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Himalaya on the Threshold of Change

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Preface

The seeds of the book, *Himalaya on the Threshold of Change* were sown in the early days of 2014. I had a long discussion on academic pursuance, mainly on changing Himalayan Environment and Development with Prof. Kamlesh Kumar at his residence—42 Nalapani Road, Dehradun. He wanted my academic presence in the Central Himalayan region through initiating out-standing academics and thus, we decided to pursue two academic ventures—start publishing a Journal on Himalayan Sciences and composing a book on the changing aspects that have been occurring in the Himalaya. The idea was to review the book ‘The Himalaya: Aspects of Change’, edited by J. S. Lall during the 1980s. However, it was difficult for me to invite quality papers from the academicians, working on the aspects of the Himalaya, because of my limited accessibility, and I, therefore, decided to compose a reference book and be its sole author. Further, the Himalaya, as a whole, is so vast to conduct empirical study (observational); thus, I chose the Indian Central Himalayan region (ICHR), i.e. the Uttarakhand Himalaya for my study.

I have been working on the Uttarakhand Himalaya since 1989 when I first got registered to pursue Doctor of Philosophy (D.Phil.) from the HNB Garhwal University, Srinagar Garhwal, Uttarakhand. Although I could not receive substantial research training during the commencement of the doctoral degree yet, my incessant research on the Himalaya has enhanced inside knowledge to understand the changing Himalayan Environment and Development. My overall focus has always been on the several aspects of the Himalaya, both natural and cultural, that include natural resources and their management, sustainable livelihoods, socio-economic development, farming systems, and environment and development. I have contributed to substantial research on many of the above-mentioned burning issues about the Himalaya and my research findings have been published and well documented. Meanwhile, there has existed a huge gap in terms of a comprehensive study on change pattern in the Himalaya. The present study has been conducted in such a way that certainly bridges the gap and strengthens substantial knowledge about the Himalaya and the aspects of change.

The term ‘Himalaya’ is derived from the two words ‘*Him*’ and ‘*Alaya*’, literary meaning ‘the abode of snow’. It is a common belief that the folk deities and saints have their dwellings in the Himalaya, where they perform penance. The people symbolize the Himalaya as Lord Shiva and worship it. The Himalaya has a number of pilgrimages, where exodus pilgrims visit every year. Therefore, the cultural significance of the Himalaya is immense. On the importance of the Himalaya, the Hindu scripture, ‘The Vishnu *Purana*’ says that during the submergence of the Earth into ocean, only the Himalaya existed. Lord Vishnu took the incarnation of Fish, called the ‘*Matsyavatara*’, to save the Himalaya. In Bhagwat Geeta (Chap. 10), while preaching to Arjuna about his various forms, Lord Krishna said that ‘*Sthironam Cha Himalaya*’, which means that among the stable objects, I am the Himalaya.

The Himalaya has enormous natural and cultural significance, as it provides livelihoods to the hundreds of thousands of people, living in the upstream and downstream regions of the Ganges, Sind and the Brahmaputra rivers’ systems. The rivers, panoramic landscapes, forests, climate and land resources are abundant in the Himalaya that provide sufficient bases for economic development and sustaining livelihoods. Besides, the Himalaya protects the Indian sub-continent/territory from the cold waves of the north and from the intruders of the neighbouring countries. In spite of having such huge quantity of natural resources, people of the Himalayan regions are economically underdeveloped and socially backward. They suffer a lot and struggle even for having meal two times a day.

The Himalayan region is highly sensitive to climate related phenomena because of its verticality, angularity and seasonality. Further, geological events such as tectonic movements and earthquakes are very active, as the region has received several earthquakes’ tremors of high magnitude and it falls in zones IV and V of the earthquake zoning map. Landscape fragility/vulnerability is very high, which leads to severe catastrophes, such as landslides and mass movements, mainly during the monsoon season. Weather induced natural hazards like debris-flow and flashfloods are very common. The Himalaya receives heavy downpour called cloudburst during the monsoon season, causing for landscape degradation and huge losses to properties and lives.

Change is the law of nature. Every object on the Earth is moving and changing. Climate change is not new. After the origin of the Earth, it was fully covered by snow during the eight geological timescales (four times after Pleistocene era) which are called ‘snow ages’. Scientists observed that there was a ‘little ice age’ that occurred between 1400 and 1800 century A.D. Owing to the vast impact of climate change on bio-diversity and landscape, many species have become extinct and many are on the verge of extinction. On the other hand, new species have originated. However, the recent change in all the aspects on the Earth is unique however, not uniform. The Himalaya has also been facing enormous changes. Change in natural systems—climate, water, forests and extreme events—and cultural aspects—agrarian system, migration, population structure, social systems, economy, and culture and customs—have become very common during the recent past and are continuously increasing on a day to day basis. Several scientific reports on

the Himalaya indicated that the Himalayan glaciers are melting. Erratic rainfall, warming of the valleys and the mid-altitudes and increasing events of cloudbursts are the other dimensions of change in the Himalaya.

The very idea of composing this book was to evaluate the present situation of change and its future severity. I have reviewed a large number of literatures on the Himalaya, mainly on the Uttarakhand Himalaya, and noted that still there is a need to conduct studies on several aspects. Lack in availability of data on natural and cultural aspects has impeded to conduct a precise study. Because, a few meteorological stations have been recording climate data in Uttarakhand and the data availability is minimal, a comprehensive climate change study is still not possible. However, I have collected climate data from the two meteorological stations of Uttarakhand, i.e., Dehradun and Mukteshwar, both representing the tropical and temperate climate of the region. Keeping all these impediments in mind, I made this study observational, based on my long experience about the region, although, time series data of the last fifteen years was collected and interpreted. I conducted this study on two aspects—natural and cultural and then divided the book into two parts.

