The Role of Official Statistics in Measurement of the Impacts of Climate Change: Indian Experience

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Abstract

Climate is the long-term statistical expression of short-term weather which can be defined qualitatively as 'Expected Weather' or quantitatively by statistical expressions such as central tendencies and variances in key parameters. Changes in climate are the differences between the average conditions in terms of key parameters over time. There is broad consensus that major or minor climate change leads to many hazards and disasters viz increased flood, land slides, avalanche and mud slide damage, increased soil erosion, increased flood run of, increased recharge floodplain aquifiers etc. It also causes displacement of people and increased deaths and serious illness in older age groups and urban poor, increased heat stress in life stock and wild life, increased risk of damage to a number of crops, decreased crop yields, decreased water resource quantity and quality, increased risk of forest fires etc. Relating such disaster like events to climate change can provide robust basis for assessing the impacts of such changes. These would require availability of sound database on the indicators of climate changes and occurrences of disaster type events.

In India different Ministries/Organisations/Institutions measures and monitors some indicators of climate changes but as such there is no regular information on climate change induced events such as flashfloods. Central Statistical Organisation in collaboration of National Institute of Disaster Management initiated a joint exercise to develop a Disaster Statistics database. This database will be one which can help researchers and policy makers to assess the impact of climate changes on major or minor disaster. The database will contain data of both hazards and disasters. Some of these hazards and disasters are manmade while most of them are due to change of climate over a considerable period of time. This paper will try to highlight the progress of this endeavour and also will try to explore the possibilities of measuring the impacts of climate change on hazards and disasters.

1. Introduction

The term climate change is often used inter-changeably with the term global warming, but according to the National Academy of Sciences, “the phrase ‘climate change’ is growing in preferred use to ‘global warming’ because it helps convey that there are other changes in addition to rising temperatures”. Climate change refers to any significant change in measures of climate such as, temperature, precipitation or wind; lasting for an extended period say, decade or longer. Climate change may results from (a) natural factors, such as changes in the sun’s intensity or slow changes in the Earth’s orbit around the sun; (b) natural processes within the climate system such as changes in ocean circulation; (c) human activities that change the atmosphere’s composition (such as burning fossil fuels) and the land surface (deforestration, reforestration, urbanization, desertification). Global warming is an average increase in temperature in atmosphere near the Earth’s surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, ‘global warming’ often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities.

The climate system involves dynamic physical, chemical, and biological interactions between the atmosphere, hydrosphere, cryosphere (snow, ice, and permafrost on and beneath the earth and ocean surface), land surface, and the biosphere at varying temporal and spatial scales. Any factor affecting the balance between the incoming solar radiation energy and the outgoing terrestrial radiation, or the energy redistribution between atmosphere, land, and water can affect the climate. Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or more) (IPCC 2001). The earth’s atmosphere is primarily made up of three gases - nitrogen (78.09%), oxygen (20.95%), and argon (0.93%). However, it is the gases present in trace quantities such as CO_2, CH_4 (methane), NOx (oxides of nitrogen), CFCs (chlorofluorocarbons), and ozone that greatly influence the radiation balance of the earth and lead to the ‘greenhouse effect’. The increased concentration of GHGs (greenhouse gases) in the atmosphere enhances the absorption and emission of infrared radiation, leading to an ‘enhanced greenhouse effect’ over and above the natural phenomenon.

In every country development activities are measured in terms of national products, which in turn are defined as production of goods and services during accounting period. However, certain environmental functions, which are crucial for economic performance and generation of human welfare such as provision of natural resources to production and consumption activities, waste absorption by environmental media and environmental services of life support and other human amenities, are taken into account only partly in conventional accounting system. The scarcities of natural resources now threaten the sustained productivity of the economy and economic production and consumption activities. These activities impair environmental quality by over loading natural sinks with wastes and pollutants. The environmental consequence of development tends to offset many benefits that may be accruing to individuals and societies on account of rising incomes. There are direct costs on the health of individuals, their longevity and on quality of life. More importantly, the environmental damage can also undermine sustainable future attainments, if the factors of production are adversely affected. The environmental stress caused by developmental activities emanating from emissions and discharges of various substances into air, water and soil. These emissions and discharges not only have local effects but also have regional and global effects too.

