JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

URBAN CLIMATE RESILIENCE

Poojitha Nalluri,Mardana Gnaneshwar
Ms, Mr
Gitam University Hyderabad

ABSTRACT

Climate change poses significant challenges to urban environments, threatening their resilience and sustainability. This review examines the scientific understanding of climate change, its causes, and the diverse impacts on urban areas. It highlights essential mitigation strategies and adaptation measures necessary to build climate-resilient cities. The report also explores current policies, international cooperation frameworks, and future prospects to strengthen urban climate resilience. Emphasizing the urgent need for climate-smart initiatives, such as affordable housing, nature-based solutions, and sustainable waste management, this review calls for immediate and coordinated action to safeguard the environment and ensure sustainable urban development for future generations.

1.INTRODUCTION

1.1 Background on Climate Change

The long-term changes in the average weather patterns resulting in temperature changes can be termed climate change. The changes in climate can both be natural as well as man-made. The global climate change over the entire earth has resulted in hot temperatures and changes in precipitation. The intensive climate change has also been the effect of global warming, rising levels of the sea and shrinking of the glaciers. According to scientists, the later part of the 19th century has been the point at which human activities started interfering with the climate. However, according to new studies, this dates back to the 1830s. Since then, man-made influences have been causing turbulence in the environmental climate (Bonneuil, Choquet and Franta, 2021).

1.2 Significance and Relevance

Climate change is one of the defining issues of all time, and the present decade is a defining moment to bring about positive changes and adopt ways to slow down the rapid climate changes affecting the environment. The shifting weather patterns or the precipitation rates worldwide have threatened food production (Farooq et al., 2022). The rising sea levels have increased the chances of catastrophic flooding, and if these go unchecked, this will have a detrimental effect on human life. Climate affects nearly everything in human lives, from food production to transportation to infrastructure to medical complications. This has had a significant impact on the past and is affecting the present and future. The changes in climate patterns and weather are putting everyone's lives at risk and have made the environment much more intense and unpredictable for human lives.

1.3 Purpose of the Review

Since 1988, the detrimental impacts on the environment, like global warming and the depletion of the ozone layer, have become an increasingly prominent issue internationally and have become a public agenda overall (Schummer,2021). In this paper, the concept of urban climate resilience will be discussed. This embraces climate change adaptation and will help explore mitigation strategies and disaster risk reduction. The aim of this paper is to talk about the ability of cities to manage the threats that the urban population faces while managing the associated risks with climate change.

2.CLIMATE CHANGE SCIENCE

2.1 Greenhouse Effect and Global Warming

At present, one of the most critical problems is global climate change. This is related to the extreme weather patterns, making the temperatures more intense. The high levels of economic and manufacturing activities comprise the emissions of greenhouse gasses like carbon dioxide, methane, etc. According to recent research, the whole Earth's temperature has increased by 0.5-1 ℃ over the last 100 years (Mikhaylov et al., 2020).

The significant factors in the emission of greenhouse gasses consist of using combustible minerals in industries, like natural gas, oil and coal, thus leading to the emission of large quantities of carbon dioxide and other harmful components into the atmosphere. Cars and trucks emitting exhaust fumes are associated with increasing pollution and greenhouse gas emissions. Deforestation, population increase, and the growing industrial production are also some cases of greenhouse gas emissions. The total greenhouse gas emissions, especially in Russia, comprise 404.9 million metric tons of CO2 per capita (Teremranova, 2023). The emission of greenhouse gasses due to man-made activities has led to an increase in the temperature of the surface of the earth due to the heating of the lower layers of the atmosphere. This is the reason why the air temperature is greater than what it actually should be, thus leading to irreversible consequences leading to climate change and global warming in the long run.

2.2 Key Climate Change Indicators

The key performance indicators consider the essential factors that are generally related to environmental degradation or aspects that need to be considered for reducing the impacts of climate change on the environment. There are eight general clusters that can be regarded as the key climate change indicators in recent times. Pollution comprising air, water, soil or solid waste comes under the key elements responsible for greenhouse gas emissions and subsequent global warming and degradation of Earth (Schokker, Kamilaris and Karatsiolis, 2021). The increased population growth has put pressure on the resource demands, leading to the scarcity of natural resources. Climate hazards can be considered one of the major factors caused by climate change other than the loss of biodiversity. Excessive burning of fossil fuels, transportation, and deforestation are some factors driving climate change. The changes in temperature and climate across the globe have had a significant detrimental impact on human health and future generations. The sustainability reports published by companies and industries are an essential indicator of climate change, and analysing the issues can help identify climate change's originators effectively (Mi et al., 2019). Both the formal and informal settlements across the globe play a significant role in climate change. This can be shown in the statements below as published by the "Intergovernmental Panel on Climate Change (Dodman, Archer and Satterthwaite, 2019).

- At 1.5℃, twice as many megacities (including Lagos, Nigeria and Shanghai, China) could become heat-stressed, exposing more than 350 million people to potentially deadly heat by 2050 under midrange projections for population growth.
- At 2℃, Karachi (Pakistan) and Kolkata (India) could expect annual climatic conditions equivalent to the deadly 2015 heat waves (without considering adaptation options).
- Stabilising at 1.5℃ warming could decrease extreme temperature-related mortality compared with stabilisation at 2℃ for key European cities (assuming no adaptation and constant vulnerability).
- The impacts of heat waves in cities at 1.5℃ and 2℃ are substantially more significant than in the present climate".