Lord Shiva is the deity I adore. My body and mind is always indebted of him. The Himalaya itself for me has been a godly feature, an embodiment of Lord Shiva. It has inspired me in such a way that I could compose this volume and now it is in your hands. Further, my long journey from unreal to real and from darkness to knowledge was possible only due to the nourishment/*Samaskara* that was provided by my beloved mother. Her everlasting dreams on my success and perfection brought me upto the level where I stand today. She ever lives within me. Although her mortal remains no more exist, yet, her true legacy has been enlightening me, my pathways. So, I dedicate this piece of work to my beloved mother Smt. Saradi Devi Sati. Ms. Vishwani Sati, CSE undergraduate at Amity University, Noida, India has edited the whole manuscript. I acknowledge my gratitude towards her for her patience, dedication and this incredible work. I am also thankful to Mr. Lalrinpuia and Mr. Remlalruata, Department of Geography and Resource Management, Mizoram University, for their assistance.

Rome, Italy
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Vishwambhar Prasad Sati

About This Book

The Himalaya has been passing through the transitional phase in terms of changes in natural and cultural aspects, which have greater implications on nature, society and economy. The book *Himalaya on the Threshold of Change* is unique and comprehensive because of no substantial works have been conducted on this theme so far. It precisely describes all the changes—natural and cultural, their implications and suggests policy measures to cope with them. The book has been divided into two parts keeping change in natural and cultural aspects in mind. There are total 11 chapters—six are related to change in natural aspects, four are related to change in cultural aspects and conclusions. Besides, a separate chapter has been devoted for introduction. A case study of eight villages was conducted. The study has been carried out using participatory observation method and time series data were also gathered from the secondary sources to analyze change. Data were presented constructing colour graphs, models, maps and photographs (total 71 in numbers) and 19 tables have been incorporated to further understand these changes in the Himalaya. The book is useful for the policy makers, who are involved in framing policies and implementing them in the mountainous region, particularly in the Himalaya. It is equally useful to all the stakeholders such as academicians, researchers, students and the agents of development.

Contents

Part I Natural Aspects

1	Geography and Geology	3
	1.1 The Himalaya	3
	1.2 The Uttarakhand Himalaya	4
	1.2.1 Location and Extension	4
	1.2.2 Administrative Divisions	5
	1.2.3 Physiographic Divisions	7
	1.3 Major Landforms of Uttarakhand	10
	1.3.1 The River Systems	12
	1.4 Glaciers	16
	1.4.1 Lakes and Water Bodies: Highlands and Valleys	17
	1.4.2 Geology and Its Features	17
	References	19
2	The Climate of the Uttarakhand Himalaya	21
	2.1 Analysis of Climate Data	24
	2.1.1 Analysis of Rainfall Data	24
	2.2 Analysis of Temperature Data	26
	2.3 Analysis of Humidity Data	30
	2.4 Annual Mean Value of Temperature, Rainfall and Humidity	30
	2.5 Correlation Between Temperature, Rainfall and Humidity	31
	2.6 Climate Variability and Change in the Himalaya	31
	2.7 Impact of Climate Change	34
	References	36
3	Glaciers of the Uttarakhand Himalaya	39
	3.1 Inventory of Uttarakhand Glaciers	40
	3.2 Receding Glaciers of Uttarakhand	42

3.3	Climate Change Impact on the Himalayan Glaciers	43
	References	44
4	Water Resources and Change	47
4.1	Surface Water Resource Potential	48
4.2	Hydroelectricity Projects	49
4.3	Irrigation Projects	51
4.4	Groundwater Potentials	54
4.5	Water Scarcity in Plenties	55
4.6	Sustainable Development of Water Resource	58
	References	60
5	Forests of Uttarakhand Himalaya	63
5.1	Diversity and Distribution Pattern of Forests	64
5.2	Area Under Tree Species	67
5.3	Forest Area Change in Uttarakhand	67
5.4	District Wise Forest Cover and Change	69
5.5	Impact of Climate Change on Forests	69
5.6	Ecosystem Services and Livelihoods	72
	References	75
6	Increasing Events of Disasters	79
6.1	Major Disasters in the Himalaya	80
6.2	Terrestrial Disasters	80
6.2.1	Earthquakes	80
6.3	Atmospheric Disasters	83
6.3.1	Cloudburst Triggered Flashfloods and Debris Flow	83
6.4	Heavy Rainfall in Uttarakhand	84
6.5	Landslides and Mass-Movements	84
6.6	Avalanches and GLOF	87
6.7	Droughts	88
6.8	Thunder/Wind/Hailstorms	88
6.9	Manmade Disasters	88
6.9.1	Forest Fires	88
6.10	Forest Fires Sensitive Zones	90
6.11	District Wise Forest Fires Incidences	91
6.12	Forest Fires Affected Areas and Rainfall	92
6.13	Increasing Trends of Disasters	95
6.14	Major Causes and Implications of Disasters	96
6.15	Prevention and Mitigation Measures	97
	References	98

Part II Cultural Aspects

7	Change in Culture and Custom	103
7.1	Worshiping Nature and Folk Deities	104
7.2	Celebrating Fairs and Festivals	106
7.3	Performing <i>Samskaras</i>	107
7.4	Cultural Processions	108
7.5	Folklores and Folkdances	108
7.6	Changing Cultural Space and Boundaries	109
	References	111
8	Population, Social and Economic Change	113
8.1	Change in Population Profile	114
8.2	Change in Population Distribution at District Level	116
8.3	Change in Decadal Growth Rate at District Level	117
8.4	Change in Literacy/Education at District Level	117
8.5	Change in Sex Ratio and Population Density at District Level	118
8.6	Rural-Urban Population	120
8.7	Social Structure and Change	121
8.8	Caste Systems	123
8.9	Brahmins	124
8.10	Rajputs	126
8.11	Scheduled Castes	127
8.12	Scheduled Tribes	128
8.13	Economic Disparity and Change	133
8.14	Change in Population, Social Structure and Economy	135
	References	137
9	Migration and Agrarian Change	139
9.1	Migration: Characteristics, Causes and Implications	140
9.2	Characteristics of Migration	141
9.3	Migration Pattern and Types	142
9.4	Virtually Uninhabited (Ghost) Villages and Land Abandonment	144
9.5	Causes of Migration	147
9.6	Implications of Migration in Sending and Receiving Areas ...	149
9.7	Agrarian Change	150
	9.7.1 Land Use Pattern	150
9.8	Agro-Ecological Zones and Farming Systems	151
9.9	Change in Livestock Farming	158
9.10	Climate and Agrarian Change	159
	References	167