The advent of Industrial Revolution extended the impact of human activities on the environment from a local to global scale. CO_2 concentration levels have increased by more than 30% compared to those during the pre-industrial times, and are continuing to increase on an average of 0.4% per year. Human activities, in particular those involving the combustion of fossil fuels for industrial or domestic use, and burning of biomass produce GHGs and aerosols which in turn affects the composition of the atmosphere. Although certain gases such as NOx and CO, emanating from agricultural, industrial, and other human activities, are not GHGs, they play a significant role in the atmospheric chemistry and have led to an increase in tropospheric ozone (a GHG) by 40% since pre-industrial times. CFCs and some other halogen compounds do not occur naturally in the atmosphere but have been introduced by human activities. These CFCs and other halogen compounds are GHGs and have depleted stratospheric ozone layer. Most of these GHGs have long atmospheric lifetimes hence their emissions today will have a lasting effect for much longer time (IPCC 2001).

Climate change causes geophysical effects such as more intense precipitation events; higher maximum temperatures, more hot days/ heat waves; higher minimum temperatures, fewer cold days, frost days/cold waves; increase summer drying and associated risk of drought etc. There is broad scientific consensus that more intense precipitation leads to increased flood, land slides, avalanche and mud slide damage, increased soil erosion, increased flood run of, increased recharge floodplain aquifiers. Higher maximum temperatures caused by global warming results in accelerated sea level rises threatening many low lying islands and coastal zones. It also causes displacement of people and increased deaths and serious illness in older age groups and urban poor, increased heat stress in life stock and wild life, increased risk of damage to a number of crops. Higher minimum temperatures results in decreased co-related human morbidity and mortality. It also causes damage to a number of crops and extended range and activity of pests and disease vectors. Increased summer drying results in decreased crop yields, decreased water resource quantity and quality, increased risk of forest fires. The geophysical effects of climate change individually and collectively results in increase in flood and drought magnitude/damages, decreased agricultural productivity in drought and flood prone regions, increased risk to human life and risk of infectious diseases, epidemics, increased coastal erosion and damage to coastal buildings and infrastructure. Major health impacts of climate change can be changes in the pattern of vector borne viral diseases.

The greenhouse effect

The atmospheric particles and gases absorb energy from the incoming solar radiation in different wavelength regions. Molecules emit lower energy than they absorb. Therefore, after absorption, the solar radiation is transformed and radiated back in the far-infrared region of the spectrum at longer wavelengths (lower energy). Gases such as water vapour, carbon dioxide, and methane trap the outgoing radiation in the far-infrared zone, except in a transparent par t of the spectrum called the 'atmospheric window'. They reradiate a large fraction of the heat wavelength downward, thus heating the earth surface (analogous to the function of the glass cover of a greenhouse, hence the term 'greenhouse effect'). These gases are called 'greenhouse gases'. This 'greenhouse effect' maintains the earth's average surface temperature at +15 °C, a condition that supports life forms on the planet, in the absence of which the average temperature would be –18 °C.

Climate models at the global and regional scale (general and regional circulation models) can be used to study and simulate variations in climate because of the human-induced perturbations. The trends in the climate change that have been highlighted in Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) are given below.

- Increase in atmospheric concentrations of CO_2, CH_4, and N_2O by about 31% (±4%), 151% (±25%), and 17%, respectively, between 1750 and 2000 has been reported.
- Increase in mean global surface temperature by 0.6 °C (±0.2 %) over the 20th century has been reported.
- Snow cover has decreased by about 10% since the late 1960s, and sea ice extent during spring and summer has decreased by about 10% - 15% since 1960s. Shifting of alpine plantation and melting of continental glaciers have also been reported.
- Rise in global average sea level between 0.1 m and 0.2 m during the 20th century has been reported.

