अधिक जानकारी के लिए कृपया सम्पर्क करें:

मुख्य मृदा सर्वेक्षण अधिकारी,
भारतीय मृदा एवं भू-उपयोग सर्वेक्षण
कृषि, सहकारिता एवं किसान कल्याण विभाग,
भारतीय कृषि अनुसंधान संस्थान परिसर (पूसा) , नई दिल्ली - ११००१२
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सतत भूमि प्रबंधन के लिए मृदा संसाधन सूचना संग्रह, उत्तराखंड

Compendium of Soil Resources for Sustainable Land Management of Uttarakhand

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सतत भूमि प्रबंधन के लिए मृदा संसाधन सूचना संग्रह, उत्तराखंड

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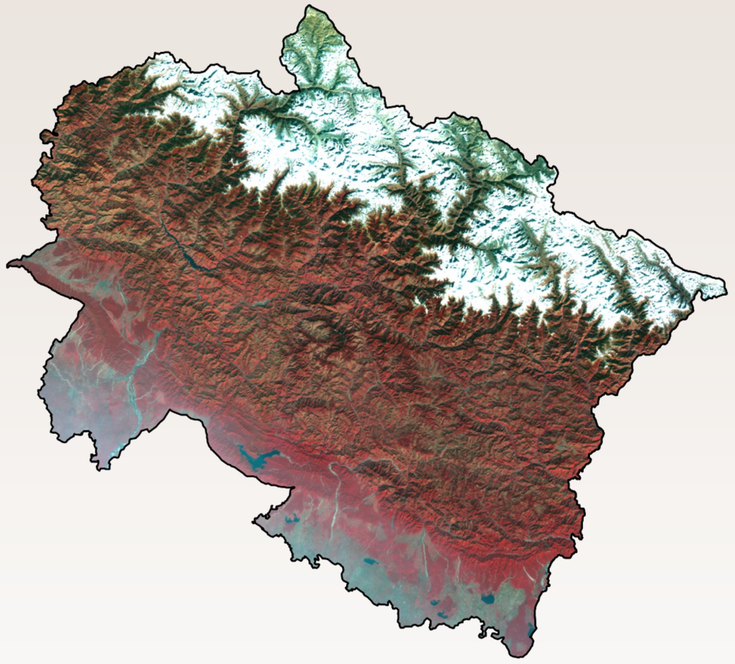

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Soil and Land Use Survey of India

कृषि, सहकारिता एवं किसान कल्याण विभाग

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Ministry of Agriculture and Farmers

भारत सरकार
Government of India

“सतत भूमि प्रबंधन के लिए मृदा संसाधन सूचना संग्रह, उत्तराखंड”

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Soil and Land Use Survey of India
(Department of Agriculture, Co-operation & Farmers welfare)
Ministry of Agriculture & Farmers Welfare
Government of India
I.A.R.I. Buildings, PUSA
New Delhi- 110 012

प्रस्तावना

जीवन सहायक प्रणाली के लिए भूमि और पानी सबसे कीमती प्राकृतिक संसाधन हैं। भोजन और अन्य जरूरतों की बढ़ती मांग के तहत घटते प्राकृतिक संसाधन तथा इसके स्थायी प्रबंधन का अभाव, प्राकृतिक संसाधन पर दबाव बना रहा है। विकास के विशेष संदर्भ में भूमि संसाधनों से संबंधित आजीविका मुद्दो पर वास्तविक समय की जानकारी आर्थिक क्षेत्रीकरण समय की आवश्यकता है।

खाद्य और पोषण सुरक्षा के लिए उपज की पर्याप्तता एवं मृदा के सतत रखरखाव प्रबंधन के लिए भूमि संसाधनों की उत्पादकता में सुधार करना बड़ी चुनौती है। इन के तहत मृदा, प्रकृति, उनकी विस्तार, विशेषताओं और उपयोग की क्षमता का ज्ञान स्थायी आधार पर भूमि उपयोग नियोजन मे महत्वपूर्ण है। योजनाकारो के लिए मृदा अपरदन एवं अन्य कारणो से हो रहे बदलाओ को मॉनिटर करने के लिए मृदा बहुमूल्यता की जानकारी आवश्यक है।

क्षेत्र में उपलब्ध मृदा एवं भूमि संसाधनों की वास्तविक क्षमता का दोहन करने के लिए 1:50,000 पैमाने पर एक व्यवस्थित मृदा संसाधन सूची की योजना बनाई गई । यह संसाधन मानचित्र विभिन्न मृदा प्रकार, सीमा और विस्तार, उनकी प्रकृति, विशेषताओं, समस्या और क्षमता पर एक जानकारी प्रदान करते हैं, ताकि न केवल राज्य के प्राकृतिक संसाधन आधार को बढ़ाने के लिए रणनीतियों का विकास किया जा सके बल्कि भविष्य में मानव सभ्यता की आवश्यकता को बनाए रखने के लिए पारिस्थितिक संतुलन बनाए रखा जा सके। ।

मृदा संसाधन मानचित्र में कई मृदा मानचित्रित इकाइयाँ दिखाई देती हैं और इसमें प्र्प्तेक एकाई मे निर्मित मुदाओ के लिए एक या एक से अधिक मृदा श्रेणिया का मृदा वर्गीकरण शामिल हैं । इन मानचित्रत इकाईया / मैप यूनिटस मे मृदा संबधित भू-आकृति, ढलान, मृदा श्रेणियाँ, उपयोग और मृदा प्रकारो को प्रदर्शित किया है , इसके लिए लैंडस्केप यूनिट को चरणों की संख्या में विभाजित किया गया है। उपयोगकर्ता एजेंसी की आवश्यकता को देखते हुए विषयगत मानचित्रन के तहत मृदा संसाधन मानचित्र में मृदा वर्गीकरण नाम के अलावा मृदा की बनावट, गहराई, जल निकासी, कटाव, जैविक कार्बन आदि का वर्णन करती है। मृदा संसाधन का नक्शा मानचित्रण इकाइयों के साथ निर्मित किया गया है।

मैं, भारतीय मृदा एवं भू-उपयोग सर्वेक्षण के अधिकारियों और कर्मचारियों को मृदा संसाधन मानचित्रण को प्रकाशन में लाने के लिए किए बधाई और सराहना करती हूं। यह बुलेटिन भूमि उपयोग को अधिक तर्कसंगत बनाने के साथ विभिन्न भूमि उपयोगकर्ताओं जैसे कृषक, प्रशासक , योजनाकारों के लिए अत्यधिक उपयोगी होगा। यह स्थापित मृदा विज्ञान पर अनुसंधान करने और क्षेत्र में पाई जाने वाली विभिन्न मृदा श्रेणियों पर प्रौद्योगिकी विकसित करने में अनुसंधान वैज्ञानिको की मदद करेगा। मृदा बुलेटिन मृदा संसाधन के उपयोग को अनुकूलित करने और लंबे समय तक टिकाऊ आधार पर फसलों एवं पौधों की उत्पादकता बढ़ाने में एक मिल का पत्थर साबित होंगा।

(रजनी तनेजा)
मुख्य मृदा सर्वेक्षण अधिकारी

PREFACE

Land and water are the most precious natural resources for the life supporting system. The sustainable management of these depleting natural resource base under ever growing demand for food and other needs are building pressure on natural resource base. The real time information on livelihood issues related to land resources is need of hour with special reference to economic zoning of area for development.

There is big challenge to improve productivity of land resources to ensure sufficiency of produce for food and nutritional security and discourage unsustainable management of soils. Under these conditions, the knowledge of soils, nature and extent of their distribution, characteristics and use potential has gain importance in optimizing land use on sustainable basis. The wealth of soil information is needed to educate the planner how to enrich and monitor the changes in characters of soils when put in different uses.

In order to harness the true potential of soil and land resources available in area a systematic soil resources inventory at 1:50K scale was planned and undertaken state. The maps provide an information on the kind, extent and distribution of different soils, their nature, characteristics, problem and potential so as to develop strategies not only to increase the natural resource base of state but also maintain ecological balance to sustain the future generation need.

The soil resources map shows several soil map units and comprises one or more soil family most important soil classification category for determining vegetation growth. The landscape unit has been divided in number of phases to create map unit useful in predicting land form characters such as land slope, physiography and use for management and behavior of soils. From the soil resource map number of thematic map generated looking in to need of the user agency. The legend narrates the soil properties such as texture, depth, drainage, erosion, etc. besides the soil taxonomic name for understanding of soil taxa on different platform (National and International). The soil map was generated with mapping units.

I congratulate and appreciate the team efforts of officers and officials of Soil and Land Use Survey of India for bringing in the publication. The bulletin will be of immense use to different land users including framers, administrator and planners for rationalizing the land use. It will also help research workers in undertaking the research on established soils and in developing technology on different soils found in the region. The soil bulletin will go a long way in optimizing use of soil resource and increase in productivity of crops and plants in long run on sustainable basis.

(Rajni Taneja)
Chief Soil Survey Officer

भारतीय मृदा एवं भू-उपयोग सर्वेक्षण

भारतीय मृदा एवं भू-उपयोग सर्वेक्षण (SLUSI), कृषि, सहयोग और किसान कल्याण विभाग के तहत कृषि और किसान कल्याण मंत्रालय, भारत सरकार नई दिल्ली, द्वारा स्थापित एक प्रमुख संगठन है। इसे मुदा और भूमि उपयोग सर्वेक्षण के कार्य का संचालन करने के लिए स्थापित किया गया था। संस्था विगत साठ वर्षो से विभिन्न पैमानों पर भू स्थानिक प्रोद्योगिकी का इस्तेमाल कर मृदा सर्वेक्षण द्वारा स्थानिक मृदाओ के प्रकार, सीमा और विस्तार, उनकी प्रकृति, विशेषताओं, समस्या और क्षमता पर आंकड़ो एवं नक्शो का निर्मान का कार्य संपादित कर रही है । मृदा सर्वेक्षण कृषि एवं मृदा के सतत रखरखाव प्रबंधन के लिए की मिट्टी और भूमि संसाधनों की जानकारी प्रदान कर रहा है। इन सर्वेक्षणो मे भौगोलिक एवं /या प्रशासनिक स्थान निर्दिष्ट क्षेत्र या वाटेर्शेड्स के भीतर वर्तमान वास्तविक स्थिति दर्शाने वाले मानचित्र (उपग्रह चित्र) का उपयोग कर मृदा सर्वेक्षण और मैपिंग कर स्थानिक जानकारी एकठा की जाती है। यह संभावित कृषि क्षेत्रों को रेखांकित करने एवं चयनित कृषि क्षेत्रों का विकास, योजना और प्रबंधन में सहायक है

मृदा और भूमि उपयोग मानचित्रण का कार्य भारतीय मृदा और भूमि उपयोग सर्वेक्षण के वर्तमान में दो स्तर किया जा रहा हैं- प्रत्येक स्तर डेटा संग्रह की एक अलग तीव्रता का प्रतिनिधित्व करता है। जिस से, गावों,तहसील स्तर या फिर जिले/रेज्य एकाई मे कृषि भूमि विकास की जरूरतों और प्राथमिकताओं को पूरा करने के लिए एक सुव्यवस्थित योजना /कार्यक्रम तैयार किया जा सके।

दो स्तरों पर विकसित मृदा और भूमि उपयोग डेटाबेस हैं:

