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# The Food Security, Biodiversity, and Climate Nexus



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Mohamed Behnassi · Himangana Gupta ·  
Mirza Barjees Baig · Ijaz Rasool Noorka  
Editors

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## Foreword by Prof. Kazuhiko Takeuchi

Over recent decades, technological innovation has improved food production efficiency so much that the net loss of land has been reduced to zero worldwide, even as the global population continues to grow. However, some of the most biodiverse parts of the world—mostly in the tropics—are still being converted to agriculture. The global population is not expected to peak until around the end of the twenty-first century, and consumption patterns continue to rise, so agricultural efficiency will have to continue improving to meet growing demand and avoid even more ecological transformation. Meanwhile, in many temperate parts of the world, the abandonment of agricultural land can also result in the net loss of biodiversity.

Most of the media's attention to environmental issues is devoted to the threat of climate change. But terrestrial and marine biodiversity loss, mostly through the conversion of tropical ecosystems to large-scale agriculture, and the wild-catching of ocean fish, is already compromising the well-being of millions. And, this issue is not divorced from the climate. Climate change can exacerbate biodiversity loss, while functioning ecosystems can help mitigate and adapt to climate change.

Global attention to the links between food, climate, and biodiversity dates back decades. Coverage has increased recently, with publications like the OECD's "Towards Sustainable Land Use: Aligning Biodiversity, Climate and Food Policies," and a report jointly produced by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC). Renewed attention has been directed at nature-based solutions such as socio-ecological production landscapes and seascapes (SEPLS), which are characterized by production but managed in such a way that biodiversity can thrive. Well-managed SEPLS can also contribute to climate change mitigation and help build resilience to its effects.

This book attempts to illustrate the nexus between food, biodiversity, and climate and to highlight both the synergies and the trade-offs involved in decision-making around these issues. Featuring conceptual and empirical research covering 24 case studies from around the world, it addresses the impacts of climate change on biodiversity, ecosystem services, and food security, as well as its broader implications. It explores scientific and traditional solutions and biodiversity-friendly technologies

to tackle climate change. It is well timed to coincide with the IPBES assessment on the interlinkages between biodiversity, water, food, and health. I trust that it proves to be a useful resource to the assessment authors and to researchers in integrated sustainability science more generally.



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## Foreword by Fred Kruidbos

Ecology is the study of the relationships between organisms and their natural environment. An easily understandable way in which these relationships can be interpreted is that between plant, herbivore, and predator. Because the conditions on Earth vary by region, the form, function, and relationships of species are expressed in different biomes, such as those of tropical forest, savanna, and desert, and the forests and grasslands of the temperate regions which all include humans. One of the most important ways in which humans influence their natural environment is their enormous technological capacity to provide for their basic needs. This has contributed greatly to the growth of the human population to about eight billion people today, but has also led to the disappearance of original habitats, biodiversity loss, and the unsustainability of social–ecological systems.

As in any ecosystem, humans are also distributed in some way within the boundaries of their habitat, preferably close to water. This distribution is therefore not homogeneous by nature and so present-day humans mainly live aggregated in urban areas and where farming and fishing can be practiced. What is striking here is that there are areas where few people live but a lot of food is produced and areas where this is the other way around. This implies an inequality in the availability of food. Due to international trade and logistics, food can in principle be distributed all over the world; but in practice, however, this is not the case. Food shortage often leads to extremes ranging from malnutrition and starvation to severe obesity and all the secondary consequences that result. One of the main causes of these inequalities lies not only in the nature of the habitat in which the affected human populations reside, but in the man-made economic system that prevails. An important indicator is financial inequality.

Financial inequality can be related, among other things, to capitalism from which deep traces have been left in so many households, including in the areas of food security, biodiversity, and climate change. Or, as economist James Galbraith puts it in his book *The Predator State*, public institutions have been undermined to serve private profits for business elites acting as “predators” whose interests run the state “not for any ideological project—but simply in a way that would bring to them, individually and as a group, the most money.” A simple example in which these

relationships are expressed is the large parts of tropical forests that have been cleared to provide for the production of soy, palm oil, wood, and meat. This often leaves the local population underpaid with a completely vulnerable social–ecological context while a few take the loot. Other examples of unsustainable business can be found in the production of cut flowers and Harico verts that are flown from East Africa to Western Europe or in cattle that grow up in arid landscapes of East Africa as a competitor to wild animals, contributing to desertification, before being shipped to Saudi Arabia for consumption. Precisely because of the scale and duration at which these practices take place, it has even had an impact on the global climate and therefore on all of us. So, the behavior of some has an influence on all.

Through a more holistic view and integration of current knowledge in the areas of food technology, land use, food safety, and equality, it is possible to contribute in a sustainable way to the food needs of every citizen worldwide. A major advantage of equal distribution of resources, and thus reducing inequalities, is that this will contribute enormously to human well-being and security. This is not only important from a humanitarian point of view, but it also contributes to slowing down global population growth. After all, it is known that an increase in prosperity leads to a decrease in reproduction, one of the important factors that contributes to the mitigation of the current resource scarcity challenge. A very important factor therefore remains the fundamental inequality between the Global North and the Global South. That is why the United Nations has formulated the following three sustainable development goals first: no poverty, no hunger, and good health and well-being.