3. CAUSES OF CLIMATE CHANGE

3.1 Anthropogenic Factors

Global environmental changes and variations in climate patterns are the impacts of different natural factors. Nonetheless, most anthropogenic factors or man-made aspects cause such drastic climate changes (Mikhaylov et al., 2020). These can be categorised into causing deforestation, excess burning of fossil fuels through transportation or industry manufacturing, and farming livestock, thus increasing Earth's temperatures.

3.1.1 Greenhouse Gas Emissions

In the modern day, one of the characteristic occurrences is climate change. This is the byproduct of the greenhouse effect, which is a natural phenomenon sustaining life on this planet (Mikhaylov et al., 2020). However, excess population and growing pressure on the environment by humans have led to the rise of an unbalanced amount of greenhouse gasses in the atmosphere. Thus, the anthropogenic aspect of climate change has grown to be much more influential. The greenhouse effect is the cause of the excess concentration of some gasses, like "carbon dioxide, methane, nitrous oxide, ozone, water vapour, etc." in the atmosphere (Mikhaylov et al., 2020). These greenhouse gasses are majorly responsible for trapping the sun's heat into the atmosphere, thus warming the Earth's surface. There is also a natural phenomenon that involves some heat being released into space since otherwise, the Earth would not have been inhabitable below -18 C (Driga and Drigas, 2019). However, over the past 50 years, the natural pattern of the atmospheric concentration of greenhouse gasses has been broken due to anthropogenic factors, thus leading to an escalation of climate change. The man-made aspects responsible for extensive climate change due

to greenhouse gas emissions are the combustion of fossil fuels up to 57% to obtain electricity, the use of fossil fuels for transportation and the contribution of 26% carbon dioxide gasses (Driga and Drigas, 2019). The other factors are agricultural activities, changes in land use, excessive use of industrial processes and improper treatment of the accumulated wastes in the environment. This has increased temperature by 0.9˚C in the last decades (Driga and Drigas, 2019).

3.1.2 Deforestation

Forests, trees and plantations across the globe are the natural reservoirs of oxygen and are the filters of the ongoing effects of pollution (Zhang and Wei, 2021). However, due to the increase in population and excessive pressures on the land to meet the shelter and food needs of the humans, the plantation covers are being scraped off from the face of the Earth, and large establishments are being built for the population. But all humans do forget that deforestation's biophysical effects can amplify carbon losses and cause variations in the regional climate across different continents. The warming and drying, which is a cause of deforestation, has led to a loss of 5.1 ± 3.7% of the aboveground biomass (Li et al., 2022). The carbon emissions due to deforestation have been recorded as high as 0.8 and 2.2 Pg C yr−1 in the last few decades (Li et al., 2022). This is also associated with the alteration of the surface biophysical properties, changes in annual rainfall and the blocking of pathways to release the growing temperatures of the Earth into space.

3.1.3 Industrial Processes

As per the reports of 2019, the industrial sector is responsible for about 43% of global CO2 emissions (Al-Ghussain, 2019). Besides carbon dioxide gasses, nitrous oxides are also released into the environment by industrial processes, thus leading to temperature rises and imminent climate change. Moreover, large quantities of methane are emitted into the atmosphere during agricultural and industrial processes, which plays a crucial role in climate variations. Mining, among other industrial processes, also releases greenhouse gasses into the atmosphere, besides reducing the natural resources of the planet (Yoro and Daramola, 2020). Specific industrial processes comprising of cement industry or food manufacturing units release lots of gasses and a lot of waste. The improper management of the wastes in the environment causes pollution, thus harming the overall environment to a large extent.

3.2 Natural Factors

Over the past millions of centuries, the planet has had to go through Ice Age, volcanic eruptions, earthquakes, etc. (Harde, 2022). The Earth's existence has been somewhat affected by these natural factors, which have led to climate changes or variations in weather patterns. The natural elements comprise the changes in the sun, volcanic eruptions or ocean currents, as discussed further.

3.2.1 Solar Variability

Besides the anthropogenic factors, solar variability can be associated with two-thirds of the increase in the temperature of the Earth, leading to changes in the climate. Solid solar variability has been an extensive dominant influence on the Northern Hemisphere trends in temperature since 1881 (Harde, 2022). The variation in the solar radiation emitted by the Sun due to the Milankovitch cycle can be explained in this scenario. According to this cycle, which occurs every 10,000 years, natural global cooling and warming are launched upon the Earth (Al-Ghussain, 2019). This is caused by the eccentricity, precession and obliquity of the earth's surface, which leads to some of the solar radiations staying back into the Earth's atmosphere without getting emitted back into space.

3.2.2 Volcanic Activity

Explosions happening during volcanic eruptions have a significant impact on climate variations. This affects the stratospheric volcanic sulfate aerosol lifecycle. This also majorly affects the radiative forcing, which leads to changes in weather patterns (Aubry et al., 2021). The volcanic eruptions over the years have caused strong cooling, followed by a period of unusually heavy activity. The episodic volcanic eruptions, especially during the 17th and early 19th centuries, caused short-term cooling followed by increased Earth temperatures (Hegerl et al., 2019). The vast amount of aerosol droplets and volcanic gasses emitted during volcanic eruptions, like ash, are directly injected into the stratosphere. This can lead to increased changes in climate only if, during significant eruptions, heavy quantities of CO2 are released into the atmosphere, thus accumulating greenhouse gasses.

