ASSESSING GLOBAL CLIMATE CHANGE: EXTENT AND EFFECTS

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Abstract

All environmental problems that touch any nation lead to adverse effects on the lives and health of their populations. Climate disasters are on the rise. Around 70 per cent of disasters are now climate related - up from around 50% from two decades ago. These disasters take a heavier human toll and come with a higher price tag. In the last decade, 2.4 billion people were affected by climate related disasters, compared to 1.7 billion in the previous decade. The cost of responding to disasters has risen tenfold between 1992 and 2008. Destructive sudden heavy rains, intense tropical storms, repeated flooding and droughts are likely to increase, as will the vulnerability of local communities in the absence of strong concerted action. Climate change is not just a distant future threat. It is the main driver behind rising humanitarian needs and we are seeing its impact. The number of people affected and the damages inflicted by extreme weather has been unprecedented. Unless we can reduce the amount of carbon dioxide in the atmosphere to 350 parts per million, we will cause huge and irreversible damage to the earth. Keeping these things in view the objectives of the study are a) to discuss the global environmental issues with special reference to climate change, b) to formulate the historical evidences of climatic records, c) to assess the extent and effects of climate change, and d) to describe the climate change modeling and prediction. The risks inherent in gathering and interpreting observed evidence made it essential to design a methodology that allowed access to a diverse range of sources, so that data could be verified before being accepted as evidence. The methodology made different types of data. Relevant data collected from printed materials, internet, books, journals, articles and thesis etc.

Keywords: Environment, Climate Change, Modelling, Prediction

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Introduction

At the dawn of the third millennium, a powerful and complex web of interactions is contributing to unprecedented global trends in environmental degradation. These forces include rapid globalization and urbanization, pervasive poverty, unsustainable consumption patterns and population growth. Global climate change, the depletion of the ozone layer, desertification, deforestation, the loss of the planet's biological diversity and the transboundary movements of hazardous wastes and chemicals are all environmental problems that touch every nation and adversely affect the lives and health of their populations. As with other environment-related challenges, children are disproportionately vulnerable to and suffer most from the effects of these global trends. Moreover, all of these global environmental trends have long-term effects on people and societies and are either difficult or impossible to reverse over the period of one generation. Climate change has become more than obvious over the past decade, with nine years of the decade making it to the list of hottest years the planet has ever witnessed. The rise in temperature has also ensured that the equations on the planet have gone for a toss. Some of the most obvious signs of this include irregularities in weather, frequent storms, melting glaciers, rising levels of sea etc. Going by the prevailing conditions, it is not difficult to anticipate that the planet is heading for a dramatic climate change, some wherein, near, future.

Overview of Literature

Literature is available global environmental issues in general and on climate change in particular. Scholars from different fields have provided different dimension on the environmental issues ranging from macro, meso and micro levels. Among all the global environmental issues, climate change is the most profound problem as not only human beings but a microorganism survival is also at stake. Bannett (2003) explains the ways in which climate change is a security issue are connected and also includes other aspects such as national security considerations, human security concerns, military roles, and a discussion of the widely held assumption that climate change may trigger violent conflict. Grothmann, T and Patt, A (2005) emphasize on the processes of individual adaptation to climate change. Adaptation has emerged as an important area of research and assessment among climate change scientists. Empirical research on adaptation has not addressed the importance of measurable and alterable psychological factors in determining adaptation. A socio-cognitive Model of Private Proactive Adaptation to Climate

Change (MPPACC) has been developed based on the psychology and behavioral economics. Germany (urban area) and Zimbabwe (rural area) were selected to explore the validity of MPPACC in explaining adaptation. In the German study, MPPACC provides better statistical power than traditional socio-economic models. In the Zimbabwean case study, a qualitative match between MPPACC and adaptive behavior has been found. Tuner et al stressed that land change science has emerged as a fundamental component of global environmental change. Furtherance to that, the dynamics of land cover and land use coupled with human–environment system to address theory, concepts, models, and applications relevant to environmental and societal problems, including the intersection of the two. Adger et. al, (2005) have reviewed the nature of adaptation and the implications of climate change at different spatial scales for the physical and ecological systems. A set of normative evaluative criteria for judging the success of adaptations in terms of the sustainability of development at different scales such as elements of effectiveness, efficiency, equity and legitimacy are important. It has been found that the process by which adaptations are to be judged at different scales will involve new and challenging institutional processes.

