Springer Climate

Simone Lucatello
Elisabeth Huber-Sannwald
Ileana Espejel
Natalia Martínez-Tagüeña *Editors*

Stewardship of Future Drylands and Climate Change in the Global South

Challenges and Opportunities for the Agenda 2030

Springer

Springer Climate

Series editor

John Dodson, Institute of Earth Environment, Chinese Academy of Sciences
Xian, Shaanxi, China

Springer Climate is an interdisciplinary book series dedicated to climate research. This includes climatology, climate change impacts, climate change management, climate change policy, regional climate studies, climate monitoring and modeling, palaeoclimatology etc. The series publishes high quality research for scientists, researchers, students and policy makers. An author/editor questionnaire, instructions for authors and a book proposal form can be obtained from the Publisher, Dr. Michael Leuchner (michael.leuchner@springer.com).

More information about this series at http://www.springer.com/series/11741

Simone Lucatello • Elisabeth Huber-Sannwald
Ileana Espejel • Natalia Martínez-Tagüeña
Editors

Stewardship of Future Drylands and Climate Change in the Global South

Challenges and Opportunities for the Agenda 2030

Springer

Editors
Simone Lucatello
Estudios Ambientales y Territoriales
Instituto Mora
Mexico City, Mexico

Ileana Espejel
Facultad de Ciencias
Universidad Autónoma de Baja California
UABC
Ensenada, Baja California, Mexico

Elisabeth Huber-Sannwald
División de Ciencias Ambientales
Instituto Potosino de Investigación
Científica y Tecnológica
San Luis Potosi, San Luis Potosí, Mexico

Natalia Martínez-Tagüeña
Cátedra CONACYT
Consortium for Research, Innovation and
Development of Drylands
Instituto Potosino de Investigación
Científica y Tecnológica
San Luis Potosi, San Luis Potosí, Mexico

ISSN 2352-0698 ISSN 2352-0701 (electronic)
Springer Climate
ISBN 978-3-030-22463-9 ISBN 978-3-030-22464-6 (eBook)
https://doi.org/10.1007/978-3-030-22464-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

The world has entered a period of unprecedented change, as conveyed by the Great Acceleration. Our planetary life support system has the potential to be overwhelmed by the combined forces of climate change, declining biodiversity, pollution and social unrest or more positively to chart a course to a sustainable future that pacifies these forces for coming generations. Equally positively, in 2015, the world came together to endorse Agenda 2030 with its set of Sustainable Development Goals (SDGs), a remarkable agreement among all nations of the world as to the form of the future we want.

Nowhere are the challenges and opportunities more evident than in the drylands of the world. Drylands are the 'canary in the mine' for human disruption due to global change. The dependence of a billion of their inhabitants' livelihoods on ecosystem services means that dryland peoples are among the first to be affected by widespread changes such as land degradation, climate change and undermined water cycles. Not surprisingly, many of the world's refugee movements can be linked to resource pressures in drylands. Yet in the past, their challenging environments also made them a source of many social and technical innovations; and this continues today, with persisting traditional linguistic and cultural diversity. Thus, there is hope.

But this hope will only be realized through systematic efforts to entrain research and local knowledge towards an understanding of how to support the drylands better, as well as the implementation of this understanding. This book is a first major product of a relatively new network, RISZA, focused on collective learning about the sustainability of the drylands of the Global South. It builds on advances in drylands thinking over the past two decades, including the evolving Drylands Development Paradigm, but is the first to frame this effort in conjunction with the SDGs.

The contributors to the book frame the challenges of drylands as guiding complex adaptive social-ecological systems, looking through various sectoral lenses but with the whole framework of the SDGs in view. Parts of the book emphasize the potential for alliances at all scales from local transdisciplinary engagement to regional alliances, like the Agadir Platform, and global networks, like RISZA itself, as well as alliances across disciplines and technologies and even in to the arts and

humanities that are so important for framing the cultural norms and messaging through which the world views drylands.

I look forward to see the fruits of the discussions and partnerships which have taken root through the development of this book and which are so important for the future of the drylands and their inhabitants.

CSIRO Land and Water, Canberra, Australia Mark Stafford Smith
May 2019

Introduction

Current global risks emerging from socio-environmental changes are clearly linked to inappropriate and misleading models adopted for natural and socio-economic development (Sena et al. 2016). Among them, the destruction of ecosystems, loss of biodiversity and ecosystem function, land use, occupation, land use change and deforestation and the increasing expansion of drylands, together with misgovernance and other socio-political factors, constitute clear threats to the provision of natural resources, especially at the local level. These processes affect the environment and its interrelationship with society by modifying local populations' conditions of life, health, education and future development perspectives, among others. At the same time, the recent adoption of the Sustainable Development Goals (SDGs) adopted in 2015 paves the way for a new global framework under which nations worldwide must increase their efforts to stop poverty and improve life conditions of millions of people while conserving nature as life support systems by 2030 (UN 2015). The SDGs are firmly rooted in the sustainable development paradigm, which renders them conceptually appealing.