10	Sustainable Development Under Changing Environment	171
10.1	Current Trends of Development	171
10.2	Economic Development	172
10.3	Industrial Development	172
10.4	Tourism Development	174
10.5	Infrastructural Development	176
	10.5.1 Transportation	176
	10.5.2 Electrification	177
10.6	Human Resource Development	177
	10.6.1 Educational Development	177
	10.6.2 Medical Facilities	178
	10.6.3 Policy Initiatives for Sustainable Development	178
	10.6.4 Key Policy Initiatives	179
	10.6.5 Major Policy Perspectives	179
	10.6.6 Social Inclusion	179
	10.6.7 Sectoral Development	180
	References	183
11	Conclusions	185
11.1	Major Drivers of Change	185
11.2	Drivers of Change in Natural Aspects	186
11.3	Drivers of Change in Cultural Aspects	187
11.4	Resilience and Adaptation	189
11.5	Climate Smart Agriculture/Horticulture	189
11.6	Crop Suitability Analysis	189
11.7	Cultivation of Cash Crops	190
11.8	Restoring Traditional Livestock Farming	190
11.9	Adequate Irrigation Facilities	191
11.10	Market Accessibility	191
11.11	Cold Storages	191
11.12	Transportation Facilities	191
11.13	Co-operative Farming	192
11.14	Employment Opportunity	192
11.15	Good Governance	192

About the Author



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a number of academic sessions; served as Resource Person in several national and international conferences; and serving many international professional bodies as member, editor and reviewer.

Abbreviations

CNP	Corbett National Park
COI	Census of India
DMMC	Disaster Mitigation and Management Center
DMR	Dudhatoli Mountain Range
DST	Department of Science and Technology
FSI	Forest Survey of India
GBPNIHESD	Govind Ballabh Pant National Institute of Himalayan Environment and Sustainable Development
GDP	Gross Domestic Products
GIS	Geographical Information System
GLOF	Glacial Lake Outburst Floods
GMVN	Garhwal Mandal Vikas Nigam
GSDP	Gross State Domestic Products
ICHR	Indian Central Himalayan Region
ICIMOD	International Centre of Integrated Mountain Development
IPCC	Intergovernmental Panel for Climate Change
ISRO	Indian Space Research Organization
KMVN	Kumaon Mandal Vikas Nigam
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MGNREGA	Mahatma Gandhi Rural Employment Guarantee Act
MoEF	Ministry of Environment and Forest
MSMEP	Micro, Small and Medium Enterprises Policies
NAPCC	National Action Plan on Climate Change
NDMA	National Disaster Management Authority
NIDM	National Institute of Disaster Management
NRSC	National Remote Sensing Centre
PA	Protected Areas
RNP	Rajaji National Park
SEP	Solar Energy Policy

SESD	State Economic and Statistical Directorate
SFD	State Forest Department
SFRI	State Forest Report of India
USN	Udham Singh Nagar
VP	<i>Van Panchayats</i>
WMDU	Watershed Management Directorate of Uttarakhand

Acronyms

<i>Barahnaza</i>	Twelve grain, grown in a single cropland, mainly in the highlands
<i>Bhabhar</i>	Hot and humid plain part of the Kumaon and Garhwal Himalaya, characterised by infertile soil, stony and forestland
<i>Bugyals</i>	The highland pasturelands, covered by snow during the winter season
<i>Chaumas</i>	Four months of the rainy season
<i>Crore</i>	A unit measuring numbers. Ten million is equal to one <i>Crore</i>
<i>Danda</i>	The highland forestlands
<i>Doon</i>	Plain valley, located in the Garhwal Himalaya, mainly in Dehradun district
<i>Dwar</i>	Hot plain region of Garhwal, including Haridwar and Kotdwar regions
<i>Gad/Gadhera</i>	Seasonal/perennial small streams
<i>Gagar</i>	Water vessel, mainly made of copper/bronze
<i>Gangar</i>	The river valley regions
<i>Ghost villages</i>	Virtually uninhabited villages in the Uttarakhand Himalaya
<i>Gondwana</i>	The southern part of India. It is a tectonic plate, moving towards the north
<i>Gool</i>	Traditional water canal, used for irrigating land
<i>Jada</i>	Cold season, takes place from the month of November to the month of February
<i>Jhaud</i>	It takes place during the winter season. Snow falls continue for several days and cold waves blow
<i>Kedarkhand</i>	The ancient name of the Uttarakhand Himalaya. The name is derived from ‘Kedarnath’ pilgrimage

<i>Khal-Chal</i>	Traditional manmade water bodies, constructed in the forest areas to keep climate cool and to restore water for drought period
<i>Kund/Taal</i>	Lakes, natural water bodies
<i>Leesa</i>	Resin extract from the pine trees
<i>Naula/Mangyaura</i>	Water bodies, supply water in the rural areas
<i>Pirul</i>	Pine litter, very explosive, causes forest fires during summer season
<i>Prayag</i>	Meeting point of the two rivers. Uttarakhand has numerous prayags, among them eight are well known
<i>Ringal</i>	Small variety of Bamboo, used for making agricultural tools and handicrafts
<i>Ritu</i>	Seasons. Uttarakhand characterises six seasons
<i>Ruri</i>	The hot and dry season, takes place during the summer season
<i>Sagain</i>	Rain occurs continue for several days during the monsoon season
<i>Seela</i>	North facing sloppy area, where sun rays do not reach. During the winter season, these areas are very cold
<i>Tailla</i>	Sun facing sloppy area
<i>Tarai</i>	Marshy land, found in the plain regions of the Kumaon Himalaya. The area is fertile and suitable for cultivation of paddy, wheat and sugarcane
<i>Tethys geosynclines</i>	It was a long, narrow and shallow water body, surrounded by the two land masses—Sino-Siberian plate in the north and Indian plate in the south. It gave birth to the mighty Himalaya

