

Advances in Geographical and Environmental Sciences

Swarnima Singh  
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# Simulating Climate Change and Livelihood Security

A Western Himalayan Experience, India



 Springer

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Swarnima Singh · R. B. Singh

# Simulating Climate Change and Livelihood Security

A Western Himalayan Experience, India

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# Preface

Change is the law of nature, and the fragile Himalaya is no exception to this, where changing climate and its feedback mechanisms have become inescapable because its unconceivable impacts are experienced almost in all realms of existence and will continue to affect in the future as well. These high altitudinal areas have been undergoing through the transitional phase not only in terms of natural changes but also in terms of socio-economic. The extent and frequency of extreme climate-related events are not new, and it has been happening since the origin of this planet and is on the continuous rise throughout. The continuous and persistent impact of climatic variability on the flora, fauna and crops is much evident; therefore, it could not be called a myth. Consequently, it has awakened even the non-believers through the amplified vulnerability and their outcomes on livelihoods and food security. Subsequently, it has become one of the chief concerns to monitor and analyze the changing climate and its impact with the help of several calibrations/simulation models and ground observations. In its Fourth Assessment Report (AR4), IPCC has provided irrefutable observations regarding an increase in surface air temperatures (SATs) and surface skin temperatures (SSTs) triggering an extensive yet slow and steady rise in temperature leading to a modification of human lives and livelihoods, especially in the agrarian economy. The thermally induced change in the length of growing period of plants and crops is gradually altering agro-ecological zones (AEZs), pushing incessant pressure on the marginal and small farming communities, where current trends in GHGs emissions and potential agricultural losses have induced alarm on livelihood sustainability. While knowledge on the effects of climate change on livelihood is increasing, there is still a dearth of micro-level studies that can provide a better understanding. This work is an attempt to analyze the impact of changing climate on livelihood security by creating a baseline scenario of temperature and rainfall records through the regional circulation model from both ground stations and satellite data to investigate existing and projected livelihood security in the Western Himalayan district of Himachal Pradesh, India. It is one of the largest districts of Himachal Pradesh, in terms of its population, agricultural production and the resource richness where climate change impact on this agrarian village's livelihood is likely to be very alarming. No sector or society is untouched by the impact of climate change; therefore, this book is an attempt to present the inception of climatic variability

and livelihood security. It is a quite unique and inclusive study because substantial work has been piloted on regional climate change modeling and simulated results on livelihood security that has not been attempted before.

The research work in the book has been penned down into eleven chapters; Chap. 1 presents the conceptual evolution of climate change, its relation to livelihood, the probable indicators to study livelihood security and an argument on of physical, socio-economic, ecological and equity interface approach to analyze livelihood security. Further, an overview of the changing climate in India is discussed. Chapter 2 conceptualizes the research problem, detailed literature review on the state of changing global climate, GHGs emissions, climate change modeling, sustainable livelihood, adaptation and mitigation strategies in climate impacted livelihoods. All related concepts to study have been significantly defined. Further, it deals with a brief description of the study area, research questions, objectives and a concise account of the methodology of each objective. Chapter 3 dispenses with a detailed description of the study area. It discusses the geographical location, physiography including elevation and slope, soil zones, water resources, kuhl irrigation, climatic conditions, status of forests and vegetation cover, sanctum sanctorum, brief description of land use, socio-economic and demographic characteristics, occupational structure, operational landholding size, infrastructure characteristics, social empowerment, work participation, etc. Chapter 4 discusses climate and climate change scenario modeling of Kangra district where the investigation thrusts upon the causes of climatic variability, climatic zonation of the study region to determine the baseline data required to create a methodology for baseline and simulated spatiotemporal precipitation and temperature trend for impact analysis. The regional climate has been scaled down for regional adaptive responses on the WRF model, where several databases including IMD, AIRS and TRMM have been used and interpolated. The gridded data have been overlaid on the ArcGIS map to generate climate change scenarios for 2020, 2050 and 2080 for temperature and precipitation, shaped by GHGs emissions preceded from Intergovernmental Panel on Climate Change-Special Emission Scenario (IPCC-SRES) Change Modeling Mechanism. Chapter 5 deals with the dynamics of livelihood capitals security, where all livelihood capital variabilities have been calibrated from Pearson's product-moment correlation coefficient (®) multiple regression analysis, cellular automation analysis to analyze poverty gap ratio (PGR), head count indices, etc., to illustrate in the form of capital assets pentagon (spider diagram). Therefore, to study a micro-level livelihood, a new framework has been constructed for this particular study, wherein a micro-level sustainable livelihood security index (MSLSI) has been constructed over a period of several months regress analysis based on the Department for International Development's (DFID) sustainable livelihoods framework (SLF) because it was realized that SLF does not enable accord among different supporting groups and it needs regional responses embedded within them. Therefore, the capital assets/endowments (human, social, natural, financial and physical capital) for livelihood security have been prepared for all 27 villages. Chapter 6 is an extension of the previous Chap. 5, where sustainable livelihood analysis (SLA) has been depicted through the SLF core. The SLF core is called the capital pentagon; here, it has been comprehended, assessed and