Ever since the conception of 'sustainability' as a guiding paradigm, it has become evident how difficult it is to integrate social, political, ecological and economic aspects—because of their complex interrelations and trade-offs (Berg 2015). In the specific case of drylands, challenges multiply due to the complex management of the so-called *fragile ecosystems*, like deserts which are constantly under pressure by climatic variations and human-induced activities. Desertification affects as much as one-sixth of the world's population, 70% of all drylands and one-quarter of the total land area of the world (WAD 2018). It results in the widespread poverty as well as in the degradation of billion hectares of rangeland and cropland (UNCED 2015). Understanding the drylands socioecological systems, integrated with stewardship (i.e. planning, management and governance), must be set out in order to fulfill the ambitious agenda of the SDGs.

Cross-sectoral aspects of decision-making for the sustainable use and development of natural and cultural resources as well as a transdisciplinary approach to the study of drylands are essential for the implementation of a robust and integral 2030 agenda.

This collective book is meant to explore cutting-edge views from different scholars about drylands and their interactions with a socio-ecosystemic environment and its projections towards the compliance of the SDGs agenda. The authors will explore from different angles the issue of drylands and will analyse the trade-offs as well as the link of social and economic development with environmental protection and enhancement for reaching the goals set by the 2030 agenda.

Contents

Contributors

E. M. Abraham Instituto Argentino de Investigaciones de las Zonas Aridas (IADIZA-CONICET-Universidad Nacional de Cuyo), Mendoza, Argentina

A. El Alaoui Natural Resources and Environment Research Team (NR & E), Department of Chemistry, Faculty of Science and Technology Errachidia, Moulay Ismail University, Meknes, Morocco

M. T. Alarcón-Herrera Centro de Investigación en Materiales Avanzados, S.C. Durango, Durango, Mexico

S. Alfonso de Nehren Institute for Technology and Resources Management in the Tropics and Subtropics, TH Köln, Köln, Germany

G. Arámburo Facultad de Ciencias Administrativas y Sociales, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

M. C. Arredondo-García Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico

N. Badan Rancho El Mogor, Ensenada, Mexico

M. Ballardo Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

L. Bouchaou Laboratoire de Géologie Appliquée et Géo-Environnement (LAGAGE) Faculté des Sciences, Université Ibn Zohr, Agadir, Morocco

R. Camacho-López Programa de Maestría en Manejo de Ecosistemas de Zonas Áridas, Universidad Autónoma de Baja California, Ensenada, Mexico

L. Carreño Programa de Doctorado en Medio Ambiente y Desarrollo, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

R. Cázares Reyes Ejidatario de La Soledad, Reserva de la Biosfera de Mapimí, Mapimi, Mexico

D. L. Coppock Department of Environment and Society, Utah State University, Logan, UT, USA

A. Cota Programa de Maestría en Manejo de Ecosistemas de Zonas Áridas, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

C. Delgado-Ramírez Escuela de Antropología e Historia del Norte de México, INAH, Chihuahua, Mexico

N. Dennig Dindum Kulturkommunikation e.V., Pulheim-Manstedten, Germany

I. Espejel Facultad de Ciencias, Universidad Autónoma de Baja California UABC, Ensenada, Baja California, Mexico

E. Estrada Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

B. Ferraz Centro de Gestão e Estudos Estratégicos (CGEE), Brasilia, Brazil

D. Galván-Martínez Programa de Doctorado en Medio Ambiente y Desarrollo, Universidad Autónoma de Baja California, Ensenada, Mexico

S. García Independent Consultant, Mexico City, Mexico

C. Gutiérrez Programa de Doctorado en Medio Ambiente y Desarrollo, Universidad Autónoma de Baja California, Ensenada, Mexico

G. Gutiérrez Secretaria de Protección al Ambiente de Baja California, Ensenada, Mexico

M. Gutiérrez Department of Geography, Geology and Planning, Missouri State University, Springfield, MO, USA

A. Hernández El Colegio de la Frontera Norte, Tijuana, Mexico

E. Huber-Sannwald División de Ciencias Ambientales, Instituto Potosino de Investigación Científica y Tecnológica, A.C. (IPICYT), San Luis Potosí, Mexico

L. Ibarra Programa de Maestría en Manejo de Ecosistemas de Zonas Áridas, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

O. Jiménez-Orocio Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, BC, Mexico

C. Leyva Facultad de Ciencias, Universidad Autónoma de Baja California (UABC), Ensenada, Mexico

S. Lichtenberg Department of Physical Geography, University of Passau, Passau, Germany

D. Núñez López Centro de Investigación en Materiales Avanzados, S.C., Durango, Mexico

J. J. López Pardo Instituto Potosino de Investigación Científica y Tecnológica, A.C., San Luis Potosí, Mexico

S. Lucatello Estudios Ambientales y Territoriales, Instituto Mora, Mexico City, Mexico

D. Martínez Centro de Investigación en Materiales Avanzados, S.C. Durango, Durango, Mexico

N. Martínez-Tagüeña Cátedra CONACYT, Consortium for Research, Innovation and Development of Drylands, Instituto Potosino de Investigación Científica y Tecnológica, San Luis Potosi, San Luis Potosí, Mexico

R. I. Mata Páez Instituto Potosino de Investigación Científica y Tecnológica, A.C., San Luis Potosí, Mexico

H. Mertin Freelance Musician, Sound Performer and Music Ethnologist, Cologne, Germany

M. Millones Department of Geography, University of Mary Washington, Fredericksburg, VA, USA

J. Morán El Colegio de San Luis, San Luis Potosí, Mexico

T. Moreno-Zulueta Programa de Doctorado en Medio Ambiente y Desarrollo, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