List of Figures

Fig. 1.1	Location map of the Indian Himalayan Region showing the study area ‘Uttarakhand’. <i>Source</i> By author	5
Fig. 1.2	Location map of the Uttarakhand Himalaya. <i>Source</i> By author	6
Fig. 1.3	Paddy crop ready to get harvested in a village Harbhajwala surrounded by Raja Ji National Park, <i>Doon Valley</i> . <i>Photo</i> By author	8
Fig. 1.4	Vertical and horizontal extension of the Uttarakhand Himalaya. <i>Source</i> By author	9
Fig. 1.5	a The Mount Trishul facing to Gwaldom town in Chamoli district b Bedni Bugyal in Chamoli district c Salan cultural realms of Pauri district and d the Alaknanda River flowing near Srinagar town. <i>Photo</i> By author	11
Fig. 1.6	Major rivers of Garhwal Himalaya— a Alaknanda River at Srinagar b Bhagirathi River at Gangotri c Yamuna River flowing in the upper-middle catchment area c Tons River flowing in its middle catchment. <i>Photo</i> By author	13
Fig. 1.7	The river systems in the Uttarakhand Himalaya. <i>Source</i> By author	14
Fig. 1.8	a The Kali River between Jauljibi and Tanakpur b the Gomti River near Baijnath c the Ramganga (W) near Chaukhutiya and d the Saryu River in Bageshwar. <i>Photo</i> By author	15
Fig. 1.9	Geological map of Uttarakhand. <i>Source</i> Digitalized by author	18
Fig. 2.1	Annual average rainfall. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20mukteshwar.pdf , http://utrenvis.nic.in/data/climate%20ddun.pdf	25

Fig. 2.2	Variation in monthly rainfall in Dehradun. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20ddun.pdf	25
Fig. 2.3	Variation in monthly rainfall in Mukteshwar. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20mukteshwar.pdf	26
Fig. 2.4	Annual average of minimum and maximum temperature in Dehradun. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20ddun.pdf	27
Fig. 2.5	Annual average of minimum and maximum temperature in Mukteshwar. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20mukteshwar.pdf	28
Fig. 2.6	Mean value of annual temperature in Dehradun and Mukteshwar. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20mukteshwar.pdf , http://utrenvis.nic.in/data/climate%20ddun.pdf	28
Fig. 2.7	Average monthly temperature in Dehradun. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20ddun.pdf	29
Fig. 2.8	Average monthly temperature in Mukteshwar. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016), http://utrenvis.nic.in/data/climate%20mukteshwar.pdf	29
Fig. 2.9	Annual average humidity in Dehradun and Mukteshwar. <i>Source</i> Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016).	30
Fig. 3.1	Map showing the major glaciers of Uttarakhand Himalaya. <i>Source</i> By author	41
Fig. 3.2	a Satopanth Lake below Swargarohini peak in Chamoli district of the Garhwal Himalaya b Pindari Glacier in Kapkot district of the Kumaon Himalaya. <i>Source</i> By author.	41
Fig. 4.1	Hydroelectricity projects in the Uttarakhand Himalaya. <i>Source</i> By author	50
Fig. 4.2	a Asia's highest Tehri high dam b Vishnuprayag hydroelectricity project. <i>Photos</i> By author	50

Fig. 4.3	Clockwise a Natural springs in the highlands of the Mandakini river basin b Abundant unused pure water of the upper Mandakini River c People are waiting for their turn in a hand pump to filling their water vessels at Khirsu town d A girl carrying filled water vessel (<i>Gagar</i>) near Gairsain town. <i>Photos</i> By author	56
Fig. 5.1	Horizontal and vertical distribution of forests in the Uttarakhand Himalaya. <i>Source</i> By author	65
Fig. 5.2	Forest types— a Sub-tropical deciduous forests in <i>Doon</i> valley b Dense pine forests in Jaharikhhal, Pauri district c Mixed-oak forest in the lower altitude of Khirsu and d Coniferous forests in the higher altitude of Khirsu (Pauri district). <i>Photo</i> By author	66
Fig. 5.3	Area under tree species. <i>Source</i> SFRI (2015)	68
Fig. 5.4	Forest map of Uttarakhand showing types and distribution. <i>Source</i> By author	68
Fig. 5.5	Forest area change (1980–2015). <i>Source</i> SESD, Dehradun.	69
Fig. 5.6	Forest cover and change (2001–2015). <i>Source</i> Land Use Statistics, Ministry of Agriculture, GOI 2001 and 2015	70
Fig. 5.7	a Fragile alpine pastureland in Kedarnath valley b Pine forests are invading mixed-oak forests in Gwaldom forest area. <i>Photo</i> By author	71
Fig. 5.8	Environmental services a Kedarnath peak in the Indian Central Himalayan Region b Alpine Bugyal located in downstream of the Kedarnath Dham c Dense oak and coniferous forests in the Mandakini River Basin d The Alaknanda River flowing near Kirtinagar. <i>Photo</i> By author	72
Fig. 6.1	The major disasters in the Himalayan region	80
Fig. 6.2	Earthquake zoning map of Uttarakhand. <i>Source</i> By author.	82
Fig. 6.3	A & B Massive landslides near Kaliasaur along the river Alaknanda. <i>Photo</i> By author.	85
Fig. 6.4	Death toll due to landslides in the Gangotri National High way, Uttarkashi District. <i>Source</i> Compiled by author	87
Fig. 6.5	Forest fire zones in the Uttarakhand Himalaya. <i>Source</i> By author	90
Fig. 6.6	Forest fires sensitive zones of the Uttarakhand Himalaya. <i>Source</i> Re-digitalized by author, basic source FSI 2016.	91
Fig. 6.7	District wise forest fires incidences based on FSI fire monitoring system (2005–2015). <i>Source</i> SFD, 2017.	92
Fig. 6.8	Forest fires affected areas (ha) and rainfall (mm) in Uttarakhand (2000–2017). <i>Source</i> SFD and meteorological department	93

