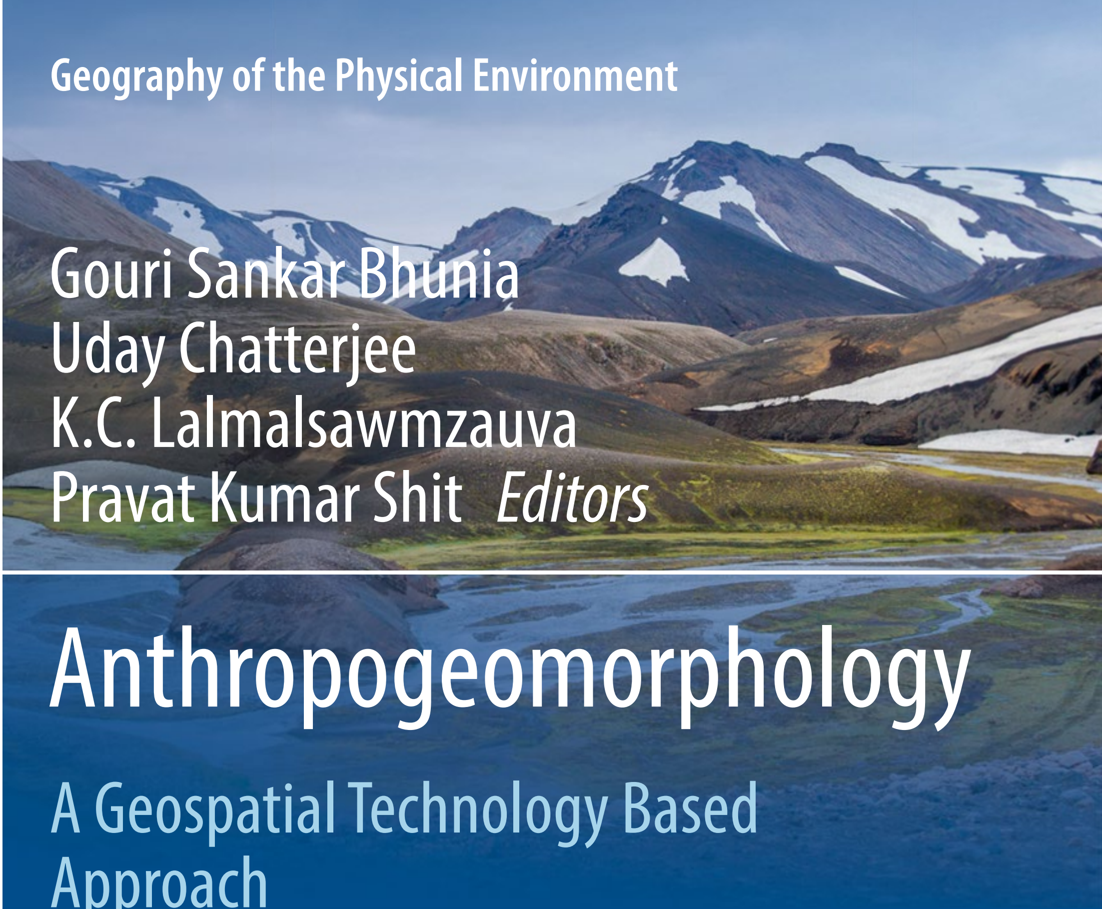

Geography of the Physical Environment

Gouri Sankar Bhunia
Uday Chatterjee
K.C. Lalmalsawmzauva
Pravat Kumar Shit *Editors*

Anthropogeomorphology

A Geospatial Technology Based Approach

Springer

Geography of the Physical Environment

The *Geography of the Physical Environment* book series provides a platform for scientific contributions in the field of Physical Geography and its subdisciplines. It publishes a broad portfolio of scientific books covering case studies, theoretical and applied approaches as well as novel developments and techniques in the field. The scope is not limited to a certain spatial scale and can cover local and regional to continental and global facets. Books with strong regional focus should be well illustrated including significant maps and meaningful figures to be potentially used as field guides and standard references for the respective area.

The series appeals to scientists and students in the field of geography as well as regional scientists, landscape planners, policy makers, and everyone interested in wide-ranging aspects of modern Physical Geography. Peer-reviewed research monographs, edited volumes, advance and undergraduate level textbooks, and conference proceedings covering the major topics in Physical Geography are included in the series. Submissions to the Book Series are also invited on the theme 'The Physical Geography of...', with a relevant subtitle of the author's/editor's choice. Please contact the Publisher for further information and to receive a Book Proposal Form.