D. M. Muñoz-Pizza Programa de Doctorado en Medio Ambiente y Desarrollo, Universidad Autónoma de Baja California, Ensenada, Mexico

U. Nehren Institute for Technology and Resources Management in the Tropics and Subtropics, TH Köln, Köln, Germany

M. Niamir-Fuller Vice-Chair International Support Group, International Year of Rangelands and Pastoralists, Purcellville, VA, USA

E. Nickl University of Delaware, Newark, DE, USA

A. Ocaña Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

L. Ojeda-Revah Colegio de la Frontera Norte, Tijuana, Mexico

L. Ortega El Colegio de San Luis, San Luis Potosí, Mexico

B. Parmentier Department of Geography, University of Mary Washington, Fredericksburg, VA, USA

SESYNC, Annapolis, MD, USA

L. Pedrín Programa de Maestría en Manejo de Ecosistemas de Zonas Áridas, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

D. Pinedo Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico

C. Raedig Institute for Technology and Resources Management in the Tropics and Subtropics, TH Köln, Köln, Germany

J. C. Ramírez Instituto Municipal de Investigación y Planeación de Ensenada, Ensenada, Mexico

R. F. Rentería-Valencia Anthropology and Museum Studies in Central Washington University, Ellensburg, WA, USA

V. M. Reyes Gómez Red Ambiente y Sustentabilidad, Instituto de Ecología, A.C., Chihuahua, Mexico

M. Reyes-Orta Facultad de Turismo y Mercadotecnia, Universidad Autónoma de Baja California, Ensenada, Mexico

A. Rizzo UMR ESPACE-DEV (IRD, Université de Montpellier, Université de la Réunion, Université de Guyane, Université des Antilles), Montpellier, France

P. Rojas Rancho El Mogor, Ensenada, Mexico

M. A. Cordero Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

J. Sandoval Instituto Municipal de Investigación y Planeación de Ensenada, Ensenada, Mexico

D. S. Savín Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

Y. Savín Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

G. Seingier Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, BC, Mexico

M. Silva Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

A. Sifeddine UMR LOCEAN (IRD, CNRS, MNHN, Sorbonne Université), Departamento de Geoquimica-UFF-Brazil, UNAM-IRD-Mexico, Ciudad de México, Mexico

M. C. Tonche Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

Y. Torres Grupo Mujeres con Alas, Domicilio conocido Bahía de los Ángeles, Ensenada, Mexico

A. Trejo Universidad Nacional Autónoma de México, Mexico City, Mexico

C. Turrent Taller de Arquitectura Contextual ClaCla, Ensenada, Mexico

J. Urquidi Macías Ejidatario de La Soledad, Reserva de la Biosfera de Mapimí, Mapimi, Mexico

C. Uscanga Programa de Maestría en Manejo de Ecosistemas de Zonas Áridas, Universidad Autónoma de Baja California, Ensenada, Mexico

I. Vaillard Rancho Tres Mujeres, Ensenada, Mexico

C. Vázquez-León El Colegio de la Frontera Norte, Tijuana, Mexico

Á. Vela Instituto Municipal de Investigación y Planeación de Ensenada, Ensenada, Mexico

L. Vera Instituto Mora, Mexico City, Mexico

M. Villada-Canela Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California UABC, Ensenada, Mexico

C. Villarreal Wislar Comisión Nacional de Áreas Naturales Protegidas, Torreón, Mexico

H. Zgou Polydisciplinary Faculty of Ouarzazate, Ibn Zohr University, Agadir, Morocco

M. Zortea UNESCO Engineering for Human and Sustainable Development, DICAM – Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy

About the Editors

Simone Lucatello is a full-time researcher and professor at the Instituto Mora, a public research centre belonging to the Mexican National Agency for Science and Technology (CONACYT) in Mexico City, Mexico. He is one of the leading authors of the IPCC (Intergovernmental Panel on Climate Change) Working Group II, which deals with the impacts, adaptation and vulnerability to climate change for the next IPCC Sixth Assessment Report (AR6, due in 2021), and coordinating leading author of the AR6 North American Chapter. His research interests include climate change impacts in the Global South and risk assessment and disaster risk reduction in Latin America. He served as a consultant to several international organizations, such as the Inter-American Development Bank (IDB), UNEP, UNIDO, OCHA and European Union (Europe Aid) in the Balkans, Central America and Mexico. He is member of the International Network for Sustainable Drylands (RISZA) and of the Scientific Committee of the Humanitarian Encyclopedia at the Genève Centre for Education and Research in Humanitarian Action (CERAH, Switzerland). He is also actively engaged in national and international academic networks and projects across the Americas, Europe and Africa. He holds a master's degree in International Relations from the London School of Economics (LSE) and a PhD in Governance for Sustainable Development from the Venice International University, Italy.