Thompson (2010) highlighted the observation of 20th and 21st century glacier shrinkage in the Andes, the Himalayas, and on Mount Kilimanjaro as glaciers serves as early indicator of climate change. It has been found that the current global warming is affecting our climate, so prevention is no longer an option. To deal with this crisis only three options are left i.e. mitigate, adapt and suffer. Schneider and Lane paper attempts to outlines the basic science on climate change as well as the IPCC assessments on emission scenario and climate impacts. Literature on assessment of dangerous anthropogenic inferences with the climate system has also been summarized with emphasis on recent probabilistic analysis.

Objectives

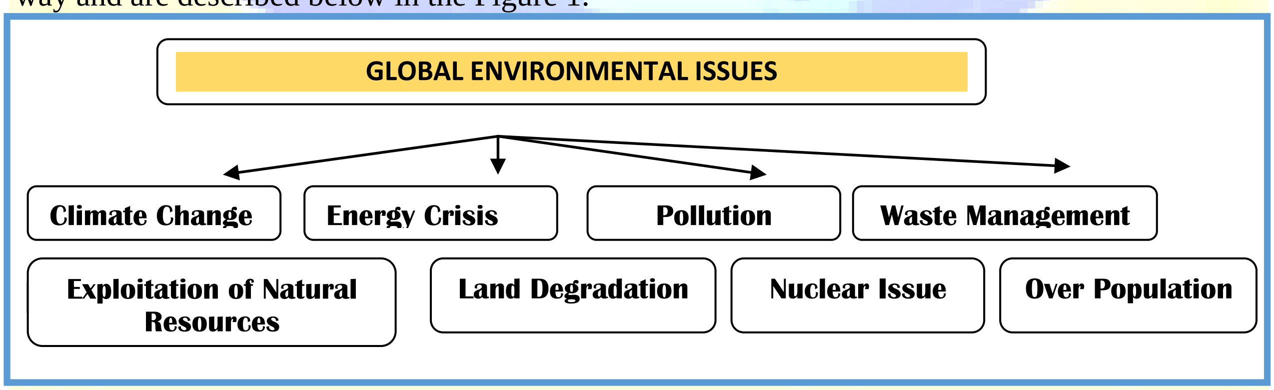
- To discuss the global environmental issues with special reference to climate change.
- To assess the extent and effects of climate change.
- To describe the climate change modeling and prediction.

Database and Methodology

The risks inherent in gathering and interpreting observed evidence made it essential to design a methodology that allowed access to a diverse range of sources, so that data could be verified before being accepted as evidence. The methodology made different types of data. Relevant data collected from printed materials, internet, books, journals, articles and thesis etc.

Result and Discussion

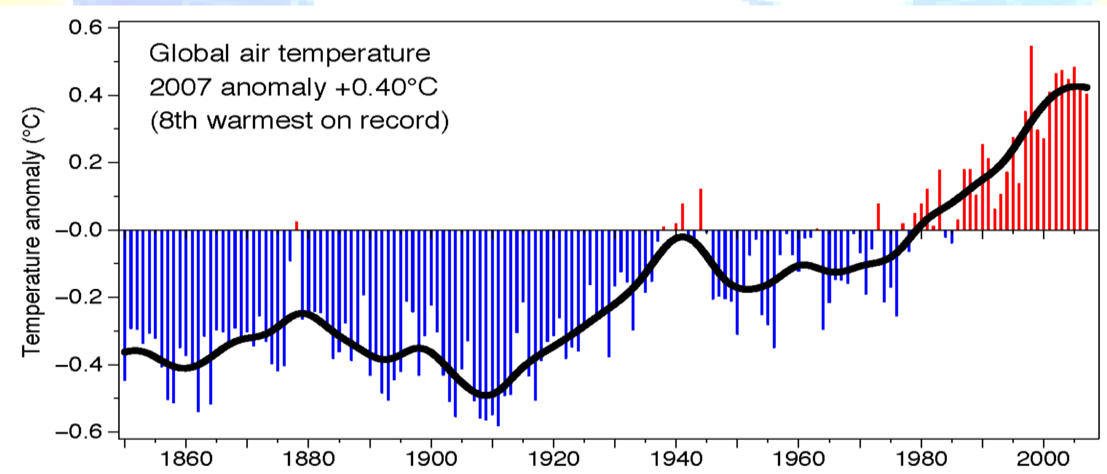
Environmental Issues at Global Level: Since 1990 global population has grown from roughly 5.3 to 6.8 billion and sustained global economic growth, accompanied by total and per capita increases in consumption in many parts of the world, not least in Brazil, Russia, India and China. However, our world remains riven by differences in access to resources and per capita consumption both between and within countries. The scientific community has clearly documented and quantified global environmental change with increasing precision and improved models to understand the future consequences of our actions, although large uncertainties remain. The global environmental issues that the planet faces today go beyond global warming and energy crisis and there are several other issues of global concern, each of which is equally hazardous. More importantly, all these issues are related with each other by some or the other way and are described below in the Figure 1.