Fig. 6.9	A regression model (curve estimation) correlating intensity of rainfall and forest fires incidences. <i>Source</i> By author.	93
Fig. 6.10	a Massive landslide between Narainbagar and Tharalibagar b Flashflood in the Pindar River at Narainbagar town. <i>Photo</i> By author.	96
Fig. 7.1	a A priest offering sari (a colourful cloth) to Lord Shiva at Pant (Pindar valley) b A <i>Peepal</i> tree is worshipped by local people at Narainbagar (Pindar valley).	105
Fig. 7.2	a Doli and Naishan of Kobeshwar Mahadev dancing at Pant, Narainbagar b Pilgrims waiting for the welcoming procession of Shri Nanda Devi Raj Jat. <i>Photo</i> By author.	107
Fig. 8.1	Population, literacy, sex ratio and urban population (1951–2011). <i>Source</i> Census of India, 2011.	115
Fig. 8.2	District wise change in population 2001–2011.	117
Fig. 8.3	Change in the decadal growth rate at district level (1991–2011).	118
Fig. 8.4	Literacy rate (2011) and change in literacy rate (2001–2011).	118
Fig. 8.5	Sex ratio at district level (2001–2011).	119
Fig. 8.6	Change in population density (2001–2012).	120
Fig. 8.7	Population by religion in Uttarakhand. <i>Source</i> Census of India (2011).	122
Fig. 8.8	Caste system in Uttarakhand. <i>Source</i> By author.	124
Fig. 8.9	Population, population change and change (%) of tribal people. <i>Source</i> Censuses of India 2001–2011.	129
Fig. 9.1	Number of people out-migrated from districts of Uttarakhand Himalaya. <i>Source</i> Economic and Statistical Directorate, Statistical Diary, 2013, Dehradun. <i>Note</i> Original data on migration was gathered at household level. I multiplied it by five to get number of out-migrants (Five is an average family size in Uttarakhand 2011).	141
Fig. 9.2	Migration hotspots in the Uttarakhand Himalaya. <i>Source</i> By author.	142
Fig. 9.3	(Left): Ruined settlement (inset): an abandoned house and (right): land abandonment (village Prethi). <i>Photo</i> By author.	144
Fig. 9.4	Virtually uninhabited (ghost) villages and land abandonment in the districts of Garhwal region. <i>Source</i> Economic and Statistical Directorate, Statistical Diary, 2015, Dehradun.	145
Fig. 9.5	Correlation between the ghost villages and land abandonment.	146
Fig. 9.6	Causes and implications of out-migration in Uttarakhand. <i>Source</i> By author.	149

Fig. 9.7	Slums emerging along the Rispana: A dying river in Dehradun. <i>Photo</i> By author	150
Fig. 9.8	Agro-ecological zones and the major crop races/cultivars. <i>Source</i> By author	152
Fig. 9.9	Yield of crops under Kharif and Rabi crops. <i>Source</i> National Horticultural Board, Ministry of Agriculture, Govt. of India (Indian Horticulture Database 2014).	154
Fig. 9.10	Wheat is grown in the cluster of villages (Kaub) in the middle Pindar Basin. <i>Photo</i> By author	157
Fig. 9.11	Change in livestock farming 2001–2002 to 2013–2014. <i>Source</i> Livestock Census 2015	158
Fig. 9.12	a Calves are grazing in the temperate grassland in Bharadisain b Goats, lambs and sheep are grazing in the alpine pastureland of Dayara Bugyal c Paddy straw for stall feeding in Prethi village and d Cows and buffaloes in the cowsheds in Prethi village. <i>Photo</i> By author.	160
Fig. 9.13	Changing cropping pattern a Traditional cropland in Takorigarh b Paddy field in Narainbagar village c Off-season vegetables in Khandagarh and d Tea cultivation near Gairsain. <i>Photo</i> By author	162
Fig. 9.14	Changing cropping pattern in the Uttarakhand Himalaya. <i>Source</i> By author	163
Fig. 10.1	GSDP at current price (% billion USD). <i>Source</i> Statistical Diary Uttarakhand (2014).	172
Fig. 10.2	Growth rate of GSDP in industrial sector. <i>Source</i> Statistical Diary Uttarakhand (2014).	173
Fig. 10.3	Dimensions of social inclusion. <i>Source</i> By author	180
Fig. 10.4	Policy perspective for sectoral development. <i>Source</i> By author	182
Fig. 11.1	Major drivers of changes and adaptation in Uttarakhand. <i>Source</i> By author	186

List of Tables

Table 2.1	Annual mean value of temperature, rainfall and humidity in Dehradun and Mukteshwar	31
Table 2.2	Correlation between temperature, rainfall and humidity (Dehradun and Mukteshwar)	32
Table 3.1	Inventory of glaciers in the Uttarakhand Himalaya	40
Table 3.2	Receding glaciers in the Uttarakhand Himalaya	43
Table 4.1	The major river systems and water potential in the Uttarakhand Himalaya	49
Table 4.2	Details of case study hydropower projects in Garhwal region.	52
Table 5.1	Vertical distribution of forest cover in Uttarakhand (Area in Km ²)	67
Table 6.1	Earthquakes of Uttarakhand (Since 1803)	81
Table 6.2	Major flashfloods/debris-flow events in the Uttarakhand Himalaya	84
Table 6.3	Heavy rainfall in Dehradun, Uttarakhand Himalaya 2000–2013	85
Table 6.4	Major landslides and mass-movements in the Uttarakhand Himalaya	86
Table 8.1	Levels of urban population.	121
Table 8.2	Gross state domestic products (GSDP) from agriculture and allied sectors at constant prices (2004–2005).	135
Table 9.1	Reasons for migrating	144
Table 9.2	Factors affecting migration n = 170 HHs	145
Table 9.3	Land use/cover change in Uttarakhand.	151
Table 9.4	Correlation between climate and yield of crops (Kharif and Rabi)	163
Table 10.1	Industrial units, capital investments and employment creation from industrial sector	173
Table 10.2	Tourist flow in the major tourist places of Uttarakhand	175

Introduction

Abstract Mountains of the world have been facing enormous natural and cultural changes, as they are the most vulnerable to climate change. The Himalaya, the new folded mountain system in the world and the home of rich biodiversity resources, is in the transitional phase. Change in farming system, population structure, faunal and floral resources, water resources, glaciers and climate has become a very common phenomenon during the recent past. This chapter describes the statement and scope of the study, objectives and methodology, and chapterisation of the book.

