ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

VOLUME–X, ISSUE– V SEPT – OCT 2023

Original Research Article

DISASTER MANAGEMENT: CLIMATE CHANGE AND SEISMIC RETROFITTING

*** Dr. Amrita Majumder,**

** Assistant Professor, Guru Nanak College of Education and Research. Bhandup. Mumbai.*

Introduction:

Climate change is currently the most pressing issue we face. It brings us closer to an undesirable future with far-reaching consequences for people and the environment. As stated by UN Secretary-General Antonio Guterres, climate change can be defined as alterations in Earth's environmental conditions caused by various factors, including human activities. Over the past few decades, climate change has gained international attention due to its diverse and profound impacts on the environment and ecology. These climatic shifts have led to the extinction of various plant and animal species, an increase in the frequency of disasters, and the anticipation of even more severe weather events in the future.

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Simultaneously, our existing tools and approaches for disaster prevention and climate risk mitigation offer strong potential to reduce hazards and adapt to climate change. Disaster management revolves around understanding the concepts of hazard, vulnerability, and risk. Hazard is essentially a situation or incident that poses a danger or has the potential to harm people or the environment. There are several types of hazards, including natural and human-made, such as earthquakes, floods, forest fires, and nuclear accidents.

Vulnerability, on the other hand, refers to the susceptibility or resilience of individuals or groups to external influences. Susceptibility represents the capacity to be affected by external factors, while resilience is the ability to recover quickly from setbacks. Vulnerability is determined by various factors and plays a crucial role in disaster management.

Risk, a commonly used term, encompasses both the probability and possibility of an event occurring. Probability reflects the likelihood of an event happening, while possibility is the concept of something being conceivable but uncertain. The measurement of probability involves assessing the degree of possibilities, resulting in a comprehensive understanding of risk. Risk is the combination of the likelihood of an event occurring and the potential consequences if it does. The term "disaster" itself originated from the idea of "bad stars," suggesting that it is related to bad luck. Hence, any event that brings misfortune in the form of significant losses to life and property is considered a disaster. The classification of an event as a hazard or disaster depends on its potential to harm people or the environment.

Climate change is an established reality, supported by extensive scientific evidence, as highlighted in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Observations of changes such as rapid Arctic ice melting further confirm the severity of the situation.

ISSN: P-2455-0515
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VOLUME–X, ISSUE– V SEPT – OCT 2023

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Between 1991 and 2005, catastrophes affected 3.47 billion people, resulting in 960,000 fatalities and economic losses of $1.193 billion. Developing nations bear the brunt of climate change effects due to their vulnerabilities and limited resources for risk reduction. Smaller nations are particularly at risk, as exemplified by Grenada's significant losses after Hurricane Ivan in 2004. Wealthier nations can absorb large losses due to their diversified economies and risk-management mechanisms.

The majority of natural disasters over the past two decades were hydrological, meteorological, or climatological in origin, leading to significant fatalities and economic losses. The Global Assessment Report on Disaster Risk Reduction highlights the increasing frequency and cost of disasters, largely driven by exposure and susceptibility to climate hazards. Poor individuals and nations are most at risk because they lack the means to protect their assets and livelihoods.

Urbanization concentrates populations and resources in high-risk areas, resulting in cities vulnerable to storms, floods, earthquakes, and volcanic events. Environmental degradation and overexploitation of natural resources compound the problem. The concentration of vulnerability can undermine development gains and lead to political unrest. Climate change is a significant new risk factor that exacerbates disaster risk.

Humanitarian organizations are concerned that the demand for assistance is surpassing their capacity to respond effectively, particularly in response to climate-related disasters. The rise of humanitarian "flash appeals" reflects the growing impact of climate-related catastrophes. A key responsibility of humanitarian organizations is disaster risk reduction, which also addresses the increased risks posed by climate change.