More information about this series at http://www.springer.com/series/15117

Gouri Sankar Bhunia • Uday Chatterjee
K.C. Lalmalsawmzauva • Pravat Kumar Shit
Editors

Anthropogeomorphology

A Geospatial Technology Based Approach

Springer

Editors
Gouri Sankar Bhunia
Department of Geography
Visiting Faculty, Seacom Skills University
West Bengal, West Bengal, India

Uday Chatterjee
Department of Geography
Bhatter College, Dantan
Paschim Medinipore, India

K.C. Lalmalsawmzauva
Geography & Resource Management
Mizoram University
Aizawl, India

Pravat Kumar Shit
PG Department of Geography
Raja N. L. Khan Women's College
(Autonomous)
Midnapore, West Bengal, India

ISSN 2366-8865 ISSN 2366-8873 (electronic)
Geography of the Physical Environment
ISBN 978-3-030-77571-1 ISBN 978-3-030-77572-8 (eBook)
https://doi.org/10.1007/978-3-030-77572-8

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

Dedicated to
Young Scholars in the Field of Applied
Geomorphology and Geosciences

Foreword

Population and development have walked hand in hand since the dawn of civilization. Before the appearance of *Homo sapiens* on Earth, the purely natural system ruled our planet. Many geophysical events such as earthquakes, volcanic eruptions, landslides, and floods threatened only the prevailing flora and fauna. After the appearance of *Homo sapiens*, human society has evolved to such an extent that human beings, at present, have a great impact on the physical environment of Earth. Some scientists believe that the latest geological epoch, labelled Anthropocene or the Age of Man, began when man's activities set about impacting the planet's physical environment, which will endure in the geological record long after human civilization has perished.

To ease their existence, humans have also disturbed the spontaneous rhythm of nature, overexploiting resources to make life more comfortable. In the one-million-year-old history of man's arrival on this planet, humans have altered the Earth in just the past century or two, kicking off this all-new epoch, which has transformed geophysical events into natural disasters. Thus, the theme of this edited book is very much relevant to the present scenario.

There is constant confusion about the name of the subject, whether it should be anthropogeomorphology or anthropogenic geomorphology. Many discussions and deliberations have been going on, but geoscientists of the world are yet to draw a conclusive decision. Thus, use of the term anthropogeomorphology can be continued until scientists reach a unanimous decision.

The present book, entitled *Anthropogeomorphology: A Geospatial Technology-Based Approach*, edited by Gouri Sankar Bhunia, Uday Chatterjee, KC Lalmalsawmzauva, and Pravat Kumar Shit, is a worthy contribution to earth sciences because human activities change the Earth's surface continuously and are responsible for altering geomorphological processes and geomorphological hazards. Addressing such an important issue through geospatial technology has given an additional flavour to the subject.

The book is well designed, organized into 32 chapters and written by different authors covering almost all features of geomorphology, mapping, techniques, and management issues. I believe that the book will attract wide attention from the scientific community, including geomorphologists, environmentalists, environmental activists, and planners.

Sunil Kumar De

Vice President, International
Association of Geomorphologists
(IAG), Department of Geography,
North-Eastern Hill University, Shillong,
Meghalaya, India
26.01.2021

Preface

The intensity of involvement has been proportional to the size of the human population to its demands upon the environment and to the level of technological progress achieved to satisfy growing demands. Since the 1970s in the research of the physical environment regularly interweaving trends between natural environment and human economic intervention are protuberant. In the last two decades, concern with global environmental change has brought the role of anthropogeomorphology into sharper focus. Global warming has important implications for many geomorphological processes and phenomena as a result of the direct effects of warming, as a consequence of other related climatic changes. Anthropogeomorphology concerns about the number of landforms associations of extreme variability depending on the given way and goal of their formation, which have been completed by the man-induced activity. However, the scope of anthropogeomorphology does not only include the study of man-made landforms but also the investigation of man-induced surface changes, the prophecy of consequences of upset natural stabilities along with the preparation of proposals with the purpose of impede detrimental effects. Therefore, anthropogeomorphology can be regarded as a discipline that supports to explain both socio-economic as well as environmental and natural protection issues. This book provides an innovative approach and exercise to explore our physical environment with the growing demands from society against geography due to scientific-technical rebellion, to encourage competently the rational exploitation of natural resources and capacities, and to accomplish an environmental management sustaining social condition and prospects.

