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Roshan Babu Ojha
Dinesh Panday *Editors*

The Soils of Nepal

World Soils Book Series

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The Soils of Nepal

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Foreword



Government of Nepal

NEPAL AGRICULTURAL RESEARCH COUNCIL

(Established by the Government of Nepal under the Nepal Agricultural Research Council Act, 2048 B.S.)

(..... Division)



Ref. No.:-
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Achieving food and nutrition security is always a challenge. Increased pressure to grow quality food under increasing human population, market preferences, and climate change are some of the triggering factors that demand to make soil sustainably productive. Understanding soil and making it more productive has been a prime concern in the agriculture sector. Nepal Agricultural Research Council (NARC) is conducting dynamic research on soil science since its establishment and has developed and generated several technologies for soil management. Attempts to understand the complexities and interactions among different factors in soil systems have resulted in broad research and publication record. I believe findings of soil research from the beginning of soil science research in Nepal have been included in this book with wide coverage in the soil science sector.

Climatic variation in the country has resulted in diverse soil types and systems. This demands the wide knowledge and use of multiple strategies for better management of soil. Major problems noted across the country are soil erosion, soil acidity, and nutrient mining which accelerates land degradation. Knowledge, both basic and applied, in soil science is therefore needed to make the diverse soil systems more dynamic and productive. Nepalese soil scientists must be applauded for their relentless efforts in developing comprehensive information regarding the soil status of Nepal through this book entitled "The Soil of Nepal". I am confident that this book helps national and international audiences about soil types and class of Nepal. I also hope that this resource has met the learning goals of researchers, students, and development professionals to be well acquainted with the foundations of soil genesis, management, utilization, and conservation.

I am very pleased with the efforts put by the Nepalese soil scientists in bringing this excellent publication as an outcome of their long years of experience and knowledge. I thank the editors, authors, and co-authors for their hard work and the strong team spirit they demonstrated in developing and bringing out this publication. I believe that this book will serve as a valuable reference for researchers, development professionals, students, academicians, farmers, and relevant stakeholders not only in Nepal but globally as well.



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Preface

Soil formation in Nepal is dynamic due to continuing active weathering that makes Nepalese soils young and fragile. Nepalese farming is largely based on the soil medium and must ensure food security for around 29 million people. Globally, soil solely produces 95% of the food required for human beings, making soil vital for human food and nutrition security along with delivery of numerous eco-system services. The importance of soil is even more pronounced for food production in Nepal due to its landlocked geography. To ensure food and nutritional security, maintaining and enhancing soil fertility is of prime importance. Soil fertility is governed by a multitude of factors, including parent materials, soil types, input management, soil microbial activity, and many others. In this book, we elucidate different aspects of soils to inform national and international readers about the key features of the soils of Nepal. We also aim to make this effort a national soil reference book that will help others understand the young and dynamic soils of Nepal.

There have been numerous soil studies conducted in Nepal but most are produced as gray literature or inaccessible journal articles, and very few open-access articles are available. Because researchers and academics have always struggled to find consolidated information on the soils of Nepal, our contributing authors have together collected more than 1500 references to assemble the key information about Nepalese soils in one place. We have decided to publish this book as part of the “World Soil Book Series” to make this information available to global audiences who are eager to learn about the soils of Nepal. We believe this book will fulfill readers’ quests to some extent.

The authors in this book are subject matter specialists for their respective chapters who understand Nepalese soils from both local and national perspectives. Authors from geology, environmental, and soil backgrounds together combined their efforts to make this book informative. The affiliation of authors to different institutions, such as the Nepal Agricultural Research Council, Kathmandu University, Institute of Forestry, Institute of Engineering, the International Fertilizer Development Center, the University of Tennessee-Knoxville, New Mexico State University, University of New England, and Chinese Academy of Sciences, among others, showed a wide range of collaboration. This collaborative work helps to shape the book chapters concisely and comprehensively for the global academic community.

Lalitpur, Nepal
Knoxville, USA

Roshan Babu Ojha
Dinesh Panday

Acknowledgments

This book, *The Soils of Nepal*, would not be possible in the current shape without the support of our valuable authors who agreed to write each of its chapters. Our sincere thanks go to all lead authors and co-authors of this book. We are grateful to Dr. Renuka Shrestha, Chief of Agronomy Research Center, NARC, for her valuable suggestions; Prof. Roshan Man Bajracharya for reviewing chapter “soil issues and future perspective”; and are equally grateful to Dr. Deepak Bhandari, Executive Director of NARC, for providing a graceful foreword. We would also like to thank Mr. Ian Rogers for his English editing service, Er. Bikesh Twanabasu for mapping, Mr. Suresh Rettagunta facilitating during book publication process, and series editor Prof. Alfred E. Hartemink for providing critical review and feedback on the book. Additionally, this book would not come to this shape without the reference work and data collected by several researchers and institutions. We would like to pass our immense gratitude to all those who involved including National Land Use Planning project, Nepal. Finally, we received immense support and best wishes from our senior soil scientists, fellows, and family members, and wish to send them all a great round of applause.

