Chapter 1
Introduction

The debate over climate change, both from natural causes and human activity, is not new and goes even back to the intellectual tradition of two prominent English scholars, Thomas Malthus (1798) and William Stanley Jevons (1865), who feared the demand for resources would ultimately outstrip supply. Malthus is well known for his views of population expanding exponentially while food supplies expand arithmetically, with the imbalance eventually dooming society. The economist Jevons focused on the finite nature of resources. In particular, he examined coal, which fuelled the British Empire. With a finite supply of coal, he argued, new technology would increase the consumption of coal and threaten the viability of the economy over the long run. Such thinking spawned an anti-growth movement that ultimately fed into the modern environmental movement. One twist along the way, prompted by early environmentalist Rachel Carson’s *Silent Spring*, (1962) was to add a focus on pollution, a by-product of growth and consumption. Although the Baron C.-L. de Montesquieu (1758) is undoubtedly the best known Enlightenment thinker on the topic of climatic determinism, others, notably the Abbe Du Bos (1748), David Hume (1875), and Thomas Jefferson (1785), observed that climatic changes exerted a direct influence on individuals and society and that human agency was directly involved in changing the climate.

Climate- from the Greek term klima, meaning slope or inclination- was originally thought to depend only on the height of the Sun above the horizon, a function of the latitude. A second tradition, traceable to Aristotle, linked the quality of the air (and thus the climate) to the vapors and exhalations of a country. The Hippocratic tradition further linked climate to health and national character. As late as 1779, the Encyclopedie of Denis Diderot and Jean le Rond D’Alembert defined "climat" geographically, as a "portion or zone of the surface of the Earth, enclosed within two circles parallel to the equator," in which the longest day of the year differs in length on its northern and southern boundaries by some quantity of time, for example one-half hour. The idea that climate influenced culture was derived in part from the writings of ancient and medieval philosophers, geographers, and historians, including the works of Hippocrates, Albertus Magnus, and Jean Bodin. With no established science of climatology, Enlightenment thinkers apprehended climate and its changes primarily in a
literary way. They compared the ancient writings to recent weather conditions, linked the rise
and fall of creative historical eras to changes in climate, and promoted a brand of climatic
determinism based on geographic location and the quality of the air.

The theory, behind climate change- is over a century old. It arose in the context of the
massive use of fossil fuels- coal in particular- that was transforming European economies at
the end of the 19th and the beginning of the 20th centuries. As early as the 1850's, such
industrial centers as Manchester, England were notorious for surrounding themselves and
nearby countryside in a shadow of coal smoke. Across the Atlantic, travelers wrote of the
great banner of haze that announced the approach to Chicago from across the prairies in the
1880's.

To the Swedish chemist Svante Arrhenius in 1896, such sights represented the growing
appetite of modern industry for fuel. In order to meet industrial needs, he argued, tons of
carbon, buried in the earth for millions of years, were being rapidly dissolved directly into the
atmosphere. The rate at which this was occurring, then as now, was historically
unprecedented. When this observation was linked to the well-established heat-trapping
property of carbon dioxide and other atmospheric gases, the prospect of human, gas-
generating activity leading to a warming of the earth's atmosphere became a disturbing
possibility. Over time, this simple theory, and the uncontroversial gas physics that underlie it,
have become so compelling that they are now the backbone of an international research effort
to untangle the much more complex patterns of global atmospheric behaviour.

Despite the fact that the bulk of measured warming in global mean temperatures
occurred before 1940, scientists during this period were confident that the carbon being
released into the atmosphere was maintained at equilibrium by the ability of the earth's
oceans to absorb it in vast amounts. It was not until the 1950's, a period of innovation in the
geophysical and atmospheric sciences, that concerted research began on the subject of
greenhouse gases.

The tide of scientific opinion began to turn when Roger Revelle (1957), working at the
Scripps Institution of Oceanography at the University of California, San Diego, proposed that
the volume of carbon dioxide in the earth's atmosphere was out of equilibrium with the
capacity of the oceans and landmasses to absorb it. Revelle, was able to prove this by
performing a number of experiments measuring the carbon content of the air, and in seafloor
sediments. It was under his supervision that the carbon dioxide monitoring station on Mauna
Loa, Hawaii, was established. Readings from this station and another, younger one in
Antarctica established that atmospheric carbon dioxide has increased steadily since 1957, and that this is the result of human activities.

Focused research on climate science gathered momentum in the 1970's, when the issues of world population growth and the oil-related energy crisis became issues of primary concern for both the public and policy makers. The latter sought to understand the likely consequences of a world increasingly dependent on energy derived from fossil fuels, especially a potential surge in the use of coal. The first reports commissioned by the government of the United States dealing with carbon dioxide emissions addressed the economic, political, and environmental impacts of increased fossil fuel consumption both in the developed and developing worlds. Although awareness of the role of greenhouse gas emissions in climate change was increasing at this time, the energy and environmental legislation of the 1970's and 1980's was motivated largely by an interest in reducing U.S. dependency on foreign oil and in cutting acid rain-causing emissions from cars and power plants.