Evidence for climate change in the recent past and predictions for the future

Humans are accustomed to climatic conditions that vary on daily, seasonal and inter-annual time-scales. Accumulating evidence suggests that in addition to this natural climate variability, average climatic conditions measured over extended time periods (conventionally 30 years or longer) are also changing, over and above the natural variation observed on decadal or century time-scales. The causes of this climate change are increasingly well understood. Climatologists have compared climate model simulations of the effects of greenhouse gas (GHG) emissions against observed climate variations in the past, and evaluated possible natural influences such as solar and volcanic activity. They concluded that "there is new and stronger evidence that most of the warming observed over the last 50 years is likely to be attributable to human activities" (IPCC 2001b). The Third Assessment Report of the IPCC (IPCC 2001b) estimates that globally the average land and sea surface temperature has increased by 0.6 to 0.2 ^{o} C since the mid-19th century, with much of the change occurring since 1976 (Figure). Warming has been observed in all continents, with the greatest temperature changes occurring at middle and high latitudes in the Northern Hemisphere. Patterns of precipitation have also changed: arid and semi-arid regions are apparently becoming drier, while other areas, especially mid-to-high latitudes, are becoming wetter. Where precipitation has increased, there has also been a disproportionate increase in the frequency of the heaviest precipitation events (Karl and Knight 1998; Mason et al. 1999). The small amount of climatic change that has occurred so far has already had demonstrable effects on a wide variety of natural ecosystems (Walther et al. 2002).

Figure 1: Observed Global average Land and Sea Surface Temperatures from 1860 to 2000



Climate model simulations have been used to estimate the effects of past, present and likely future GHG emissions on climate changes. These models are primarily based on data on the heat-retaining properties of gases released into the atmosphere from natural and anthropogenic (man-made) sources, as well as the measured climatic effects of other natural phenomena, as described above. The models used by the IPCC have been validated by "back-casting"—that is, testing their ability to explain climate variations that already occurred in the past. In general, the models are able to give good approximations of past patterns only climatic records for the past

500 years suggest fluctuations on three time intervals: fifteen to thirty five years with a peak amplitude of 0.3^{o} C; fifty to a hundred years with a 1.0^{o} C amplitude over the North Atlantic-Arctic; and 100 to 400 years global oscillations of about when anthropogenic emissions of non-GHG air pollutants (particulates, dust, oxides of sulfur, etc.) are included along with natural phenomena (IPCC 2001b). This emphasizes that (i) the models represent a good approximation of the climate system; (ii) natural variations are important contributors to climatic variations, but cannot adequately explain past trends on their own; and (iii) anthropogenic GHG emissions are an important contributor to climate patterns, and are likely to remain so in the future.Considering a range of alternative economic development scenarios and model parameterizations, the IPCC concluded that if no specific actions were taken to reduce GHG emissions, global temperatures would rise between 1.4 and 5.8 ^{o} C from 1990 to 2100. The projections for precipitation and wind speed are less consistent in terms of magnitude and geographical distribution, but also suggest significant changes in both mean conditions and in the frequency and intensity of extreme events.

Table 1: Estimates of confidence in observed and projected changes in extreme weather and climate events

Changes in phenomenon	**Confidence in observed changes (latter half of 1900s)**	**Confidence in projected changes (during the 21st century)**
Higher maximum temperatures and more hot days over nearly all land areas	likely	Very likely
Reduce diurnal temperature range over most land areas	Very likely	Very likely
Increase of heat index over land areas	Likely over many areas	Very likely, over most areas
More intense precipitation events	Likely, over many northern hemisphere mid to high latitude land area	Very likely, over many areas

Source: Adapted from IPCC (2001b)