Mountains cover a total land area of 16.5 million km², which is 27% of the earth's terrestrial surface. They inhabit about 511 million people of the world, representing 7% of the global human population (Korner et al. 2011; Schild 2008). In the meantime, >50% of the global human population draws benefits, directly or indirectly, from resources and services emanating from the mountain ecosystems (Messerli and Ives 1997), which include forests, water, fresh air and fertile soil. Livelihood of the rural people, constituting above 70% population, is fully dependent on the output of the ecosystem services, provided by mountains. Mountain regions also support tourism and pilgrimages services to people of lowland. Here, human habitats are mostly concentrated in the lower montane zone (Korner et al. 2017). However, human habitats are located upto the height of 4,200 m in the Andes and 3,300 m in the Himalaya.

Mountains are the most dynamic, sensitive and vulnerable landscapes worldwide. They characterise steep, precipitous, rough and rugged terrain. Altitude, slope aspects and latitude change the climate—vertically and horizontally. Diversity in all the aspects—natural and cultural—is the characteristic features of the mountains. The formation mechanism of the mountains is different, whereas the new folded mountains are formed by the similar tectonic movements. Although mountains are the tough features on the earth's surface yet, they provide livelihoods to a large number of people living in the downstream areas (Sati 2014). The mountains are the home to nearly half of the global biodiversity hotspots. They are the major tourist hotspots, centre for highland pilgrimages, and the hub of cultural diversity (Sati 2013a, b). They are also called the World Water Tower as their glaciers, snow,

wetlands and lakes provide two-thirds of the Earth's freshwater. Further, the mountains provide 40% of the global ecosystem services.

The Mountain communities are hard working, optimistic and the keepers of the valuable traditional ecological knowledge. However, they are innocent with diverse socio-economic and cultural identities, and the most vulnerable to change. The socio-ecological treasures of mountain diversity have been facing threats during the recent pasts. Recently, the societies are transforming the mountains more profoundly than even before (Steffen et al. 2007; Ellis 2015, 2018a, b).

Mountains have always been the place of challenging environments and the most rugged landscape on the Earth (Korner 2018) and thus, species and habitats have long struggled to adapt them. Lives in mountain regions have always faced the challenges of these environments/landscapes. Through millions of years of glacial and interglacial cycles, mountain species and habitats have thrived, descending and ascending, towards the warmer and cooler climates that have suited them. In the Anthropocene, mountain species and habitats seem to have nowhere to go but up and away. In mountain regions, habitats and ecosystems have faced profound environmental challenges from droughts, flooding, pests and diseases and many have collapsed (Tainter 1990; Butzer and Endfield 2012). Some species have thrived and many others have adapted the changing environment due to climate change in mountain regions (Hobbs et al. 2013; Thomas 2017). The species in the cooler region are overwhelmed by climate change in some regions they cannot exist if they do not move to much more cooler regions (Thomas 2011). Under the unprecedented pressure of the Earth's newest 'great force of nature', the mountain regions have much to teach and much to learn (Ellis 2018a, b).

The Himalaya, the 'King of the Mountains' is a unique feature on earth. The Hindus believe it to be the abode of Lord Shiva—the God of destruction. Kenneth Mason called it the greatest physical feature of the earth. The Greater Himalayan region, the 'Roof of the World', the largest snow and ice cover and one of the most important mountain systems, is referred to as the 'Third Pole' (Schild 2008) and the 'Water Tower of Asia' (Xu et al. 2009). The Himalayan landscape is fragile and highly susceptible to natural hazards, leading to current and future climate change impacts in the region (Cruz et al. 2007). However, it affects lives and livelihoods of over 300 million people (Schild 2008). The entire Himalaya is ecologically fragile, geographically remote, geologically sensitive, tectonically and seismically active, economically underdeveloped and socially backward (Sati 2008). Tectonic moments are still active. The mountain peaks of the Himalaya are escalating and river valleys are deepening due to active internal and external forces. As a result, the landforms are transforming largely. This is also having a changing impact on the natural and cultural aspects.

The Sage Nagasena, answering a question put to him by the King Milinda, states, 'The Himalaya, the king of the mountains, five and three thousand leagues in extent at the circumference, with its ranges of eight and forty thousand peaks, the source of five hundred rivers, the dwelling place of multitudes of mighty creatures, the producer of manifold perfumes. Enriched with hundreds of magical drugs, it is seen to rise aloft, like a cloud from the centre of the earth' (Lal 1981, p. xiii).

Various geomorphologic features of the Himalaya, which includes snow clad mountain peaks, cliffs, rocky slopes, waterfalls, major and minor ridges, river valleys, river terraces, alpine meadows and mid-altitude hills, make the Himalaya unique. India's biggest river system, the Ganges system—the Bhagirathi, the Alaknanda, the Yamuna, the Kali, the Saryu, the Ramganga and their numerous tributaries, originates from the largest glaciers of the Indian Central Himalayan region (ICHR) and flow through the mainland of Uttarakhand. The river system supports the most densely populated areas of the Ganges plain. The Himalaya has an extremely active geodynamic condition, even small tampering with the geo-ecological balance can initiate environmental changes that may eventually lead to an alarming proportion (Valdiya 2001; Gaur 1998). Its topography is diverse that makes Himalaya as one amongst the most fragile ecosystems in the world. Different geological orogenies have vast impacts on the distribution pattern of the biotic elements (Singh 2004).