The organization of the books follows a general introduction of aims and scope of this discipline, and the individual chapters focus on the various sectors of human activity. Generally, the following fields of anthropogeomorphology have been considered, namely mountain, coast, riverine, forest, urban, agricultural, hydrometeorology, industry, mining, and tourism. Finally, qualitative and quantitative summary of the human impact on Earth's surface has been described. The fieldwork is combined with references and the comparison of the present-day situation with the achievement.

West Bengal, India — Gouri Sankar Bhunia
Paschim Medinipore, India — Uday Chatterjee
Aizawl, India — K.C. Lalmalsawmzauva
West Bengal, India — Pravat Kumar Shit

Acknowledgments

The preparation of this book has been guided by several geomorphologic pioneers. We are obliged to these experts for providing their time to evaluate the chapters published in this book. We thank the anonymous reviewers for their constructive comments that led to substantial improvement to the quality of this book. Because this book was a long time in the making, preparation of this book became a tedious and time-consuming job for the editors. We want to thank our family and friends for their continued support. This work would not have been possible without constant inspiration from our students, knowledge from our teachers, enthusiasm from our colleagues and collaborators, and support from our family. Finally, we also thank our publisher, Springer, and its publishing editor for their continuous support in the publication of this book.

Disclaimer

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

Contents

Contributors

Zulfequar Ahmad Department of Civil Engineering, IIT Roorkee, Roorkee, India

T. Akhil National Centre for Earth Science Studies, Thiruvananthapuram, India

Wajahat Annayat Department of Civil Engineering, National Institute of Technology, Silchar, Assam, India

Kumar Ashwini Department of Civil Engineering, National Institute of Technology, Silchar, Assam, India

Arnab Banerjee U.T.D, Department of Environmental Science, Sarguja Viswavidyalaya, Ambikapur, Chattisgarh, India

Shiboram Banerjee Department of Conservation Biology, Durgapur Government College, Durgapur, West Bengal, India

Anindya Basu Department of Geography, Diamond Harbour Women's University, Sarisha, West Bengal, India

Sukla Basu Department of Rural Studies, West Bengal State University, Barasat, West Bengal, India

Suman Bera Department of Geography and Environment Management, Vidyasagar University, Midnapore, West Bengal, India

Adrija Bhattacharjee Department of Geography, Diamond Harbour Women's University, Sarisha, West Bengal, India

Soumik Bhattacharya Aerospatial Solution Pvt. Ltd., Thane, Maharashtra, India

Gouri Sankar Bhunia Randstad India Private Limited, New Delhi, India
Bihar Remote Sensing Application Centre, Bihar, India

Uday Chatterjee Department of Geography, Bhatter College, Dantan (Vidyasagar University), Paschim Medinipur, West Bengal, India

Aksha Chowdhary Department of Geography (Geoinformatics), Savitribai Phule Pune University (SPPU), Pune, Maharashtra, India

Pinakesh Das Department of Soil and Water Conservation and AICRP on Agroforestry, Bidhan Chandra Krishi Viswavidyalaya, Haringhata, West Bengal, India

Swarupa Das Department of Geography, Barjora College, Barjora, West Bengal, India

Anusree Dutta Department of Geography, Purwanchal Vidyamandir, Kolkata, India

Karishma Dutta Department of Geography, School of Human and Environmental Sciences, North Eastern Hill University, Shillong, Meghalaya, India

RupamKumar Dutta Department of Geography, Kultali Dr. B.R. Ambedkar College (University of Calcutta), Parganas, West Bengal, India

P.K. Garg Department of Civil Engineering, IIT Roorkee, Roorkee, India

MintuE. George Cochin University of Science and Technology, Ernakulam, India

Pranamee Gogoi Department of Geography, Rajiv Gandhi University, Itanagar, Arunachal Pradesh, India

Jayanta Gour Department of Geography, Sambhu Nath College, Birbhum, India

Anwesha Haldar Department of Geography, East Calcutta Girls' College, Kolkata, India

K. Justin George Agriculture & Soils Department, Indian Institute of Remote Sensing, Dehradun, India

KishorChandra Kandpal Uttarakhand Space Application Centre, Dehradun, India

Jayashree Karmakar Bankura Zilla Saradamani Mahila Mahavidyapith, Bankura, West Bengal, India

Nuruzzaman Kasemi Department of Geography, Raiganj University, Raiganj, India

N. Kasongi Department of Geography and Environmental Studies, University of Dodoma, Dodoma, Tanzania

Kaushik Kharghoria Department of Geography, School of Human and Environmental Sciences, North Eastern Hill University, Shillong, Meghalaya, India