It is my belief that the intentions of the editors of this volume to contribute in a multidisciplinary manner to a better understanding of the interrelationships between food security, biodiversity, and climate will certainly influence the achievement of the UN-appointed sustainable development goals. Precisely, by (re)exposing a number of fundamentally important aspects from a biological basis, such as the importance of biodiversity as the source of current and future ecosystem services, emphasizing the sensitivity of ecosystems to climate change, and the associated food security, it fuels the resistance against inequality. It is my fervent hope that this volume, which is complementary to the previous volumes published by CERES—Social-Ecological Systems: From Risks and Security to Viability and Resilience and The Climate Change-Conflict-Displacement Nexus—will contribute to the realization of a paradigm shift for the benefit of humanity and nature.





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Fred Kruidbos

**Fred Kruidbos** is Biologist specialized in animal ecology. He studied at the prestigious Wageningen University and Fontys University of Applied Science, Tilburg. He is an independent researcher and the director of K-SN Ecological Services B.V. based in the Netherlands. His company operates worldwide and consists of three branches focused on: ecological research and consultancy; ecological products; and ecological safety and security services. This setup makes it possible to study problems from a multidimensional approach facilitating more holistic solutions. His current research is pragmatic in nature and focuses mainly on the interface between spatial planning and nature conservation. In addition to his civil studies, he completed the training as reserve officer and senior officer at the Netherlands Defense Academy (NLDA) and is attached to the Ministry of Defense as a Senior Operational Advisor. Supported by the combination of his ecological and military knowledge, he highlights issues from a different angle than is usual within both disciplines.

# Acknowledgements

The idea of publishing this contributed volume, as a part of a series of CERES publications, stemmed from my contribution as a nominated expert in the Scoping assessment of the interlinkages among biodiversity, water, food, and health in the context of climate change undertaken by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on 2020. At the moment of writing these words, two co-editors of this book, Dr. Himangana Gupta and I, have been selected by the IPBES as lead author and review editor, respectively, to take part in the Nexus assessment of the interlinkages among biodiversity, water, food, and health, to be released on 2024.

This volume is the outcome of an international cooperation between 73 authors—scientists, experts, and practitioners—from many countries, disciplines, and professional areas. It aims at providing a comprehensive understanding of the linkages between food security, biodiversity, and climate change, especially in the context of Global South. Based on a multi-regional and cross-sectoral analysis, the approach consists of: assessing the different natural and anthropogenic factors currently affecting ecosystems and their services, especially the impacts of environmental and climatic changes; highlighting the different linkages between the state of biodiversity and food systems in many contexts and scales; and exploring and assessing the effectiveness of various response mechanisms to effectively manage the implications of such linkages.

I have been honored to share the editorship of this volume with my colleagues: Dr. Himangana Gupta (Manager, Sustainable Landscapes and Restoration Program, World Resources Institute (WRI), India); Dr. Mirza Barjees Baig (Researcher, Prince Sultan Institute for Environmental, Water, and Desert Research, King Saud University, Saudi Arabia); and Ijaz Rasool Noorka (Professor, Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Pakistan). I seize this opportunity to thank all of them for their precious collaboration during the publishing process.

The real value of this volume should be, however, credited to chapters' authors, whose works had been accepted for publication after a rigorous peer review and proofreading. Their collaboration, reactivity, and engagement during the process

were indeed very remarkable and impressive. Therefore, any shortcomings are undoubtedly the editors' responsibility.

The chapters published in this volume are also the result of the invaluable contribution made by reviewers, who generously shared their time and energy to provide insight and expertise regarding the volume's chapters. On behalf of my co-editors, I would specifically like to acknowledge, with sincere and deepest thanks, the following reviewers:

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Mohamed Behnassi

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## **The Center for Environment, Human Security and Governance (CERES), Morocco**

CERES, previously the North-South Center for Social Sciences (NRCS), 2008–2015, is an independent and not-for-profit research institute founded by a group of Moroccan researchers and experts in 2015 and joined by many partners worldwide. It aspires to play the role of a leading think tank in the Global South and to serve as a reference point for relevant change processes. Since its creation, CERES managed to build a robust network involving various stakeholders such as researchers, experts, Ph.D. students, decision-makers, practitioners, and journalists from different spheres and scientific areas. These achievements are being rewarded by the invitation of CERES members to contribute to global and regional assessments and studies (especially IPBES, MedECC, EuroMeSCo, etc.) and the invitation of the Center to become a member of the MedThink 5+5, which aims at shaping relevant research and decision agendas in the Mediterranean Basin. The Center has organized so far five international conferences and several training/building capacity workshops, provided expertise for many institutions, and published numerous books, scientific papers, and studies which are globally distributed and recognized. These events and publications cover many emerging research areas mainly related to the human–environment nexus from a multidimensional, multiscale, interdisciplinary, and policy-making perspectives. Through its initiatives, the CERES attempts to provide expertise, to advance science and its applications, and to contribute to effective science and policy interactions.