To address climate change and its associated disaster risks, it is crucial to foster a culture of preparedness and adaptability. While resistance to change is natural, increased awareness of climate change's risks and the need for both adaptation and mitigation measures has prompted action. Mitigating greenhouse gas emissions is a primary focus of climate negotiators, as it necessitates significant socio-economic changes. However, adaptation remains essential, particularly for developing nations that have contributed less to the issue but are most affected by its consequences. A committed and practical approach is necessary to effectively address the challenges posed by climate change and the increasing threat of disasters.

Catastrophes and Climate Change:

To the best of our knowledge, natural hazards themselves do not lead to disasters; instead, a disaster arises when a hazard event coincides with a population or community that is exposed, vulnerable, or ill-prepared. Consequently, climate change will influence disaster risks in two significant ways. First, it will increase the occurrence of weather and climate-related hazards, as well as the impacts of rising sea levels. Second, it will heighten the vulnerability of communities to natural hazards due to factors like ecosystem degradation, reduced access to water and food, and changes in livelihoods. Consequently, alongside environmental degradation and rapid, unplanned urban growth, climate change will make it more challenging for communities to adapt to even current levels of weather-related risks.

In addressing catastrophe risk and climate change, our primary learning objectives are as follows: first, introducing the concept of climate change; second, understanding various climate change models; third,

ISSN: P-2455-0515
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VOLUME–X, ISSUE– V SEPT – OCT 2023

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exploring the connections between climate change and disasters; and fourth, comprehending local, national, and international efforts to combat climate change. Climate is typically defined as the long-term statistical description of various variables, including temperature, precipitation, and wind, occurring more frequently over periods ranging from months to millions of years. According to the World Meteorological Organization, the classical period for climate definition is 30 years.

The ongoing increase in global air temperatures and the resulting disruption of the hydrological cycle pose a significant challenge to sustainable development. Comprehensive policy interventions are necessary to reduce the impact of disasters and the effects of climate change. These interventions should encompass prevention, preparedness, mitigation, community-based strategies, and capacity development.

Established in 1988 with the support of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC) seeks to gather the latest scientific knowledge on climate change through periodic assessment reports. The IPCC defines climate change as "a change in the state of the climate that can be identified by changes in its mean and variability and persists for an extended period, typically decades or longer." Research indicates that temperature increases have already impacted human physical and biological systems, and future projections suggest continued warming, increased heat waves, and more powerful tropical cyclones if greenhouse gas emissions persist.

The challenge of adaptation to climate change is particularly critical for developing nations that have made minimal contributions to the issue but face severe consequences. Climate change is leading to visible effects such as the melting of snow and ice, rising global sea levels, loss of biodiversity, loss of fertile coastal land due to sea-level rise, increased frequency of extreme weather events, extended growing seasons, and the spread of vector-borne diseases. Long-term weather pattern fluctuations can also disrupt fish and seafood distribution, affecting agricultural productivity.

It is worth noting that the average global temperature has increased by approximately 0.8 degrees Celsius since 1880, with the majority of this warming occurring since 1975, at a rate of about 0.15 to 0.20 degrees Celsius per decade. While it is challenging to directly attribute specific weather events to climate change, many regions worldwide experience urban flooding and other hydro-meteorological disasters as a result of altered precipitation patterns, changing temperature, and imbalances in the hydrological cycle.

Additionally, urban heat islands influence hydrological cycles and can contribute to urban flooding. Climate change is also linked to more frequent heat waves and droughts, as indicated by research showing increased heat wave-related fatalities in the late 20th century due to global warming.

India's extensive coastline, measuring approximately 7500 km, exposes even its heartland to the impacts of sea-level rise. With its coastal territories like the Andaman and Nicobar Islands and Lakshadweep, India's Low Elevation Coastal Zone (LECZ) is home to around 16 million people, with approximately 31 million residing in urban areas covering about 81 thousand square kilometers. The Indian coast is projected to experience sea-level rise ranging from 30 to 80 centimeters during this century, impacting coastal residents if no preventive measures are taken.

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What important sectors will be impacted by climate change?