टोही मृदा सर्वेक्षण (1: 50,000 पैमाने)

i) प्राथमिकता परिसीमन सर्वेक्षण
ii) भूमि क्षरण सर्वेक्षण
iii) मृदा संसाधन मानचित्रण

विस्तृत मृदा सर्वेक्षण (1:4000, 1:8000 से 1:10,000 पैमाने पर कैडस्ट्राल, हवाई फोटो और उच्च रिज़ॉल्यूशन उपग्रह डेटा)।

इन दोनों सर्वेक्षण में मृदा सर्वेक्षक और अधिकारियों द्वारा अध्ययन, पहचान और मिट्टी और भूमि के उपयोग का सीमांकन, सुदूर संवेदी उपग्रह विकास के अंतर्गत रिमोट सेंसिंग और जीआईएस का उपयोग करके सही जानकारी प्राप्त की जाती है। SLUSI राष्ट्रीय स्तर यह कार्य बैंगलोर, नोएडा, कोलकाता, नागपुर, अहमदाबाद, रांची और हैदराबाद में सात क्षेत्रीय केंद्रों के माध्यम से चला रहा है। संगठन मृदा सर्वेक्षण के क्षेत्र में उपयोगकर्ता एजेंसियों के अधिकारियों को प्रशिक्षण प्रदान कर रहा है। यह डेटाबेस के राज्य कृषि, वन विभाग और राज्य भूमि उपयोग बोर्ड संस्था मे विभिन्न कार्यक्रमों के क्रियान्वयन मे उपयोग लाया जा रहा है ।

"उत्तराखंड के सतत भूमि प्रबंधन के लिए उत्तराखंड के सतत भूमि प्रबंधन के लिए मृदा संसाधनों का संकलन" पर प्रकाशन, उत्तराखंड राज्य के तेरह जिलों के मृदा संसाधन मानचित्रण का संचालन करके SLUSI द्वारा विकसित डेटाबेस का परिणाम है। यह प्रति इकाई क्षेत्र में अधिकतम उत्पादन के लिए व्यवहारिक और टिकाऊ कृषि भूमि उपयोग योजनाओं को विकसित करने में मदद कर सकता है।

ABOUT SLUSI

Soil and Land Use Survey of India (SLUSI), New Delhi, a premiere organization of department of Agriculture, Cooperation and Farmer Welfare under Ministry of Agriculture and farmer welfare, Government of India, was established in 1958, mandated to conduct soil and land use surveys at different scales. Soil survey provides information on the soil and land resources of the farming community. The principal activity is the characterization of soils, soil properties and soil suitability for agriculture, forestry, pasture development and presenting the information of location with spatial extent by mapping on suitable base map within suitable framework i.e. watershed of designated area/tehsil district etc. the information is instrumental in outlining potential agriculture areas, the development, planning and management of selected agriculture areas. The program also provides technical advice to the farming community and state user department viz. agriculture, forest, irrigation, rural development on the adaptability of soils for various crops, trees/orchards, soil and water conservation planning and for other purposes, limitation of the in present use for sustainable agriculture development by using Remote sensing and Geographic information system.

The soils and land use mapping services section of Soil and Land Use Survey of India currently have two levels of soils and land use data- each level represents a different intensity of data collection. As such, the soil survey program has been prepared to fulfill the needs and priorities of the agricultural land development.

The soil and land use database developed on two levels are:

Reconnaissance Soil Survey (1:50,000 scale)

i) Priority delineation survey
ii) Land degradation survey
iii) Soil resource mapping

Detailed Soil Survey (from 1:4000, 1:8000 to 1:10,000 scale using cadastral, aerial photo and high resolution satellite data). Each type of survey involves scientific study of soils, identification and demarcation of the soil and land use information accurately by using remote sensing and GIS in field survey with ultimate objective of sustainable agriculture development. The SLUSI has the mandate to carry out field surveys to identify & map soils of the country and develop land use plan. The SLUSI is implementing its mandate through seven regional centres at Bangalore, Noida, Kolkata, Nagpur, Ahmadabad, Ranchi and Hyderabad are involved in soil resource mapping, soil correlation, classification and in land use planning. The organization is also imparting training to officers of the user agencies in the area of soil survey, soil survey interpretations for land use planning using recent advances in remote sensing and GIS which are essential part of integrated Watershed Development Programme. The SLUSI working in collaboration with SAC, NRSC, State Agriculture, forest department and state land use board to develop scientific soil database for sustainable agriculture development.

The publication on **"Compendium of Soil Resources for Sustainable Land Management of Uttarakhand for Sustainable Land Management of Uttarakhand"** is the outcome of the database developed by the SLUSI by conducting Soil Resource Mapping of thirteen districts of Uttarakhand state. It may help to evolve viable and sustainable agricultural land use plans for maximizing production per unit area.

इस की प्रतियों के लिए संपर्क सूत्र:

मुख्य मृदा सर्वेक्षण अधिकारी,
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CONTENTS

अध्याय १

परिचय

प्राकृतिक संसाधन जीवन मे मूलभूत उपयोग मे आने वाले चीजों और सार्वजनिक सेवाएँ प्रणाली प्रदान करते हैं। मृदा यह प्राकृतिक पारिस्थिति की तंत्र को स्थायी आधार प्रदान करने वाला प्राकृतिक संसाधन है, बढ़ती आबादी के साथ अपनी बुनियादी जरूरत को पूर्ण करने लिए मृदा को उच्च उत्पादकता की स्थिति में बनाए रखना अति महत्वपूर्ण है।

इष्टतम भूमि उपयोग योजना विकसित करने हेतु मृदा एवं भूमि विशेषताओं पर पर्याप्त जानकारी का संग्रह करना एक व्यवहार्य रणनीति तैयार करने के लिए जरूरी है। प्राकृतिक पारिस्थिति की तंत्र के संरक्षण और स्थायित्व को ध्यान में रखते हुए विभिन्न भूमि विकास कार्यक्रम मे साइट-विशिष्ट मास्टर प्लान तैयार करने के लिए उत्तराखंड राज्य के सभी जिलों के मृदा संसाधनों पर एक स्थानिक डेटाबेस तैयार करने का प्रयास किया गया है ।

यह क्षेत्र हिमालय पर्वत श्रुखला के केंद्र में स्थित है, जो की पूर्वी हिमालय के आर्द्र और पश्चिमी हिमालय शुष्क से लेकर उप-आर्द्र क जल वायु के बीच के क्षेत्र मे आता है।

बढ़ती हुई जनसंख्या की बढ़ती जरूरतों के परिणामस्वरूप पर्यावरणीय संसाधनों जैसे कि वनों और घास के मैदानों, जल संसाधन आदि का शोषण होता है। पर्यावरण का बहुत अधिक क्षरण इस पर निर्धरित होता है। राज्य के क्षेत्र को ऊंचाई वर्ग के आधार पर स्थानिक वितरण से यह पता चलता है कि राज्य के कुल भौगोलिक क्षेत्र में से लगभग 26.00% 200 - 1000 मीटर की ऊँचाई के बीच स्थित है, 1000 - 3000 मीटर मे लगभग 46.00% और 3000 मीटर से अधिक लगभग 28.00% क्षेत्र में आता है। राज्य की जनसंख्या मुख्य रूप से आजीविका के लिए कृषि पर निर्भर करती है; लगभग 70% आबादी कृषि में लगी हुई है। कुल सूचित क्षेत्र में से केवल 20.37% कृषि भूमि उपयोग के अंतर्गत है। राज्य में उपलब्ध खेती योग्य भूमि मे 55.00% से अधिक के क्षेत्र पर वर्षा होती है। फसल की गहनता 160.6% है। भूमि जोत अधिकतर छोटे और सीमांत किसानी के अंतर्गत आते हैं। पहाड़ियों में औसत भूमि जोत 1 हेक्टेयर से भी कम है (वह भी कई पैच में विभाजित है) और मैदानी इलाकों में 1.77 हेक्टेयर।

किसी भी क्षेत्र के उपयोग को अनुकूलित करने के लिए कार्यात्मक योजना तैयार करना जरूरी है। इसके लिए मृदा एवं भूमि संसाधनों की वर्तमान दशा पर विवरण कर डिजिटल डेटाबेस को अदयावत करना आवश्यक है। भारत सरकार ने उत्तराखंड राज्य को मृदा संसाधन मानचित्रण के माध्यम से जिलावार मृदा संसाधन सूची तैयार करने के लिए भारतीय मृदा एवं भूमि उपयोग सर्वेक्षण (एसएलयूएसआई) को कार्य सौंपा था। जिसमें रिमोट सेंसिंग और भौगोलिक सूचना प्रणाली (जीआईएस) तकनीक का उपयोग कर 1:50K स्केल सर्वेक्षित किया गया है।

उद्देश्य:

उत्तराखंड के तेहरह जिलों की मृदा एवं भूमि उपयोग का डेटाबेस IRS-LISS-III सेंसर द्वारा निर्मित उपग्रह डेटा का उपयोग करते हुए 1: 50,000 पैमाने पर आधारभूत मानचित्र के रूप में प्रमुख उद्देश्यों के साथ निर्माणकिया गया:

1. उत्तराखंड राज्य में विभिन्न प्रकार की मृदा एवं भूमि उपयोग की पहचान करना और उनका वर्गीकरण करना।
2. मृदा फॅमिली एवं श्रेणीओ का जिलेवार मृदा एवं भूमि उपयोग संसाधन मानचित्र तैयार करना।
3. विभिन्न मृदा की भूमि उपयोग मे क्षमता की पहचान और लक्षण वर्णन करना ।
4. मृदा सर्वेक्षण डेटा मे राज्य के विषयगत मानचित्र के माध्यम से विवेचन कर प्राकृतिक संसाधनों के स्थायी प्रबंधन को बढ़ावा देना।

CHAPTER 1

INTRODUCTION

Natural resources provide fundamental life support system in the form of both consumptive and public good services. Soil is most precious natural resource, maintaining soil in state of high productivity is important for providing ever-increasing population with their basic need on sustainable basis.

Acquisition of adequate information on soil and land characteristics is thus, prerequisite to formulate a viable strategy to develop an optimal land use plan. Keeping this in view, an attempt has been made to generate a spatial database on soil resources of all districts of Uttarakhand state to frame site-specific master plan for various land development programme for protection and restoration of natural ecosystem.

The region, being situated centrally in the long sweep of the Himalaya, forms a transitional zone between the per-humid eastern and the dry to sub-humid western Himalaya.

Increasing needs of growing population is resulting in squeezing of environmental resources such as forests and grasslands, water resource, etc. Much of the environmental resource degradation is governed by it. The altitude zones wise spatial distribution of area of state shows that out of total geographic area of the state about 26.00 % is located between the height 200 to 1000 m, that in 1000 - 3000 m is about 46.00% and above 3000 m about 28.00 % of area of the state. The population of the state primarily depends on agriculture for livelihood; about 70 % of the population is engaged in agriculture. Out of total reported area, only 20.37 % is under agriculture land use. More than 55.00% of the cultivated land in the state is rainfed. The cropping intensity is 160.6%. The land holdings are small and scattered. The average land holding is less than 1 ha (that too is divided into many patches) in the hills and 1.77 ha in the plains.

