



Climate Change and Environment



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Leonard Sonnenschein, 46 years experience in keeping fish, 35 years experience in scientific research, 23 years experience in science education innovation, over 100 publications, and extensive performance in conservation collaboration, climate change issues and public awareness. Leonard Sonnenschein opened St. Louis Children's Aquarium in 1993 and on June 8, 2004 (World Ocean Day) opened its expansion facility, the World Aquarium. Leonard regularly supervises students from over 45 universities which collaborate with the research component of the aquarium in facility development, exhibit design, fisheries, aquatic sciences, ecology, aquariology, legal frameworks, consumer awareness, cultural comprehension of environmental issues, and public understanding through field, conference and inter-governmental work. In 2006, Sonnenschein founded the Conservation for the Oceans Foundation to expand the World Aquarium's focus. The mission of the Conservation for the Oceans Foundation (CFTO) is to support grassroots-level conservation, education and research projects that bring about positive changes to ecosystems worldwide through local and multi-stakeholder actions. In 2009, Youth Voices in Conservation was developed for additional youth engagement opportunities (ages 3-50). In 2011, based upon the Low Carbon Lifestyles' campaign, the Youth Voices in Conservation's GreenLeaf Program was developed to allow for raising capital for residual support mechanism based upon the carbon offset credit from worldwide projects' actions. Leonard regularly collaborates with international agencies such as UNESCO, UNEP, WHO, International Ocean Institute, the Global Forum on Ocean, Coasts and Islands and is a co-founder of the World Ocean Network. Leonard recently started Innovative Drug Manufacturing, LLC to bring new patented technology to the pharmaceutical, nutraceutical, cosmetic and aquaculture industries.

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Foreword

Climate change is one of the inexorable physical phenomena happening on the earth. The change induced by the humans is leading towards adverse effects, which is now being recognized as an immediate threat to the environment and ecological systems. Many manifestations of the climate induced changes have been reported by the scientific community all across the Globe. Climate change impacts also spans over spatial and temporal scales. These changes will have an adverse impact on the development of the nations and human well-being.

IPCC in its fourth assessment report has highlighted the possible adverse effects due to climate change. It has been reported that ambient air temperature and precipitation will increase in certain parts of the world, while these will decrease in some other parts. It is imperative to assess in detail the various environmental changes and their subsequent consequences on our ecosystem. While most of the climate change studies focus on the climate modelling, impacts on various resources as well as mitigation and adaptation, little attention has been made to understand environmental consequences climate change.

This book, *climate change and environment*, provides a collection of chapters that span over different dimensions of environmental aspects of climate change. The chapters are systematically organised to different sections to deal with the climate change and weather changes, physio-chemical aspects of environmental changes, effect on biological systems and mitigation and adaptation options to salvage the environment. The authors of different chapters have explored very innovative and different methods to probe the climate-linked transformations. Thus, the entire realm of climate change science has been addressed in the various sections of this book.

The environmental consequences of climate change are not yet fully understood by the scientific community. The book provides glimpses of environment changes due to climate change through various case studies by eminent scientists, researchers and scholars from various ecological locations. The book opens new thoughts for further investigations and

understanding. The contributors and editors of this book deserve special appreciation in bringing together diverse knowledge on climate change impact on environmental system. I am sure that this book is an eye opener for the research community engaged in climate change research in this country as well as around the World.



(VAYALAR RAVI)

Minister for Science & Technology
and Vice President, CSIR
Government of India

Preface

There is a reciprocal relationship between climate and the environment. The change in one will bring about changes in the other. The positive and negative feedback mechanisms accelerate or decelerate the process of change depending on the global regions. The climate change, mostly induced by natural causes, had many repercussions on the environment. It varied from the species extinctions to modification of the thermal regimes. Most of these changes are gradual. However, in recent times the changes reported in the climate of the World are human induced and are swift. Such sudden modifications in climate have many ramifications to the environmental systems.

Climate change has already made observable changes in the environment. According to IPCC's fourth assessment report the global average surface temperature has increased at the rate of 0.13°C per decade in the last 50 years. The glaciers and ice sheets are melting at alarming rate resulting in raising sea levels. In addition there will be observable northerly shifts in climate regimes in different regions of the world. There are perceptible modification of the vegetation regimes of the world and also their biological productivity. Certain species are facing the threat of extinction or changing phyto-sociological characteristics due to climate change. It is evident that changes in climate can have both adverse and favourable effect on the environment. It is imperative to assess the possible changes in the environmental conditions and monitor those changes over space and time.

This book, *climate change and environment*, provides an insight to the changing complex relationship between climate and the environment. It offers an overview of the effect of climate change on environment and how environmental changes are also contributed to climate change phenomenon. The research papers are organized in five sections ranging from understanding the science and impact of climate change, changes in weather, climate change effect on biological and physico-chemical systems and the mitigation and adaptation options.