Climate change could have wide-ranging impacts on various aspects of our society if proactive measures are not taken. Here are the primary expected effects:

Water:

- Drought-affected areas are likely to expand further.
- An increased frequency of heavy precipitation events may lead to higher flood risks.
- Water supply, especially in mid-latitudes, dry tropics, and regions dependent on mountain range meltwater, is expected to decrease by the middle of the century. A substantial portion of the global population currently relies on mountain range meltwater.

Food:

- Some regions in mid- and high-latitude areas may initially benefit from increased agricultural production.
- Conversely, many lower-latitude regions, particularly those in seasonally dry and tropical areas, may face reduced crop production due to rising temperatures, droughts, and floods.
- This could lead to more people at risk of hunger, as well as increased levels of displacement and migration.

Livelihood, Communities, and Societies:

- Industries, communities, and civilizations in coastal regions and river floodplains are particularly vulnerable, especially those heavily reliant on climate-sensitive resources.
- This vulnerability is exacerbated in regions already susceptible to extreme weather events, especially those experiencing rapid urbanization.
- Stronger or more frequent extreme weather events could result in higher economic and societal costs.

Health:

- Predicted climatic changes are expected to impact the health of millions of people.
- Health consequences may include increased illness, injuries, and mortality due to heatwaves, floods, storms, fires, and droughts, among other factors.
- Prolonged damage to health systems caused by disasters could undermine development goals and increase susceptibility to major public health issues like hunger, diarrheal diseases, and malaria in specific regions.

Security:

- The security implications of climate change are complex and may vary in different contexts.
- Potential concerns include competition for dwindling water resources, particularly in transnational settings, as well as competition and migration related to arable land in low-rainfall areas.
- Mass migration from inundated coastal zones or small islands and civil unrest stemming from severe disaster events, especially in urban areas, are also potential issues.

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- Political tensions and conflicts may arise when groups or nations feel unfairly affected by climate change.

It is imperative to recognize and address these potential impacts of climate change and work collectively to mitigate and adapt to these challenges.

Health Effects on People:

Climate change is expected to lead to a surge in environmental diseases. Warmer conditions driven by global warming can create ideal breeding environments for disease-carrying mosquitoes. Mosquito-borne diseases, such as malaria, can spread more easily due to increased mosquito breeding seasons caused by excessive rainfall or droughts. Additionally, the lack of sanitation and clean water can result in a higher incidence of water and food-borne illnesses like cholera, typhoid, diarrhea, hepatitis, gastroenteritis, and parasitic infections. High temperatures exacerbate pollution, leading to an increase in respiratory diseases. Changes in temperature and precipitation can facilitate the spread of diseases to new areas and exacerbate conditions in already affected regions.

Climate Change Models: One example of the many physicochemical processes occurring in the Earth's climate system is the water cycle, which involves evaporation, condensation, and precipitation. Modeling the water cycle is challenging due to the various parameters involved in each of its sub-processes. Rising temperatures, deforestation, and increased greenhouse gas concentrations can lead to increased evaporation and cloud formation. Urbanization can alter surface water runoff patterns, leading to urban flooding and water logging issues. Climate models use quantitative approaches to represent the physio-geochemical processes of the Earth's climate system, allowing for trend analysis and future predictions. These models are run on supercomputers to simulate the behavior of various climate system components.

Climate System Components: The climate system comprises four fundamental components: the surface, the hydrosphere, the atmosphere, and the cryosphere. Climate models aim to quantitatively analyze how these components interact to provide a detailed description of the system and predict future climate conditions. Due to the complex interactions and feedback between these components, climate models typically focus on a subset of dynamic processes to facilitate computation.

Types of Climate Models: Different types of climate models focus on specific aspects of the climate system. Energy balance models (EBMs) consider solar radiation and energy balance, with one-dimensional EBMs taking latitude into account. Radiative-convective models (RCMs) emphasize vertical column energy balance. General circulation models (GCMs) are comprehensive models that consider multiple layers of the atmosphere and ocean, simulating energy transfers and interactions based on physical laws and thermodynamics. These models may vary in resolution, allowing for the study of impacts at different scales and the development of disaster risk reduction measures.