The acquisition of real time digital database as soil & land resources is essential prerequisite for preparing functional plan for optimizing the use of any area. The Government of India has entrusted the task to Soil and Land Use Survey of India (SLUSI) for the preparation of district wise Soil Resource inventory through soil resource mapping the State of Uttarakhand, using remote sensing and geographical information system (GIS) technique at 1:50,000 scale.

OBJECTIVES:

The database on soil and land of all thirteen districts of Uttarakhand generated using IRS-LISS-III satellite data as base map at 1:50,000 scale with following major objectives.

1. To identify and classify different types of soils in Uttarakhand state.
2. To generation district wise Soil and Land resource map with soil family association.
3. Identification and characterization of nature and extent of different soils.
4. To promote sustainable management of the natural resources through Interpretation of soil survey data and generation of thematic map of state.

अध्याय २

प्रमुख निष्कर्ष - मृदा संसाधन का मानचित्रण

उत्तराखंड राज्य, भौगोलिक स्थिति 28°43' - 31°27' उत्तर अक्षांश और 77°34 - 81°02' पूर्व देशांतर के बीच स्थित है एवं इसका भौगोलिक क्षेत्र 53,48,379 हेक्टेयर है। उत्तराखंड राज्य भौतिक विज्ञान, जलवायु, भूविज्ञान और प्राकृतिक वनस्पतियों में व्यापक विविधता से संपन्न है, जो मृदा की एक विशाल विविधता के विकास के लिए जिम्मेदार हैं।

भारतीय मृदा एवं भू उपयोग सर्वेक्षण ने उत्तराखंड राज्य का 1: 50,000 पैमाने पर मृदा संसाधन मानचित्र तैयार कर इसे मुद्रित किया।

भौगोलिक वितरण के संदर्भ में, पर्वतीय क्षेत्र कुल भौगोलिक क्षेत्र के 44,79,397 हेक्टेयर (84.7%) को कवर करते हैं, जिसमे बहुत खड़ी ढलान से (33-50%) से बहुत बहुत खड़ी (> 50%) अविभाजित ढलान वाले पर्वत क्षेत्र आते हैं। इसके बाद जलोढ़ / पीडमोंट मैदान में 6,64,668 हेक्टेयर क्षेत्र में, पैलियो चैनल के तहत 1434 हेक्टेयर, नदी किनारो वाले क्षेत्र मे 23,509 हेक्टेयर और नदी क्षेत्रों में 50-5011 हेक्टेयर क्षेत्र शामिल हैं।

उत्तराखंड राज्य की मृदा 4 मृदा ओर्डर्स - इनसेप्टिसोल, एंटिसोल, मोलिसोल और अल्फिसोल, 10 सब-ओर्डर्स, 17 ग्रेट ग्रुप, 39 सब-ग्रुप और 93 मृदा श्रेणीओ के अंतेर्ग्त है। इन 4 ओर्डर्स में से, इनसेप्टिसोल प्रमुख ऑर्डर है। इनके अंतर्गत उड़ेप्ट्स, उसटेप्ट्स और ओर्थेंट्स प्रमुख सब-ओर्डर्स हैं, हप्लुस्टेप्ट्स, यूडूडेप्ट्स और उड़ोर्थेंट्स ग्रेट ग्रुप हैं।

मृदा संसाधन मानचित्र के आधार पर कई विषयगत मानचित्र, जैसे मृदा कटाव, मृदा गहराई, बनावट, आदि तैयार किए गए हैं। मिट्टी कटाव, मृदा गहराई आदि के बारे में ज्ञान से भूमि उपयोगकर्ताओं को मृदा संसाधन का इष्टतम उपयोग करने में मदद मिलेगी।

क्षमता:

• उत्तराखंड की अलग-अलग भौगोलिक विशेषताओं में प्रमुख रूप से हिमालय पर्वतो के साथ-साथ, तराई और गंगा के मैदानी क्षेत्रों के साथ मिलकर एक अनूठा क्षेत्र बनाता है जहाँ फलों, फूलों और अन्य बागवानी फसलों की किस्मों को उगाना संभव है। औसत समुद्र तल के ऊपर 250 मीटर से 7,187 मीटर तक की ऊंचाई में तीव्र ढलान वाले पर्वत के साथ, विशिष्ट भौगोलिक क्षेत्रों की मौजूदगी कई किस्म के फलों की फसलों के लिए अनुकूल जलवायु की स्थिति को निर्धारित करती है। नतीजतन, उष्णकटिबंधीय से समशीतोष्ण वातावरण मे फलने वाले सभी प्रकार की फलों की फसलें आसानी से उगाई जा सकती हैं। उपयुक्त फसल / बागों / औषधीय जड़ी बूटियों का चयन भौगोलिक परिस्थितियों और मृदा संसाधन के भू-स्थानिक आंकड़ों के अनुसार किया जा सकता है।

• उत्तराखंड में सीढी नुमा कृषि भूमि पर्वत के ढलान पर 15-33% से 33-50% में स्थापित है। चूंकि इस क्षेत्र में वर्षा की तीव्रता अधिक है, इसलिए इस क्षेत्र का उपयोग फसल की तीव्रता बढ़ाने और बागवानी फसलों और औषधीय जड़ी-बूटियों को बढ़ाने के लिए किया जा सकता है।

• औषधीय जड़ी बूटियों और पर्वतीय बागवानी के लिए उत्तराखंड की मृदा एवं पर्यावरणीय कारक आदर्श रूप से उपयुक्त हैं। कम उष्ण – अर्ध-नमी मौसम वाली परिस्थिति में प्रमुख मृदा ओर्डर्स जैसे टिपिक हप्लुस्टेप्ट्स, टिपिक उस्टोर्थेंट्स और शीत-अधिक नमी मौसम वाली परिस्थिति में तहत उस्टारेंट्स, मोलिक उड़ारेंट्स और अल्फिक उड़ारेंट्स प्रेकर की मृदाओ को चिन्हित किया गया है। जिन क्षेत्रों मे नियमित रूप से फसल / हॉर्टिकल्चर बागों के

अलावा औषधीय प्रजातियों की विविधता के लिए इष्टतम मृदा नमी रहती हैं, उन स्थान की विशेषता और मृदा के प्रकार को डिजिटल मैप किया जाता है। विशेष औषधीय / बाग / फसल के प्रकार के चयन में यह डाटाबेस मदद करता है।

• क्षेत्र को ग्रेट ग्रुप के आधार पर हेप्लुडोल्स, आर्जीउड़ोल्स एवं ह्यूमूडेप्ट्स में बांटा गया है जो की गहरी सघन, अच्छी तरह से विकसित संरचना और घने वन वाली भूमि प्रजाति के प्रकार की वनस्पतियों के लिए उपयुक्त है। इस डाटाबेस में राज्य के अन्य जगह मे विकसित इसी प्रकार के मृदा क्षेत्र को मध्य और ऊपरी हिमालयी क्षेत्र मे चिन्हित किया गया है। इन मृदाओ वाले क्षेत्रों को उनके वनस्पतिओ के पोषित करने वाले गुणो के आधार पर बायोस्फीयर रिजर्व के रूप में संरक्षित किया जा सकता है। इन मृदाओ को इनके जलवायु परिवर्तन के दुष्प्रभाव को कम करने क्षमता के आधार पर कार्बन सिंक के रूप मे विकसित किया जा सकता है जो कि आज अति महत्वपूर्ण क्षेत्रों मे एक क्षेत्र होने के संकेत देते हैं।

• मृदा ग्रेट ग्रुप उस्टोर्थेंट्स, उड़ोर्थेंट्स और हैप्लुस्टेप्ट्स मे जो मृदा बहुत अधिक ढलान पर है, जिनमें मृदा गहराई कम है एवं जिसकी बनावट स्केलेटल या खंडित मृदा की तरह होती है, कम उपजाऊ और वृक्षहीन होती है। इन क्षेत्र में भूमि कटाव अधिक होता है तथा मृदा क्षरण, कटाव, भूस्खलन के लिए सबसे संवेदनशील हैं। अतः इसको मजबूती प्रदान करने हेतु इन क्षेत्रों मे भूमि के स्थिरीकरण के लिए स्थायी रूप से वन / घास वनस्पतियों के अधीन रखा जाए, यह राज्य के पर्यावरणीय और सामाजिक-आर्थिक उद्देश्य / जरूरतों को पूरा करेगा।

• डिजिटल मृदा डेटाबेस में शीत-अधिक नमी की स्थिति एवं तापमान श्रेण के तहत पर्वतीय ढलानों पर कृषि उपयोग में ली जाने वाली मृदा क्षेत्रों की जानकारी शामिल होती है। इस स्थान पर मौजूद नमी जैविक कृषि के लिए उपयुक्त स्थिति प्रदान करती है। जैसे कि जैविक गतिविधियों मे किसानों की बढ़ती संख्या ने राज्य में जैविक उत्पादन को बढ़ाया। इसके कारण, राज्य में जैविक खेती के लिए किसानो को प्रेरित करने के लिए जैविक गतिविधियों और इससे सम्बाधित प्रयासों को बढ़ावा देने के साथ समन्वय के लिए एक संगठन का गठन करने की आवश्यकता है।

Major Findings – Mapping of Soil Resource

The state of Uttarakhand located between 28° 43' – 31° 27' N latitudes and 77° 34' – 81° 02' E longitudes with a geographical area of 53,48,379 ha. The state is endowed with wide variation in physiography, climate, geology and natural vegetation, which are responsible for development of a large variety of soils.

Soil and Land Use Survey of India prepared a Soil Resource Map of Uttarakhand state on 1:50,000 scale and it has been printed.

In terms of sheer extent of landmass, Mountainous area cover about 44,79,397 ha (84.7%) of the total geographical area among these, very steep (33-50%) to very very steep (>50%) undifferentiated mountain slopes are equally preponderant. It is followed by 6,64,668 ha area having in alluvial/ piedmont plain, 1434 ha under Paleo channel, 23,509 ha under stream banks/ Dissected stream banks and 50,911 ha covered under River terraces.

Soils of Uttarakhand belong to 4 orders- Inceptisols, Entisols, Mollisols and Alfisols, 10 suborders, 17 Great groups, 39 subgroup and 93 soil families. Among these orders, Inceptisols is the dominant order. Udepts, Ustepts and Orthents are the dominant suborder, Haplustepts, Eutrudepts and Udorthents are dominant great group.

Based on Soil Resource Map, several thematic maps, such as soil erosion, soil depth, texture, etc. have been prepared. Knowledge on extent of soil erosion, soil depth etc. will help the land users to make optimum use of soil resource.

POTENTIALS:

- The distinct geographical features of Uttarakhand with dominantly mountainous part, coupled with Tarai and Ganga plain regions makes it a unique region where it is possible to grow varieties of fruits, flowers and other horticultural crops. With altitude gradient varying from 250 m to 7,187 m above MASL, combination of geographical features determines the climatic condition favorable for many fruit crops. Consequently, nearly all types of fruit crops ranging from tropical to temperate fruits can be grown easily. The selection of suitable crop/ orchards/medicinal herbs can be done as per the geographic conditions and soil type mapped geo spatial data.

- Agriculture is well established in Uttarakhand as side slope of mountain terraces on 15-33% to 33-50% slope class. Since the rainfall intensity in the area is high, the area can be exploited

for increasing crop intensity and for growing horticultural crop and medicinal herbs according to the suitability of terrain and climate.