In the section on climate change science and impact the authors discussed the impacts under different environmental conditions. The high resolution coupled GCM model was used to study the changes in atmospheric-ocean-land interaction due to land use changes consequent upon the Indonesian deforestation (Chapter 1). The study reported the strengthening of South East Asian monsoon, and modification in ENSO and tropical cyclone activity in Indonesian region. In Chapter 2, authors found that there is no significant variation in water quality parameters in Chalakudy and Periyar river basins. The water quality variations are linked to fluctuations in discharge of these rivers. The rise in mean

temperature and diurnal temperature in recent years in comparison with last 100 years data are reported for Chennai (Chapter 3). This study also found statistically significant low correlation values between temperatures and sunspot cycles.

The section on changing weather deals with pattern of changes in weather parameters across different geographies. An increasing trend in lightening activity is observed in India (Chapter 4) around pre-monsoon season during the period 1998-2009. This rise in lightening activity is closely related to rise in temperature. This finding is in tune with the observations from other parts of the World. In Bangladesh the monthly and seasonal mean minimum temperature showed an increasing trend (Chapter 5). The authors found an increase in thunder storm activity only in some months in certain regions of Bangladesh. This trend is linked to the warming temperatures. In contrast the annual and seasonal rainfall showed a decreasing trend in adjoining Arunachal Pradesh in India (Chapter 6). However, the decreasing trend is not universal. In Chapter 7 an attempt has been made to predict the wet and dry spells within monsoon season using a simple Lorenz model. The model found to be effective in predicting the seasonal rainfall with 70% accuracy. In Chapter 8 the authors found a negative relationship between the cloud optical depth and cloud effective radius especially during the dry years. The deficiency in rainfall resulted in accumulation of fine mode aerosols giving rise to effective cloud condensation nuclei causing further reduction in rainfall.

The third section discusses the effect of climate change on biological system. In Chapter 9 the author assessed the resilience of sweet potato under different environmental conditions. Yield and biochemical response varied with genome type of sweet potatoes. In Bangladesh there is abundance of pest, predators and pollinators in certain cotton species (Chapter 10). Such abundance may be enhanced further owing to warming tendency. The oil sardines showed adaptive capacities over the last two decades under the elevated seawater temperature by expanding its territories (Chapter 11) along the southwest coast of India. In Chapter 14 the changes in mangrove cover is reported from the Sunderbans delta of West Bengal. Such changes caused morphologic changes to the deltaic islands. Some of these deltaic islands witnessed accelerated erosion due to rising sea levels. The incidence and severity of various insects and pathogens will increase consequence upon the rising temperature and increasing precipitation (Chapter 13). Increment and decrement in phyto-chemical constituents are observed in different coconut varieties of west coast of India under elevated temperature and CO₂ (Chapter 14). In chapter 15 the responses of forest insects to climate change is discussed.

The fourth section deliberates on the physico-chemical changes observed in environmental systems. In Chapter 16 authors reported many fold increase in ion concentration between 1987 and 2007. It is attributed to increase in weathering rate due to warming temperatures, atmospheric deposition or both. The Chapter 17 discusses the effectiveness of regional WRF-CO₂ model simulating CO₂ flux and resultant meteorology for Far East Asia. They found high resolution fossil

flux model is more effective than a low resolution model. The ground based observations in Kullu valley of North West Himalayas showed that the aerosols extract about 46% and 37% of incoming direct solar flux at 0.45 and 0.5 μm wavelengths respectively (Chapter 18). The maximum extinction is during winter months and minimum during summer months. At this site the AOD concentration is maximum during summer season and minimum during autumn season (Chapter 19). This ground based observation is in close correlation with MODIS satellite observations. In Chapter 20 the vertical distribution of aerosols showed high seasonality in the Indian region which is in agreement with former two regional studies. The Chapter 21 analyses the characteristics and climatic correlates of Holocene sediments of wetlands of Southern Kerala, India. The study indicated the periods of major climatic events.

The last section deliberates on some of the possible mitigation and adaptation options. In Chapter 22 identified the weak pillars, finance, technology and international cooperation, that exist in India. The author suggests equitable burden sharing approach to theoretically address this problem. The Chapter 23 and 24 explores the possibility of using fly ash for carbon sequestration since it is rich in carbon stabilization enzymes. In Chapter 25 the option of using improved dry compost latrines as a perceptible measure to reduce the contamination of fresh groundwater in Lakshadweep islands that are under threat from sea level rise is discussed.

The scientific community is yet to reach a consensus on the nature and scale of impact of climate change on environment. Most of the climate change forecasts are based on the emission of greenhouse gases. Hence it is not crystal clear the extent and scale of changes that can happen to the environmental systems. This collection of research papers is a good contribution to enrich the scientific knowledge on the impact of climate change on environment. This book will be a stepping stone for the researchers to further the knowledge and information

This edited volume is an outcome of the collaborative effort of many researchers who assembled at the School of Marine Science, Cochin University of Science and Technology and also at Kadamet Island, Union Territory of Lakshadweep, India to brainstorm the impact of climate change on environment. The editors are thankful to the generous academic and administrative support extended to us by School of Marine Science, Cochin University of Science and Technology, Kochi and the Administrator and other officials of Science and Technology Directorate of the Union Territory of Lakshadweep.