Since 1850, North America and Europe have contributed to about 70% of CO_2 emissions from energy production while the share of developing countries (non-Annex I nations) has been less than a quarter of the total emissions. However, recent study by Stern (2006) shows that owing to the mounting number of energy-intensive industries and rapid economic growth rates, developing countries will account for more than three-fourth of the rise in fossil fuel emissions by 2030. In the Asia-Pacific region, increased economic development has led to rapid urbanization and industrialization, and the subsequent rise in fossil fuel use has resulted in increasing the region's contribution to GHG emissions. In 1990, the region produced 435 MT (million tonnes) (8%) more CO_2 than North America. By 2002, the figure rose to 2628 MT (41% more). Focusing only on the total emission levels, however, would only give a myopic view of the GHG emission scenario, as the countries having the largest absolute emissions are not necessarily the ones with largest per capita emissions.

Among the top 25 total GHG emitters, Australia, USA, and Canada are among the top per capita emitters (global rank fourth, sixth, and seventh, respectively). Their per capita emissions are about six times that of China (global rank 99) and about 13 times that of India (global rank 140). There is a strong correlation between emissions per capita and income per capita, with affluent countries having higher emissions per capita because of higher consumption rates and energy-intensive lifestyles. One of the greatest challenges of implementing emission abatement measures is that GHG emissions result from almost every major human activity, with large contributions from electricity and heat, transport, buildings, industry, land-use change, forestry, and agriculture sectors. The future rise in emissions is predicted to be mainly in the electricity and transport sectors, highlighting the importance of suitable technological interventions and appropriate policy changes in these sectors. As per the current scenario as well as future energy projections, coal is leading the energy front in global power generation. In order to reduce the current GHG levels, high emitters would need to curtail their oil dependency and reduce coal use. In this regard, natural gas offers a potential substitute in crucial energy sectors because of its lower carbon content. World energy consumption is projected to increase by 71% from 2003 to 2030 (IEO 2006). It is also estimated that reduction in total GHG emissions to three-fourths of the current levels by 2050 shall entail costs that would be in the range –1.0% to +3.5% of GDP (gross domestic product; with an average estimate of about 1%).

Revisiting the Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) that highlights ‘stabilization of the GHG concentrations to a level that avoids dangerous interference with the climate system, and within a time frame sufficient to allow ecosystems to adapt to climate change and ensure food production is not threatened and economic development proceeds in a sustainable manner’, brings the fact that the role of GHG mitigation technologies cannot be undermined. Many options can be deployed to realize this objective and reduce GHG emissions, such as carbon sequestration and storage, reduction of non-CO_2 gases in sectors apart from energy, and decarbonization of the energy systems. A study states that technologies to sustain the world’s energy needs over the next 50 years are currently operational in various parts of the world; however, the biggest challenge remains to upscale them and overcome the associated issues and barriers.

Glimpse of Kyoto protocol

The adoption of the UN Framework Convention on Climate Change (UNFCCC) in 1992 was a major step forward in tackling the problem of global warming. Yet as greenhouse gas (GHG) emission levels continued to rise around the world, it became increasingly evident that only a firm and binding commitment by developed countries to reduce emissions could send a signal strong enough to convince businesses, communities and individuals to act on climate change. Member countries of the UNFCCC therefore began negotiations on a Protocol – an international agreement linked to the existing Treaty, but standing on its own. After two and a half years of intense negotiations, the Kyoto Protocol was adopted at the third Conference of the Parties to the UNFCCC (COP 3) in Kyoto, Japan, on 11 December 1997. The Protocol shares the objective and institutions of the Convention. The major distinction between the two, however, is that while the Convention encouraged developed countries to stabilize GHG emissions, the Protocol commits them to do so. The detailed rules for its implementation were adopted at COP 7 in Marrakesh in 2001, and are called the "Marrakesh Accords."

Because it will affect virtually all major sectors of the economy, the Kyoto Protocol is considered to be the most far-reaching agreement on environment and sustainable development ever adopted. However, any treaty not only has to be effective in tackling a complicated worldwide problem, it must also be politically acceptable. Most of the world's countries eventually agreed to the Protocol, but some nations chose not to ratify it. Following ratification by Russia, the Kyoto Protocol entered into force on 16 February 2005.