Climate Change in India: Developing countries, such as India, are considered more vulnerable to climate change due to their geographic location, heavy reliance on climate-dependent agriculture, and higher population vulnerability resulting from inadequate vulnerability reduction measures. India anticipates several consequences

ISSN: P-2455-0515
E- 2394-8450

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of climate change, including reduced crop yields, water resource scarcity, sea-level rise, extreme temperatures, biodiversity loss, and increased disease risk. India emphasizes the need to include climate change adaptation in its planned contributions, as outlined in its national communications to the United Nations Framework Convention on Climate Change.

The study of India's climate change impacts, combined with climate model results, suggests that droughts and floods may worsen across the nation, with some areas facing severe water shortages. Changes in evapotranspiration and precipitation may affect ground-level water balance, potentially leading to reduced agricultural productivity due to shorter crop seasons. The forest ecosystem may experience shifts in borders, biodiversity changes, and increased biotic stress due to reduced adaptability to adverse climatic conditions. Coastal areas may face flooding, erosion, submergence, and ecosystem deterioration, while national ecosystems like grasslands, mangroves, and coral reefs could be harmed. Human health may also be affected, with diseases like malaria potentially spreading to higher latitudes and elevations in India.

Facilities and Energy:

The consequences for energy and infrastructure could lead to significant financial losses as a result of operational downtime and increased demands for water pumping and terrestrial cooling. The Network for Climate Change Assessment for 2030 was established as a scientific research program aimed at evaluating the factors driving climate change and its associated consequences. The Network produces climate change assessments biennially to facilitate the development of decision support systems and enhance capacity for effective management. The assessment focused on the four key sectors of agriculture, water resources, natural ecosystems, biodiversity, and public health in four distinct geographic regions, including the Himalayas, North Eastern, Western Ghats, and Coastal areas.

Risk Management for Climate:

Climate Risk Management Component: An effective climate risk management strategy comprises six key elements.

1. Prioritizing Projects and Assessing Climate Risks
2. Addressing Impacts: This involves integrating climate change considerations into disaster management, community risk reduction, healthcare, food security, water and sanitation, migration, and conflict-related programs and activities.
3. Building and Strengthening Collaborations
4. Increasing Awareness
5. Shaping Global Climate Change Policies through International Advocacy
6. Sharing and Documenting Knowledge and Experiences

Natural disasters are major disturbances caused by various risks, such as earthquakes, floods, hurricanes, and volcanic eruptions, which have adverse environmental consequences. They result in significant damage in terms of human lives, financial losses, and structural damage. Their impact on communities and infrastructure lingers long after the initial event has passed. Earthquakes, in particular, are one of the primary natural disasters affecting

ISSN: P-2455-0515
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people worldwide and can significantly alter the societal landscape.

Seismic retrofitting is a method used to enhance the structural stability of existing reinforced concrete structures, preventing failures and ensuring the resilience of buildings and infrastructure. Retrofitting, rather than replacing structures, is often more cost-effective and provides rapid relief in the event of a crisis.

In recent years, seismic safety requirements for structures have become more stringent due to widespread non-compliance with these standards. These regulations apply to both new construction projects and existing structures. Seismic retrofitting involves modifying an existing structure to enhance its resistance to seismic activity, ground motion, or soil instability resulting from earthquakes.

Disaster Management Using Retrofitting for Seismology:

Natural disasters are substantial disruptions caused by various hazards, such as earthquakes, floods, hurricanes, and volcanic eruptions, leading to adverse environmental consequences. They result in extensive damage in terms of human lives, financial losses, and structural failures. Their impact persists long after the initial event, significantly affecting the community's residents and infrastructure. One of the most widespread natural calamities worldwide is earthquakes, which have a substantial adverse effect on the way society constructs its infrastructure.

Seismic retrofitting is employed to rectify deficiencies in the structural integrity of existing reinforced concrete structures, addressing issues in buildings and other infrastructure. Rather than replacing structures, retrofitting proves to be a more cost-effective and immediate solution to these problems.