3.2.3 Ocean Currents

Ocean currents like the conveyor belts are major in transporting warm waters and precipitation originating in the Equator towards the poles. The ocean currents also transport the cold water from the poles to the tropics. The regulation of ocean currents plays a major role in climate change across the globe (Yang et al., 2020). This is because the transportation of the warm and the cold waters counteracts the uneven distribution of the solar radiation reaching the Earth's surface. As solar radiation does not entirely reflect into space, some of it gets trapped in the Earth's atmosphere, increasing temperatures (Yang et al., 2020). Besides this, the cycling of gasses and the delivery of nutrients and larvae to the marine ecosystems also causes changes in the water bodies across the globe, having a significant impact on the precipitation rates, thus the variations in rainfall throughout the regions (DeCarlo et al., 2020).

4.IMPACTS

4.1 Environmental Impacts

Climate change has a direct impact on the environment. There are chances of increased and frequent droughts and heat waves, especially during the summers. There can be storms and increased water levels during the rains, thus leading to floods, especially in regions closer to the water bodies (Abbass et al., 2022). There are chances of increased temperatures in the oceans and melting glaciers, worsening the environmental situation throughout the regions. There are also chances of ocean acidification, accumulation of wastes or oil spills causing water pollution, thus making the habitat surrounding the oceans inhabitable.

4.1.1 Rising Temperatures

The rising temperatures due to natural and anthropogenic activities lead to frequent wildfires and increased chances of droughts. There is an increase in the intensity of the winds, more rainfall from tropical cyclones and increased precipitation in some areas (Abbass et al., 2022). Due to the increase in Earth's temperatures, some areas might be facing warmth throughout the year, leading to a lessened number of rainy and winter days. The high temperatures can result from excessive burning of fossil fuels, agricultural residues, and deforestation, thus leading to climatic catastrophes (Abbass et al., 2022). The increased temperatures can also be associated with ecological, societal, and economic impacts, which will be discussed further. The urban heat island phenomenon, documented in around 400 cities across the globe, is aggravated by anthropogenic heat and environmental variations, thus leading to turbulence in weather and climate variations, especially in urban cities (Santamouris, 2020).

4.1.2 Melting Ice and Rising Sea Levels

The rise in sea levels due to climate change and environmental variations significantly impacts the planet's coastal regions. According to reports, the sea level rise is expected to be around 0.24 - 0.32 m by the year 2050 (Priestley, Heine and Milfont, 2021). This will be the effect of the melted ice caps due to the increased heat being trapped inside the Earth's atmosphere. The meltwater from the ice sheets and glaciers will eventually flow into the oceans, causing rising sea levels. This can be associated with problems like the destruction of habitat, flooding, and the destruction of human lives and infrastructures, especially around the coastal regions (Priestley, Heine and Milfont, 2021). Ice is an essential element that can reflect the energy of the Sun more than land and water. But the Earth will absorb when these ice caps melt due to the natural and anthropogenic activities leading to global warming and increased temperatures. It will not reflect the energy captured from the Sun, thus disrupting the normal climate (Griggs, 2021).

4.1.3 Ocean Acidification

Ocean acidification is critical, especially in the Southern Ocean (Figuerola et al., 2021). This is related to the shallowing of the saturation horizon, the depth below which calcium carbonate dissolves. The shallowing will likely increase the vulnerability of the different marine calcifiers to dissolution. This is associated with ocean warming and harming the habitats under the ocean and after the ocean boundaries. Ocean acidification is likely to impact the compositions of the phytoplankton as the concentration of CO_2 in the ocean waters has risen in the past decades due to natural and anthropogenic activities. This is majorly due to the lowering of the pH of the surface waters of the oceans by ~ 0.1 since the pre-industrial times (Jin, Hutchins and Gao, 2020). This has been aggravated by the increased oil spills, accumulation of wastes, water pollution, chemical discharges from industries, etc., thus hampering the pH levels of the water and altering the food chain altogether.

4.2 Ecological Impacts

Climate change is a significant environmental influence on the ecosystem. Earth's warming temperatures may force species to migrate to higher latitudes or higher elevations where the habitat will be much more conducive to their survival (Jaureguiberry et al., 2022). The sea level rises, or the intrusion of saltwater into the freshwater systems, can lead to the rehabilitation or extinction of species, thus hampering the ecological balance of the environment to a large extent.

4.2.1 Biodiversity Loss

The direct exploitation of natural resources, excessive use of the land or the sea and the associated change brought about by artificial aspects, the introduction of invasive alien species and pollution are some of the significant effects that lead to the loss of biodiversity (Jaureguiberry et al., 2022). The loss of different dimensions of biodiversity, i.e., the species and the ecosystems, results in the loss of cultural heritage. This is associated with increased vulnerability of the species to the changing climate and weather patterns as well as natural disasters caused by increased anthropogenic pollution. The loss of biodiversity endangers the well-being of humans by affecting the soil and the water of the ecosystem, which are directly linked to food production. The extensive biodiversity loss due to climate change and the accumulation of greenhouse gasses leading to the warming of Earth's temperatures has led to the emergence of infectious disease outbreaks, thus leading to the loss of human lives to a large extent (Schmeller, Courchamp and Killeen, 2020).

4.2.2 Habitat Disruption

Habitat loss refers to the removal of trees and plants from the ecosystems. This can occur due to natural disasters as well as because of anthropogenic activities like deforestation. The loss of habitat, especially trees and plantation, disrupt the soil quality, leading to soil erosion and soil leeching, which is the reduction in the soil's nutrient level in the terrestrial ecosystems (Fahad et al., 2022). When there is habitat loss, this also significantly impacts the agricultural cultivation and production in the region, thus leading to decreased food production for human beings and other animals' dependent on these agricultural produces. The habitat disruption is also associated with reduced water quality, as there will be more sediment accumulation and the fertilisers and pesticides used to increase agricultural produce will flow into the rivers and cause water pollution (Abd Wahaba et al., 2019). This will, in turn, harm the water zooplanktons and phytoplanktons, thus causing turbulence in the food chain.