The Protocol requires developed countries to reduce their GHG emissions below levels specified for each of them in the Treaty. These targets must be met within a five-year time frame between 2008 and 2012, and add up to a total cut in GHG emissions of at least 5% against the baseline of 1990. Review and enforcement of these commitments are carried out by United Nations-based bodies. The Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities." This has two main reasons. Firstly, those countries can more easily pay the cost of cutting emissions. Secondly, developed countries have historically contributed more to the problem by emitting larger amounts of GHGs per person than in developing countries. In order to give Parties a certain degree of flexibility in meeting their emission reduction targets, the Protocol developed three innovative mechanisms - known as Emissions Trading, Joint Implementation and the Clean Development Mechanism (CDM). These so-called 'market-based mechanisms' allow developed Parties to earn and trade emissions credits through projects implemented either in other developed countries or in developing countries, which they can use towards meeting their commitments. These mechanisms help identify lowest-cost opportunities for reducing emissions and attract private sector participation in emission reduction efforts. Developing nations benefit in terms of technology transfer and investment brought about through collaboration with industrialized nations under the CDM.

The Kyoto Protocol is generally seen as an important first step towards a truly global emission reduction regime that will stabilize GHG concentrations at a level which will avoid dangerous climate change. As a result of the Protocol, governments have already put, and are continuing to put legislation and policies in place to meet their commitments; a carbon market has been created; and more and more businesses are making the investment decisions needed for a climate-friendly future. The Protocol provides the essential architecture for any new international agreement or set of agreements on climate change. The first commitment period of the Kyoto Protocol expires in 2012. By then, a new international framework needs to have been negotiated and ratified which can deliver the stringent emission reductions the IPCC tells us are needed.

The targets cover emissions of the six main greenhouse gases:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

The maximum amount of emissions (measured as the equivalent in carbon dioxide) that a Party may emit over the commitment period in order to comply with its emissions target is known as a Party's assigned amount.

2. Impacts of Climate Change on Different Sectors

There is increasing evidence that climate changes have affected a diverse set of physical and biological systems across the world and in case of inaction, the effects would only multiply manifold. Developing countries, in particular, are more vulnerable to the impacts of climate change owing to the underlying socio-economic conditions: lack of proper financial markets, institutional and legal structures, technological expertise; and inadequate access to information and education for majority of the population. The climate varies naturally as well as in response to human influences and therefore it is only one of the determinants of the impacts. The process of climate change is detectable only over long term and the resultant impacts will be rather slow to emerge. Therefore, monitoring of the performance and analysis of routine measurements aimed at detecting changes in the climate, environment and their impacts on different sectors would need to be done.

Asia has a highly variable climate, and experiences frequent wrath of climatic extremes, the disastrous consequences of which further narrow down the coping capacities of millions of poor in the region, who are already grappling with changes in the economic and social systems. In a country like India, which is closely tied to its natural resource base, climate change poses further stress on various sectors in addition to the existing pressures of high population, urbanization, and economic development. IPCC estimates of monetary damages under conditions of doubling of CO_2 (damages expressed as percentage of GDP) indicate that on an average, the economic losses worldwide would be between 1.5% and 2%. This figure lies between 1% and 2% for the developed countries and between 2% and 9% for the developing countries. Analysis of sector-specific impacts of climate change reveals the overlap of the sensitivities among the sectors and also the variety of implications that rapid change in climate might pose.

Over time, as the climate changes, other changes may also occur that alter the populations vulnerability. Vulnerability to extreme weather events, including floods and storms will depend on where and how residential housing is built. This would involve parallel measurements of population and environmental data. The data needed for measuring the impacts on population and different sectors comprise: climatic variables, population, health and other sectoral variables.

Impacts on water resources

Since water forms a core component of climate, one of the major impacts of climate change would be on the hydrological regime and regional water availability. This would further have implications on freshwater supply, rain-fed agriculture, groundwater resources, forestry, biodiversity, and sea level. Scientists have studied the hydrological consequences of future climate scenarios by considering time series analysis of run-off and meteorological parameters, taking into account the long-term variations and trends, use of general circulation and regional models, and specific hydrological models.

Impacts on agriculture and food security

Despite many technological advances such as better crop varieties and irrigation systems, the role of climatic factors in influencing agricultural productivity remains pivotal. Variations in climatic factors can affect crop yields either directly via changes in temperature, precipitation, or CO_2 concentrations, or indirectly through changes in soil properties and distribution, frequency of infestations by pests and insects, and diseases. In the short term, extreme events are more likely to have an adverse effect on agricultural production; however, gradual changes in temperature and rainfall patterns will impact yields in the long run. Variability in patterns of precipitation has implications for both economic growth of agriculture- based economies and also the food security of the poor.