Elisabeth Huber-Sannwald is research professor at the Division of Environmental Sciences, Instituto Potosino de Investigación Científica y Tecnológica (IPICYT), San Luis Potosi, Mexico. She co-founded the area of Global Environmental Change and Ecology and co-designed the Environmental Sciences Postgraduate Program with the specialty in Global Environmental Change and Ecology. She is an expert in dryland systems considering the influence of global and social changes. She has 15 years of experience in interdisciplinary and 5 years of transdisciplinary research. Her work focuses on the integrity and resilience of dryland socioecological systems and the sustainable development of rural livelihoods. She is founder of and currently coordinating the International Network for Drylands Sustainability (RISZA) and is member of the Executive Committee of the Transatlantic Agadir Platform fostering transdisciplinary dryland research in Latin America, Southern Europe and

Northern Africa. She is member of the Continuing Committee of the International Rangeland Congress since 2011. In addition, she served as international member of the Science Council of the Ecological Society of America from 2010 to 2014 and as vice chair and chair of the Rangeland Section of the Ecological Society of America from 2016 to 2018 and is regional president of the Mexican Scientific Ecological Society since 2012. She forms part of the Executive Committee of the International Network for Desertification ARIDnet and contributed to the formulation of the Dryland Development Paradigm. She has been associate editor of *Rangeland Ecology and Management* from 2008 to 2010 and of *Ecological Applications* since 2012. She has organized national and international scientific and multi-sector workshops, meetings and congresses. Her publications have over 5290 citations (without self-citations). Moreover, she has been PI of 15 national and international research grants; has graduated 1 bachelor, 12 masters and 6 doctorate students; and has taught 15 different graduate-level courses at national and international institutions.

Ileana Espejel is teacher-researcher at the School of Sciences, Universidad Autónoma de Baja California (UABC), and leader of the academic group Manejo de Recursos Costeros y Terrestres. In 2011, she received Ecology and Society Award and an honorific mention by Semarnat-Ecological Award in 2014. She is cofounder of three postgraduate programmes and a bachelor's in environmental issues, member of the Research National System level III and jury member of several academic and meeting committees. She has professional experience of 35 years in interdisciplinary research and teaching in arid and coastal environments and received Academic Award in 2012 and Semarnat-Ecological Award in 2017. She is part of the editorial board of Frontera Norte and Economía Sociedad y Territorio and peer reviewer of journals like *Tourism Management* and *Ocean and Coastal Management*. She has been responsible of 30 projects on environmental and ecosystem management issues. Most projects and papers have a main goal of inter- and transdisciplinary research seeking for the sustainable development of arid and coastal communities in Mexico. As a professor, she has given 40 types of lessons on diverse issues and institutions (ecology ecosystem management, interdisciplinary research methodology and thesis workshops). Moreover, she is advisor of four bachelor's theses, 7 diploma levels, 37 master's theses and 17 PhD theses besides being member of the interdisciplinary thesis committees of several postgraduate students. She completed her bachelor's degree in Biology in 1980 at the Autonomous National University of México; master's at INIREB in Xalapa, Veracruz; and PhD in Vegetation Ecology at Uppsala University, Sweden, in 1986 and received the Leadership for Environment and Development (LEAD) (Fundación Rockefeller) in 1997 at El Colegio de México.

Natalia Martínez-Tagüeña started her career as an anthropologist specialized in archaeology with a degree from the Universidad de las Américas, Puebla. Since then, her work focuses on dryland regions. Her first studies reconstructed a past that is relevant for the future, looking for an understanding of subsistence practices and climate change in the following topics: transitions from hunter-gatherers to

agriculture, agave cultivation, coastal adaptations in dryland regions and human impact in ancient environments. She continued her graduate studies at The University of Arizona where she started teaching and participated in several interdisciplinary and transdisciplinary projects. During her graduate work, she transitioned from an ethnoarchaeological approach to a participatory and community-based research. Since 2009, she established a long-term commitment with the Comcaac indigenous community to develop in collaboration the documentation of their cultural landscape, through archaeology, ethnography, oral history and oral tradition. She employs participatory methodologies like community workshops and participatory mapping. She is now a member of the National Research System (SNI) as candidate level and is a researcher in CONACYT, Instituto Potosino de Investigación Científica y Tecnológica (IPICYT), Centro de Investigación, Innovación y Desarrollo para las Zonas Áridas (CIIDZA). She has the opportunity to collaborate in and to develop transdisciplinary research projects to jointly understand humans and nature as a unity whose particularities vary upon each context and temporal trajectories to thus develop management plans, adopt social technologies and sustainably use natural and cultural resources.

Abbreviations

ACI	Adaptation Capacity Index
AI	Aridity Index
AMIMP	Asociación Mexicana de Institutos de Planeación
AMO	Atlantic Multidecadal Oscillation
ANP	Área Natural Protegida
BR	Biosphere Reserve
BRM	Biosphere Reserve of Mapimí
CAP	Community Action Plan
CAS	Complex Adaptive Systems
CC	Climate Change
CGIAR	Consultative Group for International Agricultural Research
CESPE	Comisión Estatal de Servicios Públicos de Ensenada
CHARISMA	Changement et VariabilitéS Climatiques
CLCU	Changes in Land Cover/Use
CMSD	Community Model of Sustainable Development
CNEED	Conseil National de l'Environnement pour un Développement Durable
CONABIO	Comisión Nacional de Biodiversidad
CONACYT	Consejo Nacional de Ciencia y Tecnología
CONANP	Comisión Nacional de Áreas Naturales Protegidas
CONAGUA	Comisión Nacional del Agua
COP	Conference of the Parties
COTAS	Comité Técnico de Aguas Subterráneas
CFSR	Climate Forecast System Reanalysis
CV	Coefficient of Variation
DAC	Development Assistance Committee
DESA	Department of Economic and Social Affairs
DSES	Dryland Socioecological Systems
DWL	Depletion of Aquifers
ECOWAS	Economic Community of West African States
EM	Environmental Mainstreaming