4.2.3 Species Extinctions

Species extinction refers to the dying out of a particular species due to changes in habitats because of natural or anthropogenic factors. When a specific species becomes extinct, it is taken out of the food chain and causes an imbalance in the local ecosystems (Heleno, Ripple and Traveset, 2020). All organisms dwelling in an ecosystem depend upon a large variety of consumptive and non-consumptive interactions established with other organisms, thus forming an intricate web between them based on interdependencies. When the concentrating energy flow in the food chain pathways gets disturbed by the extinction of the species, the food web collapses, and the entire ecosystem is pushed out of the safe zone in the long run (Ryser et al., 2019). For establishing global scale synergies and balancing the tradeoffs of climate and biological change, the conservation of natural food webs is an essential context on which every individual needs to focus.

4.3 Societal and Economic Impacts

Climate change is one of the eminent threats to the economic stability of a nation and its subsequent social stability in that country (Anderson, Bayer and Edwards, 2020). The disruption in the climate or the weather patterns are related to food supply upheaval, disturbance in the financial markets and the industrial supply chains, leads to infrastructure damages and harms human health, thus stagnating global development.

4.3.1 Food Security

Agricultural production and food security are significantly impacted by the changes in the climate. With the increased population, agriculture is urgently needed to ensure food security (Anderson, Bayer and Edwards, 2020). The climate risks and the changing weather patterns have triggered shocks in food production and availability in the market. There is increased demand, but the supply has diminished over time due to the agricultural lands being converted to industrial sectors or establishments for housing the region's people (Leisner, 2020). The commodity prices have increased too, thus leading to the poor becoming poorer and unable to afford basic food items for themselves. The use of excess fertilisers and pesticides on agricultural products has led to decreased nutritional value and caused detrimental health impacts among humans (Leisner, 2020).

4.3.2 Water Scarcity

Changes in the climate exacerbate water scarcity and the increase in water hazards, impacting humans' lives in the long run (Schilling et al., 2020). The rising temperatures in the environment due to global warming have disrupted precipitation patterns and the entire water cycle of the ecosystem. By 2050, approximately 1.693–2.373 billion people are forecasted to face water scarcity problems (He et al., 2021). The increased unpredictability in the weather patterns has led to the lowering of the water table over time, increasing the chances of future generations suffering from water scarcity to a large extent.

4.3.3 Health Risks

Climate changes due to global warming and increased pollution have caused significant turbulence in the health and well-being of humans. Cardiovascular and respiratory diseases are some of the significant illnesses seen among humans. Cancers and genetic mutations due to the change in climate and the pollution of most of the natural resources have led to future generations being born with these illnesses (Mora et al., 2022). Besides these infectious diseases, which the whole had to face regarding COVID-19 can be seen because of the variations in the climate. Besides the undernutrition being developed due to the lack of nutrients in the agricultural produce, many allergies, cases of injuries, and poisoning are also happening. Besides affecting physical health, climate change has also taken a toll on the mental health of humans (Cianconi, Betrò and Janiri, 2020). The increase in heat waves, droughts or floods leading to the loss of many human lives directly impacts the mental health of those families and trauma arising from the loss of ecosystems and variations in climate patterns.

4.3.4 Migration and Displacement

Climate change is associated with worsening living conditions and loss of livelihood for different local populations (Hoffmann et al., 2020). Droughts, floods, and increases in heatwaves in a region lead to migration or displacement of animal species or humans from one place to another, which has a more habitable environment. As of 2021-2022, there have been 23.7 million internal displacements within the European

Union. Global migration and displacement further play an essential role in the stability of future generations in the long run (European Commission, 2022).

5 Mitigation Strategies

5.1 Renewable Energy Sources

The urban climate resilience being talked about in this report can be established through the use of renewable sources of energy. Clean, renewable energy sources like solar, wind or hydropower can generate electricity, which can help decrease the pressure on non-renewable fuels in the environment (Sharifi, 2021).

5.2 Energy Efficiency

Energy conservation or energy efficiency can be done with the help of upgraded infrastructure. This can be done by using the least amount of energy resources possible so that less pressure on the environment and the carbon footprint decreases, thus saving the entire Earth from imminent destruction. But in urban cities, this can only be achieved by providing the required education to all the citizens who will thus give their best to preserve the environment (Jorgenson, Stephens and White, 2019).

5.3 Afforestation and Reforestation

Afforestation and reforestation are the adaptation opportunities that can be taken to ensure urban climate resilience. This helps increase evapotranspiration in the areas, thus normalising the precipitation rates. When the precipitation rates are normalised, the heat waves and the warming of the Earth will also decrease eventually, and the CO2 concentration from the atmosphere can also be reduced to a large extent (Teuling et al., 2019).

5.4 Carbon Capture and Storage (CCS)

CCS in climate resilience is a technique to reduce the impact of global climate change. This is done by lowering emissions and burning fossil fuels in countries with the highest emission rates. This is also associated with the proper methods of disposing of the waste and the subsequent waste treatment and incineration so that the carbon trapped in the waste effectively decomposes into the environment (Bisinella et al., 2021).

5.5 International Agreements (e.g., Paris Agreement)

The main aim of the Paris Agreement was to strengthen the global response and to fight against climate change by keeping the global temperature rise below 2 degrees Celsius (Murthy, 2019). The global treaty acts as a transnational legal process and, upon providing education to citizens across the globe, will be effective in achieving urban climate resilience in the upcoming years.