**The Prince Sultan Institute for Environmental, Water and Desert Research (PSIEWDR), King Saud University, Riyadh, Kingdom of Saudi Arabia**

PSIEWDR was established in 1986 to conduct scientific research related to environmental issues and water resources. It also engages with vital issues related to the problem of aridity and the desert environment. It conducts development initiatives for the country's desert areas, particularly programs for combating desertification in the Arabian Peninsula. PSIEWDR designed and carried out two major water harvesting and storage programs, including the construction of purpose-built infrastructure, throughout the Kingdom of Saudi Arabia using novel techniques and equipment. The institute actively applies remote sensing technologies using advanced satellite image processing systems and GIS to study the country's environment and natural resources. In 2007, the institute published *The Space Image Atlas of the Kingdom of Saudi Arabia*, and it is currently developing *The Environmental Atlas of the Kingdom of Saudi Arabia*. The institute has been the primary sponsor of the biennial International Conference on Water Resources and Arid Environments (ICWRAE) held in Riyadh, Saudi Arabia, since 2004. The institute hosts the General Secretariat of the Prince Sultan Bin Abdulaziz International Prize for Water (PSIPW) which honors scientists all over the world for their innovative water-related research. PSIPW, in turn, has many agreements with various international water associations as well as a close partnership with the United Nations. PSIPW and the United Nations Office of Outer Space Affairs (UNOOSA) jointly produce and maintain the International Space4Water Portal, an online hub for all stakeholders involved in utilizing space technologies for water resources applications.

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Dr. Gupta received her Ph.D. degree in Environment Science from Panjab University, Chandigarh, in 2015. She is a certified expert in Climate Adaptation Finance. She has 27 research publications in national and international journals and four co-edited books, covering climate policy, forestry, biodiversity, social-ecological systems, and women and climate change. She has been an expert reviewer for many IPCC and IPBES reports.



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# Abbreviations and Acronyms

AFTs	Agroforestry trees products
AKF	Aga Khan Foundation
BAU	Business as usual
BNF	Biological N Fixation
CA	Conservation agriculture
CAL	Cocoa agroforestry landscapes
CBR	Central Board of Revenue
CDA	Capital Development Authority
CEC	Cation-exchange capacity
CERES	Center for Environment, Human Security and Governance
CFCs	Chlorofluorocarbons
CRU	Climate Research Unit
CSA	Climate smart agriculture
CSL	Consumer surplus loss
CSSVDP	Cocoa Swollen Shoot Virus Disease Program
CT	Conventional tillage
CTF	Powder form
CTO	Coconut Testa Oil
DAAD	German Academic Exchange Service
DLIS	Desert Locust Information Service
DSC	Differential scanning calorimetry
ECTPP	Emergency Centre established for Transboundary Plant Pests
EIA	Environmental Impact Assessment
EWFs	Edible wild fruits
FC	Field capacity
FEWSNET	Famine Early Warning Systems Network
FRAP	Ferric reducing antioxidant power
FYM	Farmyard manure
GBAO	Gorno-Badakhshan Autonomous Oblast
GDLA	Global Dryland Alliance Countries
GHGs	Greenhouse gases

GLOFs	Glacial lake outburst floods
GM	Green manuring
ICRAF	International Centre for Research in Agroforestry
IEE	Initial Environmental Examination
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KSA	Kingdom of Saudi Arabia
LPG	Liquefied petroleum gas
MAPs	Medicinal and Aromatic Plants
MDGs	Millennium Development Goals
MDS	Minimum Data Set
MHAs	Mountainous and hilly areas
MINADER	Ministry of Agricultural and Rural Development, Cameroon
NBSAP	National Biodiversity Strategy and Action Plan, Pakistan
NCCP	National Climate Change Policy, Pakistan
NGOs	Non-governmental organizations
NSP	Plant Production and Protection Division
NTFPs	Non-timber forest products
NWFP	Non-wood forest products
OER	Office of Emergencies and Resilience
PAM	Polyacrylamide
PMD	Pakistan Meteorological Department
PPAF	Pakistan Poverty Alleviation Fund
PPS	Population proportional to size
RRA	Rapid rural appraisal
RS	Remote sensing
SAPs	Superabsorbent polymers
SDGs	Sustainable development goals
SEPA	State Environmental Protection Agency, Nigeria
SOC	Soil organic carbon
SRWC	Salt Range Wetlands Complex
SVDP	Soon Valley Development Program
SWAC	Desert Locust in South-West Asia
TBTP	Ten Billion Trees Tsunami Program, Pakistan
TEAC	Trolox equivalent antioxidant capacity
TMPs	Traditional medicine practitioners
TPL	The plant list
TPS	Tribal protection system
UNRISD	United Nations Research Institute for Social Development
USAID	US Agency for International Development
VPD	Vapor pressure difference
WEF	Water–energy–food
WF	Wheat flour

WFP	World Food Programme
WUE	Water use efficiency
WWF	World Wide Fund for Nature

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