- Soil and environmental factors of the area are ideally suitable for medicinal herbs and spices. The dominant soils in Thermic-Ustic condition like Typic Haplustepts, Typic Usorthents, and under Mesic-udic conditions Typic Ustarents, Mollic Udarents and Alfic Udarents having possesses the optimum soil moisture suites to the variety of medicinal species apart from regular crop/horticultural orchards. The site characteristic and soil type mapped in digital environment location specifically helps in selection of medicinal/ orchards/crop type.

- Soil of great group Hapludolls, Argiudolls and Humudepts are are having deep ty over deep soil depth, well developed structure, and under dense forest land use suitable for variety of species of mixed deciduous to temperate evergreen type of vegetation. The area of similar soil types occurring in the state may be protected as or by forming biosphere reserves in middle and upper Himalayan region. These soil types signify as areas for carbon sinks crucial in mitigating the ill effects of climate change.

- Soils of great group Udorthents and Ustorthents and Haplustepts on very very steep slope and escarpment are having gravelly, skeletal or fragmental soil texture and posing root zone limitations due to varying soil depth are most sensitive and are vulnerable for degradation, erosion, landslides, should be permanently put under forest/ grass vegetation for land form stabilization also it will serve the environmental and socio-economic purpose/ needs of the state.

- The digital soil data base contains the information on soil series mapped in agriculture use on mountain terraces under Mesic-Udic soil temperature and moisture regime provide optimal condition for organic agriculture. As such increased the number of organic activities and farmers growing organic produce reported in state. Due to this, a great need to constitute an organization to promote and coordinate dispersed organic activities and efforts for organic farming in the state.

STATE PROFILE

3.1 LOCATION AND EXTENT

Uttarakhand which came into existence on 9th November 2000 is the 27th Indian state and the 10th in Himalayan region. The total geographical area of the state is **53,48,379 ha**, of which approximately **84.7%** is mountainous. Of the total geographical area, about **20.03%** is under snow bound/glaciers and steep slopes. The total population of the state is 10.11 million (Census, 2011) Uttarakhand is a part of the North-Western Himalayas bounded by Nepal in the East and Himachal Pradesh in the West. The Northern boundary goes up to Tibet/China, whereas southern boundary extends into Indo-Gangetic Plains. The major North Indian Rivers the Ganga and the Yamuna, originate from this region. Uttarakhand state covers 13 districts within two revenue divisions **(Fig:1 Administrative Map of Uttarakhand).**

3.2 PHYSIOGRAPHY, RELIEF AND DRAINAGE

The mountainous terrain of Uttarakhand consists of series of interlacing ridges rising one above other, from south to the foot of the high peaks, which mark the abode of snow in the North. The Himalayas are divided into the following distinct non-mountain and mountain physiographic zones as follows:

A. Non-mountain

i. Bhabhar: This is a level surface zone at the foothills of the Himalayas 34 km wide containing extremely porous soil type.

ii. Tarai: Situated below the Bhabhar and parallel to it, the Tarai is damp tract having high organic matter containing fertile soils with good water retention capacity.

B. Mountain

i. Sub-Himalayas: It consists of two zones, the **Shivaliks** - the youngest of the Himalayan ranges and the **Doon** (flat longitudinal structural valleys) to the north of Shivaliks. The Shivaliks extend in a narrow varying width of 6 to 30 km with altitudes of 300 to 1000 m.

ii. Mid-Himalayas: This zone extends in a varying width of 60-90 km in an abrupt rise in elevation between 1000 m to 3000 m.

iii. Greater Himalayas: This zone has a varying width of 40-60 km. The altitude varies between 3000-7000 m. Except for lower valleys; this zone is perpetually covered with snow hence called Himadri. The region covers glacial landforms above 3000 m.

Uttarakhand has a highly varied topography, with snow-covered peaks, glaciers, deep canyons, roaring streams, beautiful lakes, and a few patches of dusty plains in the south. Some of the highest mountains in the world are found in Uttarakhand. Most notably, these include Nanda Devi 7,817 m, which are the second highest peak in India, Kamet 7,756 m, and Badrinath 7,138 m.

The state is drained by various rivers of the Ganges (Ganga) system. The western most watersheds are formed by the Yamuna River and its major tributary, the Tons. The land to the east of this basin is drained by the Bhagirathi and the Alaknanda—which join to form the Ganges at the town of Devaprayag and the Mandakini, Pindar, and Dhauliganga, all principal tributaries of the Alaknanda. To the east again are the southward-flowing Ramganga and Kosi Rivers, and draining to the southeast in the same region are the Sarju and Goriganga, both of which join the Kaliganga at Uttarakhand's eastern border with Nepal.

3.3 GEOLOGY

The Himalaya has been geologically divided into four lithotectonic subdivisions (Gansser, 1964). From south to north these are: Outer Himalaya, Lesser Himalaya, Greater or Higher Himalaya and Tethys Himalaya.

3.4 CLIMATE

The climate of Uttarakhand is varies generally from subtropical to alpine depending upon the elevation of the place. Within the same catchment, subtropical even tropical climate is often observed at the lower end of the watershed i.e. in valleys, while temperate climate is prevailing in the upper reaches of the stream.

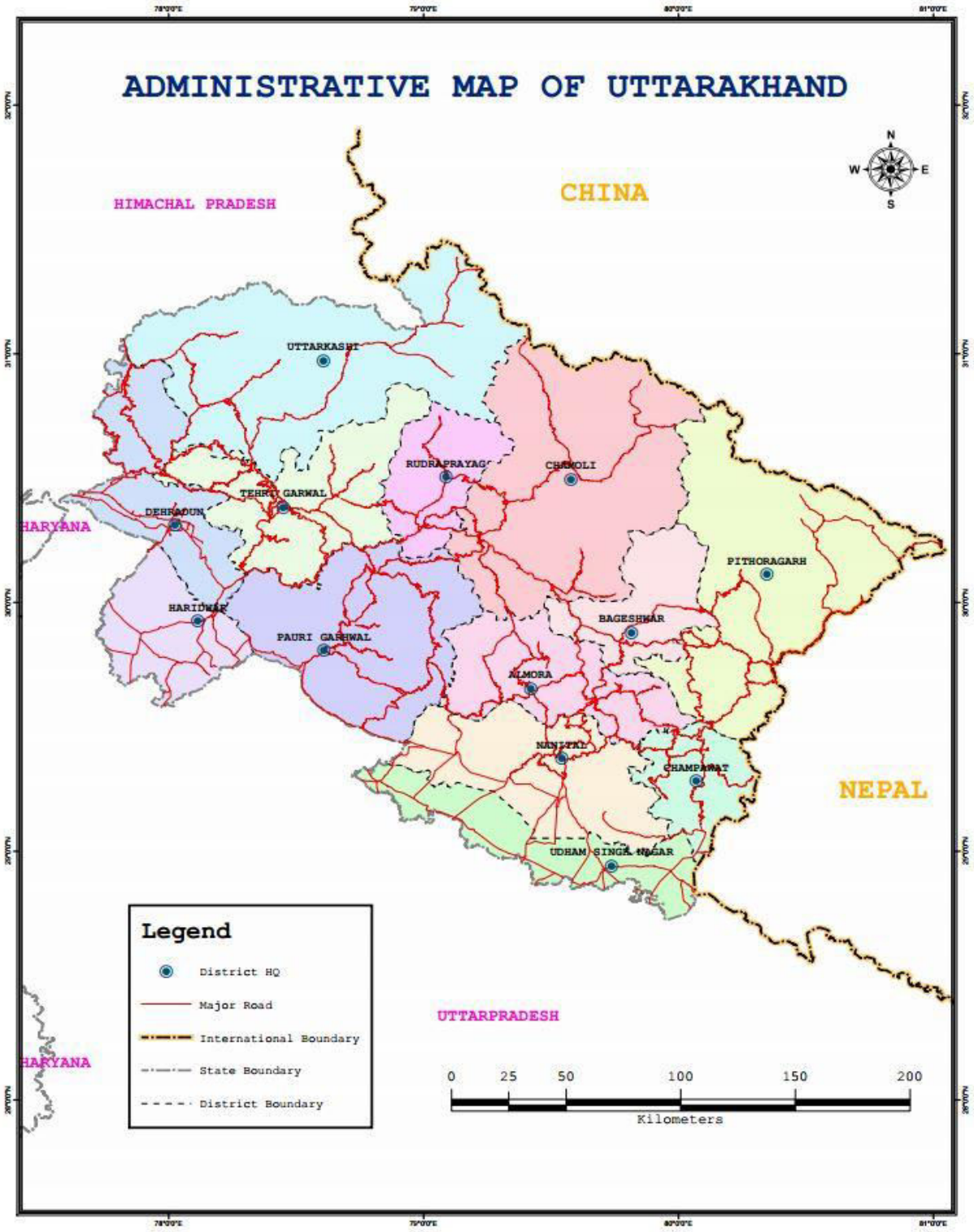
The mean annual rainfall varies from 1100 to 1600 mm with intensity ranging from drizzling to torrential rain. The rainfall is heavy and well distributed in from June to September the wet season accurse during these months, the rainfall is moderate during May and October and the rainfall is low during November to February

Temperate, marked by seasonal variations in temperature but also affected by tropical monsoons. Temperature varies with altitude and slope aspects. It generally decreases with increasing altitudes. Three temperature classes are identified Thermic, Mesic and Isofrigid January is the coldest month in the year.

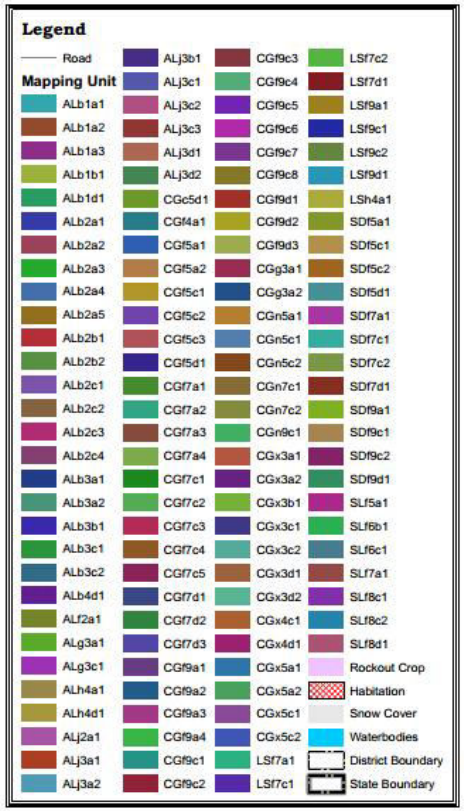
To obtained the better understanding of climate with respect to the land use pattern the following climate types may be distinguished