6. ADAPTATION MEASURES

6.1 Climate Resilience in Infrastructure

The climate-resilient infrastructure will be planned, designed, built and operated to help the government and residents prepare for and adapt to the changing climate conditions in the region (Hayes et al., 2019). This will focus on leveraging the socio-economic resilience theory and decreasing the associated costs for the government and the citizens while designing these buildings.

6.2 Agricultural Adaptation

Autonomous and planned adaptation in agriculture can help in innovatively approaching climate change. This will help the farmers and the government understand the precipitation patterns and plant those agricultural crops that will flourish during that time (Anderson, Bayer and Edwards, 2020). This will meet population demands and reduce the waste in excess agricultural produce.

6.3 Coastal Protection

Nature-based coastal protection will help build the defence systems more robustly and fight against the natural disasters that might be imminent in the regions. Early notification of any storms and the building of shelter homes will help the government and the citizens save more lives and livestock and decrease infrastructural damages (Toimil et al., 2020). The shores can be protected, and the government can restore the wetlands with complex structures but at lowered costs such that the coming dangers can be averted to a large extent.

6.4 Public Health Preparedness

Estimating and quantifying the associated outcomes of the health disorders related to climate change can help lessen the burden of medical costs. Identifying suitable health interventions and educating citizens about public health can be beneficial (Kotcher et al., 2021). Writing a proper adaptation plan and subsequent monitoring and follow-ups need to be ensured by the region's healthcare authorities and local governments to deal with the disorders happening due to extensive climate change.

7.CURRENT POLICY AND INTERNATIONAL AGREEMENT

7.1 National Climate Policies

National climate resilience policies are undertaken to protect people, their properties, infrastructure, etc., from the changing climate conditions. As of now, 1,800 climate change laws and policies are present in the world, covering both climate mitigation and adaptation (Eskander and Fankhauser, 2020). These policies differ for different regions based on the climate patterns and the prevalence of natural disasters in the area, besides the pollution rates. By following these laws and policies, every country needs to transform its legislative activities and achieve urban climate resilience in the long run.

7.2 Role of Intergovernmental Organizations

Intergovernmental organisations across the globe focus on establishing sustainability in the upcoming years to help create and facilitate professional networks in building resilient cities and infrastructure by mobilising renewable resources. These organisations publish climate assessment reports on a quarterly or yearly basis, thus helping the governments to prepare a national greenhouse gas inventory and reduce the amount of global warming extensively (Bracking and Leffel, 2021). For urban climate resilience, climate financing is also provided by these intergovernmental organisations to come up with practical eco-friendly approaches and structures and adapt to the changing climate.

7.3 Progress and Challenges

While adapting to the climate and enabling urban climate resilience, there has been enough progress across the globe., This has been in terms of providing medical care to every person irrespective of any discriminatory factors, the establishment of robust buildings, the building of coastlines and wetlands to guard the coastal areas, etc. (Sharifi, 2021). But still, education is lacking in most of the places, especially in the underdeveloped and the developing nations. Due to a lack of education, the citizens cannot adapt to climate adaptation strategies. The increased population and the inability of the government to manage the waste also make it a far more achievable aim of the world to attain sustainability in the upcoming years.

8.FUTURE PROSPECTIVES

8.1 Climate Models and Predictions

"Artificial Neural Network (ANN) optimised with the Backtracking Search Algorithm (BSA-ANN)" can be used for predicting urban water demand (Zubaidi et al., 2020). This model can be utilised to prevent water shortage in an area and take precautionary steps before the inhabitants' face water scarcity problems. This will help predict future water consumption based on the water consumption by the people of that area in the previous months, thus helping to achieve urban climate resilience in the upcoming years.

8.2 Emerging Technologies

Digital technologies, especially AI, can be used to introduce urban climate resilience. This acts as a powerful tool to make the governments and citizens aware of the strengths and weaknesses of the regions. Subsequent steps can then be taken to adjust to the changing patterns of the climate, thus making more robust progress towards achieving resilience (George, Merrill and Schillebeeckx, 2021). AI technologies will also help in sustainable planning and management practices in emerging urban cultures, thus lowering the economic and social consequences of changing weather patterns.

8.3 Public Awareness and Engagement

Participating in the public by building local climate resilience can help empower the communities to develop. This helps implement adaptation strategies to ensure climate-related shocks and stresses can be effectively dealt with by a particular region's governments or residents. Incorporating psychosocial and behavioural adaptation in climate transformation policies will help to increase public engagement and awareness in the long run (Hügel and Davies, 2020).

9.CONCLUSION

9.1 Recap of Key Points

The review report has discussed the climate changes and the required adaptations to attain urban climate resilience. The scientific thoughts associated with climate change have been discussed, along with the causes behind the alterations in weather patterns. The different impacts of climate change and mitigation strategies required to deal with climate variations have also been discussed. The different adaptation measures, current policy and international cooperation and prospects that are associated with urban climate resilience have been delineated in this report.

9.2 Call to Action

Climate-smart projects need to be introduced by the governments for the local regions and across the globe. This will focus on affordable housing structures, coming up with nature-based solutions and sustainable waste management systems to achieve climate resilience in the long run.

9.3 The Urgency of Addressing Climate Change

The planet Earth is at a dangerous tipping point, and until and unless effective decisions are taken to control the variations in climate and global warming, the world is progressing towards impending doom. Every aspect of the environment is being degraded by the maximum use of anthropogenic elements and the increased population, which is why proper steps need to be taken, and the public needs to be made aware of the situation so that future generations can be saved from the degraded environment.