Due to widespread non-compliance with safety standards, seismic safety requirements for structures have become noticeably more stringent in recent years, applying to both new construction projects and existing ones. The process of modifying existing structures to enhance their resistance to seismic activity, ground motion, or soil instability resulting from earthquakes is referred to as seismic retrofitting. Retrofitting methods are also valuable for mitigating other natural disasters, including tornadoes, tropical cyclones, and severe thunderstorms. Why is it necessary? To ensure public safety and the security of critical buildings, it is essential to reduce risks and losses from non-structural elements, primarily focusing on structural improvements to reduce seismic hazards. This is particularly crucial for significant buildings, such as hospitals, where uninterrupted services are essential immediately after an earthquake. The evaluation of existing structures involves assessing the fundamental characteristics and factors contributing to the deterioration of masonry, concrete, and steel structures. Various tests, including destructive and non-destructive load testing, can be conducted to assess material quality and gain insights into their properties. Test results help determine the quality of the building materials utilized. Retrofitting is the process used to enhance the lateral and ductile qualities of the structure.

Conclusion:

Climate is typically characterized as the average weather conditions that prevail over a given period, ranging from months to millions of years, offering a statistical representation of relevant parameters' mean and variability. Climate change, as defined by the United Nations Framework Convention on Climate Change, is any alteration in climate directly or indirectly attributed to human activities that modify the composition of the Earth's

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–X, ISSUE– V SEPT – OCT 2023

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global atmosphere. This is in addition to the natural climate variations, serving as a reference starting from 1988. The Intergovernmental Panel on Climate Change, founded by the World Meteorological Organization, made significant findings about climate change in 2007, unveiling both its direct and indirect effects on our planet. To mitigate the repercussions of climate change on agriculture, it's crucial to address the primary impacts, such as the loss of biodiversity in fragile ecosystems, deforestation, and the loss of fertile coastal regions. Additionally, rising sea levels and the heightened occurrence of extreme weather events, including floods, droughts, and storms, must be countered with comprehensive policies and unwavering commitment to their implementation.

There are evident linkages between sector-specific management, disaster risk reduction, and climate change. Significant technological capabilities, international strategies, and action frameworks are essential. However, these resources have yet to be seamlessly and efficiently integrated, with all competent and responsible domains working in unison to achieve a global-scale reduction in risks. The proliferation of vulnerabilities and the impact of disasters indicate numerous challenges. While developing nations are most susceptible, these problems affect all countries and cannot be disregarded. National Meteorological and Hydrological Services must play a pivotal role in these processes due to their specialized knowledge, extensive experience, and sector partnerships. They are well-positioned to address the consequences of weather and climate variability, offering crucial expertise in bridging various time scales, from short-term hazard management to long-term climate variability and change.

Efforts should encompass best practices for predicting tropical storms and public responses, the implementation of monitoring and response systems for heavy rainfall, flash floods, and landslides, especially in urban areas. There's also room for improvement in El Niño/La Niña management, as well as the monitoring and management of regional-scale droughts and multi-year anomalies. Providing data and relevant spatial and temporal information is essential for global systematic data collection and distribution for climate research and industry management. National Meteorological and Hydrological Services can actively support the establishment of institutional mechanisms to connect disaster risk reduction and adaptation policymaking at the national level.

International organizations like the World Bank's Global Facility for Disaster Risk Reduction and Recovery, the WMO system, the IPCC, the ISDR, and the Global Facility for Disaster Reduction and Recovery, along with their various frameworks and forums such as the Hyogo Framework, the Global Platform for Disaster Risk Reduction, and the Third World Climate Conference, are instrumental in fostering new commitments, ideas, and coordination. These organizations provide essential tools for shaping and directing expedited, tangible actions where they are most needed—ensuring the lasting reduction of vulnerability and risk for all nations, serving as pivotal platforms for these objectives.

Cite This Article:

**** Dr. Majumder A., (2023).*** *Disaster Management: Climate Change and Seismic Retrofitting,* ***Educreator Research Journal, Volume–X, Issue–V****, Sept – Oct, 2023, 96-103.*