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Contents

Climate Change Science and Impacts

1. Impact of deforestation in indochina on Pacific-Indian tropical areas simulated in CGCM
Tomonori Matsuura, Ryuichi Kawamura & Satoshi Iizuka 1
2. Impact of urbanization on surface and ground water resources of the coastal lands of central Kerala, south west India
Santhosh, V, Padmalal, D, Sobha, V, Baijulal, B & Maya, K 16
3. Chennai's regional temperature variation and its correlation with sunspot numbers and CO₂ emission
R. Samuel Selvaraj, P R Uma Rani, N Mahalakshmi & M Jayanthi 28

Changing Weather

4. A possible relationship between global warming and lightning activity in India during the period 1998-2009
Priyadarsini G, T E Girish & Felix Pereira B 37
5. Trends in minimum temperature and its impact on thunderstorm frequency during the pre-monsoon season in Bangladesh
Samarendra Karmakar, Abdul Mannan & Sultana Shafee 45
6. Searching evidence for trend in rainfall of Arunachal Pradesh
Salil K Shrivastava, R K Rai, Yesin Phukan & Nich Teli 59
7. Prediction of Intra seasonal rainfall occurrence using Lorenz model
R Samuel Selvaraj & R Gayathri 71
8. Evidence of aerosol induced alteration of cloud parameters and its impact on the climate system over the Indian subcontinent
B Abish & K Mohanakumar 80

Climate Change Science and Biological System

9. Climatic resilience and salinity cum submergence stresses tolerance of sweet potato (*Ipomoea batatas* L.) genotypes
Archana Mukherjee 89
10. Pest, predator and pollinator abundance in the cotton field of Bangladesh: A climate change country
M R Amin, H M S Azad, S M A Hossain & D A Tithi 100
11. Adaptive capacity of the oil sardine *Sardinella longiceps* in the new distributional area with reference to food type
R Remya & E Vivekanandan 107
12. Change in mangrove forest cover and deltaic islands in sundarban areas of West Bengal: A temporal analyses using NCI technique on LANDSAT TM5 data
Dipendra Nath Das, Arun Mondal & Subhanil Guha 113
13. Impact of climate change on pesticide usage
R L Gupta 128
14. Variation in total phenols concentration in coconut (*Cocos nucifera* L.) seedlings under elevated CO₂ and temperature in different seasons
John Sunoj V S, S Naresh Kumar & K S Muralikrishna 140
15. Effect of climate change on insects: An analysis of responses with special reference to forest insects
George Mathew 150

Physico-Chemical Aspects of Environmental Changes

16. Decadal variation in the major ion chemistry of Chhota Shigri glacier meltwater, Lahaul-Spiti valley, Himachal Pradesh, India
Virendra Bahadur Singh, A L Ramanathan, P G Jose, Parmanand Sharma, Anurag Linda & Mohd Farooq Azam 159
17. Establishment of regional model WRF-CO₂ for simulation of CO₂ concentration over far east Asia
Srabanti Ballav & U K De 167

18.	Changes in surface solar irradiance due to atmospheric aerosols: Climatic implications in the northwestern Himalaya, India	
	<i>Raj P Guleria, Jagdish C Kuniyal, Pitamber P Dhyani, Pan S Rawat, Nand L Sharma, Mahavir Singh, Harinder K Thakur & Manum Sharma</i>	182
19.	Synoptic temporal variations and meteorological correlations of aerosol parameters retrieved using ground based solar extinction studies in the kullu valley of northwest Himalayan region, India	
	<i>Nand L Sharma, Jagdish C Kuniyal, Mahavir Singh, Raj P Guleria & Pan S Rawat</i>	193
20.	Seasonal variability in the vertical distribution of aerosols over Indian region	
	<i>Sivaprasad, P & C A Babu</i>	205
21.	Palaeoclimatic records in the holocene sediments of polachira wetland, southern Kerala, SW India	
	<i>Vishnu Mohan S., Padmalal D. & Santhosh V.</i>	215
Mitigation and Adaptation Climate Change		
22.	A log frame analysis of India's climate change mitigation policies and technology implications	
	<i>Joy Vazhayil P & R Balasubramanian</i>	229
23.	Soil carbon sequestration through fly ash	
	<i>Masto R E, L C Ram, V A Selvi, T Sengupta, Kapil K Sunar, Joshy George & A K Sinha</i>	250
24.	Carbon sequestration via in-situ infusion of fly ash with CO ₂ in thermal power plants	
	<i>L C Ram, A K Sinha, R E Masto, S K Upadhyay & R C Tripathi</i>	259
25.	Improved dry compost latrines as ecosanitation for small Islands – Lakshadweep Islands	
	<i>K Sreedharan & M V Kiran</i>	278
	Subject Index	284