Climate Change – Extent and Effects

It is now widely recognized that global warming over the past 50 years is largely due to human activities that have released green- house gases into the atmosphere. The most recent assessment report by the Intergovernmental Panel on Climate Change (IPCC) concludes that the global average surface temperature has increased by about 0.6°C during the 20th century. The seemingly small rise of mean temperature is already showing adverse effects. One of the consequences has been a rise in the global average sea level. Another effect has been more frequent and intensified droughts in recent decades in parts of Asia and Africa. Additionally, in most mid and high latitudes of the Northern Hemisphere continents, precipitation has increased by 0.5 to 1.0 per cent per decade in the 20th century. The world's emissions of greenhouse gases, notably carbon dioxide, continue to increase. The most recent estimates are that atmospheric concentrations of the greenhouse gas carbon dioxide (CO_2) will double or triple pre-industrial levels by the end of this century. As a result, global surface temperature is expected to increase by 1.4 to 5.8 degrees Celsius from 1990 to 2100 The repercussions of climate change will disproportionately affect those who are least able to adapt - the poor and the most vulnerable sections of society, including children. For example, scientists project that this level of warming could, among other things:

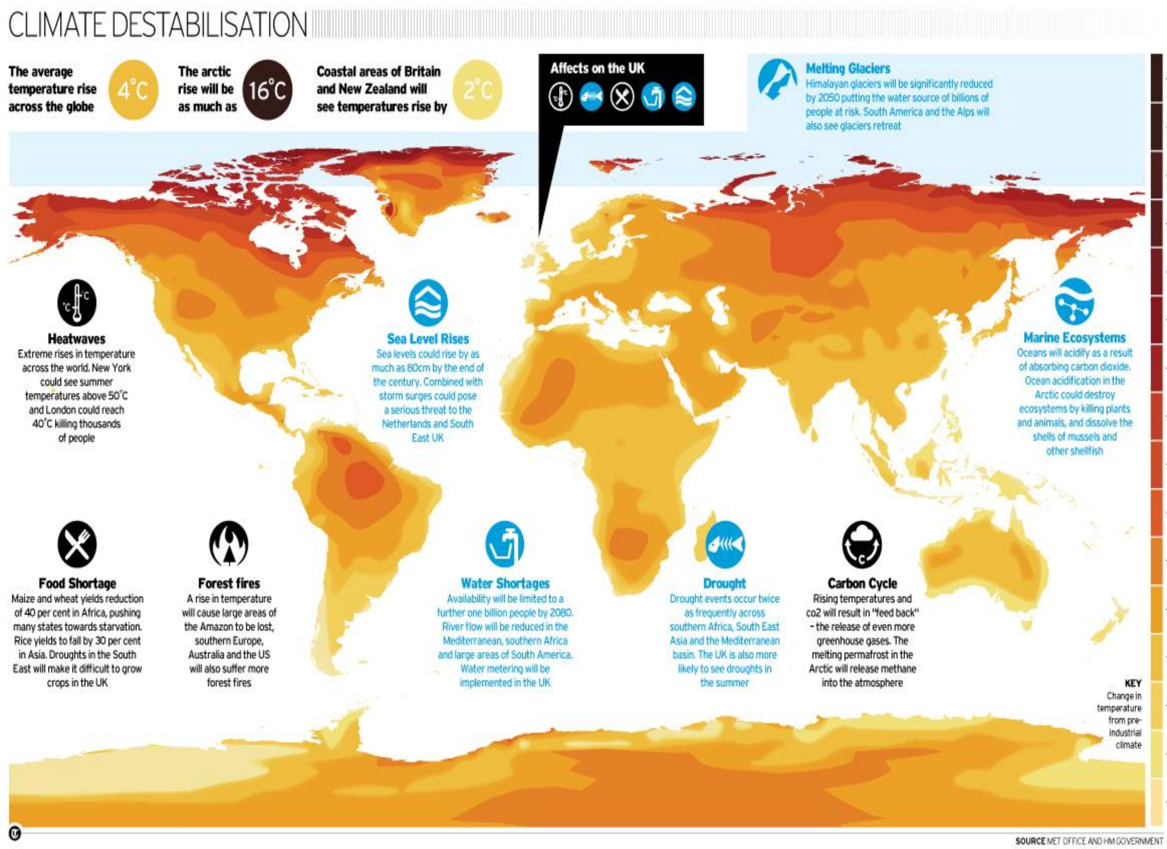
❖ Greatly exacerbate the range, frequency and intensity of natural disasters, from flooding, to droughts, to torrential rains, ice-storms, tornadoes and hurricanes;

❖ Cause sea levels to rise by between nine and 80 centimeters by 2100 due to the expansion of warming waters and the melting of polar icecaps and other glaciers, which in turn may produce deadly flooding in many low-lying areas and small island States, displacing millions from their homes;

❖ Increase the number of environmental refugees resulting from weather-related disasters;

