

Springer Climate

Uday Chatterjee · Angela Oyilieze Akanwa ·  
Suresh Kumar · Sudhir Kumar Singh ·  
Abira Dutta Roy *Editors*


# Ecological Footprints of Climate Change

Adaptive Approaches and Sustainability

 Springer

# Springer Climate

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*Dedicated to Young Scholars in the Field of  
Geography, Environmental Science and  
Sustainability Science*

# Foreword



Climate plays a vital role in regulating agriculture productivity and practices, food habits and drinking water needs of our Earth and thus socio-economy of developing nations such as India. Global warming driven-climate change impacts both fauna and flora and thus ecological footprints across the regions. The book entitled ‘Ecological footprints of climate change: Adaptive Approaches and Sustainability’ edited by Uday Chatterjee, Angela Oyilieze Akanwa, Suresh Kumar, Sudhir Kumar Singh and Abira Dutta Roy to be published by Springer is timely and extremely relevant in the present scenario. The chapters written for this book are outstanding examples of advance works applied to the relevant field.

With fast depleting natural resources due to expanding human requirements and intense economic activities, there is a need to adopt people friendly development models which will help in sustaining human civilization on this mother earth. Overutilization of land resources and rampant urbanization as well as industrialization in developing economies contribute to severe land degradation and contamination of groundwater table worldwide. Such environmental severity impacts both food production and drinking water aquifers.

This volume is a collection and compilation of 30 chapters outlined under six major parts viz.

Part I: Introduction; Part II: Climate change and contemporary issues, challenges and sustainability; Part III: Agriculture and Forestry and Climate Change; Part IV: Food Security and Livelihoods; Part V: Infrastructure and Resilient Cities and Settlements; and Part VI: Global Health and Sustainable and Adaptive Approaches and Sustainability. The topics identified in these parts are diverse and of vital importance for climate resilience and sustainable development.

I would like to congratulate the editors for their noble initiative in bringing out this precious volume of contemporary relevance. This book forms a valuable addition to the existing knowledge and is aimed for university students and researchers in climate change, agriculture, forestry, livelihoods and sustainable development. I hope it will be widely acclaimed by geographers, environmental scientists, climate workers and policy planners as well as decision-makers engaged in dealing with climate change impacts.

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# Preface

The concept of ecological footprint is employed to determine the extent of population pressure on natural resources and the estimated quantity expedient for human satisfaction. It covers the endless demands placed on nature and estimated quantity of renewable resources consumed and the regenerative bio-capacity of the earth. The concept of ecological footprint is globally employed in the process of analysing sustainability assessments. Globally, ecological footprint assessments reflect the vast pressure of human population on the earth in comparison with the earth's renewability potentials. Climate change is a wicked problem sponsored by wanton anthropogenic exploitation of natural resources. Its impacts have been etched deep into the national and global ecosystems leaving intractable ecological footprints. Mankind has been under ecological overshoot since the 1970s, with annual resource requirements surpassing Earth's biocapacity. Assessing the ecological footprint (EF) is basically an expedient to measure and estimate the human demands and impacts on our global environment. According to the 2022 release of the National Footprint and Biocapacity Accounts, humankind would require resources equivalent to 1.75 planets similar to that of the Earth in order to meet their growing demands and absorb human produced garbage.

Earth's average surface temperature has increased by 1.4 °F (0.8 °C) from pre-industrial era. This increase is mainly due to burning of coal and petroleum products in power stations, factories and motor vehicles, which act as major source of carbon dioxide. To regulate the uncontrolled greenhouse gas emission, the Kyoto Protocol was signed in 1997, which is an international agreement intended to cut the greenhouse gas emissions, but many nations failed to limit their emissions. Furthermore, in 2018, the Paris Agreement was signed by over 200 nations with the purpose of preventing global temperatures from reaching a 3.6 °F (2.0 °C) increase and reducing greenhouse gas emissions to a rate where they can be naturally absorbed by the environment between 2050 and 2100. Recently, a total of 190 countries agreed at COP26 to phase out coal power, which is considered as the single largest contributor to human-caused climate change. Its goal was exclusively to continue the endeavors of restricting global warming to 1.5 °C, and the Glasgow Climate Treaty

also aided in achieving this goal. Despite these initiatives, outcomes from various climate model simulations proposed that planet's average temperature could be between 2 and 9.7 °F (1.1–5.4 °C) warmer by 2100 than it is today. Hence, efficient framework, sustainable management policies and stringent implementation are very much required for tackling these concerns. Subsequently, delivery of these goals, proper climate resilience through adaptation and mitigation will be possible.