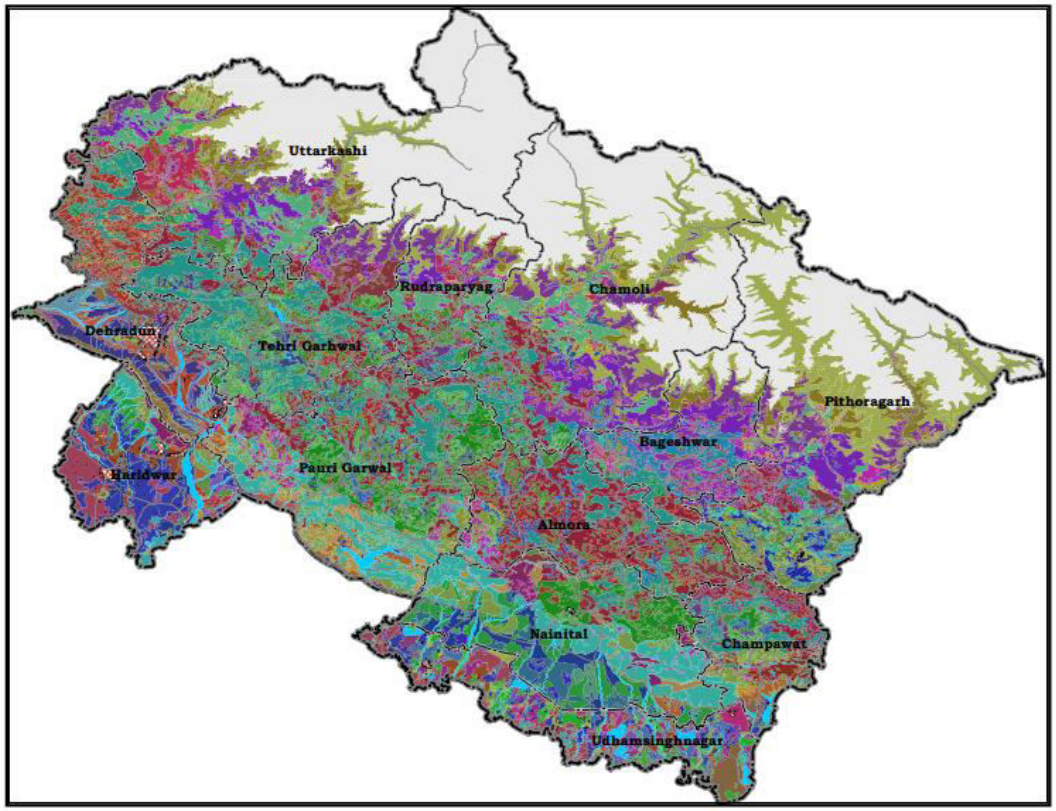
1. Alpine Type- It includes the climate above 4000 m above MSL. The mountain peaks are mostly covered by snow. The precipitations mainly through snowfall. Cultivable lands are not available.
2. Subalpine Type- This includes the climate between 2700-4000 m MSL. During winter it is mostly snow clad and in summer there is intense rainfall.
3. Temperate Type- It comprises climate prevailing between 1500-2700 m MSL. Precipitation is mainly through rainfall. Snowfall is common during winter months of December and January. Heavy rainfall during June-July is the characteristic feature at elevations between 1700-2700 m MSL. Climate is dry with occasional drizzling during winter and heavy rainfall in summer.
4. Subtropical Type- It includes climate at elevations of 500 to 1500 m MSL. The winters are dry and comparatively warm while summers are hot and have comparatively low rainfall.

Figure 1 : Administrative map of Uttarakhand State



Soil Resource Map of Uttarakhand State





40 20 0 40 80 120
Kilometers

Map Prepared By-

Remote Sensing Cell,
Soil and Land Use Survey of India (HQ)
New Delhi

Each unit represents five level mapping, eg.: Alb1a1
AL- Landscape, b- Physiography, 1- slope class, a- Land use, 1- Soil series association

Table 3.1: Mapping Units wise classification showing in soil resource map

Sr No.	Mapping Unit	Landscape	Physiography	Slope %	Land Use	Soil Association	Soil Classification
1	ALb1a1	Alluvium	Alluvial plain/ Flood plain	0-1	Agriculture	1	Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts Fine , Mixed, Hyperthermic, Typic Haplustepts
2	ALb1a2	Alluvium	Alluvial plain/ Flood plain	0-1	Agriculture	2	Fine Loamy, Mixed, Hyperthermic, Fluventic Haplustepts Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts
3	ALb1a3	Alluvium	Alluvial plain/ Flood plain	0-1	Agriculture	3	Coarse Loamy, Mixed, Hyperthermic, Fluventic Haplustepts Coarse Loamy, Mixed, Hyperthermic, Typic Haplustepts
4	ALb1b1	Alluvium	Alluvial plain/ Flood plain	0-1	Plantation	1	Coarse Loamy, Mixed, Hyperthermic, Typic Ustorthents Fine Loamy, Mixed, Hyperthermic, Aquic Haplustepts
5	ALb1d1	Alluvium	Alluvial plain/ Flood plain	0-1	Open scrub	1	Coarse Loamy, Mixed, Hyperthermic, Typic Haplustepts
6	ALb2a1	Alluvium	Alluvial plain/ Flood plain	0-.3	Agriculture	1	Fine Loamy, Mixed, Hyperthermic, Oxyaquic Haplustepts Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts Fine Loamy, Mixed, Thermic, Typic Haplustepts
7	ALb2a2	Alluvium	Alluvial plain/ Flood plain	0-3	Agriculture	2	Coarse Loamy, Mixed, Hyperthermic, Typic Ustifluvents Loamy, Mixed, Hyperthermic, Fluventic Haplustepts
8	ALb2a3	Alluvium	Alluvial plain/ Flood plain	0-3	Agriculture	3	Coarse Loamy, Mixed, Hyperthermic, Typic Haplustepts
9	ALb2a4	Alluvium	Alluvial plain/ Flood plain	0-3	Agriculture	4	Fine, Mixed, Hyperthermic, Vertic Haplustepts
10	ALb2a5	Alluvium	Alluvial plain/ Flood plain	0-3	Agriculture	5	Coarse Loamy, Mixed, Hyperthermic, Typic Ustorthents
11	ALb2b1	Alluvium	Alluvial plain/ Flood plain	0-3	Plantation	1	Loamy Skeletal, Mixed, Hyperthermic, Typic Ustorthents
12	ALb2b2	Alluvium	Alluvial plain/ Flood plain	0-3	Plantation	2	Fine Loamy, Mixed, Hyperthermic, Aquic Haplustepts
13	ALb2c1	Alluvium	Alluvial plain/ Flood plain	0-3	Forest	1	Fine Loamy, Mixed, Hyperthermic, Humic Haplustepts Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts
14	ALb2c2	Alluvium	Alluvial plain/ Flood plain	0-3	Forest	2	Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts Fine, Mixed, Hyperthermic, Dystric Haplustepts
15	ALb2c3	Alluvium	Alluvial plain/ Flood plain	0-3	Forest	3	Fine, Mixed, Hyperthermic, Dystric Haplustepts

16	ALb2c4	Alluvium	Alluvial plain/ Flood plain	0-3	Forest	4	Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts
17	ALb3a1	Alluvium	Alluvial plain/ Flood plain	1-5	Agriculture	1	Coarse Loamy, Mixed, Hyperthermic, Fluventic Haplustepts Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts
18	ALb3a2	Alluvium	Alluvial plain/ Flood plain	1-5	Agriculture	2	Fine Loamy, Mixed, Thermic, Humic Ustorthents
19	ALb3b1	Alluvium	Alluvial plain/ Flood plain	1-5	Plantation	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts
20	ALb3c1	Alluvium	Alluvial plain/ Flood plain	1-5	Forest	1	Coarse Loamy, Mixed, Thermic, Typic Ustifluvents Fine Loamy, Mixed, Hyperthermic, Typic Ustifluvents
21	ALb3c2	Alluvium	Alluvial plain/ Flood plain	1-5	Forest	2	Coarse Loamy, Mixed, Thermic, Typic Ustifluvents
22	ALb4d1	Alluvium	Alluvial plain/ Flood plain	3-10	Open scrub	1	Fine Loamy, Mixed, Hyperthermic, Typic Ustifluvents
23	ALf2a1	Alluvium	Paleo channels	0-3	Agriculture	1	Coarse Loamy, Mixed, Hyperthermic, Aquic Haplustepts
24	ALg3a1	Alluvium	Stream banks	1-5	Agriculture	1	Coarse Loamy, Mixed, Hyperthermic, Aquic Ustifluvents Coarse Loamy, Mixed, Thermic, Typic Ustifluvents
25	ALg3c1	Alluvium	Stream banks	1-5	Forest	1	Sandy, Mixed, Thermic, Typic Psammaquents
26	ALh4a1	Alluvium	Dissected stream banks	3-10	Agriculture	1	Fine, Mixed, Hyperthermic, Oxyaquic Haplustepts Fine, Mixed, Hyperthermic, Vertic Haplustepts
27	ALh4d1	Alluvium	Dissected stream banks	3-10	Open scrub	1	Fine Loamy, Mixed, Hyperthermic, Typic Haplustepts
28	ALj2a1	Alluvium	River terraces	0-3	Agriculture	1	Coarse Loamy, Mixed, Thermic, Typic Ustifluvents Fine Silty, Mixed, Thermic, Typic Fragiudepts
29	ALj3a1	Alluvium	River terraces	1-5	Agriculture	1	Fine Loamy, Mixed, Thermic, Fluventic Haplustepts Fine Loamy, Mixed, Thermic, Typic Eutrudepts
30	ALj3a2	Alluvium	River terraces	1-5	Agriculture	2	Coarse Loamy, Mixed, Thermic, Typic Udifluvents
31	ALj3b1	Alluvium	River terraces	1-5	Plantation	1	Fine Loamy, Mixed, Thermic, Typic Eutrudepts
32	ALj3c1	Alluvium	River terraces	1-5	Forest	1	Coarse Loamy, Mixed, Thermic, Typic Udifluvents
33	ALj3c2	Alluvium	River terraces	1-5	Forest	2	Coarse Loamy, Mixed, Thermic, Dystric Eutrudepts
34	ALj3c3	Alluvium	River terraces	1-5	Forest	3	Fine Loamy, Mixed, Thermic, Typic Eutrudepts
35	ALj3d1	Alluvium	River terraces	1-5	Open scrub	1	Coarse Loamy, Mixed, Thermic, Typic Udifluvents
36	ALj3d2	Alluvium	River terraces	1-5	Open scrub	2	Coarse Loamy, Mixed, Thermic, Dystric Eutrudepts
37	CGc5d1	Complex Geology	Mountain tops	5-15	Open scrub	1	Coarse Silty, Mixed, Mesic, Typic Haplustepts
38	CGf4a1	Complex Geology	Undifferentiated mountain side	3-10	Agriculture	1	Fine Loamy, Mixed, Mesic, Typic Haplustepts Fine, Mixed, Mesic, Haplic Ustarents