Impacts on forest ecosystems

Changes in climate could alter the configuration and productivity of the forest ecosystems. Rising temperature, changes in availability of water, and enriched CO2 are expected to bring significant changes in species composition in approximately one-third of the forests worldwide.

Impacts on coastal areas

Accelerated SLR (sea-level rise) is one of the most certain outcomes of climate change along with possible increases in the frequency and intensity of cyclones and storms. Rising sea levels result in inundation of land, salt water ingression, and threaten life, livelihood, and property. The situation in small island states becomes more precarious under such circumstances. Complications arise with the displacement of population, and direct and indirect impacts on freshwater reservoirs, fisheries sector, health, and tourism.

Impacts on human health

The impacts of climate change on health could be direct in the form of increasing mortality from extreme temperature and weather events, and also indirect in the form of changes in ecological and socio-economic systems such as transmission of vector-borne diseases, changes in agricultural productivity, malnutrition etc. Communicable diseases such as malaria have been prevalent over the years and it is becoming harder to control the vector because of development of insecticide-resistant strains. Malaria is currently most endemic in South and South-East Asia, but there are concerns that it may spread due to changing climate, urbanization, irrigation, changing agricultural practices, and deforestation.

Impacts on infrastructure and energy

To meet the increasing demands of economic growth, governments make huge investment in infrastructure development. However, changes in the frequency and intensity of extreme events, temperature, and precipitation patterns endanger the financial investments in infrastructure. Studies indicate that increased temperatures would increase the need for better space cooling, thereby enhancing electricity demand. Also, projected changes in water availability would affect energy consumption in the agricultural, industrial, and commercial sectors. The increase in energy consumption can be due to a need for more space cooling/heating, depending on temperature fluctuations. Variability in precipitation patterns would require more reliance on personal irrigation means and increased groundwater usage. High-energy requirement begins a circuitous path leading to higher energy demand, and hence, higher emission rates.

3. Availability of Official Statistics on Climate Change in India

India, the seventh largest country in the world and the second largest in Asia, has a total geographical area of 329 Mha, of which only 305 Mha is the reporting area (the area as per the land records of villages and towns). The mainland stretches from 8^{o}4' N to 37^{o}6' N and 68^{o}7' E to 97^{o} 25' E. It has a land frontier of 15,200 km and a coastline of 7,516 km. While the global environment waits for the world to reach some form of agreement on climate policy, developing countries such as India are entering a phase of higher economic growth. In India, climate change could represent an additional stress on ecological and socioeconomic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development. With its huge and growing population, a 7500-km long densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, India is considerably vulnerable to the impacts of climate change.

The various studies conducted in the country have shown that the surface air temperatures in India are going up at the rate of 0.4^{o}C per hundred years, particularly during the post-monsoon and winter season. Using models, they predict that mean winter temperatures will increase by as much as 3.2^{o}C in the 2050s and 4.5^{o}C by 2080s, due to Greenhouse gases. Summer temperatures will increase by 2.2^{o}C in the 2050s and 3.2^{o}C in the 2080s. Extreme temperatures and heat spells have already become common over Northern India, often causing loss of human life. Climate change has had an effect on the monsoons too. India is heavily dependent on the monsoon to meet its agricultural and water needs, and also for protecting and propagating its rich biodiversity. Subtle changes have already been noted in the monsoon rain patterns. Scientists warn that India will experience a decline in summer rainfall by the 2050s. The summer rainfall accounts for almost 70% of the total annual rainfall over India and is crucial to Indian agriculture. Relatively small climatic changes can cause large water resource problems, particularly in arid and semi-arid regions such as northwest India. This will have major impacts on agriculture, drinking water and on generation of hydro-electric power.