Climate of the Himalaya is highly variable and it changes according to the altitude and seasons (Singh et al. 2010; Mishra 2014; Bhatt et al. 2000; Dash et al. 2007). However, no substantial study has been carried out on it (Mani 1981; Kumar et al. 2010 and Duan et al. 2006). The Himalaya protects the Indian subcontinents from the cold waves of the Mongolian cold desert. It has been observed that if there were no Himalaya, the northern parts of India would have been converted into cold deserts. Further, the Himalaya regulates the climate of the central India and the Ganges valley. The author noticed high climate variability and change in the entire Himalayan region. On one hand, temperature has increased by 0.4 °C and rainfall has decreased by 1.4% in the eastern extension of the Himalaya (Sati 2017), while on the other hand, in the ICHR, temperature has remained unchanged and rainfall has increased with high intensity and frequency during the last two decades. Climate scientists have stated that the climate change impacts on the floral diversity and its distribution in the Himalaya have been significant (Gaur 1999; Negi and Hajra 2007; Bisht et al. 2010; Holm et al. 1977). Further, they have a considerable impact on farming systems and natural resources.

The Himalayan glaciers have been receding, impeding water resources and livelihoods (Krishna 2005; Lee et al. 2008; Kulkarni et al. 2002, 2007). Warming of the Himalayan region has changed snow cover mass balance (Kulkarni and Bahuguna 2002; Ageta and Kadota 1992; Kripalani et al. 2003). In the Himalayan region, the valleys and the mid-altitudes are warming and therefore, the warming has implications on the highlands and glaciers although the impact of climate variability and seasonality is high.

In Uttarakhand, the rivers are the major sources of surface water, however, quality of water in these rivers has been deteriorating. Increasing population, urbanization along the river valleys and deforestation are the matters of serious concern today, which have been influencing water quality and quantity. Findings of research depict that river water is depleting in both quantity and quality (Sati and Paliwal 2008; Desai and Tank 2010; Shrivastava et al. 2013). The river (Ganges) systems such as the Yamuna-Tons Systems, the Bhagirathi-Alaknanda System and the Kali System are the largest river systems in the world. These rivers are fed by

the Himalayan glaciers and their volume and velocity are high in the Uttarakhand Himalaya. Natural springs, which are the major sources of drinking water in the rural areas, have been depleting and some of them have been dried up thus, water scarcity has been increasing in rural areas of the Uttarakhand Himalaya.

Forests vary from the monsoon deciduous to pine, mixed-oak and coniferous. Shrubs, bushes and grasslands—subtropical and alpine—also obtain substantial areas. Diversity is high in monsoon deciduous forests and mixed-oak forests. It is also high in coniferous forests and alpine grasslands. Meanwhile, pine forests are growing independently. These forests are economically viable, whereas they are largely unused because of their inaccessibility (Sati 2006). Uttarakhand is among the few states of India where forest land has increased, as about 23 km² green cover in Uttarakhand has increased in 2017 (FSI 2017). In the meantime, area under different forests is changing. For instance, pine forests have invaded mixed-oak forests because of warming of the mid-altitudes and temperate region. As a result, oak forests have disappeared from many locations in temperate region (Sati 2004), mainly from the east-south slopes. Forest fire has become the major threats for forest diversity in the Shivaliks, river valleys and the mid-altitudes.

Dense forests and large temperate and alpine grasslands enrich the ecology of the region (Sati 2018). Some of the rarest faunal and floral species of the world are found here. The state has diversity in topography, climate, vegetation, people and culture, which depicts varied and complex characteristics of the region and thus, it is rich in cultural, physical and favourable ecological supports to lives and livelihoods.

Tectonic activities, lithological, structural and ecological settings, topography and changing landscape, because of anthropogenic and nature led phenomena, cause severe natural disasters in the Uttarakhand Himalaya. Among the major natural disasters, earthquakes, landslides, land subsidence, slope failure, rockfall, avalanches, cloudbursts, hailstorms, Glacial Lake Outbursts Flow (GLOF), flash-floods, lightning and forest fires are prominent, intense and frequent, causing major loss to life and property from time to time. An increasing trend in atmospheric disasters has been observed (Sati 2013a, b). Cloudburst triggered disasters such as flashfloods and debris flow are common. High intensity and variability in rainfall have been resulting in occurrences of huge disasters. During the recent past, rainfall frequency and intensity have increased, leading to devastating flashfloods and mass movements, affecting human settlements, agricultural and forestland, and landscape largely.

Forest fires, during the summer, are catastrophic. More than 95% of the forest fires are anthropogenic and the rest (5%) are caused by natural reasons (Satendra and Kaushik 2014; Dobriyal and Bijalwan, 2016; Kinnaird and O'Brien 1998; Butry et al. 2001). They have caused adverse impacts on the environment as fire produces a large amount of trace gases and aerosol particles, and impacts the floral and faunal species, severely (Hao et al. 1996; Fearnside 2000; Crutzen and Andreae 1990; Sugihara et al. 2006). In Uttarakhand, forest fire is the most catastrophic disaster, which occurs mainly during the summer season, called the fire season, resulting in huge biodiversity loss. Here, forest fire occurs mainly in the Shivalik

hills, the river valleys and mid-altitudes. Pine forests are the most susceptible to forest fires. The author has observed that forest fires' intensity and frequency have been increasing during the recent pasts.

Development oriented activities such as the construction of roads and buildings and setting up of hydro-electricity projects have gotten fast paced after the formation of the State (Sati 2014). On the other hand, agricultural and horticultural practices are facing challenges from several internal and external forces. Tourism, projected as the major source of livelihood in the hills, has gained boom. Side effects of construction activities have considerably amplified the intensity of naturally occurring disasters and their impacts. A sectoral approach for sustainable development is the key that can mitigate the changes being faced by the Uttarakhand Himalaya.