Nasira Khatun Department of Geography, Women's College, Kolkata, India

Bappaditya Koley Department of Geography, Bakim Sardar College, Paraganas, West Bengal, India

Suresh Kumar Agriculture & Soils Department, Indian Institute of Remote Sensing, Dehradun, India

K.C. Lalmalsawmzauva Department of Geography & Resource Management, Mizoram University, Aizawl, India

Ramkrishna Maiti Department of Geography and Environment Management, Vidyasagar University, Midnapore, West Bengal, India

Sima Majumdar Department of Education, Government of Tripura, Agartala, India

Sushobhan Majumdar Department of Geography, Jadavpur University, Kolkata, India

Saikat Mandal Department of Zoology, Raghunathpur College, Raghunathpur, West Bengal, India

Durdanah Mattoo Department of Geography and Regional Development, University of Kashmir, Srinagar, Jammu and Kashmir, India

Swati Mollah Dumkal College, Murshidabad, West Bengal, India

Tahir Muntazari Department of Civil Engineering, National Institute of Technology, Srinagar, Jammu and Kashmir, India

Gardinia Nongbri Department of Environmental Studies, North-Eastern Hill University, Shillong, India

Adikanda Ojha GIS Analyst, ICZMP-SPMU, Bhubaneswar, Odisha, India

Debnath Palit Department of Botany, Durgapur Government College, Durgapur, West Bengal, India

Papia Nandy Palit Department of Geography, Barjora College, Barjora, West Bengal, India

Subhabrata Panda Department of Soil and Water Conservation and AICRP on Agroforestry, Bidhan Chandra Krishi Viswavidyalaya, Haringhata, West Bengal, India

S. Panneerselvam Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

SantanuK. Patnaik Department of Geography, Rajiv Gandhi University, Itanagar, Arunachal Pradesh, India

Sellaperumal Pazhanivelan Department of Remote Sensing and Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

T.K. Prasad Kannur University, Kannur, India

MdFazla Rabby Department of Geography and Environment, Jahangirnagar University, Savar Dhaka, Bangladesh

M.K. Rafeeque University of Kerala, Thiruvananthapuram, India

Nusrat Rafique Department of Geography and Regional Development, University of Kashmir, Srinagar, Jammu and Kashmir, India

MdShahedur Rashid Department of Geography and Environment, Jahangirnagar University, Savar Dhaka, Bangladesh

Neelam Rawat Uttarakhand Space Application Centre, Dehradun, India

Rezaul Roni Department of Geography and Environment, Jahangirnagar University, Savar Dhaka, Bangladesh

Jajnaseni Rout Remote Sensing and GIS Consultant, Bhubaneswar, Odisha, India

AbiraDutta Roy Bankura Zilla Saradamani Mahila Mahavidyapith, Bankura, West Bengal, India

Bhaswati Roy Department of Geography, Raiganj University, Raiganj, India

KrishnaRao Sadasivuni Department of History and Archaeology, University of Dodoma, Dodoma, Tanzania

Venkadesh Samykannu Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Ranajit Sardar Acharya Prafulla Chandra College, New Barrackpore, West Bengal, India

Lakshminarayan Satpati Department of Geography, UGC-HRDC, University of Calcutta, Kolkata, India

Pravat Kumar Shit Department of Geography, Raja N. L. Khan Women's College (Autonomous), Midnapore, West Bengal, India

BaiaroihunWar Shymbin Department of Geography, Mawsynram Border Area College, Mawsynram, India

BritiSundar Sil Department of Civil Engineering, National Institute of Technology, Silchar, Assam, India

Mst.Rebeka Sultana Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi, Bangladesh

D.S. Suresh Babu National Centre for Earth Science Studies, Thiruvananthapuram, India

E.L. Temu Ministry of Culture, Dodoma, Tanzania

RowshonAra Toma Department of Geography and Environment, Jahangirnagar University, Savar Dhaka, Bangladesh

Ch. Udaya Bhaskara Rao Department of Geography and Resource Management, Mizoram University, Aizawl, India

Swapnil Vyas Department of Geography (Geoinformatics), Savitribai Phule Pune University (SPPU), Pune, Maharashtra, India

ShoibB. Wani Civil Engineering Department, B.S. Abdur Rahman University, Chennai, Tamil Nadu, India

