. Followings are the detailed information of these maps:

10. Cold wave: The cold wave conditions signify a certain amount of fall of temperature at a given place with respect to normal climatological value. In India, the cold wave (CW) conditions are generally experienced during the period from November to March However; the disaster data shows that the damages and casualties are associated with CWs during the months of December to March. It has a severe impact on human health, varying from Cough and cold, bronchitis and respiratory diseases, Blood pressure issues, Skin problems, and even Bone, joint, and muscle pain due to lack of sunlight. The health conditions, particularly of the poor people, are seriously affected, and in extreme cases even it causes casualty.

The criteria adopted by IMD to define Cold Wave is given below:

(a) Cold Wave is considered when the minimum temperature of a station is 10^0C or less for plains and 0°C or less for Hilly regions.

(i) Based on Departure

Cold Wave: Negative Departure from normal is 4.5°C to 6.4°C

Severe Cold Wave: Negative Departure from normal is more than 6.4°C

(ii) Based on Actual Minimum Temperature (For plain stations only)

Cold Wave: When minimum temperature is ≤ 04°C

Severe Cold Wave: When minimum temperature is ≤ 02°C

b) Cold Wave conditions for coastal stations

When minimum temperature departure is -4.5°C or less over a station, “Cold Wave” may be described if the minimum temperature is 15^0C or less.

Annual Disaster Weather Report published by India Meteorological Department reports the cold wave cases over India that caused hazards in terms of human death. Though actual cold wave cases were more, only the cases that caused human death were reported and are considered in our analysis. For each of four months and annual scale, there are two maps showing the total number of cold wave days that caused casualties to the humans, and the Normalized Vulnerability Index calculated for each district as per the formula mentioned in equation 1.

11. Heatwave: The heatwave conditions signify a certain amount of rising of temperature at a given place with respect to normal climatological value. In India, heatwave (HW) conditions are generally experienced during the period from March to July. Annual Disaster Weather Reports published by India Meteorological Department show records of the heatwave cases over India that caused hazards in terms of human death. Disaster data shows that the

damages and casualties associated with HWs are observed during the months of May to July. Heatwave is an emerging public-health problem. Extreme heat can lead to minor illnesses, such as heat rash, heat edema, heat cramps, and tetany, and serious illnesses such as heat syncope, heat exhaustion, and heatstroke. Heatstroke is the most severe form of heat-related illness.

The criteria adopted by IMD to define Heat Wave is given below:

Heatwave is considered if the maximum temperature of a station reaches at least 40^0C or more for Plains and at least 30^0C or more for Hilly regions.

a) Based on Departure from Normal
Heatwave: Departure from normal is 4.5^0C to 6.4^0C
Severe Heatwave: Departure from normal is >6.4^0C
b) Based on Actual Maximum Temperature
Heatwave: When the actual maximum temperature ≥ 45^0C
Severe Heatwave: When the actual maximum temperature ≥47^0C
c) Criteria for describing Heatwave for coastal stations
When maximum temperature departure is 4.5^0C or more from normal, Heatwave may be described, provided the actual maximum temperature is 37^0C or more.

For each of four months and annual scale, there are maps showing the total number of heatwave days that caused casualties to the humans. In addition, the Normalized Vulnerability Index is being calculated and presented for each month and annual for each district as per the formula mentioned in equation 1.

12. Flood: Floods are associated with heavy to very heavy or extremely heavy rainfall for a spell from 1 day to 3 days or even more than three days. Also, some floods like flash floods and urban floods occur due to occurrences of intense rainfall for a very short duration of time. Some areas are even flooded due to intense rainfall in the upper catchment or due to the release of water from the dam or reservoir. Floods have an impact on both individuals and communities and have social, economic, and environmental consequences. The consequences of floods, both negative and positive, vary greatly depending on the location and extent of flooding and the vulnerability as well as the value of the natural and constructed environments they affect. The immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases. As communication links and infrastructure such as power plants, roads, and bridges are damaged and disrupted, some economic activities may come to a standstill, people are forced to leave their homes, and normal life is disrupted.

In the present vulnerability map for flood, we are showing the total number of flood events during the period of disaster data. In addition, the Normalized Vulnerability Index is being calculated for each district as per the formula mentioned in equation 1.

13. Lightning: Lightning is an electrical discharge caused by imbalances between storm clouds and the ground or within the clouds themselves. Most lightning occurs within the clouds. In the early stages of development, air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges build up enough, this insulating capacity of the air breaks down and there is a rapid discharge of electricity that we know as lightning. The flash of lightning temporarily equalizes the charged regions in the atmosphere until the opposite charges build up again. Lightning can set off building or farm fires, damage electrical equipment, and electrocute humans and livestock. Lightning can enter your home by following wires and pipes that go into the ground; it can also travel through metal reinforcing wire or bars in concrete and explode. Lightning often knocks out power lines and sends powerful electrical surges through electrical and phone lines. Once in your home, they can burn out appliances and other electronics.

    Annual Disaster Weather Report published by India Meteorological Department reports the lightning cases over India that caused hazards in terms of human death. Though actual lightning cases were more, only the cases that caused human death were reported during February to October and are considered in our analysis. For each of nine months and annual scale, maps are showing the total number of lightning days that caused casualties to humans. In addition, the Normalized Vulnerability Index is being calculated for each district as per the formula mentioned in equation 1.

14. Snowfall: Snow is formed from condensed water on the atmosphere. Water vapour in clouds condenses to form droplets. Cold air then freezes the water to form ice crystals. As these ice crystals bind with more water vapour they become heavier. Eventually, the ice crystal falls from the cloud, collecting more water vapour as it falls. As the ice crystal descends and the air temperature increases, the ice crystal can melt slightly. This melting can cause crystals to bind together to form larger flakes. Snow will remain on the ground if the temperatures are cold enough to keep it from melting. Snowfall is another hydrological hazard as a large amount of snow can affect transport routes, crops, and people. The secondary risks of snowstorms include vehicle accidents, hypothermia, infections from frostbite and possibly fires, and carbon monoxide poisoning due to the use of alternate heat sources.

    Annual Disaster Weather Report published by India Meteorological Department reports the snowfall cases over India that caused hazards in terms of human death. Though it starts in some parts of the country in November month in some years, the disaster data shows that the damages and casualties happened during the months of December to February. For each of three month and annual scale, there are maps showing the total number of snowfall days that caused casualties to humans. In addition Normalized Vulnerability Index is being calculated for each district as per formula mentioned in equation 1.

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