❖ Augment the risk of disease migration and disease out-breaks; and

❖ Render large areas of the world "uninsurable" due to the magnitude of property damage from disasters. It is widely recognized that climate change, by altering local weather patterns and by disturbing life-supporting natural systems and processes, has significant implications for human health. While the range of health effects is diverse, often unpredictable in magnitude, and sometimes slow to emerge, children remain among the most vulnerable to these threats. Higher temperatures, heavier rainfall, and changes in climate variability would encourage vectors of some infectious diseases (such as malaria, schistosomiasis, dengue fever, yellow fever and encephalitis) to multiply and expand into new geographical regions, intensifying the already overwhelming threats to children from such diseases. There is also evidence that El Niño - a vast natural climatic phenomenon that can bring intense floods and droughts in many parts of the globe - is becoming more frequent as a result of global warming and could further aggravate health problems in many parts of the world. Excessive flooding is, for example, a prime cause of cholera and other water-borne and food-borne infections to which children are particularly susceptible. While heavy rains will become more frequent, there will also be more periods of drought and increased spreading of the deserts. Scientists predict that a lack of rain, warmer



temperatures and increases in evaporation could have severe implications in terms of water availability and food security, reducing crop yields in Africa, further compromising child nutrition. There are also numerous health effects, both in terms of disease and injury, associated with extreme weather events, such as heat waves, storms and floods. Extreme weather events can exacerbate health issues such as asthma and respiratory problems due to worsening air pollution, precisely those diseases that most significantly burden children.

Adaptation Experience

Throughout history, people and societies have adjusted to and coped with climate, climate variability, and extremes, with varying degrees of success. This section focuses on adaptive human responses to observed and projected climate-change impacts, which can also address broader risk-reduction and development objectives. Adaptation is becoming embedded in some planning processes, with more limited implementation of responses (high confidence). Engineered and technological options are commonly implemented adaptive responses, often integrated within existing programs such as disaster risk management and water management. There is increasing recognition of the value of social, institutional, and ecosystem-based measures and of the extent of constraints to adaptation. Adaptation options adopted to date continue to emphasize incremental adjustments and co-benefits and are starting to emphasize flexibility and learning (medium evidence, medium agreement). Most assessments of adaptation have been restricted to impacts, vulnerability, and adaptation planning, with very few assessing the processes of implementation or the effects of adaptation actions (medium evidence, high agreement). 17 Adaptation experience is accumulating across regions in the public and private sector and within communities (high confidence). Governments at various levels are starting to develop adaptation plans and policies and to integrate climate-change considerations into broader development plans. Examples of adaptation across regions include the following.

1. In Africa, most national governments are initiating governance systems for adaptation. Disaster risk management, adjustments in technologies and infrastructure, ecosystem-based approaches, basic public health measures, and livelihood diversification are reducing vulnerability, although efforts to date tend to be isolated
2. In Europe, adaptation policy has been developed across all levels of government, with some adaptation planning integrated into coastal and water management, into environmental protection and land planning, and into disaster risk management.

3. In Asia, adaptation is being facilitated in some areas through mainstreaming climate adaptation action into subnational development planning, early warning systems, integrated water resources management, agroforestry, and coastal reforestation of mangroves.

4. In Australasia, planning for sea-level rise, and in southern Australia for reduced water availability, is becoming adopted widely. Planning for sea-level rise has evolved considerably over the past two decades and shows a diversity of approaches, although its implementation remains piecemeal.

5. In North America, governments are engaging in incremental adaptation assessment and planning, particularly at the municipal level. Some proactive adaptation is occurring to protect longer-term investments in energy and public infrastructure.

6. In Central and South America, ecosystem-based adaptation including protected areas, conservation agreements, and community management of natural areas is occurring. Resilient crop varieties, climate forecasts, and integrated water resources management are being adopted within the agricultural sector in some areas.

7. In the Arctic, some communities have begun to deploy adaptive co-management strategies and communications infrastructure, combining traditional and scientific knowledge.

8. In small islands, which have diverse physical and human attributes, community-based adaptation has been shown to generate larger benefits when delivered in conjunction with other development activities.

9. In the ocean, international cooperation and marine spatial planning are starting to facilitate adaptation to climate change, with constraints from challenges of spatial scale and governance issues

Five integrative reasons for concern (RFCs) provide a framework for summarizing key risks across sectors and regions. First identified in the IPCC Third Assessment Report, the RFCs illustrate the implications of warming and of adaptation limits for people, economies, and ecosystems. They provide one starting point for evaluating dangerous anthropogenic interference with the climate system. All temperatures below are given as global average temperature change relative to 1986-2015 (“recent”).