39	CGf5a1	Complex Geology	Undifferentiated mountain side	5-15	Agriculture	1	Fine Loamy, Mixed, Mesic, Typic Haplustepts Loamy Skeletal, Mixed, Mesic, Typic Haplustepts
40	CGf5a2	Complex Geology	Undifferentiated mountain side	5-15	Agriculture	2	Fine Loamy, Mixed, Mesic, Mollic Udarents
41	CGf5c1	Complex Geology	Undifferentiated mountain side	5-15	Forest	1	Fine, Mixed, Thermic, Udic Haplustolls
42	CGf5c2	Complex Geology	Undifferentiated mountain side	5-15	Forest	2	Coarse Loamy, Mixed, Mesic, Typic Ustorthents Fine, Mixed, Thermic, Udic Haplustolls
43	CGf5c3	Complex Geology	Undifferentiated mountain side	5-15	Forest	3	Fine, Mixed, Mesic, Typic Dystrustepts
44	CGf5d1	Complex Geology	Undifferentiated mountain side	5-15	Open scrub	1	Loamy Skeletal, Mixed, Thermic, Typic Ustorthents Sandy, Mixed, Mesic, Typic Ustipsamments
45	CGf7a1	Complex Geology	Undifferentiated mountain side	15-33	Agriculture	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts Fine Loamy, Mixed, Thermic, Dystric Eutrudepts Fine Loamy, Mixed, Thermic, Typic Calciustepts Fine Loamy, Mixed, Mesic, Aquic Udorthents
46	CGf7a2	Complex Geology	Undifferentiated mountain side	15-33	Agriculture	2	Fine Loamy, Mixed, Mesic, Haplic Ustarents Fine Loamy, Mixed, Mesic, Humic Eutrudepts Fine Loamy, Mixed, Mesic, Typic Haplustepts Fine Loamy, Mixed, Thermic, Typic Haplustepts Loamy, Mixed, Thermic, Typic Hapludolls
47	CGf7a3	Complex Geology	Undifferentiated mountain side	15-33	Agriculture	3	Fine Loamy, Mixed, Mesic, Aquic Udorthents Fine Loamy, Mixed, Mesic, Humic Eutrudepts Fine Loamy, Mixed, Mesic, Dystric Eutrudepts
48	CGf7a4	Complex Geology	Undifferentiated mountain side	15-33	Agriculture	4	Fine Loamy, Mixed, Mesic, Humic Eutrudepts Loamy Skeletal, Mixed, Mesic, Lithic Udorthents
49	CGf7c1	Complex Geology	Undifferentiated mountain side	15-33	Forest	1	Fine Loamy, Mixed, Thermic, Dystric Eutrudepts Fine Loamy, Mixed, Thermic, Dystric Haplustepts Fine, Mixed, Thermic, Dystric Haplustepts
50	CGf7c2	Complex Geology	Undifferentiated mountain side	15-33	Forest	2	Fine Loamy, Mixed, Thermic, Typic Haplustepts Loamy Skeletal, Mixed, Thermic, Dystric Eutrudepts Loamy Skeletal, Mixed, Thermic, Typic Haplustepts
51	CGf7c3	Complex Geology	Undifferentiated mountain side	15-33	Forest	3	Fine Loamy, Mixed, Mesic, Typic Humudepts Sandy, Mixed, Mesic, Humic Haplustepts Fine Loamy, Mixed, Thermic, Typic Hapludolls
52	CGf7c4	Complex Geology		15-33	Forest	4	Fine Loamy, Mixed, Mesic, Entic Hapludolls

			Undifferentiated mountain side				Fine Loamy, Mixed, Mesic, Typic Hapludolls Fine, Mixed, Mesic, Typic Dystrustepts
53	CGf7c5	Complex Geology	Undifferentiated mountain side	15-33	Forest	5	Fine Loamy, Mixed, Mesic, Humic Haplustepts Fine Loamy, Mixed, Mesic, Typic Hapludolls
54	CGf7d1	Complex Geology	Undifferentiated mountain side	15-33	Open scrub	1	Loamy shallow, Mixed, Thermic, Udic Ustorthents Loamy Skeletal, Mixed, Thermic, Typic Ustorthents Loamy, Mixed, Thermic, Udic Ustorthents
55	CGf7d2	Complex Geology	Undifferentiated mountain side	15-33	Open scrub	2	Fine Loamy, Mixed, Mesic, Typic Udorthents Loamy Skeletal, Mixed, Mesic, Entic Hapludolls
56	CGf7d3	Complex Geology	Undifferentiated mountain side	15-33	Open scrub	3	Loamy Skeletal, Mixed, Mesic, Entic Hapludolls
57	CGf9a1	Complex Geology	Undifferentiated mountain side	33->50	Agriculture	1	Coarse Loamy, Mixed, Thermic, Typic Ustorthents Fine Loamy, Mixed, Thermic, Typic Hapludolls
58	CGf9a2	Complex Geology	Undifferentiated mountain side	33->50	Agriculture	2	Fine Loamy, Mixed, Mesic, Humic Eutrudepts Fine Silty, Mixed, Mesic, Oxyaquic Humustepts Loamy, Mixed, Mesic, Typic Haplustepts Loamy Skeletal, Mixed, Thermic, Typic Ustorthents
59	CGf9a3	Complex Geology	Undifferentiated mountain side	33->50	Agriculture	3	Fine Loamy, Mixed, Mesic, Aquic Udorthents Fine Loamy, Mixed, Mesic, Humic Eutrudepts Loamy Skeletal, Mixed, Thermic, Lithic Hapludolls
60	CGf9a4	Complex Geology	Undifferentiated mountain side	33->50	Agriculture	4	Fine Loamy, Mixed, Mesic, Humic Eutrudepts
61	CGf9c1	Complex Geology	Undifferentiated mountain side	33->50	Forest	1	Fine Loamy, Mixed, Thermic, Typic Hapludolls Fine Loamy, Mixed, Thermic, Typic Haplustepts Fine Loamy, Mixed, Thermic, Typic Humustepts
62	CGf9c2	Complex Geology	Undifferentiated mountain side	33->50	Forest	2	Fine Loamy, Mixed, Mesic, Typic Haplustepts Fine, Mixed, Mesic, Typic Dystrustepts Loamy Skeletal, Mixed, Thermic, Typic Hapludolls
63	CGf9c3	Complex Geology	Undifferentiated mountain side	33->50	Forest	3	Coarse Loamy, Mixed, Thermic, Typic Ustorthents Fine Loamy, Mixed, Thermic, Typic Humudepts Loamy, Mixed, Thermic, Lithic Hapludolls
64	CGf9c4	Complex Geology	Undifferentiated mountain side	33->50	Forest	4	Fine Loamy, Mixed, Mesic, Typic Humudepts Loamy, Mixed, Mesic, Lithic Hapludolls
65	CGf9c5	Complex Geology	Undifferentiated mountain side	33->50	Forest	5	Fine Loamy, Mixed, Mesic, Entic Hapludolls
66	CGf9c6	Complex Geology	Undifferentiated mountain side	33->50	Forest	6	Coarse Loamy, Mixed, Mesic, Udorthentic Haplustolls Fine Loamy, Mixed, Mesic, Typic Humustepts

67	CGf9c7	Complex Geology	Undifferentiated mountain side	33->50	Forest	7	Fine Loamy, Mixed, Mesic, Entic Hapludolls Fine Loamy, Mixed, Mesic, Typic Hapludolls
68	CGf9c8	Complex Geology	Undifferentiated mountain side	33->50	Forest	8	Fine Loamy, Mixed, Mesic, Entic Hapludolls
69	CGf9d1	Complex Geology	Undifferentiated mountain side	33->50	Open scrub	1	Loamy shallow, Mixed, Thermic, Udic Ustorthents Loamy Skeletal, Mixed, Thermic, Typic Ustorthents Loamy, Mixed, Thermic, Lithic Hapludolls
70	CGf9d2	Complex Geology	Undifferentiated mountain side	33->50	Open scrub	2	Loamy Skeletal, Mixed, Mesic, Entic Hapludolls Loamy Skeletal, Mixed, Thermic, Lithic Hapludolls
71	CGf9d3	Complex Geology	Undifferentiated mountain side	33->50	Open scrub	3	Loamy Skeletal, Mixed, Mesic, Entic Hapludolls Loamy Skeletal, Mixed, Mesic, Lithic Cryorthents
72	CGg3a1	Complex Geology	Narrow mountain valleys	1-5	Agriculture	1	Fine Loamy, Mixed, Mesic, Aquic Ustifluvents Fine Loamy, Mixed, Thermic, Typic Haplustepts
73	CGg3a2	Complex Geology	Narrow mountain valleys	1-5	Agriculture	2	Fine Loamy, Mixed, Thermic, Typic Haplustepts
74	CGn5a1	Complex Geology	Undifferentiated hill side slopes	5-15	Agriculture	1	Fine Loamy, Mixed, Thermic, Dystric Eutrudepts
75	CGn5c1	Complex Geology	Undifferentiated hill side slopes	5-15	Forest	1	Loamy Skeletal, Mixed, Thermic, Dystric Eutrudepts
76	CGn5c2	Complex Geology	Undifferentiated hill side slopes	5-15	Forest	2	Fine Loamy, Mixed, Thermic, Typic Hapludolls
77	CGn7c1	Complex Geology	Undifferentiated hill side slopes	15-33	Forest	1	Loamy, Mixed, Thermic, Typic Hapludolls
78	CGn7c2	Complex Geology	Undifferentiated hill side slopes	15-33	Forest	2	Loamy, Mixed, Thermic, Typic Hapludolls
79	CGn9c1	Complex Geology	Undifferentiated hill side slopes	33->50	Forest	1	Loamy, Mixed, Thermic, Lithic Hapludolls
80	CGx3a1	Complex Geology	Piedmont plain	1-5	Agriculture	1	Fine Loamy, Mixed, Thermic, Aquic Haplustepts Fine Loamy, Mixed, Thermic, Dystric Eutrudepts
81	CGx3a2	Complex Geology	Piedmont plain	1-5	Agriculture	2	Fine Loamy, Mixed, Thermic, Dystric Eutrudepts
82	CGx3b1	Complex Geology	Piedmont plain	1-5	Open scrub	1	Fine Loamy, Mixed, Thermic, Typic Hapludalfs
83	CGx3c1	Complex Geology	Piedmont plain	1-5	Forest	1	Fine Loamy, Mixed, Thermic, Aquic Ustorthents Fine Silty, Mixed, Thermic, Dystric Eutrudepts
84	CGx3c2	Complex Geology	Piedmont plain	1-5	Forest	2	Coarse Loamy, Mixed, Thermic, Dystric Eutrudepts
85	CGx3d1	Complex Geology	Piedmont plain	1-5	Open scrub	1	Fine Loamy, Mixed, Thermic, Aquic Haplustepts Fine Loamy, Mixed, Thermic, Dystric Eutrudepts
86	CGx3d2	Complex Geology	Piedmont plain	1-5	Open scrub	2	Fine Silty, Mixed, Thermic, Dystric Eutrudepts