applied in the study area. The differential pentagon diagrams have been prepared to analyze capital security gaps between 27 different villages in the district. The conventional approach to secure livelihood was not able to solve the problem because it disregarded several micro-level livelihood aspects to which assets were meticulously knotted. Therefore, this chapter surpasses this limitation. Chapter 7 provides reasoning on the computed methodology for climate dynamics and livelihood vulnerability indices assessment. It deals with the two separate methodologies to analyze livelihood security in the district, with and without climate change analysis where the observed climatic changes for almost 44 years (1970–2014) from Landsat, MODIS and IRS-P3 have been done to prepare composite livelihood vulnerability index (LVI) without climate change and CCLVI with climate change impact. To varify the results further 12 core climate indices; length of growing period (LGP), frost days, annual count when daily minimum temperature is  $<0^{\circ}\text{C}$ , maximum and minimum temperature of daily/monthly/annually ( $^{\circ}\text{C}$ ), Diurnal temperature range (DTR), number of cool nights/days and number of warm nights/days, etc., has been calculated. This is done to find out the effect of temperature and  $\text{CO}_2$  on growth, yield and productivity of selected crops in the district. Chapter 8 thrusts upon sustainable livelihood adaptation and mitigation strategies through the science of adaptive policy, spatial livelihood variation, coping mechanism and capacity building with the help of gram panchayats and local community participation/monitoring and evaluation infrastructure to support the livelihood of the weaker sections and improving their quality of life from strategic knowledge of climate change and enhancement of adaptive capacity. Chapter 9 deals with reviews and summaries of governmental plans and policies regarding the micro-level sustainable livelihood security index (MSLSI) to generate alternative and sustainable livelihoods, etc., and compiles the appendices of the study. Through realizing the fact that the climate change phenomenon can threaten the country's developing economy and livelihood structures, therefore, it has initiated various climate change policies, plans and adaptation measures, and it scrutinizes various climate issues and encapsulates landmark decisions on climate policies and initiatives undertaken by the Government of India. Afterward, it has set the scene for India's role in climate change policy, plans, missions and programs at both domestic and international levels.