ENSO	El Niño-Southern Oscillation
ERIS	Engaged Research Within an Innovation System
FAO	Food and Agriculture Organization of the United Nations
FSR&E	Farming Systems Research and Extension
FST	Faculté des Sciences et Techniques
FPO	Faculté Polydisciplinaire de Ouarzazate
GAD	Gender and Development
GDI	Global Drylands Imperative
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESP	General Ecological Spatial Plan
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	Greenhouse Gases
GIS	Geographic Information System
GO(s)	Governmental Organization(s)
GPS	Global Positioning System
ICSU	International Council for Science
IEA	International Energy Agency
IGES	Institute for Global Environmental Strategies
IGM	Integrated Groundwater Management
INDC	Intended Nationally Determined Contribution
INIREB	Instituto Nacional de Investigaciones sobre Recursos Bióticos
IPCC	Intergovernmental Panel on Climate Change
IS	Innovation Systems
ITT	Institute for Technology and Resources Management in the Tropics and Subtropics
IWRM	Integrated Water Resources Management
JCDAS	Japanese Climate Data Assimilation System
JMA	Japan Meteorological Agency
JRA	Japanese Reanalysis
LDN	Land Degradation Neutrality
LH	Laguna de Hormigas
LITK	Indigenous knowledge and technology
MAB	Man and the Biosphere Programme
MAP	Mean Annual Precipitation
MASL	Metres Above Sea Level
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MEICS	Model for the Estimation of Indigenous Community Sustainability
MPI	Message Passing Interface
MPL	Maximum Permissible Limits
NAO	North Atlantic Oscillation
NAFTA	North American Free Trade Agreement
NAP(s)	National Action Programme
NCAR	National Center for Atmospheric Research

NGO(s)	Non-governmental Organization(s)
NOAA/CDC	National Oceanic and Atmospheric Administration/Climate Diagnostics Center
NPA	Natural Protected Area
NCEP	National Centers for Environmental Prediction
NSSD	National Strategies for Sustainable Development
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
OUV	Outstanding Universal Value
P	Precipitation
PANDSOC	Program for the Sustainable Development of Oceans and Coasts of Mexico
PAR	Participatory Action Research
PCA	Principal Component Analysis
PDO	Pacific Decadal Oscillation
PET	Potential Evapotranspiration
PROCODES	Programa de Conservación para el Desarrollo Sostenible
PRONATURA	Pronatura México A.C
PRSP	Poverty Reduction Strategy Paper
PVSC	Photovoltaic Solar Cells
PRA	Participatory Rural Appraisal
RAN	Registro Agrario Nacional
RBM	UNESCO Biosphere Reserve of Mapimí
RCP	Representative Concentration Pathways
REPDA	Registro Público de Derechos de Agua
RISZA	International Network for Dryland Sustainability (Red Internacional para la Sostenibilidad de Zonas Áridas
RPC	Rotated Principal Component
RS	Remote Sensing
RW	Reclaimed Water
SAGARPA	Secretaría de Agricultura y Desarrollo Rural
SD	Aldama, San Diego
SD	Sustainable Development
SDG(s)	Sustainable Development Goals(s)
SEDAGRO	Secretaría de Desarrollo Agropecuario
SEDATU	Secretaría Desarrollo Agrario, Territorial y Urbano
SEDESOL	Secretaría de Desarrollo Social
SEDUE	Secretaría de Desarrollo Urbano y Ecología
SEGOB	Secretaría de Gobernación
SES(s)	Social/Socioecological System(s)
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
SI	Sensitivity Index
SLP	San Luis Potosí
SPA	Salud por Agua
SPI	Standard Precipitation Index

SU/TCDC	Special Unit for Technical Cooperation Among Developing Countries
TA	Tabalaopa-Aldama
TEK	Traditional Ecological Knowledge
TDS	Total Dissolved Solids
TUC	Tierra de uso común
UABC	Universidad Autónoma de Baja California
UN	United Nations
UNAM	Universidad Nacional Autónoma de México
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCOD	United Nations Conference on Desertification
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNRIP	United Nations Rights of Indigenous Peoples
UNDP	United Nations Development Programme
USA	United States of America
UV	Universidad Veracruzana
WAD	World Atlas of Desertification
WHS	World Heritage Sites
WID	Women in Development
WIPO	World Intellectual Property Organization
WL	Water Level
WQI	Water Quality Index
WRI	World Resources Institute

Chapter 1
Introduction: International Network for the Sustainability of Drylands—Transdisciplinary and Participatory Research for Dryland Stewardship and Sustainable Development