Mohammad Zakwan Department of Civil Engineering, MANUU, Hyderabad, India

About the Editors

Gouri Sankar Bhunia is working at Randstad India Private Limited, New Delhi, India. He received a PhD from the Department of Geography, University of Calcutta, India, in 2015. He also worked as a visiting faculty in a private university (Seacom Skills University) in West Bengal, India. His PhD dissertation work focused on environmental control measures of infectious disease using geospatial technology. Currently, he is involved in smart city and urban planning project. He has received the Senior Research Fellowship Award from the Indian Council of Medical Research. His research interests include environmental modelling, health GIS, risk assessment, natural resources mapping and modelling, data mining, and information retrieval using geospatial technology. Dr Bhunia is associate editor and on the editorial boards of three international journals in health GIS and geosciences. Dr Bhunia has published more than 80 articles in various Scopus-indexed journals. He published four books with International Publishing Group. He is currently the editor of the GIScience and Geo-environmental Modelling (GGM) book series, Springer Nature.

Uday Chatterjee is an assistant professor in the Department of Geography, Bhatter College, Dantan, Paschim Medinipur, West Bengal, India, and an applied geographer with a postgraduate degree in applied geography from Utkal University and doctoral degree in applied geography from Ravenshaw University, Cuttack, Odisha, India. He has contributed various research papers published in various reputed national and international journals and edited book volumes. He has authored and jointly edited the book *Harmony with nature: Illusions and elusions from geographer's perspective in the 21st century*. He has also conducted (convener) one faculty development program on "Modern methods of teaching and advanced research methods" sponsored by the Indian Council of Social Science Research (ICSSR), Govt. of India. His areas of research interest cover urban planning, social and human geography, applied geomorphology, hazards and disasters, environmental issues, land use, and rural development. His research work has been funded by the West Bengal Pollution Control Board (WBPCB) Govt. of West Bengal, India. He has served as a reviewer for many International journals. Currently, Dr Chatterjee is the lead editor of the special issue (S.I) *Urbanism, Smart Cities and Modelling, Geojournal*, Springer.

K.C. Lalmalsawmzauva graduated from St. Edmund's College, Shillong, Meghalaya, and pursued MSc geography from North Eastern Hill University, and he was awarded doctorate degree (PhD) from the same University in the year 2012. He was the founder President of NEHU-Geographical Research Forum (NEHU-GRF). He joined Mizoram University in the year 2011 as Assistant Professor. To his credit, he published three books as a single author and co-authored four books. He completed projects by the Indian Council of Social Science Research (ICSSR) and involved himself in the project of the United Nations Food and Agriculture Organization (FOA) for agricultural development in the hill regions. He also Co-PI in the consultancy project of National Rural Livelihood Mission project, Government of Mizoram. He published more than 20 research papers in various journals and books. He has actively participated in national and international academic activisties. In his academic endeavor, he has visited Europe, America, and Africa.

Pravat Kumar Shit is an assistant professor in the PG Department of Geography, Raja N. L. Khan Women's College (Autonomous), West Bengal, India. He received his MSc and PhD degrees in geography from Vidyasagar University and PG diploma in remote sensing and GIS from Sambalpur University. His research interests include applied geomorphology, soil erosion, groundwater, forest resources, wetland ecosystem, environmental contaminants and pollution, and natural resources mapping and modelling. He has published 10 books (8 books with Springer) and more than 60 papers in peer-reviewed journals. He is currently the editor of the GIScience and Geo-environmental Modelling (GGM) book series, Springer Nature.

Chapter 1
An Introduction to Anthropogeomorphology and Geospatial Technology

Gouri Sankar Bhunia, Uday Chatterjee, Pravat Kumar Shit, and K. C. Lalmalsawmzauva

1.1 Introduction

Geomorphology is a scientific study of landforms, terrain and related processes that includes explanation of earth/planetary surfaces, substances, origins, nature and history. Geomorphological processes are the factors that alter the Earth, and others are the endogenetic mechanisms that reside inside the Earth; some forces placed beyond the Earth are the exogenetic processes. Moving water, wind, glaciers, karst and sea waves are powerful agents of degradation and aggradation that operate over a significant period of time and create gradual changes that lead to systematic development of landform. Landforms formed by dynamic anthropogenic processes are much less easy to identify, not smaller, but they do not require the introduction of a new path or strategies as much as the amplification of natural phenomena.