Agriculture, horticulture and livestock intricate mixed farming system in the Uttarakhand Himalaya, upon which livelihood of the people is dependent (Sati 2016). Along with growing population and further fragmentation of small terraced and fragile landholdings, production from traditionally grown crops is not sufficient. High variability in climate has decreased crop yield during the recent pasts. The whole land has been facing changes in the cropping pattern, from subsistence cereals to cultivation of cash crops including medicinal plants, whereas the pace of change is slow and only a small proportion of arable land is devoted to cultivation of cash crops (Sati 2017). In the meantime, agro-climate is highly suitable for growing all varieties of crop races/cultivars, from subsistence cereals to cash crops (Sati 2012). One of the major obstacles, which has been influencing farming systems in the Uttarakhand Himalaya is lack in infrastructural facilities, which include market accessibility, transportation facilities, cold storages and modern innovation in the farming field.

Although, the Uttarakhand Himalaya has abundant natural and human resources in the forms of valuable forests, ample and pure water, spectacular landforms, aesthetic and touristic destinations, healthy air, huge ecosystem services and innocent and highly educated people yet, the natural resources are largely unused and educated youth have been out-migrated. The inaccessibility and remoteness of the forest areas and human settlements impede optimal use of abundant natural resources. Lack in market facilities, transportation, institutions, industrial development and high rate of unemployment are other major problems that have manifested several changes in natural and cultural aspects. Further, educated youth have out-migrated to urban centres and big cities in search of jobs (Sati 2016). This altogether has led to depopulation in rural areas and over population in urban areas. The Uttarakhand Himalaya is devoid of a detailed and systematic study on all these given aspects, mainly on climate, forest and water.

The Himalaya has been passing through changes in several socio-ecological aspects. Changes in population size, culture, social structure, landscapes, glaciers, water resources, forests, agrarian systems and land use have become very common, mainly during the recent past. The present study looks into the natural and cultural aspects of the Himalaya and focuses on the major changes that the Himalayan region has been facing. The scope of the study is limited to 'Uttarakhand

Himalaya', an integral part of the Himalaya, lying almost in its centre and known as the ICHR. The main thrust of the study is to examine the change—natural and cultural—in the Uttarakhand Himalaya. It further studies the major drivers of these changes and suggests mitigation measures to cope with them.

This study is purely empirical and observational. I have research experience of about 30 years on the Uttarakhand Himalaya. During this period, I have visited the entire Uttarakhand a number of times and published significant number of research papers and books. In this book, a case study of eight villages has been carried out. I have mainly described the changes in all aspects—natural and cultural—and drivers of these changes.

Besides, data on climate, water, forests, agriculture, migration, population, social change, natural disasters and culture were gathered from the secondary sources—State Statistical Diaries (2013–14), Census of India (2001–2011), Meteorological Centre, Dehradun, State Forest Department, Uttarakhand Tourism Corporation and literature review (books, research papers and newspapers). I have used statistical tools to analyze and describe data. Correlation method and regression model were used to describe the change and its implications. Mapping and graphic presentation of data have appropriately been carried out. There are total 10 maps, constructed using Geographical Information System (GIS), and 61 graphs, photo plates and graphic models showing information on natural and cultural aspects of change (total number of figures are 71). Data have also been analyzed through tabulations, as a total 19 tables have been presented to strengthen the study.

The book *Himalaya on the Threshold of Change* presents a holistic and comprehensive view of the Himalaya in terms of recent changes that have been observed in both natural and cultural aspects. I have divided the book into two parts—describing natural and cultural aspects. There are total 11 chapters in the book, of which, the first six chapters are devoted to natural aspects, the rest four chapters are associated with cultural aspects, and conclusions. In addition, Introduction is given separately. Introduction presents a review on change—natural and cultural in the Uttarakhand Himalaya. It briefly discusses the objectives of the study and methodology adopted to conduct the study. Chapter 1 specifically describes geography and geology of Uttarakhand, which includes a brief note on the Himalaya, location and extension of Uttarakhand, administrative divisions, physical features, landforms, river systems, glaciers and water bodies in the forms of highlands and the valleys lakes. It also illustrates the geology of Uttarakhand and its features. Chapter 2 elaborates the climate of the Himalaya. The author gathered climate data (2000–2014) of the two meteorological stations of Uttarakhand—Dehradun and Mukteshwar, and analyzed data on temperature, rainfall and humidity. Climate change impacts on natural and cultural aspects have been elaborated. Glaciers of the Uttarakhand Himalaya are described in Chap. 3. An inventory of glaciers of the Uttarakhand Himalaya has been prepared and a discussion on 'climate change and its impact on the Himalayan glaciers' has been made. A note on receding glaciers has also been carried out. Chapter 4 discusses water resources and change. A detailed description of water resource potential as surface and ground water, hydroelectricity projects, irrigation projects and water

scarcity has been carried out. Sustainable water resources development has also been illustrated in the chapter. Forests of the Uttarakhand Himalaya are described in Chap. 5. Forests diversity and distribution, area under tree species, forest cover change and climate change impact on forests, ecosystems and livelihoods are widely elucidated herewith. Chapter 6 studies increasing events of disasters. The chapter comprises types of disasters, causes and implications of disasters, and mitigation and prevention measures.

Cultural aspects of change comprise four chapters—from seventh to tenth. Chapter 7 explicates changes in culture and customs, including worshiping nature and folk deities, celebrating fairs and festivals, performing *Samskaras*, cultural processions, folklore and dances, and changing cultural space and boundaries. Population, social and economic changes have been elucidated in Chap. 8 where a detailed description on population profile and change, change in social structure, and economic disparity and change has been given. Chapter 9 discusses migration and agrarian change. The major drivers that influence out-migration from the rural areas and the impact of out-migration in sending and receiving areas have been described. Similarly, agrarian change, and its causes and implications have been discussed in the same chapter. Chapter 10 deals with sustainable development under changing environment. In this chapter, current trends and policy initiatives of sustainable development have been discussed. Along with describing chapters on natural and cultural aspects of change, case studies of the six villages have been conducted by the author. The last chapter is conclusions, in which the author has illustrated the major drivers of change and suggested measures for resilience and adaptation to change.

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