E. Huber-Sannwald, N. Martínez-Tagüeña, I. Espejel, S. Lucatello, D. L. Coppock, and V. M. Reyes Gómez

Abstract Drylands are the largest biome complex on Planet Earth and home to over 40% of the human population. Their extraordinary high biotic and cultural richness is endangered by global climate change, land use pressures including coastal/marine systems, and environmental degradation. Understanding and maintaining the functional integrity of dryland socio-ecological systems (DSES) is fundamental for sustainable development. It requires resilience-based dryland stewardship, where land users, managers and decision-makers incorporate change, as understood from the multiple actors' perspective of a SES, into their planning and governance. The linkage of America's drylands with west Africa and Southern Europe is often overseen, however increasing economic activities in these DSES have enormous impacts on their functional integrity. In response to this daunting

E. Huber-Sannwald (✉)
División de Ciencias Ambientales, Instituto Potosino de Investigación Científica y Tecnológica, San Luis Potosi, San Luis Potosí, Mexico
e-mail: ehs@ipicyt.edu.mx

N. Martínez-Tagüeña
Cátedra CONACYT, Consortium for Research, Innovation and Development of Drylands, Instituto Potosino de Investigación Científica y Tecnológica, San Luis Potosí, Mexico

I. Espejel
Facultad de Ciencias, Universidad Autónoma de Baja California UABC, Ensenada, Baja California, Mexico

S. Lucatello
Estudios Ambientales y Territoriales, Instituto Mora, Mexico City, Mexico

D. L. Coppock
Department of Environment and Society, Utah State University, Logan, UT, USA

V. M. Reyes Gómez
Red Ambiente y Sustentabilidad, Instituto de Ecología, A.C., Chihuahua, México

S. Lucatello et al. (eds.), *Stewardship of Future Drylands and Climate Change in the Global South*, Springer Climate,
https://doi.org/10.1007/978-3-030-22464-6_1

task, academic and government institutions founded the Agadir Platform as a coordinating instrument for cooperation in the Global South. As focal node of this platform, Mexico established the first international network to co-generate knowledge through transdisciplinary research partnerships. We present the conceptual framework of this network highlighting 1) the socio-ecological system's approach, 2) the transdisciplinary scope of participatory research, 3) the intercultural action scheme, and 4) the repercussions of this integrated approach on polycentric governance. This book includes diverse examples of the application of this framework in DSES ranging from co-designing socio-ecological development projects, to adaptive management, and policy development.

Keywords RISZA · Transdisciplinary networks · Co-designed projects · Arid lands · Participative research · South-South and triangular cooperation

Drylands are the largest biome complex on Planet Earth and home to over 40% of the human population. Their extraordinary high biotic and cultural richness is endangered by global climate change, land use pressures including coastal/marine systems, and environmental degradation. Understanding and maintaining the functional integrity of dryland socio-ecological systems (DSES) is fundamental for sustainable development. It requires resilience-based dryland stewardship, where land users, managers and decision-makers incorporate change, as understood from the multiple actors' perspective of a SES, into their planning and governance. The linkage of America's drylands with west Africa and Southern Europe is often overseen, however increasing economic activities in these DSES have enormous impacts on their functional integrity. In response to this daunting task, academic and government institutions founded the Agadir Platform as a coordinating instrument for cooperation in the Global South. As focal node of this platform, Mexico established the first international network to co-generate knowledge through transdisciplinary research partnerships. We present the conceptual framework of this network highlighting 1) the socio-ecological system's approach, 2) the transdisciplinary scope of participatory research, 3) the intercultural action scheme, and 4) the repercussions of this integrated approach on polycentric governance. This book includes diverse examples of the application of this framework in DSES ranging from co-designing socio-ecological development projects, to adaptive management, and policy development.

Aridity is often characterized by an aridity index (AI) (Thomas and Middleton 1992), calculated as annual precipitation divided by annual potential evapotranspiration, and ranges from a minimum of 0.05 to a maximum of 0.65 (Hulme 1996; Safriel et al. 2005). Based on the AI drylands can be classified as hyperarid, arid, semi-arid, and dry sub-humid (UNCCD 1994). In comparison to other biomes, life in the drylands has evolved under highly variable precipitation, extreme water scarcity, pronounced fluctuations in diurnal temperatures, and extended exposure to high levels of solar radiation (Noy-Meir 1973). These factors continuously exert strong selection pressures on specialized life forms (Whitford 2002). However, there is an exceptionally high species diversity across all categories of biota that contributes to varied ecosystems that span from coastal drylands to intracontinental basins and highland plateaus.

Dryland ecosystems offer a wealth of ecosystem goods and services for human well-being (Safriel et al. 2005; Stafford Smith et al. 2009). Large populations of agriculturalists, pastoralists, and coastal fishermen have enormous cultural wealth and ecological knowledge. Over millennia, humans have adapted to the scarcity and abundance cycles of natural resources, shaping their livelihoods accordingly (Stafford Smith and Cribb 2009; Davis 2016a). The long history of fine-tuning socio-economic and political life among drylands peoples reflects some of the oldest legacies of socio-ecological system (SES) development, and today are characterized by both their ecological significance in sustaining the supply of ecosystem services and their capacity to support millions of people (Safriel et al. 2005; Cherlet et al. 2018). Variability is an inherent structural property of drylands (Stafford Smith et al. 2009) to which local communities have adapted and evolved under, thereby lowering their vulnerability to unpredictable environmental changes (Krätli 2015; Davis 2016b). These adaptive social–ecological interdependencies of human activities and ecosystem services require collective knowledge-based actions supporting dryland stewardship (Chapin III et al. 2009a, b, c).