The concept of *anthropogeomorphology*, coined by Golomb and Eder (1964), is the study of the human role in forming landforms and changing the function of geomorphological processes. It therefore reflects throughout the Anthropocene on several key components of geomorphological processes. A significant aspect of the

G. S. Bhunia (✉)
Remote Sensing and GIS Expert, Randstad India Private Limited, New Delhi, Delhi, India

U. Chatterjee
Department of Geography, Bhatter College, Dantan (Vidyasagar University), Paschim Medinipur, West Bengal, India

P. K. Shit
PG Department of Geography, Raja N. L. Khan Women's College (Autonomous), Midnapore, West Bengal, India

K. C. Lalmalsawmzauva
Department of Geography & Resource Management, Mizoram University, Aizawl, Mizoram, India

G. S. Bhunia et al. (eds.), *Anthropogeomorphology*, Geography of the Physical Environment, https://doi.org/10.1007/978-3-030-77572-8_1

Anthropocene is physiographic modification, but its consequences can differ widely in space and time, and it is often underestimated in view on human interventions on the Earth's surface (Brown et al., 2013). Human behaviours impact the landscape and its natural features dramatically and cumulatively (Marsh, 1864). Geomorphological modifications arise from a variety of anthropogenic processes, namely, forest clearance, cultivation, ground drainage and filling, mining and quarrying, channelization, irrigation, and dam formation or other engineering development (Nir, 1983). Both the systematic erosion and accumulation of material and the unintended consequences of hydrological changes and the subsequent deforestation and sedimentation are implicated in these operations (Hooke, 2000).

1.2 Interaction Between Geomorphology and Human

The role of human being as a geomorphological agent is the topic of *anthropogeomorphology*. It has been presumed that the Earth's surface is a naturally occurring phenomenon capable of controlling human interaction, but that it is perhaps occasionally, if ever, strongly affected by human beings. Humans are now the most effective geomorphic entity in shaping and reforming the Earth's face, by transforming the physical climate. Exponentially the population growth has become faster, and the resources available for the demand has culminated in the widespread reworking of surface materials, which is projected to develop in the subsequent manner, at an even faster rate of population growth. In areas such as agriculture and mining, technological innovations will be designed and implemented, and growing population rates will result in more changes in land cover and in the utilization of natural resources. The early deforestation of the Neolithic slope in Central Europe, for example, may have been the most essential geomorphological process since the end of the Pleistocene, whereas in Dubai the coastline has altered during the last few centuries. Conversely, whenever significant anthropogenic modifications occurred, they have a direct global impact on the terrestrial ecosystem. Hooke et al. (2012) have estimated the terrestrial area amended by human activity in 2007 and recommend that more than 50% of the total area without ice has been altered by social existence. The Intergovernmental Panel on Climate Change (IPCC) has shown that global warming can dramatically alter biomes, contribute to major cryosphere modifications and enable sea levels to increase (IPCC, 2013). Wohl (2013) opines that geomorphologists can make a positive contribution to the management of what is now called the 'critical zone' in several contexts. This is the near-surface layer of the Earth from the tops of the trees down to the profoundest groundwater, with more and more human interactions with the surface of the Earth and the confluence of most geomorphological activity.

The dilemma of anthropogenic geomorphology is the identification of the broad and ever-expanding array of landforms on the surface, extremely varied in origin and function, generated by human activity. In a broader context, artificially generated landforms have diverse environmental effects (e.g. meso- and microclimate changes, morphology and so on) and alter natural processes. Natural environments that have been substantially changed as a result of direct management effects became anthropogenically varied systems. In geomorphology, a wide practice deals with the study of human impacts on river systems and other landscape structures (Thomas Jr., 1956). Direct anthropogenic practices, such as construction (e.g. spoil tips, embankments, sea walls), exploration (e.g. mining and quarrying), hydrological intervention (e.g. ponds and canals) and cultivation (e.g. terraces), generate numerous geomorphological features. The most common models of anthropogenic ecosystems involve agricultural fields, particularly cultivated land and pasture/grazing land and technological landscapes like urban landscapes and mining centre, etc. Slaymaker et al. (2009) pointed out the consequences of land cover modifications can be at least as significant as the changes that will be triggered by future climate change.

Nowadays, only in the sense of the impact of past human activities will the geomorphic consequences of continuing urban and suburban growth in the same communities be interpreted (Voli et al., 2013). Prolonged urbanisation is occurring globally and more quickly in the humid tropics' developing nations. The urban landscape features of LULC play a significant role in national, regional and local climate change. This accumulation will arise not only owing to variations in the patterns of susceptible and latent surface heat but also due to variation in surface albedo. The albedo is lower in an urban area in comparison to a rural region (Sailor, 2002). The lower albedo is recorded due to rooftops and asphalt roadways in the urban area. Much of the metropolitan landscape is marked by a large portion, or, if any, the proportion of urban surface coverage is disconcertingly low as a result of decreased supply of moisture. These elements of the urban landscape provide cities a much higher heat potential than natural surfaces.