Apart from monsoon rains, India uses perennial rivers, which originate and depend on glacial melt-water in the Hindukush and Himalayan ranges. Since the melting season coincides with the summer monsoon season, any intensification of the monsoon is likely to contribute to flood disasters in the Himalayan catchment. Rising temperatures will also contribute to the raising of snowline, reducing the capacity of this natural reservoir, and increasing the risk of flash floods during the wet season. Increased temperatures will impact agricultural production. Higher temperatures reduce the total duration of a crop cycle by inducing early flowering, thus shortening the `grain fill' period. The shorter the crop cycle, the lower will be the yield per unit area. A trend of sea level rise of 1 cm per decade has been recorded along the Indian coast. Sea level rise due to thermal expansion of sea water in the Indian Ocean is expected to be about 25-40 cm by 2050. This could inundate low lying areas, down coastal marshes and wetlands, erode beaches, exacerbate flooding and increase the salinity of rivers, bays and aquifers.

Deltas will be threatened by flooding, erosion and salt intrusion. Loss of coastal mangroves will have an impact on fisheries. In India the major delta area of the Ganga, Brahmaputra and Indus rivers have large populations who depends heavily on river resources for their livelihood and they will be mostly affected by any small changes in water regimes, salt water intrusions and land loss. Increase in temperatures will result in shifts of lower altitude tropical and subtropical forests to higher altitude temperate forest regions, resulting in the extinction of some temperate vegetation types. Decrease in rainfall and the resultant soil moisture stress could result in drier teak dominated forests replacing sal trees in central India. Increased dry spells could also place dry and moist deciduous forests at increased risk from forest fires. Medical Science suggests that the rise in temperature and change in humidity will adversely affect human health in India. Heat stress could result in heat cramps, heat exhaustion, heat stroke, and damage physiological functions, metabolic processes and immune systems. Increased temperatures can increase the range of vector borne diseases such as malaria.

For measuring the impacts of climate change official data on various aspects is available in India. Different Ministries/Organisations/Institutions collect and compile the data relating to different indicators of climate changes. Indian Metrological Departments (IMD) is the nodal agency for cyclone warning and monitoring in India. IMD having a list of all depressions and cyclonic storms formed in Arabian Sea as well as Bay of Bengal for more than 50 years. This data is useful in identifying the areas prone to cyclones, storms, and land slides. The daily report of the data is available in the website of IMD. IMD monitors the data on extreme weather events at 310 weather stations located in different parts of the country. The data is being collected at meteorological sub-division level. IMD also collects and maintains the rainfall data which is published on daily, weekly, seasonal and quarterly basis. IMD also maintains the district wise data on heavy/scanty rain falls which may help in identifying the hazards. As regards tropical depressions, IMD maintains data base in respect of tropical depressions in all the coastal districts.

Centre Pollution Control Board and State Pollution Control Board collects the data on different air pollutants like SO_2, NOx, SPM, RSPM at all the important locations through out the country. It also collects the data on green houses gases (GHG) for a few important locations. Ministry of Home Affairs is monitoring the data on damages due to heavy rains, flood and cyclone during South-West monsoon at State and district level. The month-wise data is also available on their website. Although Geological Survey of India (GSI) is having a wide net-work of field level offices, there is no dedicated network for land slide data collection. Only the incidents reported by the district administration to GSI are studied. With regard to floods, Central Water Commission (CWC) has 147 flood forecasting sites in all the major river basins of the country. There is no format indicting the location of the centre and the district, and the moderate, high and unprecedented flood level for dissemination of flood data at district level. Central Water Commission is also monitoring the water availability in the major reservoirs located in different parts of the country particularly in the summer season. Central Bureau of Health Intelligence publishes the data on health in their publication 'Health Information of India' every third year. Integrated Disease Surveillance Project is currently in progress and is expected to be completed by 2009 which would provide the health database. Besides, hospital level data is available on morbidity and mortality.