However, over recent decades, drylands have suffered substantial losses of productivity and biodiversity, increasing the severity and frequency of droughts, food insecurity, poverty, violence, emigration, and social disintegration (Reed and Stringer 2016; Cherlet et al. 2018; Middleton 2018). In addition, some areas have been converted to irrigated lands to expand high-input agriculture and to pastures for intensive livestock production (Jia et al. 2004; Squires 2010) triggering irreversible systemic changes. The processes underlying all these changes are often termed desertification (UNCCD 1994; Reynolds et al. 2007) undermining the sustainable regional development and threatening the global dryland SES (UNCCD 1994; Cherlet et al. 2018), which are mainly situated in the Global South. According to the sustainable development goals, the objectives include thriving lives and livelihoods, sustainable food security, sustainable water security, universal clean energy, healthy and productive ecosystems, and governance for sustainable societies (Griggs et al. 2013).

The scope of this chapter is to elucidate the challenges of understanding current human and environmental conditions in the drylands and identify emerging research needs that can help forge pathways towards improved stewardship and sustainable development in future drylands in a world that will also be buffeted by climate change. Many issues related to transforming and governing drylands have been developed theoretically at the global scale [e.g., sustainable development goals and land degradation neutrality (Orr et al. 2017; Cowie et al. 2018)]. Some plans have been implemented at a national scale (INEGI 2019; UNCCD 2019), but scaling down sustainable development to dryland local communities is still lacking. Furthermore, suitable SES research methods that fully respond to such theoretical developments are required and need to be better defined and promoted.

Therefore, we present the International Network for Dryland Sustainability ("Red Internacional para la Sostenibilidad de Zonas Áridas, RISZA") that tackles the current dryland challenges at the local and regional scale, and supports several activities and goals. These include: (1) Creation of multisectoral partnerships associated with local SESs; (2) facilitation of intercultural exchange and dialogue; (3) weaving of different

knowledge systems (Johnson et al. 2016; Tengö et al. 2017); (4) encouragement of transdisciplinary and participatory research (Schuttenberg and Guth 2015; Hickey 2018, Hickey et al. 2018; Willyard et al. 2018) for the co-production of relevant knowledge for action research (Clark et al. 2016; Durose et al. 2018); (5) generation of place-based learning communities (Davidson-Hunt and O'Flaherty 2007); (6) stimulation of the co-design of novel management, assessment, and governance schemes (Whitfield and Reed 2012; Schoon et al. 2015; Bautista et al. 2017; Bodin 2017; de Vente et al. 2017, (7) providing information for sustainable policy and socio-economic development standards in accordance with the United Nations Sustainable Development Goals (Agenda 2030). This network is the first national/international node of a recently founded international platform (see Chap. 13) to coordinate novel research, management, and assessment models in the drylands of Latin America, North Africa, and Europe in response to global environmental change in the Anthropocene.

The RISZA initiative also contributes to the wide range of activities related to the so-called *Global South* to foster the global scientific and research-development agenda on drylands. As a matter of context, the concept "Global South" refers broadly to the regions of Latin America, Asia, Africa, and Oceania. It is a term that has emerged as an alternative to the misconceived and former colonial ideas of "The Third World" and "Periphery" adopted in Europe and North America pointing to low-income and often politically or culturally marginalized countries of the planet (Dados and Conell 2012). The use of the "Global South" idea marks a shift from a central focus on underdevelopment or cultural differences in world countries, towards an emphasis on geopolitical relations of power among more equal nations. This is possible through the economic, political, cultural, and environmental changes that many developing nations in different continents have undergone over the past three decades. The Global South is rather an international political and economic concept that focuses on how world cultures, particularly those from Latin America Africa and Asia, respond to globalization and global processes linked to the environment, poverty, immigration, gender, etc., together with transformation, colonialism and post-colonialism, and modernity.

In the specific case of this book, we address the vision of drylands stewardship through the lens of a group of countries in Latin America (mostly Mexico) and Africa, through the nexus with the Agadir Platform, a transdisciplinary initiative, where countries from the two regions and Southern Europe collaborate on a common scientific agenda on sustainable development in drylands in the light of climate change.

Drylands Vulnerability in the Twenty-First Century

Over millennia the drylands have undergone innumerable transformations in climate, biotic interactions, and human conditions. Pressing current challenges in global drylands include a broad spectrum of issues as shown in Table 1.1.