Roshan Babu Ojha
Dinesh Panday

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About the Editors

Roshan Babu Ojha (M.Sc. Ag., 2014; B.Sc. Ag., 2012 Tribhuvan University), a Ph.D. candidate at the University of New England, Australia, is a soil scientist to the National Soil Science Research Centre, Nepal Agricultural Research Council (NARC) since 2015. Before joining NARC, he worked as an Assistant Professor at Purwanchal University and taught several courses of soil science. Soil fertility, soil carbon, and pedology are his field of expertise. As a national focal point from Nepal, he represented the Global Soil Partnership (GSP) program of Food and Agriculture Organization of the United Nations (UNFAO), Rome, Italy from 2016 to 2018. He is an awardee of “Young Scientist” award (2017) presented by Society of Agriculture Innovation and Development, India and “Outstanding Contribution Scientist in Soil Conservation” award (2018) jointly presented by the GSP, UNFAO, Italy and the organizing committee of soil health and sustainable development international symposium, China. Realizing the immense potentiality of soils in our life, he is keen to learn and share soil science language to the scientific and local community. Besides, he is fond of having expeditions and excursions, tasting new foods, triumphing with nature, and understanding people and culture.

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Abstract

Agriculture, the cultivation of food and goods through farming, began in Nepal thousands of years (yr) ago with bench terraces in the hillslopes, one of the most unique cropping landscapes in the world. Manipulation of soil in these bench terraces exhibits the soil reference group ‘Anthrosols’ as per world soil reference base, or ‘Anthropic epipedon’ as per the United States Department of Agriculture soil classifications. However, active weathering is still prevalent in the soils of Nepal and generally referred to as ‘young soil’. That is why the soils of Nepal lack a large area of old-aged soils such as ‘Oxisols,’ ‘Histosols,’ and ‘Vertisols.’ Climate and geology affect the formation of soil and different types of soils can be found in different climate and geological settings (Chaps. 3 and 4). Newly developed and fragile soil including ‘Entisols’ and ‘Inceptisols’ with ‘colluvial’ or ‘alluvial’ materials covered more than 50% of the total soil area in Nepal (Chaps. 6 and 7). These soils are abundantly distributed in Tarai (also spelled as Terai), Siwaliks, and the middle-Mountains (Chaps. 4 and 5) regions of Nepal. Due to their fragile nature, they are easily eroded by water, and require a proper land management strategy (Chap. 10). For proper land management, it is necessary to understand the intrinsic soil properties and inherent fertility of the soil (Chaps. 8 and 9). Additionally, we valued soil as it is worthy to human beings (Chapter 11). In this book, we delve into the wide array of young Nepalese soils that are of particular interest to the global academic fraternity. For these reasons, we have organized this book into 12 chapters.

Keywords

Book overview • Chapter summary • Nepal • Young soil

1.1 Introduction

In the second chapter the authors provide a brief history of soil science development in Nepal. As stated earlier, cultivation in Nepal began ages ago. The authors present evidence that cultivation began in the region starting in 1,000 BC with reference to the ‘Vedic’ (the infamous Eastern mythological document) land classification system. Our ancestors were aware of soil conservation, and thus built bench terraces to control soil erosion. However, our government realised the importance of the soil institution very late. Only after 1957 was a formal soil unit established under the Department of Agriculture. In this chapter, the authors focus on how the soil science institute was established and how soil science research was developed in Nepal. The authors then present the progress of soil science development under different political regimes. They mentioned soil research institute (the soil science division, now known as the National Soil Science Research Centre) was established under the Nepal Agricultural Research Council in 1991 and is the only formal government institution with a soil research mandate. The authors then summarize the research work of different research and academic institution of Nepal. In the similar manner, the authors create an overview of soil science education in Nepal.

In the third chapter, the authors present an overview of the climatic system in Nepal. Five major climatic zones (‘Tropical,’ ‘Subtropical,’ ‘Temperate,’ ‘Sub-alpine,’ and ‘Alpine’) exist in Nepal, with a drift in climate within a short gradient toward the north. The authors illustrate this drift in maps according to physiographic regions. This chapter informs readers about the climatic zones, their spatial extent, and major cultivated crops in the respective climatic zones.