10.REFERENCES

Abbass, K., Qasim, M.Z., Song, H., Murshed, M., Mahmood, H. and Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29(28), pp.42539-42559. https://link.springer.com/article/10.1007/s11356-022-19718-6

Abd Wahaba, N., Kamarudina, M.K.A., Torimanb, M.E., Juahira, H., Saada, M.H.M., Ataa, F.M., Ghazalia, A., Hassana, A.R., Abdullaha, H., Mauludc, K.N. and Hanafiahd, M.M. (2019). Sedimentation and water quality deterioration problems at Terengganu River Basin, Terengganu, Malaysia. Desalination Water Treat, 149, pp.228-241. https://www.academia.edu/download/87408092/233205b4d379d1053eefb6d620858bac8ff4.pdf

Al-Ghussain, L. (2019). Global warming: review on driving forces and mitigation. Environmental Progress & Sustainable Energy, 38(1), pp.13-21. https://aiche.onlinelibrary.wiley.com/doi/abs/10.1002/ep.13041

Anderson, R., Bayer, P.E. and Edwards, D. (2020). Climate change and the need for agricultural adaptation. Current opinion in plant biology, 56, pp.197-202. https://www.sciencedirect.com/science/article/pii/S1369526619301219

Aubry, T.J., Staunton-Sykes, J., Marshall, L.R., Haywood, J., Abraham, N.L. and Schmidt, A. (2021). Climate change modulates the stratospheric volcanic sulfate aerosol lifecycle and radiative forcing from tropical eruptions. Nature Communications, 12(1), p.4708. https://www.nature.com/articles/s41467-021-24943-7

Bisinella, V., Hulgaard, T., Riber, C., Damgaard, A. and Christensen, T.H. (2021). Environmental assessment of carbon capture and storage (CCS) as a post-treatment technology in waste incineration. Waste Management, 128, pp.99-113. https://www.sciencedirect.com/science/article/pii/S0956053X21002440

Bonneuil, C., Choquet, P.L. and Franta, B. (2021). Early warnings and emerging accountability: Total's responses to global warming, 1971–2021. Global Environmental Change, 71, p.102386. https://www.sciencedirect.com/science/article/pii/S0959378021001655

Bracking, S. and Leffel, B. (2021). Climate finance governance: Fit for purpose?. Wiley Interdisciplinary Reviews: Climate Change, 12(4), p.e709. https://wires.onlinelibrary.wiley.com/doi/abs/10.1002/wcc.709

Cianconi, P., Betrò, S. and Janiri, L. (2020). The impact of climate change on mental health: a systematic descriptive review. Frontiers in psychiatry, 11, p.74. https://www.frontiersin.org/articles/10.3389/fpsyt.2020.00074/full?ref=lawyersfornature.com

DeCarlo, T.M., Gajdzik, L., Ellis, J., Coker, D.J., Roberts, M.B., Hammerman, N.M., Pandolfi, J.M., Monroe, A.A. and Berumen, M.L. (2020). Nutrient-supplying ocean currents modulate coral bleaching susceptibility. Science Advances, 6(34), p.eabc5493. https://www.science.org/doi/abs/10.1126/sciadv.abc5493

Dodman, D., Archer, D. and Satterthwaite, D. (2019). Responding to climate change in contexts of urban poverty and informality. Environment and Urbanisation, 31(1), pp.3-12. https://journals.sagepub.com/doi/abs/10.1177/0956247819830004

Driga, A.M. and Drigas, A.S. (2019). Climate Change 101: How Everyday Activities Contribute to the Ever-Growing Issue. Int. J. Recent Contributions Eng. Sci. IT, 7(1), pp.22-31. https://www.researchgate.net/profile/Athanasios-Drigas/publication/332029427_Climate_Change_101_How_Everyday_Activities_Contribute_to_the_Ever-Growing_Issue/links/5c9b9997a6fdccd4603f1910/Climate-Change-101-How-Everyday-Activities-Contribute-to-the-Ever-Growing-Issue.pdf

Eskander, S.M. and Fankhauser, S. (2020). Reduction in greenhouse gas emissions from national climate legislation. Nature Climate Change, 10(8), pp.750-756. https://www.nature.com/articles/s41558-020-0831-z

European Commission (2022). European Migration Network Inform Displacement and migration related to disasters, climate change and environmental degradation European Migration Network. [online] Available at: https://home-affairs.ec.europa.eu/system/files/2023-05/EMN_Inform_climate_related_migration_final_May2023_090523.pdf [Accessed 31 Aug. 2023].

Fahad, S., Chavan, S.B., Chichaghare, A.R., Uthappa, A.R., Kumar, M., Kakade, V., Pradhan, A., Jinger, D., Rawale, G., Yadav, D.K. and Kumar, V. (2022). Agroforestry systems for soil health improvement and maintenance. Sustainability, 14(22), p.14877. https://www.mdpi.com/2071-1050/14/22/14877

Farooq, M.S., Uzair, M., Raza, A., Habib, M., Xu, Y., Yousuf, M., Yang, S.H. and Ramzan Khan, M. (2022). Uncovering the research gaps to alleviate the negative impacts of climate change on food security: a review. Frontiers in plant science, 13, p.927535. https://www.frontiersin.org/articles/10.3389/fpls.2022.927535/full