The upsurge of interest in fossil fuel combustion and climate change during the 1980's prompted governmental and non-governmental organizations to begin sponsoring research in climate science. Central to this effort was the establishment by the United Nations of the Intergovernmental Panel on Climate Change (IPCC) in 1988, which laid the groundwork for an international research program.

Since the science of climate change involves many gases—some natural, some synthetic—and their impact on a very complex system, the greatest challenge to climate researchers has been to isolate precise linkages of cause and effect. The instrumental measurements required must often be assembled from a number of heterogeneous data sets from around the world, and reconstructed from the historical record. Such comprehensive amassing of information, together with direct experimentation, is fundamental to differentiating the climate warming "signal" from the background noise of natural climate variability. One of the founding purposes of the IPCC was to organize a coordinated, international effort to advance scientific understanding of the atmosphere and its response to fossil fuel and other human induced emissions. At the time of the first IPCC report, monitoring climate change was a task for which the scientific infrastructure was undeveloped. Because of the paucity of existing data, the IPCC called in each of its reports (1990, 1995, 2001, 2007) for improvements in computer simulation capabilities, an increase
in the range and accuracy of observational evidence, and further international efforts to monitor climate.

By the 1990's, the prospect of climate change emerged as an issue in its own right, sufficient to justify consideration of certain energy and technology related policy measures. The 1997 Kyoto Protocol is the most well-known and general example of this but there exist a number of much more focused investigations that explore ways to mitigate greenhouse gas emissions. One report that relates global climate change directly to emissions from specific economic sectors, including transportation (second only to industry as a source of carbon dioxide), is the 1997 "Five Labs Report." Based on the collaborative research of laboratories such as Argonne, Lawrence Berkeley, Oak Ridge, Pacific Northwest National, and the National Renewable Energy Laboratory, the Five Labs Report framed its research in terms of the costs and benefits of carbon emissions reduction strategies. It concluded that, with a heightened private and public commitment to alternative technology research and development across a number of economic sectors, it would indeed be possible for the U.S. to reduce carbon emissions significantly, more than making up for the expense through increased energy efficiency.

The Global Climate Change Regime

The development of the climate change regime in the late 1980s and early 1990s rode a wave of environmental activity, which began in 1987 with the discovery of the stratospheric “ozone hole” and the publication of the Brundtland Commission report, Our Common Future (1987), and crested at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. An earlier wave of international environmental activity, culminating in the 1972 Stockholm Conference and the establishment several years later of the United Nations Environment Programme (UNEP), had tended to focus on local, acute, and relatively reversible forms of pollution—for example, oil spills and dumping of hazardous wastes at sea—by regulating particular pollutants. The more recent cycle of environmental activity has concerned longer-term, irreversible, global threats, such as depletion of the stratospheric ozone layer, loss of biological diversity, and greenhouse warming (Clark 1989, 47), and has focused not merely on environmental protection per se, but on the more general economic and social policies needed to achieve sustainable development.
The development of the climate change regime until the conclusion of the Kyoto Protocol in 1997 can usefully be divided into five periods: the foundational period, during which scientific concern about global warming developed; the agenda-setting phase, from 1985 to 1988, when climate change was transformed from a scientific into a policy issue; a pre-negotiation period from 1988 to 1990, when governments became heavily involved in the process; the formal intergovernmental negotiations phase, leading to the adoption of the FCCC in May 1992 and a post agreement phase focusing on the elaboration and implementation of the FCCC and the initiation of negotiations on additional commitments, leading to the adoption of the Kyoto Protocol in December 1997. Since then, research on climate change has expanded and grown, linking many fields such as atmospheric sciences, numeric modelling, behavioural sciences, geology and economics. The paradigm shifts in climate change discourse has been summed up in Fig. 1.1

Paradigm Shifts in Climate Change Discourse
The Indian Concern

India is considered highly vulnerable to climate change, not only because of high physical exposure to climate-related disasters (65 percent of India is drought prone, 12 percent flood prone, and 8 percent susceptible to cyclones), but also because of the dependency of its economy and majority of population on climate-sensitive sectors (e.g. agriculture, forests, tourism, animal husbandry and fisheries). Climate change shall induce changes in the complexion, distribution, quality and functionality of natural resource base. Further, it will result in ‘insecure livelihoods’ due to disruptions in the social, cultural, economic, ecological systems, physical infrastructure and human assets; increasing health
risks, and crippling or even negating the developmental gains and opportunities. The country has a unique climate system dominated by the monsoon, and the major physiographic features that drive this monsoon are its location in the globe, the Himalayas, the central plateau, the western and Eastern Ghats and the oceans surrounding the region.