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The authors explained the climatic seasons, climate, and precipitation trends of Nepal. Information on natural hazards such as floods, droughts, frosts, and cold wave trends of Nepal are supported by the literature. It is interesting to understand the soil development in different agro-ecozones and how climate change impacted the soil-forming process in Nepal, and this chapter informs readers about the climatic zones of Nepal and their relationship with these soil-forming factors.

In the fourth chapter, the authors present the geology of Nepal. Authors provide evidence of the origin of the Nepal Himalayan region due to the collision of the Indian and Eurasian plates, which occurred around 30 million (M) yr ago (late Eocene to Oligocene period) during the period new/modern life began. Since that time, the geology of Nepal has been continuously moving and soil formation still accelerating due to this dynamic geology. This dynamism is well depicted in maps and is described in this chapter. The authors describe the five geological sub-divisions of Nepal ('Tibetan-Tethys zone,' 'Higher Himalaya,' 'Lesser Himalaya,' 'Siwaliks,' and 'Indo-Gangetic Plain') along with the five physiographic zones ('High Mountain,' 'Middle mountain,' 'Hill,' 'Siwaliks,' and 'Tarai'). The authors provide field images of the geological zones and physiographic zones that manifest the clarity of this chapter. Furthermore, readers will learn how the geologic divisions of Nepal differ in terms of geologic origin and their temporal and spatial extent. Similarly, the authors explain the differences in altitude, parent materials, and dominant climate types between the physiographic zones.

In the fifth chapter, the authors illustrate the land use and land cover change in Nepal. Land is a vital and scarce resource, and the interaction between human activities and land use affects the ecosystem, landscape dynamics, and overall economy of a nation. These interactions are both positive and negative, and the authors present evidence covering the past 100 yr of land use and land cover change in Nepal. The dynamics of change between agricultural land and forested land is a worldwide issue, and Nepal is no exception. This chapter depicts how deforestation is linked with the expansion of agricultural areas as the authors review land use and land cover patterns of Nepal along with their change over time. Authors categorize land use and land cover into agricultural land, barren land, forested land, built-up area, shrub/grassland, snow/glacier/water bodies, and other types of land. The chapter further discusses the land tenure system and land use policies of Nepal as the authors identify the constraints and strengths of sustainable land use management and provide perspectives for better management of the land. In summary, this chapter informs the land use and land cover status of Nepal over the past 100 yr and provides a way forward for sustainable land use management.

In the sixth chapter, the author explains the formation of the soil and its associated factors in Nepal. Soil formation in Nepal is active and the recent products of weathering can be found there. Hill slopes are continuously eroding, which results in the loss of soil sediment from the source and deposition of the sediment across the river valleys and Tarai plain. Different types of parent materials are found in Nepal in the different physiographic zones. The author lists all the dominant rocks and minerals found in Nepal. In this chapter, it will be interesting for readers to learn about the driving factors of soil formation and resultant soil types specific to the different physiographic regions of Nepal. The author concludes the chapter with the imperatives for sustainable land management in Nepal focusing on the outlook of soil formation. In summary, this chapter reports on key soil-forming factors, dominant parent materials and soil types and future priorities and outlook for sustained land management from the point of soil formation.

In the seventh chapter, the authors classify the soils of Nepal and present the types of soils found in the different physiographic zones. Each of the physiographic regions is subdivided into different land morphological units. Soils in each morphological unit are different and the dominant soils in each morphological unit are well described. In this chapter, soil types are explained in terms of both the United States Department of Agriculture soil classification system and the World Reference Base soil classification system. This is the chapter that carries the essence of this book, and as a result, the authors have gone to great lengths to make it more informative. While a large quantity of information is available on the soil classification of Nepal, the authors only highlight the dominant soils found in each land morphological unit. Furthermore, the authors add examples of the soil profile descriptions typical to each dominant soil type along with location information.

In the eighth chapter, the authors explain the soil properties of Nepal, including the interaction of physical, chemical, and biological properties of soil governed by the distribution of soil particles or size fractions and influenced by soil-forming factors. This interaction regulates most of the soil processes that deliver different ecosystem functions and are a source of food for terrestrial life. The soils of Nepal are attributed with a mostly low to medium clay content. This attribution governs most of the soil characteristic features. In this chapter, the authors gather information on the physical, chemical, and biological properties of the soils of Nepal. Soil acidity is one of the major issues facing Nepalese soils. The authors explain why acidity is a major factor in Nepalese soils and provide ways to manage this problem. They review the status of major and micronutrients throughout Nepal with some interesting research results. The information on soil microbial diversity, which itself is a scanty work in the Nepalese context, is of great importance