Global implications of climate change adaptation endeavours can trigger the appropriate scientific, adaptive and sustainable approaches. The advances in science and technology have enhanced a nation's ability to plan for the future by investing in adaptive and mitigate measures to monitor present and future changes. Wealth, infrastructure and political stability all contribute to a nation's capacity to anticipate and respond to climate change. The adaptive-based models are essential to reduce the ecological, social and economic costs of environmental management. Adaptive management focuses upon developing alternative approaches or rather unique methods that will identify gaps in knowledge. This will in turn be very useful in setting and updating research and action priorities, applicable for climate change policy, thereby serving as a continual update on knowledge and policy needs in climate change science. At present with the availability of multiple climate footprints, there are immense opportunities to explore all ideas towards evaluating their possibilities in presenting alternative futures through developing sustainable adaptive measures and implementing alternative policies, in order to solve the intractable ecological footprints of climate change. This book attempts to amalgamate all these ideas.

The book includes a broad range of topics covering ecological footprints, climate change, sustainable development, adaptive methodologies and sustainability. Topics on agriculture, forestry, water resources, food insecurity, human settlements, global health and many more have been dealt in the chapters of this book providing adaptation measures for minimizing the footprints of climate change. Climate change and its consequences are being experienced all over the globe, although developing countries are considered as the primary victims, especially in tropical regions where the hydrological cycles are more intense and experience higher exposure to the risk of climate change. India is a developing country located in a tropical region where climate-related disasters (storms, floods, cyclones, extreme precipitation and droughts) are more prominent. Apart from this, Himalayas is considered as the water tower of Asia and plays a vital role in regulating climate as well as downstream water availability. Therefore, it requires special attention to adapt and mitigate the adverse effects of climate change. Thus, we have included book chapters with majority of the case studies from the Indian sub-continent. Consequently, this book will provide the adaptation and mitigation approach which can be implemented over this region.

The chapters in the book have been grouped into six different parts addressing issues of climate change to provide a comprehensive overview. *First (I) part* provides a holistic view of the ecological footprint, climate change and sustainability as well as the linkages between them. Chapter 1 provides an insight on changes of footprint with respect to climate change. Chapter 2 introduces the assessment of

global-scale synergy between adaptation, mitigation and sustainable development for projected climate change, whereas Chapter 3 deliberates inclusive concept concerning global warming impacts on environment in the last century. Chapter 4 delivers on the application of the earth system climate model. *Part II* focussed on contemporary issues related to climate change and environment with case studies for in-depth understanding for readers. In this part, Chapter 5 focuses on climate change impact on land degradation in hilly and mountainous landscape and the sustainability issues with adaptation strategies. Chapter 6 introduces impacts of the inherent hazards of climate change on the coastal environment. Chapter 7 sheds light on the assessment of ground water vulnerability to climate change using GIS techniques. Chapter 8 discusses the impact of climate change on water crisis, whereas Chapter 9 reviews the factors affecting governance of disaster management and delivers a comparative study of the Sundarbans. Chapter 10 introduces the application of geospatial technology in understanding seasonal flood hazard events. Chapter 11 is devoted towards application of geospatial techniques in watershed vulnerability to climate change and environmental sustainability.