New Delhi, India  
April, 2020

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# Acronyms and Abbreviations

°C	Degree Celsius
ε	Exposure
₹	Rupees (Indian currency)
μg/m <sup>3</sup>	Microgram per cubic meter
μm	Micrometer
μmol/mol	Micromol/mol
AC	Adaptive capacity
ACRP	Agro-Climatic Regional Planning
ACZs	Agro-climatic zones
AEZs	Agro-ecological zones
AIRS	Atmospheric infrared sounder
AMSL	Above mean sea level
AMSU	Advanced microwave sounding units
ANOVA	Analysis of variance
AOI	Area of interest
APL	Above poverty line
AR4	Fourth assessment report
AR5	Fifth assessment report
ASCENDS	Active sensing of CO <sub>2</sub> emissions over nights, days and seasons
BPL	Below poverty line
CBA	Cost–benefit analysis
CCC	Concept of carrying capacity
CCLVI	Climate Change Livelihood Vulnerability Index
CDE	Centre for Development and Environment
CDI	City Development Index
CDM	Clean development mechanism
CFCs	Chlorofluoro carbons
CH <sub>4</sub>	Methane
CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
COPs	Conferences of the parties
CRU	Climate Research Unit



CSVs	Cold space views
CV	Coefficient of variation
DFID	Department For International Development
DRR	Disaster risk reduction
DTR	Diurnal temperature range
EDP	Environmental adjusted domestic product
EF	Ecological footprint
EIA	Environmental impact assessment
EMC	Environmental modeling center
EPA	Environmental protection agency
EPI	Environmental Performance Index
ESI	Environmental sustainability index
ESRL	Earth System Research Laboratories
ES <i>t</i> i	Environmental Sustainability Index
ETM+	Enhanced Thematic Mapper Plus
EU	European Union
EVI	Environmental Vulnerability Index
EWI	Ecosystem Well-Being Index
EWS	Economically weaker section
FAO	Food and Agriculture Organization
FAR	First Assessment Report
FCC	False Color Composite
FCCA	Five Capital Combined Assets
FCVI	Financial Capital Vulnerability Index
FYP	Five-Year Plan
GCMs	General circulation models
GCPs	Ground control points
GDEM	Global digital elevation model
GDP	Gross domestic product
GHGs	Greenhouse gases
GIM	Green India Mission
GIS	Geographical information system
GNP	Gross national product
GOES	Geostationary Operational Environmental Satellite
GOI	Government of India
GPP	Gross primary productivity
GPS	Global Positioning System
GR	Ground radar
GSI	Genuine Savings Index
GST	General systems theory
HadRM	Hadley regional climate model
HCVI	Human Capital Vulnerability Index
HDI	Human Development Index
HDR	Human Development Report
HFI	Herfindahl Index

HHs	Households
HWI	Human Well-Being Index
HYVs	High-yielding variety of seeds
IADP	Integrated area development program
ICRC	International Committee of the Red Cross
ICSU	International Council for Scientific Union/International Science Council
ICT	Information and communications technology
IDS	Institute for Development Studies
IDW	Inverse distance weighted
IFAD	International Fund for Agriculture and Development
IFRCRCS	International Federation of Red Cross and Red Crescent Societies
IGY	The International Geophysical Year
IIED	International Institute for Environment and Development
IISD	International Institute for Sustainable Development
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
IRDP	Integrated Rural Development
IRS-P3	Indian Remote Sensing Satellite-P3
ISEW	Index of Sustainable Economic Welfare
IUCN	International Union for Conservation of Nature
JFM	Joint Forest Management
km	Kilometer
km <sup>2</sup>	Square kilometer (sq.km)
KSM	Kangra Summer Monsoon
LAI	Leaf Area Index
LGP	Length of growing periods
LHs	Landholders/holdings
LISS	Linear imaging self-scanning sensor
LPG	Liquefied petroleum gas
LPI	Living Planet Index
LRC	Livelihoods Resource Centre
LULC	Land use land cover
LULUCF	Land use, land-use change, and forestry
LVI	Livelihood Vulnerability Index
MASATs	Mean annual surface air temperatures
MATLAB	Matrix laboratory
MEA	Millennium ecosystem approach
MIR	Mid-infrared
MLR	Multiple linear regression
MLSLI	Micro-Level Sustainable Livelihood Security Index
MMM	Micro-Scale Meteorology Mission

MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MODIS	Moderate Resolution Imaging Spectroradiometer
MOP	Meeting of Parties
MRD	Ministry of Rural Development
MSLSI	Micro-Level Sustainable Livelihood Security Index
MSU	Microwave sounding unit
MSY	Maximum sustainable yield
MT	Metric ton
NAPCC	National Action Plan on Climate Change
NASA	National Aeronautics and Space Administration
NATCOM	India's National Communication
NCA	Non-cereal agriculture
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NCVI	Natural Capital Vulnerability Index
NDCs	Nationally Determined Contributions
NDVI	Normalized Difference Vegetation Index
NEERI	National Environmental Engineering Research Institute
NEP	National Environment Policy
NGO	Non-Governmental Organization
NGT	National Green Tribunal Act
NIR	Near-infrared
NMM	Non-hydrostatic mesoscale model
NO <sub>2</sub>	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO <sub>x</sub>	Nitrogen oxide
NPP	Net primary productivity
NRA	Natural resource accounting
NRHM	National Rural Health Mission
NRLM	National Rural Livelihood Mission
NSS	National sample survey
NTFPs	Non-timber forest products
O <sub>3</sub>	Ozone
ODI	Overseas Development Institute
OECD	Organization of Economic Cooperation and Development
OLR	Outgoing Longwave Radiation
PAI	Productive Assets Index
PCVI	Physical Capital Vulnerability Index
PFMs	Participatory Forest Managements
PGR	Poverty gap ratio
PHCs	Primary Health Centers
PIP	Policy Institutions and Processes
PMGSY	Pradhan Mantri Gram Sadak Yojana
PQLI	Physical Quality of Life Index
PRA	Participatory Research Appraisal

PSR	Pressure–state–response
RCMs	Regional climate models
RCPs	Representative concentration pathways
R <sub>days</sub>	Rainy days
REGPs	Rural Employment Generation Programs
RMS	Relative Measure of Sustainability
R <sub>total</sub>	Total rainfall
S	Sensitivity
SAPs	Special Action Plans
SAR	Second Assessment Report
SATs	Surface air temperature
SCSI	Shock Faced and Coping Strategies Index
SCVI	Social Capital Vulnerability Index
SD	Standard deviation
SDGs	Sustainable Development Goals
SHGs	Self-help groups
SL	Sustainable livelihood
SLF	Sustainable livelihoods framework
SLS	Sustainable livelihood security
SLSI	Sustainable Livelihood Security Index
SMS	Safe minimum standard
SNBI	Sustainable Net Benefit Index
SO <sub>2</sub>	Sulfur dioxide
SOIL	State of India’s livelihoods
SPOT	Satellite Pour I ‘Observation de la Terre
SPSS	Statistical Package for Social Scientists
SRCCL	Special Report on Climate Change and Land
SROCC	Special Report on the Ocean and Cryosphere in a Changing Climate
SSC	Species Survival Commission
SSTs	Surface skin temperatures
SWOT	Strengths, weaknesses, opportunities and threat
TAR	Third Assessment Report
TIRS	Thermal infrared sensor
TM	Thematic mapper
T <sub>max</sub>	Maximum temperature
T <sub>mean</sub>	Mean/average temperature
T <sub>min</sub>	Minimum temperature
TRMM	Tropical Rainfall Measuring Mission
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UN-ESCAP	UN Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	United Nations Centre for Human Settlements
UNICEF	United Nations International Children’s Fund

UNISDR	United Nations International Strategy for Disaster Reduction
USGS	United States Geological Survey
UV	Ultraviolet
VS	Visible spectrum
VSO	Voluntary Service Overseas
WCP	World Climate Program
WCPA	World Commission on Protected Areas
WCRP	World Climate Research Program
WG	Working groups
WHO	World Health Organization
WI	Well-Being Index
WMO	World Meteorological Organization
WRF	Weather Research and Forecasting Model
WWF	World Wide Fund for Nature

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