87	CGx4c1	Complex Geology	Piedmont plain	3-10	Forest	1	Coarse Loamy, Mixed, Thermic, Typic Ustorthents
88	CGx4d1	Complex Geology	Piedmont plain	3-10	Open scrub	1	Fine Loamy, Mixed, Thermic, Oxyaquic Ustifluvents Fine Loamy, Mixed, Thermic, Typic Ustorthents
89	CGx5a1	Complex Geology	Piedmont plain	5-15	Agriculture	1	Fine Loamy, Mixed, Thermic, Dystric Eutrudepts
90	CGx5a2	Complex Geology	Piedmont plain	5-15	Agriculture	2	Loamy Skeletal, Mixed, Thermic, Dystric Eutrudepts
91	CGx5c1	Complex Geology	Piedmont plain	5-15	Forest	1	Coarse Loamy, Mixed, Thermic, Typic Eutrudepts
92	CGx5c2	Complex Geology	Piedmont plain	5-15	Forest	2	Coarse Loamy, Mixed, Thermic, Dystric Eutrudepts
93	LSf7a1	Limestone	Undifferentiated mountain side	15-33	Agriculture	1	Fine, Mixed, Thermic, Typic Haplustepts
94	LSf7c1	Limestone	Undifferentiated mountain side	15-33	Forest	1	Fine Loamy, Mixed, Thermic, Typic Humustepts
95	LSf7c2	Limestone	Undifferentiated mountain side	15-33	Forest	2	Fine, Mixed, Thermic, Typic Haplustepts
96	LSf7d1	Limestone	Undifferentiated mountain side	15-33	Open scrub	1	Coarse Loamy, Mixed, Thermic, Typic Ustorthents
97	LSf9a1	Limestone	Undifferentiated mountain side	33->50	Agriculture	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts
98	LSf9c1	Limestone	Undifferentiated mountain side	33->50	Forest	1	Fine, Mixed, Thermic, Typic Haplustepts
99	LSf9c2	Limestone	Undifferentiated mountain side	33->50	Forest	2	Fine, Mixed, Thermic, Typic Haplustepts
100	LSf9d1	Limestone	Undifferentiated mountain side	33->50	Open scrub	1	Loamy shallow, Mixed, Thermic, Typic Ustorthents
101	LSh4a1	Limestone	Broad mountain valleys	3-10	Agriculture	1	Fine, Mixed, Thermic, Vertic Haplustepts
102	SDf5a1	Sandstone	Undifferentiated mountain side	5-15	Agriculture	1	Fine Loamy, Mixed, Thermic, Typic Ustorthents
103	SDf5c1	Sandstone	Undifferentiated mountain side	5-15	Forest	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts
104	SDf5c2	Sandstone	Undifferentiated mountain side	5-15	Forest	2	Fine Loamy, Mixed, Thermic, Typic Ustorthents
105	SDf5d1	Sandstone	Undifferentiated mountain side	5-15	Open scrub	1	Loamy Skeletal, Mixed, Thermic, Typic Ustorthents
106	SDf7a1	Sandstone	Undifferentiated mountain side	15-33	Agriculture	1	Fine, Mixed, Thermic, Typic Haplustepts
107	SDf7c1	Sandstone	Undifferentiated mountain side	15-33	Forest	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts

108	SDf7c2	Sandstone	Undifferentiated mountain side	15-33	Forest	2	Fine Loamy, Mixed, Thermic, Typic Ustorthents
109	SDf7d1	Sandstone	Undifferentiated mountain side	15-33	Open scrub	1	Loamy Skeletal, Mixed, Thermic, Typic Ustorthents
110	SDf9a1	Sandstone	Undifferentiated mountain side	33->50	Agriculture	1	Fine, Mixed, Thermic, Typic Haplustepts
111	SDf9c1	Sandstone	Undifferentiated mountain side	33->50	Forest	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts Fine Loamy, Mixed, Thermic, Typic Ustorthents
112	SDf9c2	Sandstone	Undifferentiated mountain side	33->50	Forest	2	Loamy Skeletal, Mixed, Thermic, Typic Ustorthents
113	SDf9d1	Sandstone	Undifferentiated mountain side	33->50	Open scrub	1	Fine Loamy, Mixed, Thermic, Typic Haplustepts Loamy Skeletal, Mixed, Thermic, Typic Ustorthents
114	SLf5a1	Slate	Undifferentiated mountain side	5-15	Agriculture	1	Fine Loamy, Mixed, Mesic, Typic Haplustepts
115	SLf6b1	Slate	Undifferentiated mountain side	10-25	Open scrub	1	Fine Loamy, Mixed, Mesic, Typic Haplustepts
116	SLf6c1	Slate	Undifferentiated mountain side	10-25	Forest	1	Fine Loamy, Mixed, Mesic, Typic Ustorthents
117	SLf7a1	Slate	Undifferentiated mountain side	15-33	Agriculture	1	Fine Silty, Mixed, Mesic, Typic Haplustepts
118	SLf8c1	Slate	Undifferentiated mountain side	25-50	Forest	1	Fine Loamy, Mixed, Mesic, Typic Haplustepts Fine Loamy, Mixed, Mesic, Typic Ustorthents
119	SLf8c2	Slate	Undifferentiated mountain side	25-50	Forest	2	Fine Loamy, Mixed, Mesic, Typic Haplustepts
120	SLf8d1	Slate	Undifferentiated mountain side	25-50	Open scrub	1	Fine Loamy, Mixed, Mesic, Typic Ustorthents

DIGITAL SOIL SURVEY DATA

The digital soil resource map of Uttarakhand on the scale of 1:50,000 have brought out the basic information on physiography, soils, their extent, characteristics and classification. The analysis of the digital data-base on soil resource mapping reveals different classes of slope, Land use/ land cover, degree of soil erosion, soil depth and texture family which are of considerable importance for effective sustainable land use planning.

4.1 PHYSIOGRAPHY OF SOILS

Soils and its development are being an integral part of the landscape and their characteristics. The study of landforms and their extent aids in identification and mapping of identical soil types. The physiographic situations govern the moisture and indicate the stage of soil development. The present study carried out by establishing physiography–soil relationship in Himalayan region of Uttarakhand state using remote sensing technique along with conventional field and laboratory approaches.

The Soil physiographic distribution in thirteen districts of the state is presented in **table 4.1**. A total of 947 profiles were studied and classified up to soil family level. Based on tone, texture and colour of the imageries and contour information of toposheets, different physiographic. Totally seven physiographic units were identified as Mountains/hills, summits, escarpments, pediments, pediplains, valley, recent alluvial plain and old alluvial plain.

The soil landform relations are established by adopting four tier approach. The Summits and Ridges are having 0.02% of land. Moderately steep to Steep and Very steep to Extremely Steep Undifferentiated mountain slope covers 58.9% area on landscape. The Narrow Valleys and River terraces occupy 1.13% landscape and alluvial plain area is spread out in 10.38 % area of TGA. Remaining area of the state was parted by miscellaneous uses, among them about 20.03% area was under snow covered lands followed by waterbodies (1.90 %), rock out crop (0.03%) and Habitation (0.48%).

Table 4.1: Distribution of different Physiography classes

Sl. No.	Physiography	Area (ha)	Percentage
1	Alluvial plains	555168	10.38
2	Broad mountain valleys	5806	0.11
3	Dissected stream banks	4727	0.09
4	Undifferentiated hill side slope	27003	0.50
5	Undifferentiated mountain side slope	3364322	62.90
6	Mountain tops	1151	0.02
7	Narrow mountain valleys	9534	0.18
8	Paleo channel	1434	0.03
9	Piedmont planes	109500	2.05

10	River terraces	50911	0.95
11	Stream banks	18782	0.35
12	Rockout crop	1340	0.03
13	Snow Cover	1071541	20.03
14	Habitation	25717	0.48
15	Waterbodies	101443	1.90
	Grand Total	**5348379**	**100.00**

4.2 SOIL EROSION

Soil erosion is one of the major soil degradation processes in Mountains/hills. Steep sloping lands with high rainfall are often subjected to soil loss by water erosion and landslides/land slips. Seven erosion classes have been identified in Uttarakhand viz. none to slight, slight to moderate, moderate, moderate to severe, severe, severe to very severe and very severe (**Table 4.2**).

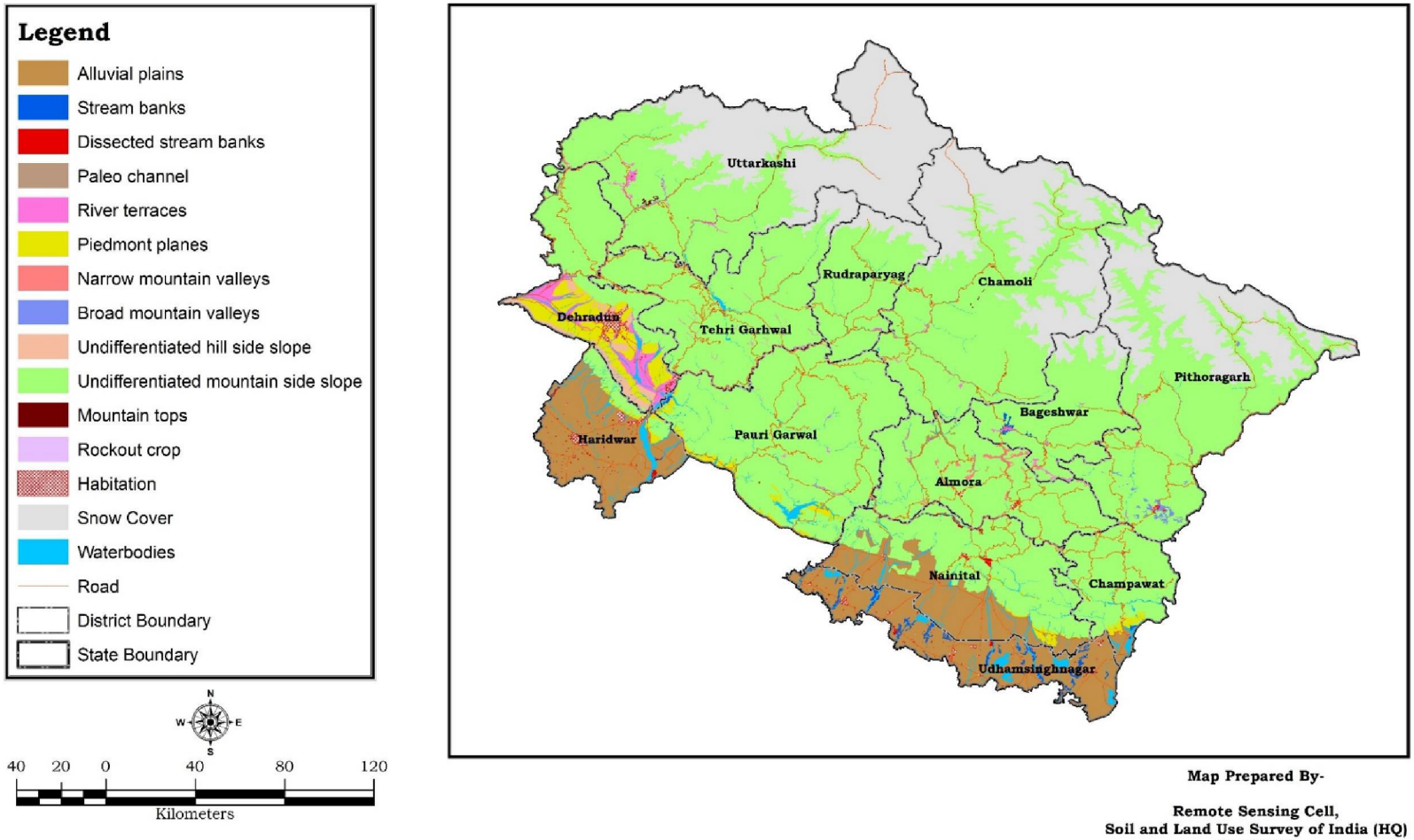
Out of total geographical area, 12,489ha (0.23%) and 2,23,065ha (4.17%) area is under very severe and severe to very severe erosion respectively. These areas are where topography is highly rugged associated with problem of deforestation and need immediate attention for soil water conservation and afforestation.

To preserve vegetative cover conservation practices for preventing further depletion of natural resources and for sustaining ecosystem services are essential.