Department of Agriculture and Cooperation maintains the data on land use as per nine fold classification. It also maintains the data on area sown under different crops for different seasons. The impact of extreme temperature on production and productivity is also monitored by the agriculture department. Till 2002, the Department of Agriculture and Cooperation was entrusted with the responsibility to coordinate relief measures, on behalf of the Central Government, in the event of natural disasters and to also handle the subject of natural disaster management in general. After the transfer of subject matter relating to National Disaster Management to Ministry of Home Affairs, Department of Agriculture and Cooperation does the coordination of relief measures necessitated by drought. It also maintains the data on drought through out the country. There is a list of 183 districts which are covered under the drought prone area programme. Ministry of Agriculture conducts all India Soil and Land Use Survey where data on degraded area across all states and union territories are available. The main reason of land degradation is the soil erosion. India's economy still depends heavily on agriculture and also large number of people depends upon agriculture. Soil erosion is one of the major outcomes of climate change. The survey covers all the aspects of land use pattern and soil characteristics. In India about 45% of total geographical area is affected by serious soil erosion through ravine and gully, shifting cultivation, cultivated wastelands, sandy areas, deserts and water logging. Soil erosion by rain and river that takes place in hilly areas causes landslides and floods. Wind erosion causes expansion of deserts, dust, storms, whirlwinds and destruction of crops while moving sand covers the land and makes it sterile. Excessive soil erosion with consequent high rate of sedimentation in the reservoirs and decreased fertility has become serious environmental problems with disastrous economic consequences.

Government of India recently formed a separate ministry which is known as the Ministry of Earth Sciences. This ministry is mandated to provide the nation with best possible services in forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena related to earth systems through well integrated programmes. The Ministry also deals with science and technology for exploration and exploitation of ocean resources (living and non-living), and play nodal role for Antarctic/Arctic and Southern Ocean research. The Ministry’s mandate is to look after Atmospheric Sciences, Ocean Science & Technology and Seismology in an integrated manner. The Earth Commission, under which the Ministry of Earth Sciences works in Mission Mode based on Commission structure, is responsible for formulating policies, oversee implementation of policies and programs in mission mode, and ensure the necessary interdisciplinary integration.

4. Database on Disaster Statistics: A New Initiative in India

Realizing the need to develop a National Statistical System on hazards and disasters which includes impacts of climate change such as droughts, floods, land slides, extreme variations temperatures etc. in India, the Central Statistical Organisation (CSO) in association with National Institute of Disaster Management (NIDM) has taken an initiative for developing a framework for compilation of hazards and disaster statistics on regular basis and publish it in the form of an annual publication. This will provide data for measuring the impacts of all type of disasters including disasters caused by climate change. In India few scientific organizations like IMD, CWC, GSI are collecting hazard/disaster data. Different organizations use different formats and different geographical levels. India is currently developing a uniform framework for compilation of Hazard and Disaster Statistics to get an overall picture of hazard/disaster profile of States and Districts on annual basis. The District has been selected as primary unit for collection of data. The details of data proposed to be collected under hazard and disaster are as follows:

I Hazard Statistics:-

(a) Rainfall:- District-wise data on heavy and scant rainfall and comparison table with normal rainfall

(b) Tropical Depressions:-District-wise tropical depressions in all coastal districts

(c) Seismic Hazards:- Seismic data of all earthquakes with magnitude of 5 and above for districts in India and neighboring countries

(d) Landslides:- Data on all reported landslides

(e) Floods:- District-wise moderate, high and unprecedented floods, Data on reservoir levels of all major reservoirs in the country

(f) Drought, Hailstorms, Pest Attacks: - District-wise data on drought, hailstorm and pest attacks

(g) Industrial Hazards:- Industrial/chemical accidents

(h) Railway hazards and Accidents:- Data on railway deaths, injuries and damages to railway infrastructure

(i) Aviation Accidents:- Aviation accidents involving deaths, injuries and danger to infrastructure

(j) Health Hazards: Important Public health hazards

II Disaster Statistics will contain three parts: Damage, Relief and Reconstruction

(a) Damage data has been classified into eight categories:

- (i) Lives (deaths & injuries)
- (ii) Livestock (deaths)
- (iii) Agriculture (Sown area affected and production loss)
- (iv) Housing (full or partial damage)
- (v) Infrastructure (damage to roads, bridges, water supply, sewerage system, irrigation, electric supply, shops/commercial buildings, other utilities)
- (vi) Environmental Damage
- (vii) Damage at macro-economic level
- (viii) Health (occurrence of epidemic due to water borne and vector borne disease)

(b) Relief and Rehabilitation

- (i) Gratuitous relief
- (ii) Supplementary Nutrition
- (iii) Assistance to small and marginal farmers
- (iv) Input subsidy to farmers other than small and marginal farmers
- (v) Employment Generation
- (vi) Assistance to small and marginal farmers/ agricultural labourers
- (vii) Assistance to fisherman