Figuerola, B., Hancock, A.M., Bax, N., Cummings, V.J., Downey, R., Griffiths, H.J., Smith, J. and Stark, J.S. (2021). A review and meta-analysis of potential impacts of ocean acidification on marine calcifiers from the Southern Ocean. Frontiers in Marine Science, 8, p.584445. https://www.frontiersin.org/articles/10.3389/fmars.2021.584445/full

George, G., Merrill, R.K. and Schillebeeckx, S.J. (2021). Digital sustainability and entrepreneurship: How digital innovations are helping tackle climate change and sustainable development. Entrepreneurship Theory and Practice, 45(5), pp.999-1027. https://journals.sagepub.com/doi/abs/10.1177/1042258719899425

Griggs, G. (2021). Rising seas in california—an update on sea-level rise science. In World Scientific Encyclopedia of Climate Change: Case Studies of Climate Risk, Action, and Opportunity Volume 3 (pp. 105-111). https://www.worldscientific.com/doi/abs/10.1142/9789811213960_0016

Harde, H. (2022). How Much CO2 and the Sun Contribute to Global Warming: Comparison of Simulated Temperature Trends with Last Century Observations. Science of Climate Change, 2(1), pp.N1-1. https://www.researchgate.net/profile/Hermann-Harde/publication/373256463_Science_of_Climate_Change_How_Much_CO2_and_the_Sun_Contribute_to_Global_Warming_Comparison_of_Simulated_Temperature_Trends_with_Last_Century_Observations/links/64e380530453074fbda51b88/Science-of-Climate-Change-How-Much-CO2-and-the-Sun-Contribute-to-Global-Warming-Comparison-of-Simulated-Temperature-Trends-with-Last-Century-Observations.pdf

Hayes, S., Desha, C., Burke, M., Gibbs, M. and Chester, M. (2019). Leveraging socio-ecological resilience theory to build climate resilience in transport infrastructure. Transport Reviews, 39(5), pp.677-699. https://www.tandfonline.com/doi/abs/10.1080/01441647.2019.1612480

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J. and Bryan, B.A. (2021). Future global urban water scarcity and potential solutions. Nature Communications, 12(1), p.4667. https://www.nature.com/articles/s41467-021-25026-3

Hegerl, G.C., Brönnimann, S., Cowan, T., Friedman, A.R., Hawkins, E., Iles, C., Müller, W., Schurer, A. and Undorf, S. (2019). Causes of climate change over the historical record. Environmental Research Letters, 14(12), p.123006. https://iopscience.iop.org/article/10.1088/1748-9326/ab4557/meta

Heleno, R.H., Ripple, W.J. and Traveset, A. (2020). Scientists' warning on endangered food webs. Web Ecology, 20(1), pp.1-10. https://we.copernicus.org/articles/20/1/2020/

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J. and Peisker, J. (2020). A meta-analysis of country-level studies on environmental change and migration. Nature Climate Change, 10(10), pp.904-912. https://www.nature.com/articles/s41558-020-0898-6

Hügel, S. and Davies, A.R. (2020). Public participation, engagement, and climate change adaptation: A review of the research literature. Wiley Interdisciplinary Reviews: Climate Change, 11(4), p.e645. https://wires.onlinelibrary.wiley.com/doi/abs/10.1002/wcc.645

International Monetary Fund (2023). Climate Change Data. [online] climatedata.imf.org. Available at: https://climatedata.imf.org/pages/climatechange-data [Accessed 31 Aug. 2023].

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D.E., Coscieme, L., Golden, A.S., Guerra, C.A., Jacob, U., Takahashi, Y., Settele, J. and Díaz, S. (2022). The direct drivers of recent global anthropogenic biodiversity loss. Science advances, 8(45), p.eabm9982. https://www.science.org/doi/abs/10.1126/sciadv.abm9982

Jin, P., Hutchins, D.A. and Gao, K. (2020). The impacts of ocean acidification on marine food quality and its potential food chain consequences. Frontiers in Marine Science, 7, p.543979. https://www.frontiersin.org/articles/10.3389/fmars.2020.543979/full

Jorgenson, S.N., Stephens, J.C. and White, B. (2019). Environmental education in transition: A critical review of recent research on climate change and energy education. The Journal of Environmental Education, 50(3), pp.160-171. https://www.tandfonline.com/doi/abs/10.1080/00958964.2019.1604478

Kotcher, J., Maibach, E., Miller, J., Campbell, E., Alqodmani, L., Maiero, M. and Wyns, A. (2021). Views of health professionals on climate change and health: a multinational survey study. The Lancet Planetary Health, 5(5), pp.e316-e323. https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00053-X/fulltext

Leisner, C.P. (2020). Climate change impacts on food security-focus on perennial cropping systems and nutritional value. Plant Science, 293, p.110412. https://www.sciencedirect.com/science/article/pii/S0168945220300145

Li, Y., Brando, P.M., Morton, D.C., Lawrence, D.M., Yang, H. and Randerson, J.T. (2022). Deforestation-induced climate change reduces carbon storage in remaining tropical forests. Nature communications, 13(1), p.1964. https://www.nature.com/articles/s41467-022-29601-0

Mi, Z., Guan, D., Liu, Z., Liu, J., Viguié, V., Fromer, N. and Wang, Y. (2019). Cities: The core of climate change mitigation. Journal of Cleaner Production, 207, pp.582-589. https://www.sciencedirect.com/science/article/pii/S0959652618330488

Mikhaylov, A., Moiseev, N., Aleshin, K. and Burkhardt, T. (2020). Global climate change and greenhouse effect. Entrepreneurship and Sustainability Issues, 7(4), p.2897. https://www.researchgate.net/profile/Alexey-Mikhaylov/publication/342372335_Global_climate_change_and_greenhouse_effect/links/5f576af2299bf13a31ab136c/Global-climate-change-and-greenhouse-effect.pdf