The Himalayan Region comprises of the highest mountain system of the world, the Himalayas and the North-Eastern hill states. The heights are covered with perpetual snow, which feeds the valley glaciers, but the greater part of the Himalayas lies below the snow-line and is dissected by fluvial erosion. Being the youngest and loftiest mountain chain of the world and still rising, the Himalayan region is naturally unstable and fragile. The Himalayas influence the climate of the Indian subcontinent by sheltering it from the cold air mass of Central Asia. The range also exerts a major influence on monsoon and rainfall patterns. They prevent frigid and dry arctic winds from blowing south into the subcontinent keeping South Asia much warmer when compared to regions located between corresponding latitudes throughout the globe. They are a barrier for the moisture-laden monsoon winds, preventing them from travelling further northwards and thus facilitating timely and heavy precipitation in the entire Northern India. Within the Himalayas, climate varies depending on elevation and location. Administratively it covers 10 states entirely i.e., Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and two states partially i.e. the hill districts of Assam and West Bengal (Fig. 1.2).
The Himalayan ecosystem is highly vulnerable to the stress caused by increased pressure of population, exploitation of natural resources and other related challenges. Climate change may adversely impact the Himalayan ecosystem through increased temperature, altered precipitation patterns, and episodes or drought. Recent studies warn an abrupt climate change and faster meltdown of the Himalayas. Uttarakhand, being the home of some very large and important glaciers viz. Gangotri, Ponting, Milam, Pindari etc, is in the centre of climate change debate (Bahuguna et al., 2007; Cruz et al., 2007; Kulkarni et al., 2007). The state is a region of outstanding natural beauty, with tremendous potential for sustainable growth and development. The northern region of the state is part of the Great Himalayan Range, covered in snow and glaciers. Other parts of Uttarakhand are covered with dense forests that make up the bulk of its natural resources base. Owing to its largely mountainous regions, the state is endowed with a unique ecosystem that is home to a large number of flora and fauna. Two of the Indian subcontinent’s most important rivers- the Ganga and the Yamuna- also originate from the glaciers of Uttarakhand. The natural resources of the region provide life supporting, provisioning, regulating, and cultural ‘eco-system’ services to millions of local as well as downstream people.

**Statement of the Problem**

The scientific opinion on climate change is that the Earth's climate system is unequivocally warming, and it is extremely likely (at least 95% probability) that humans are causing most of it through activities that increase concentration of greenhouse gases in the
atmosphere, such as deforestation and burning fossil fuels (IPCC, 2007). On the other hand several studies find no warming trend for over past two decades (Lehr, 2013; Gosselin, 2013a; Gosselin, 2013b), leaving the consensus on the climate change in swing.

In view of these concepts and counter-concepts, it is needful to examine the authenticity of climate change claims as well as to understand the real climate trends, and anthropogenic influence on the natural climate variability. In doing so, the study adopts Uttarakhand- a climate sensitive region possessing rich wealth of landforms and a good laboratory to examine the climate change processes- as case study.

The Study Area

Uttarakhand is one of the hilly states in the Indian Himalayas. It lies between the latitudes 28°43’-31°27’N and longitudes 77°34’-81°02’E having a maximum dimension of east-west 310 km. and north-south 255 km. It covers an area of 53,484 km² with the elevation ranging from 210 to 7817 mt. The state shares border with China (Tibet) in the North and Nepal in the East and inter-state boundaries with Himachal Pradesh in the West, Northwest and Uttar Pradesh in the South (Fig. 1.3). Broadly the region constitutes of 13 districts falling in two major administrative unit viz., Garhwal (northwest portion) and Kumaon (southeast portion). Garhwal Division consists of 7 districts, viz. Dehradun, Haridwar, Uttarkashi, Tehri, Pauri, Rudra Prayag and Chamoli while remaining 6 districts viz., Pithoragarh, Bageshwar, Almora, Nainital, Champawat and Udham Singh Nagar fall in Kumaon division.
Objectives and Methodology

My objectives are twofold. First, to identify the variability and shifts in climate at regional scale, and second, to access the role of human and other factors in influencing climate variability.
The present research is based both on inductive and deductive logics and for that matter both primary as well as secondary data have been collected through field work and also published material. The satellite imageries have been also adequately used in addition to mapping the data available at hand. Both quantitative as well as qualitative analysis also has been done.

Temperature and rainfall are the two most important determinants of climate, and in examining the trend of climate, pattern and trend of these two parameters have been analysed at state as well as at district level by correlation and regression techniques.

Hypothesis

Humans are being blamed for recent climate variability and changing climatic behaviours. While analysing this influence on natural climate patterns and process, my study frames on the following four hypothesises:
1. The average temperature in 100 years has not only changed, it has increased.
2. The data on rainfall variability is indicative of the fact the state is marked by several fluctuations. These fluctuations obviously point to some significant trends.
3. The change in areal spread of forest cover has a great bearing on the temperature and rainfall patterns.
4. The vehicular traffic has very heavily impinged the climatic condition of the state by adding to the level of atmospheric pollution.

Overview of Chapters

In describing the climate systems and climatic fugacity, the work is divided into following chapters:
1. Chapter One: Introduction
2. Chapter Two: Theoretical Background
3. Chapter Three: Climate Change: National Level Analysis
4. Chapter Four: Physico-cultural Milieu of the Study Area
5. Chapter Five: Components of Climate Change: The Case of Uttarakhand
6. Chapter Six: Summary, Conclusion and Important Derivatives for Articulation

References