(viii) Assistance to Artisans in handicrafts/handloom sectors by way of subsidy for repair/replacement of damaged equipments

(ix) Assistance for repair/restoration of damaged houses

(x) Provision of emergency supply of drinking water in rural and urban areas

(xi) Provision of medicines, disinfectants, insecticides for prevention of outbreak of epidemics

(xii) Medical care of cattle and poultry against epidemics as a sequel to a notified natural calamity

(xiii) Evacuation of people affected/likely to be affected

(xiv) Hiring of boats for carrying immediate relief and saving life

(xv) Provision of temporary accommodation, flood, clothing, medical care etc.

(xvi) Air dropping of essential supplies

(xvii) Repair / restoration of immediate nature of the damaged infrastructure

(xviii) Replacement of damaged medical equipment and lost medicines of government hospitals/ health centres

(xix) Operational cost of relief measure/services

(xx) Cost of clearance of debris

(xxi) Draining off flood water in affected areas

(xxii) Disposal of dead bodies/care cases

(xxiii) Procurement of essential search, rescue and evacuation equipments

(**C**) **Reconstruction**:- Information on reconstruction measures.

The main motivation of this endeavour is to develop a database which can help researchers and policy makers in analyzing different aspects related to hazards and disasters and their effects on human lives. The list is prepared keeping this fact in mind. Although the main emphasis is on capturing all types of disaster and hazards, some of the listed hazards are climate related environmental variables while some of them are outcomes of the climate change. This database captures data for all districts in India which will cover all environmentally different regions. Already in India many ministries/organizations/institutions are regularly collecting data on many climate related environmental variables. This database with the help of the existing dataset on climate change can help researchers to develop different models on impact of climate change on issues like hazards, disasters and the economic and social losses due to the climate change. Since data will be available at district level over periods of time, both cross sectional and time series analysis can be performed using this disaster dataset along with existing data on climate related environmental variables which flows regularly from different ministries/institutions/organizations. The following table gives an idea that most of the data which are proposed to be collected through hazards statistics are either climate related environmental variables or the outcome of climate changes.

Name of indicators/variables	**Type**
Rainfall, Tropical depression, Aviation accidents, Health hazards	Climate related environmental variables
Seismic hazards, landslides, Floods, Drought, Hailstorms, Pest attacks, Aviation accidents, Health hazards	Outcome of climate changes
Industrial hazards, Railway hazards	Neither climate related environmental variables nor an outcome of climate change

Linking these climate related variables and outcomes of climate changes to the data on damages, one can perform a detailed level analysis at the district level. For a country like India which is widely diversify environmentally, the effect on climate change on economic development, ecosystem and human lives can be analysed for different environmental zones once the detailed level data at district is made available. From the environment perspective, it is more interesting to analyse the data for different environmental zones rather than for different states. This database will help environmentalist along with the policy makers in this regard.

5. Concluding Remarks

Climate is the long-term statistical expression of short-term weather which can be defined qualitatively as ‘Expected Weather’ or quantitatively by statistical expressions such as central tendencies and variances in key parameters. In developing countries the trade off between economic development and environmental degradation is an issue of great concern. Sustainable development not only looks for the stable economic growth but also it has to ensure the minimum exploitation of environmental resources to attain the desired level of development. India is one of the low per capita greenhouse gas emission countries instead of its rapid growth and huge population. But the effect of global warming in the world has also been felt by India and since large populations of India still depends mainly on agriculture for their sustenance; a change in climate will affect them considerably because the change in climate will have a worse impact on agriculture sector. Government of India is now working steadily towards further reduction of GHGs using renewable energies, modern methods and technologies, publicising the importance of environmental sustainability across all stake holders by running different programmes etc. In India, different Ministries/Organisations/Institutions measures and monitors some indicators of climate changes on fairly regular basis. Central Statistical Organisation in collaboration of National Institute of Disaster Management initiated a joint exercise to develop a Disaster Statistics database. This database will be one which can help researchers and policy makers to assess the impact of climate changes on major or minor disaster because although some of these hazards and disasters are manmade but most of them are due to change of climate over a considerable period of time.

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