Mora, C., McKenzie, T., Gaw, I.M., Dean, J.M., von Hammerstein, H., Knudson, T.A., Setter, R.O., Smith, C.Z., Webster, K.M., Patz, J.A. and Franklin, E.C. (2022). Over half of known human pathogenic diseases can be aggravated by climate change. Nature climate change, 12(9), pp.869-875. https://www.nature.com/articles/s41558-022-01426-1

Murthy, S.L. (2019). States and cities as norm sustainers: A role for subnational actors in the paris agreement on climate change. Va. Envtl. LJ, 37, p.1. https://heinonline.org/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/velj37&section=4

NASA (2019). Global surface temperature. [online] Climate Change: Vital Signs of the Planet. Available at: https://climate.nasa.gov/vital-signs/global-temperature/ [Accessed 31 Aug. 2023].

Priestley, R.K., Heine, Z. and Milfont, T.L. (2021). Public understanding of climate change-related sea-level rise. PLoS One, 16(7), p.e0254348. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0254348

Ryser, R., Häussler, J., Stark, M., Brose, U., Rall, B.C. and Guill, C. (2019). The biggest losers: habitat isolation deconstructs complex food webs from top to bottom. Proceedings of the royal society B, 286(1908), p.20191177. https://royalsocietypublishing.org/doi/abs/10.1098/rspb.2019.1177

Santamouris, M. (2020). Recent progress on urban overheating and heat island research. Integrated assessment of the energy, environmental, vulnerability and health impact. Synergies with the global climate change. Energy and Buildings, 207, p.109482. https://www.sciencedirect.com/science/article/pii/S0378778819326696

Schilling, J., Hertig, E., Tramblay, Y. and Scheffran, J. (2020). Climate change vulnerability, water resources and social implications in North Africa. Regional Environmental Change, 20, pp.1-12. https://link.springer.com/article/10.1007/s10113-020-01597-7

Schmeller, D.S., Courchamp, F. and Killeen, G. (2020). Biodiversity loss, emerging pathogens and human health risks. Biodiversity and conservation, 29, pp.3095-3102. https://link.springer.com/article/10.1007/s10531-020-02021-6

Schokker, J., Kamilaris, A. and Karatsiolis, S. (2021). A Review on Key Performance Indicators for Climate Change. Environmental Informatics, pp.273-292.https://link.springer.com/chapter/10.1007/978-3-030-88063-7_17

Schummer, J. (2021). The Chemical Prediction of Stratospheric Ozone Depletion: A Moral Model of Scientific Hazard Foresight. In Ethics of Chemistry: From Poison Gas to Climate Engineering (pp. 347-374). https://www.worldscientific.com/doi/abs/10.1142/9789811233548_0013

Shaftel, H. (2023). What Is Climate Change? [online] Climate Change: Vital Signs of the Planet. Available at: https://climate.nasa.gov/what-is-climate-change/ [Accessed 31 Aug. 2023].

Sharifi, A. (2021). Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review. Science of the total environment, 750, p.141642. https://www.sciencedirect.com/science/article/pii/S0048969720351718

Teremranova, J. (2023). MULTI-LEVEL ASSESSMENT OF THE CONTRIBUTION OF END USERS TO THE PROCESS OF TRANSFORMATION OF THE ENERGY SYSTEM TOWARDS DECARBONISATION. https://ebooks.rtu.lv/wp-content/uploads/sites/32/2023/03/9789934228780-PDK_Jana_Teremranova_ENG.pdf

Teuling, A.J., De Badts, E.A., Jansen, F.A., Fuchs, R., Buitink, J., Hoek van Dijke, A.J. and Sterling, S.M. (2019). Climate change, reforestation/afforestation, and urbanisation impacts on evapotranspiration and streamflow in Europe. Hydrology and Earth System Sciences, 23(9), pp.3631-3652. https://hess.copernicus.org/articles/23/3631/2019/

Toimil, A., Camus, P., Losada, I.J., Le Cozannet, G., Nicholls, R.J., Idier, D. and Maspataud, A. (2020). Climate change-driven coastal erosion modelling in temperate sandy beaches: Methods and uncertainty treatment. Earth-Science Reviews, 202, p.103110. https://www.sciencedirect.com/science/article/pii/S0012825219303861

Yang, H., Lohmann, G., Krebs-Kanzow, U., Ionita, M., Shi, X., Sidorenko, D., Gong, X., Chen, X. and Gowan, E.J. (2020). Poleward shift of the major ocean gyres detected in a warming climate. Geophysical Research Letters, 47(5), p.e2019GL085868. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL085868

Yoro, K.O. and Daramola, M.O. (2020). CO2 emission sources, greenhouse gases, and the global warming effect. In Advances in carbon capture (pp. 3-28). Woodhead Publishing. https://www.sciencedirect.com/science/article/pii/B9780128196571000013

Zhang, M. and Wei, X. (2021). Deforestation, forestation, and water supply. Science, 371(6533), pp.990-991. https://www.science.org/doi/abs/10.1126/science.abe7821

Zubaidi, S.L., Ortega-Martorell, S., Al-Bugharbee, H., Olier, I., Hashim, K.S., Gharghan, S.K., Kot, P. and Al-Khaddar, R. (2020). Urban water demand prediction for a city that suffers from climate change and population growth: Gauteng province case study. Water, 12(7), p.1885. https://www.mdpi.com/2073-4441/12/7/1885