❖ Unique and threatened systems: Some unique and threatened systems, including ecosystems and cultures, are already at risk from climate change (high confidence). The number of such systems at risk of severe consequences is higher with additional warming of around 1°C. Many species and systems with limited adaptive capacity are subject to very high risks with additional warming of 2°C, particularly Arctic-sea-ice and coral-reef systems.

❖ Extreme weather events: Climate-change-related risks from extreme events, such as heat waves, extreme precipitation, and coastal flooding, are already moderate (high confidence) and high with 1°C additional warming (medium confidence). Risks associated with some types of extreme events (e.g., extreme heat) increase further at higher temperatures (high confidence).

❖ Distribution of impacts: Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. Risks are already moderate because of regionally differentiated climate-change impacts on crop production in particular (medium to high confidence). Based on projected decreases in regional crop yields and water availability, risks of unevenly distributed impacts are high for additional warming above 2°C (medium confidence).

❖ Global aggregate impacts: Risks of global aggregate impacts are moderate for additional warming between 1-2°C, reflecting impacts to both Earth's biodiversity and the overall global economy (medium confidence). Extensive biodiversity loss with associated loss of ecosystem goods and services results in high risks around 3°C additional warming (high confidence). Aggregate economic damages accelerate with increasing temperature (limited evidence, high agreement) but few quantitative estimates have been completed for additional warming around 3°C or above.

❖ Large-scale singular events: With increasing warming, some physical systems or ecosystems may be at risk of abrupt and irreversible changes. Risks associated with such tipping points become moderate between 0-1°C additional warming, due to early warning signs that both warm-water coral reef and Arctic ecosystems are already experiencing irreversible regime shifts (medium confidence). Risks increase disproportionately as temperature increases between 1-2°C additional warming and become high above 3°C, due to the potential for a large and irreversible sea-level rise from ice sheet loss. For sustained warming greater than some threshold, near-complete loss of the Greenland ice sheet would occur over a millennium or more, contributing up to 7m of global mean sea-level rise..

Climate Change Modeling and Prediction

Climate change predictions are based on climate models which are constructed from studies of the current climate system, including atmosphere, ocean, land surface, cryosphere and biosphere, and the factors that influence it such as greenhouse gas emissions and future socio-economic patterns of land use. A climate model is a mathematical formulation of the effects of all the key processes operating in the climate system and the effectiveness of any particular model is assessed by seeing how well it reproduces past climate behavior. Additionally, extrapolating the models to future climates incorporates not only the scientific uncertainties inbuilt in modeling complex weather systems, it implies that the broad operation of the climate system will remain constant and not undergo dramatic shifts and the much less quantifiable uncertainties in future emissions and land use. Advanced global models typically have a coarse resolution which does not allow for useful local climate change projections where local weather is heavily influenced by local topography and land use. More detailed Regional Climate Models (RCMs) are constructed for limited areas and shorter time periods. The confidence levels in the key predictions are qualitative because they are based on expert understanding of complex science, observed data, the ability to predict and the consistency of the model. Three general modelling strategies may be identified as described below.

1. Black box modelling involves the statistical extrapolation of an historical time series (e.g. of past temperatures) into the future, without real concern for the mechanism involved.
2. Grey box modelling is based on the assumption that the effects of the most important controlling variables can be identified, measured and super imposed to produce a satisfactory simulation of a past record, and that the resultant mathematical model is capable of being projected meaningfully into the future.
3. White box modelling is based on detailed understanding of the structure and operation of the earth-atmosphere-ocean system, such that its possible future states can be simulated by applying assumed forcing mechanism, particularly anthropogenic ones. Numerical model building involves bringing together locational, temporal and attributes information into a database that allows climatic processes and interactions to be simulated of how they operate.

Conclusion

At the global level, significant changes in climatic parameters are projected in the next hundred years. Climate change has implications for human health, especially with respect to vector –borne and water-borne infectious disease. The global climate change is expected to result in increased rainfall and higher temperatures. Understanding how a changing climate and environment drive emergence and re-emergence of infectious disease can lead to effective strategies to combat their development and spread. There is a need for developing and implementing adaptations strategies to minimize the adverse impacts. Ecosystem and community based approaches have proven to be valuable tools. Adapting to inevitable climate change is of great importance and has long term capacity to deal with change within critical thresholds.

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