*Third (III) part* focuses on climate change induced challenges on vital sectors such as agriculture and forest. Chapter 12 discusses about the application of crop simulation models in determining sustainable agriculture under different climate change scenarios. Chapter 13 reviews the peri-urban farmer's perception of climate change. Chapter 14 introduces the spatiotemporal drivers of agricultural vulnerability to climate change. Chapter 15 deals with forest landscape dynamics and people's livelihood dependency on forest. Chapter 16 uses the forest fire risk modelling and GIS remote sensing for impact assessment. *Fourth (IV) part* briefly explains the food security and livelihood which comprises Chapters 17 and 18 elaborates on the climate smart agricultural interventions for food security and evaluation of carbon neutral project, respectively. *Fifth (V) part* primarily focusses on infrastructure and urban development in the context of prevailing climate change issues. It includes land use/land cover change dynamics and modelling, land surface temperature analysis, urban heat island and climate change using geospatial indicators, site suitability for wasteland utilization by solar power plant installation and tsunami impact assessment, whereas the last chapter in this part discusses waterborne pathogen exposure under climate change and impact of climate change on health (Chapters 19, 20, 21, 22, 23, 24 and 25). *Sixth (VI) part* opens on health issues related to changing climate and adaptive approaches. It introduces health implications, cohort study on ambient air quality, practices of women fisher folk in response to climate change, climate change and health impacts and flood footprints in changing climate and climate related actions (Chapters 26, 27, 28, 29 and 30). Apart from these, the above-mentioned individual parts also focus on sustainability and adaptive approaches in the purview of climate change. Hence, in this way, these chapters can provide a holistic perception of components of ecological footprints.

The environment encompasses the interaction between the living and non-living components where humans exert their influence. It provides various ecosystem services that sustain human existence and civilization. Unfortunately, the unrestrained manipulations have escalated climate change issues. The introduction

of application of sophisticated technologies in resource extraction and their use has further increased the ecological footprints. Therefore, there is an urgent need as pursued by this book for proper adaptive management of the ecological resources to bring about balance and human-earth sustainability. We prepared all the chapters in a very transparent and interactive approach. It is hoped that the book as a whole will provide a timely synthesis of a rapidly growing and important field of study but will also bring forward new and stimulating ideas that will shape a coherent and fruitful vision for future work for the community of undergraduates, post-graduates and researchers in the fields of environmental sciences and geography. Research scholars, geographers, environmentalist, climatologists, policymakers, NGOs, corporate sectors, social scientists and government organisations will find this book to be of great value.

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# Disclaimer

The authors of individual chapters are solely responsible for the ideas, views, data, figures, and geographical boundaries presented in the respective chapters of this book, and these have not been endorsed, in any form, by the publisher, the editor, and the authors of forewords, preambles, or other chapters.

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**Part I**  
**Introduction**

# Chapter 1

## Ecological Footprints in Changing Climate: An Overview



Suresh Kumar , Uday Chatterjee , and Anu David Raj 

**Abstract** Human exploitation on the natural resources is continuing in an overwhelming rate. Nonrenewable natural resources are expected to deplete in the near future; in addition, humans are consuming the nonrenewable resources at a rate which is far above the time required for regeneration. The exponential growing population and global economic competency drive the overexploitation of natural resources. Apart from this, the climate change also possesses boundless threat for the natural resources as well as human habitats. Overexploitation of the natural fuels and other resources also amplifies the climate change and can act as a positive cyclic feedback mechanism. These activities drastically decrease the biocapacity and efficiency of the Earth which leads to higher ecological footprint for the products industrialized from the natural resources. The carbon emission is the one of the major contributors of ecological footprint which contributes to global warming- and climate change-related disasters as well as natural resource degradations. This demands the sustainability for land or soil, forest, and aquatic ecosystems as well as for human habitats. Sustainability is the quintessential solution which can supply the remedies for the abovementioned issues. The integrated approach of climate resilience acquiring from the adaptation and mitigation strategies, nature-based solutions, and UN sustainable development goals can deliver minimum ecological footprint generations in milieu of changing climate.

**Keywords** Biocapacity · Forest land · Crop land · Carbon footprint · Climate change · Adaptation and mitigation · Sustainability

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