Major driving forces of water, soil and air pollution are changes in land use/land cover characteristics. Mining activities can create contaminants from radioactive metals exposed in the operation. Agricultural pesticides are introduced into the soil and surface waters, including fertilizers, insecticides and pesticides, and, in some cases, persist as pollutants inside the region. Overtime, the deforestation degrades soil fertility and reduces soil suitability for potential agricultural use but also releases tremendous quantities of phosphate, nitrogen and sediments into waterways and other marine environments, with a kind of adverse effect (excessive sedimentation, turbidity, eutrophication and coastal hypoxia).

1.3 Role of Remote Sensing and GIS in Geomorphological Application

Geomorphological mapping and the study of different structures using advanced tools including remote sensing and geographic information system (GIS) serve as conceptual tools for inventory, exploration and governance of land resources and geomorphological and geological risk mitigation, along with generating baseline knowledge for other environmental research areas, such as landscape ecology, soil science, hydrology and forestry, etc. In several geomorphological research, GIS and remote sensing have been implemented to measure surface processes and landmasses. Using post classification, comparative analysis, standard image differentiation, employing image ratio, image regression and manual on-screen digitization of variations, main components evaluation and multi-temporal image classification, there are several systems designed in the earlier research work. Geospatial technology has been extensively used for classifying land type and landscape units with the continuous advancement of GIS and RS technologies, extracting those landform characteristics, quantifying process-landform interactions and defining geomorphic variations.

Punkari's (1987) study shows how imagery beyond the visible spectrum can be helpful in landform recognition. In this research, inter-drumlin regions displayed higher proportion of moisture that influenced land cover, leading to a lower reflectance in visible-near-infrared (VNIR) bands and thus better separating drumlins. In conjunction with shaded relief derived through DEMs, Jansson and Glasser (2005) found false-colour composites integrating with near infrared and thermal infrared bands to be the most effective for identifying landscape. Marchese et al. (2019) used Multispectral Instrument (MSI), Operational Land Imager (OLI), Sentinel-2A/2B and Landsat 8 satellites sensors data to test an original multichannel algorithm (normalized hotspot indices and normalized thermal index), which aims at mapping volcanic thermal anomalies at a global scale. Sensors including the Advanced Very-High-Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS), which provide high temporal resolution data in the medium infrared (MIR) and thermal infrared (TIR) bands (up to 6 h in the case of AVHRR), have also been commonly used for operational monitoring of active volcanoes (Lombardo, 2016; Coppola & Cigolini, 2013). Thematic Mapper (TM) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and image spectrometers such as Hyperion, providing medium-high spatial resolution near-infrared (NIR) and short-wave infrared (SWIR) data, are probably more useful for mapping lava flows and retrieving reliable volcanic feature information (Reath et al., 2019a, b; Davies et al., 2006). Satellite measurements of sparging, thermal variations and land breakage covering 17 years are used by Reath et al. (2019a) in 47 of the most active volcanoes in Latin America and associate these historical data with ground-based measurements documented by the Global Volcanism Program. This information offers to determine volcanic behaviour on a regional scale during, noneruptive, pre-eruptive, syneruptive and posteruptive periods. For the purpose of delineating overlapping lava flows near the summit through textural differences between flows, Smets et al. (2010) used individual SAR images and SAR pairs from ERS 1/ERS 2 (C-band), ENVISAT (C-band) and JERS (L-band: 23.5 cm) satellites. The snow has maximum reflectance accompanied by firn and ice as visible from the spectral response curve. Related reflectance of nearby rocks is observed in the debris layer on the glacier. An important remote sensing technique for distinguishing surface entities with various temperatures or emissivity is the thermal infrared (3–15 μm) (Lepparanta & Granberg, 2010).