Hence, these challenges explain why drylands currently cover over 35% of the global biodiversity hotspot area (Davies et al. 2012) and 28% of the total area of World Heritage Sites (Gudka et al. 2014). Past climate warming has been most

Table 1.1 Pressing current challenges in global drylands

Challenges	Some references
Human population growth	Wang et al. (2012), Reid et al. 2014), Cherlet et al. 2018)
Conversion of key rangeland resources to agricultural uses and groundwater exploitation	Chapter 3; Peters et al. (2015)
Sedentarization of pastoralists and other changes in traditional livelihoods	Chapter 2; Marlowe (2005), Reid et al. (2014)
Migration	Coppock et al. (2017)
Privatization of communal land	Reid et al. (2014)
Expanding urbanization	Reid et al. (2014), Peters et al. (2015)
Expansion of infrastructure for renewable energy generation and intensive agriculture	Chapter 5; Matson (2012), Reid et al. (2014), Cherlet et al. (2018)
Extraction of fossil fuels	Reid et al. (2014)
Expansion of mining	Reid et al. (2014)
Overgrazing by domestic livestock	Peters et al. (2015), Cherlet et al. (2018), Middleton (2018)
Invasive species	Reid et al. (2014)
Proliferation of water development	Chapter 3; Wilcox et al. (2011)
Aquifer overexploitation	Chapter 3; Aeschbach and Gleeson (2012)
Imposed or inadequate conservation management plans	Dudley (2008), Dressler et al. (2010) but see Gudka et al. (2014)
Inappropriate restoration and/or afforestation projects to enhance carbon capture	Wilcox et al. (2011), Veldman et al. (2015), Nolan et al. (2018)
Loss of local and indigenous knowledge	Figueroa (2011), Johnson et al. (2016) but see Gómez-Baggethun and Reyes-García (2013) for interpretation
Increased frequency of droughts	Chapter 15; Huang et al. (2017b)

pronounced in drylands, with an average increase of 1.7 °C between the years 1948 and 2008 (Huang et al. 2012); this warming trend is about 2.1 and 1.5 times greater than any increase observed in humid regions and globally, respectively (Huang et al. 2015, 2017a, b). Over a sixty-year period (1948–2008), drylands have expanded to their current extension (Feng and Fu 2013). Drylands are one of the most vulnerable biomes to climate warming, likely unable to tolerate the 2 °C warming threshold of the 2015 Paris agreement (Huang et al. 2017a). When considering high CO_2 emission scenarios (RCP 8.5), global drylands are predicted to expand at an even faster rate in that they will cover up to 56% of the terrestrial surface by 2071–2100 (Huang et al. 2015, 2017b). When considering only the CO_2 fertilization effect, drylands are predicted to increase their productivity. It has been shown that within 28 years (1982–2010) leaf cover has increased by 11% likely attributable to a 14% increase in atmospheric CO_2 concentration (Donohue et al. 2013). Finally, recent simulation models suggest that temperate drylands will shrink by a third and convert to subtropical drylands, and that drought may reduce water availability primarily at deep soil layers during the growing season with obvious implications on vegetation shifts, declines in ecosystem services supply and livelihood options (Schlaepfer et al. 2017).

Such accelerated changes in dryland use can introduce new dynamics in SES and in the transitions between stable and unstable SES states (Huber-Sannwald et al. 2012; Bestelmeyer et al. 2015). A state is characterized by certain vegetation and soil types and ecosystem processes (Bestelmeyer et al. 2015), which supplies a set of ecosystem goods and services in accordance to human demand (Yahdjian et al. 2015). Inherent and new sources of disturbances may cause changes of SES states; these changes can be abrupt, gradual, reversible, or persistent. Hence, unpredictable trends of change will be accompanied by new challenges related to understanding the combined and interacting effects of historic land use change, climate variability, alterations in the functioning of dryland SES, and their resilience and ability to deliver future ecosystem services (Folke et al. 2009, 2010). While extended droughts and increased variability in precipitation directly exacerbate socio-environmental degradation in drylands (Puigdefábregas 1998; Stott 2016), indirect policy-induced desertification also occurs (Geist and Lambin 2004; Adams 2009; Davis 2016b; Huaico Malhue et al. 2018).

Scholars have long debated on how to better manage the inherent variability of drylands to improve human living conditions. Such engineering approaches are grounded on the premise that one can reduce the inherent variability of drylands by adopting agricultural practices that have been successful where water availability is more predictable. A prominent example is crop irrigation, for instance, in the Yaqui valley in Mexico; this desert area has been the cradle of the Green revolution and the worldwide leader in wheat producer (Matson 2012). Environmental uniformity and stability, and the removal of redundancy may guarantee short-term high crop yields and temporarily increase food security, yet at the cost of irreversible loss of biotic and cultural diversity (Holling and Meffe 1996; Safriel et al. 2005; Walker and Salt 2006) along with trade-offs on sustaining ecosystem services (Papanastasis et al. 2017).

Human interventions intended to achieve sustainable development, as defined in the UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment/sustainable-development-goals/), no longer require investment in maximizing commodity production, but rather in diversifying protections afforded to the biota, cultures, and knowledge systems in order to increase the response and adaptation spectra to regional or global socio-environmental change (Chapin III et al. 2009a). This increases the system buffering capacity against unpredictable change (Huber-Sannwald et al. 2012). The role of traditional ecological knowledge in understanding SES is crucial to understand how some local communities have sustained resilient landscapes, but also for the successful stewardship of diverse SES where the division between nature and society is bridged and true ethical multisectoral collaborations are accomplished (Johnson et al. 2016).

Desertification and Land Degradation Versus Drylands Resilience

According to the United Nations Convention to Combat Desertification (UNCCD 1994) desertification refers to land degradation in drylands due to various factors, including climatic variations and/or human activities (Article 1 of the UNCCD). The