The glacier's surface temperature is lower than that of the environment, and therefore the thermal data are being distinguished. The glacier is thermally active at a depth of just 10 m and can be detected throughout the season (Gareth & Pellikka, 2010). AVHRR, MODIS, Landsat and ASTER series are the most widely used thermal band sensors for the glaciological research. The key benefit of the microwave sensor in glacier tracking is the capability to encapsulate snow and ice at different depths through microwave signals and to provide information about the underlying configuration of the glacier. The L-band radar can be used to gather data about the inner stratigraphy of the glaciers. SAR data can be used for the evaluation of glacier faces, glacier stratigraphy and other metrics, including glacier thickness and acceleration, at high quality and high resolution. In particular, Landsat MSS, TM, AVHRR, MODIS, SPOT, ASTER and IRS VNIR bands are commonly used for mapping the snow cover zone worldwide. The Normalized Snow Difference Index (NDSI) is determined according to Dozier (1989) from a reflectance in band at wavelengths when the snow is bright (e.g. TM band 2 or MODIS band 1), where it is dark (e.g. TM band 5 or MODIS band 6) along with the band for threshold lights (e.g. TM band 4 or MODIS band 2). The Advanced Microwave Scanning System for Earth Observation (AMSR-E) is used since 2002 for providing a global Snow Water Equivalent (SWE) product (Nolin, 2010). SWE and snow depth recovery techniques use effective data from the microwave. SRTM and ASTER GDEM are the two global DEMs, publicly accessible and commonly used to build on the glaciers' topographical criteria. The glacier indices offer knowledge about the input of the avalanches from the adjacent to the glacier and impact the mass balance of the glacier. The glacier ratio is the proportional upsloping area and the downslope direction (Way et al., 2014).

GIS-based geomorphological applications span the entire spectrum of process fields and related landforms. On a range of spatial scales, anthropogenic landforms are generated. Under the general heading of 'engineering mapping', Fookes et al. (2007) aggregated several applied geomorphological mapping issues. Comparative maps of morphography, morphochronology, morphogenesis, tools and hazards made it possible to understand the important mapping criteria. More applications analyse the space-time patterns of geomorphic environments, multiscale characteristics and processes, scenarios of landscape transition, changes in disorder regimes and land destruction associated with natural and human forces, often in images or scientific visualization techniques. The convergence of GIS and RS with digital elevation models (DEMs) has, especially with the development of the early twenty-first century in LiDAR (light detection and ranging) and UAV (unmanned aerial vehicle) to get high-resolution DEMs, becomes one of the most prevalent strategies for geomorphologic exploration. Both the systematic extraction and accumulation of material and the unintended consequences of hydrological changes and subsequent degradation and sedimentation are implicated in these processes (Hooke, 2000). Geomorphological modifications arise from a variety of anthropogenic processes, involving forest clearance, agriculture, land mining and excavation, mining and quarrying, infusing, irrigation and dam building or other infrastructure properties (Nir, 1983). Global satellite positioning (GPS) technology is common in defining and incorporation of different data on geographical positions of landscape features and specific patterns. These emerging capabilities represent a significant improvement relative to conventional cartography in geomorphology. Conceptual and functional challenges that have a potential for geospatial solutions also need to be understood (Table 1.1).

1.4 Anthropogenic Landform and Intervention of Geospatial Technology

On a number of spatial scales, anthropogenic landforms are formed. Human activities like excavation, mining and quarrying have brought about dramatic changes in the landscape. Landforms of local scale emerge from excavation, cutting and levelling to change slopes and channel morphology and establish flat land for infrastructure for construction and transport infrastructure. Broader landforms of size are produced by mining and quarrying, as well as subsidence due to the exploitation of water or mineral resources. Many of the researchers warned about the destructions have been caused by human activity, but perhaps more harmful to life and property are disturbances induced by these practices (wastelands, scars arising from strip mining and open-pit quarrying). In regions with concentrated human occupation (e.g. in urban areas), the combined geomorphologic impacts of human activities are more prominent and arise mainly in the early-urban to mid-urban stages of growth (Chirico et al., 2020). Some of the human actions have induced slope displacement by steeping slopes, removing the support, removing protective cover, surplus stacking, drainage blockage, increased soil moisture and vibration. Geoscientific knowledge plays a critical role in evaluating resource capacity and suitability for urban planning, defining risks and advising management policies with increasing demand on urban areas (Fookes et al., 2005).

1.4.1 Mining, Quarrying and Geomorphological Change and Application of Geospatial Technology

Remote sensing methods have been successfully used globally in mineral extraction research (Fig. 1.1). While fine-resolution data has been used to analyse improvements in the scale of surface mining, owing to its global coverage, a vast number of studies are focused on Landsat imagery (Maxwell et al., 2014). Studies integrating mine recognition with multitemporal analysis can also be strengthened by using fine-resolution data to classify and establish mine borders while doing change analysis based on medium-resolution imagery (Koruyan et al., 2012). In semiarid areas, Schimmer (2008) used normalized difference vegetation index (NDVI), wetness and grain size homogeneity to establish a new metric unique to the detection of