Table 4.2: Areas affected under different classes of erosion

Sl. No.	Erosion	Area (ha)	Percentage
1	None to slight erosion	597186	11.17
2	Slight to moderate erosion	332420	6.22
3	Moderate erosion	843077	15.76
4	Moderate to severe erosion	1458202	27.26
5	Severe erosion	681899	12.75
6	Severe to very severe erosion	223065	4.17
7	Very severe erosion	12489	0.23
8	Habitation	25717	0.48
9	Rockout crop	1340	0.03
10	Snow Cover	1071541	20.03
11	Waterbodies	101443	1.90
	Grand Total	5348379	100.00

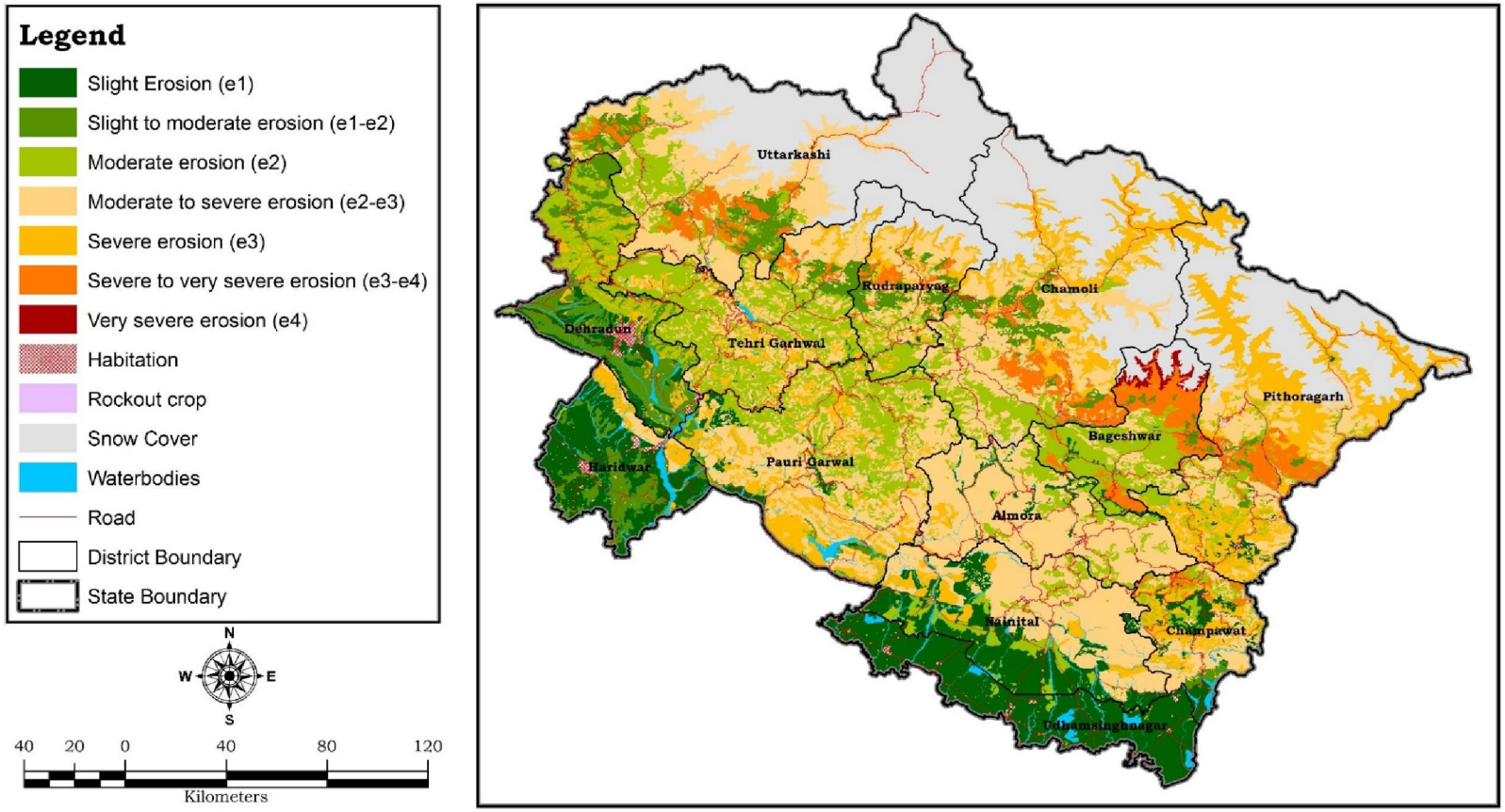
Physiography Map of Uttarakhand State



Map Prepared By-

Remote Sensing Cell,
Soil and Land Use Survey of India (HQ)
New Delhi

Soil Erosion Map of Uttarakhand State



Map Prepared By-

Remote Sensing Cell,
Soil and Land Use Survey of India (HQ)
New Delhi

4.3 SOIL DEPTH

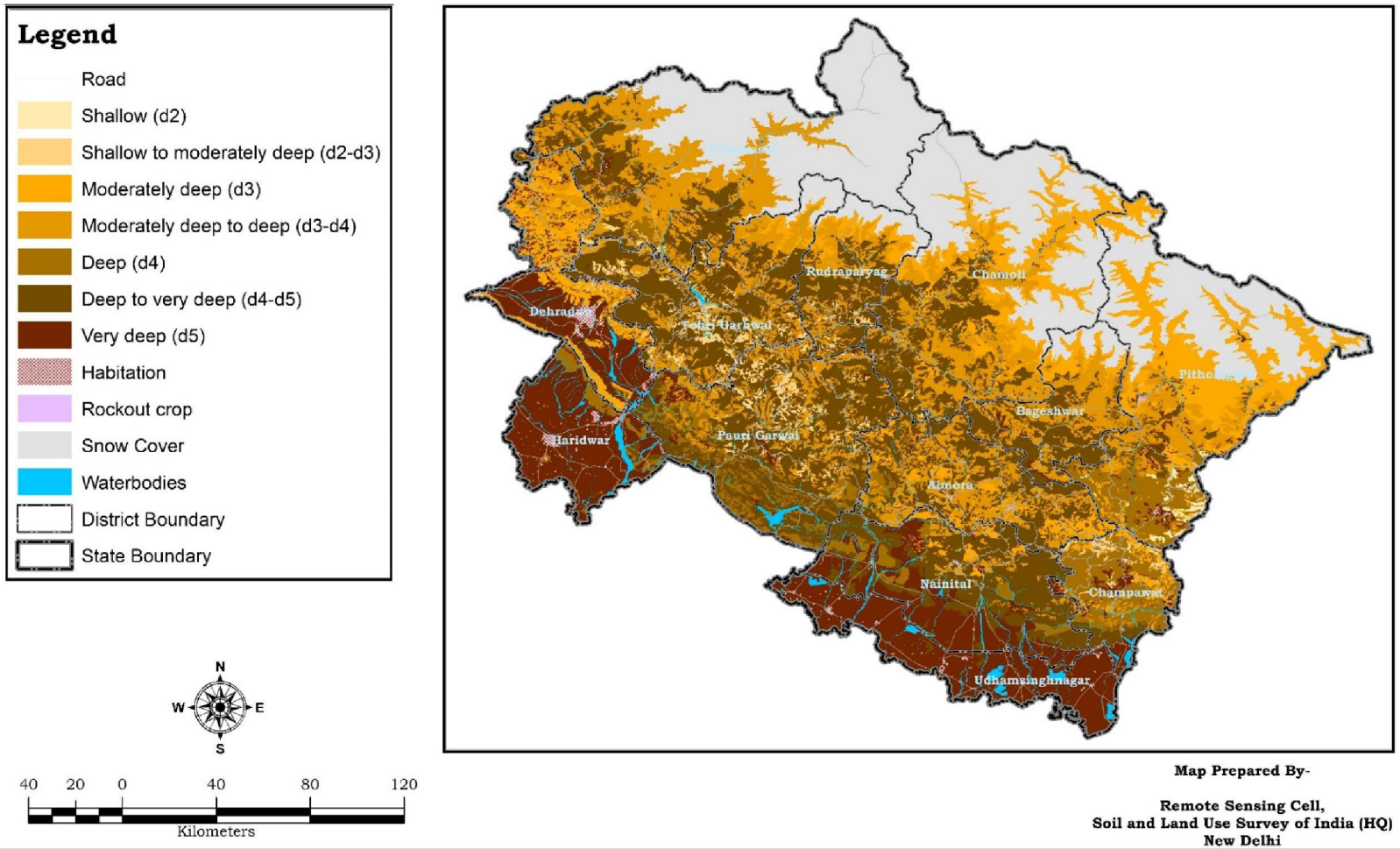
Soil depth critical for plants grow on lands. The soils with deep & very deep depth provide more water and nutrients to plants than shallow soils which physically limit root penetration. Furthermore, most plants rely on soil for mechanical support and this is especially true for shrubs, trees. The effective soil depth is an important soil parameter, which decides the type of vegetation and its performance.

The occurrence of limiting layer in soil, which is impenetrable to roots, is indicated by introduction of term Lithic (suggesting a soil depth of less than 50 cm). Nearly, 12,00,041 ha mapped as miscellaneous area are covered by habitation, rock, glacier and river. Shallow soil depth groups occupy 13,318 ha (0.25%). They dominantly occur on cliffs and precipitous slopes with Mesic and at places Isofrigid soil temperature regimes. The moderately deep soil occupies 6,28,601 ha land. Shallow to moderately deep soils have serious management problems and need to be preserved permanently under vegetative cover. The shallow to moderately deep soils occurs in 1,00,404 ha area in the state (1.88%). These soils need special care management and selection of species suited to each category of soil for best land use. Deep soils cover an area of 3,48,922 ha (6.52%). Very deep soil dominantly occurs in 7,39,748 ha area (13.83%). These soils on lower slopes and on alluvial landscape can be brought under more intensive use with adequate management. Out of five soil classes, those affecting crop growth have been identified which call for special attention. Problem soils have been described in **table 4.3** and their proportionate distribution is given in the appended figure.

Table 4.3 Areas affected under different classes of soil depth

Sl. No.	Depth	Area (ha)	Percentage
1	Shallow	13318	0.25
2	Shallow to Moderately deep	100404	1.88
3	Moderately deep	628601	11.75
4	Moderately deep to Deep	957344	17.90
5	Deep	348922	6.52
6	Deep to Very deep	1359322	25.42
7	Very deep	739748	13.83
8	Moderately deep to Very deep	679	0.01
9	Habitation	25717	0.48
10	Rockout crop	1340	0.03
11	Snow Cover	1071541	20.03
12	Waterbodies	101443	1.90
	Grand Total	**5348379**	**100.00**

Soil Depth Map of Uttarakhand State



Map Prepared By-

Remote Sensing Cell,
Soil and Land Use Survey of India (HQ)
New Delhi

4.4 SOIL TEXTURE

Soil texture refers to the relative percentage of sand, silt, and clay within a soil layer. Soil texture is a permanent characteristic of soil. Numerous soil properties are influenced by texture including Soil Drainage, Water holding capacity, Aeration, Susceptibility to erosion, Organic matter content, Cation Exchange Capacity (CEC), pH buffering capacity. It also gives an idea of total soil moisture and nutrient holding capacity. It has an important role in crop production from the stage of seeds sowing to the maturity of crops.

Soil texture governs the development of soil structure which is indicator of soil physical quality and helps in determining sustainability of land use. The declining soil structure has been major cause for soil deterioration and degradation which negatively impacts the ecosystem and productivity

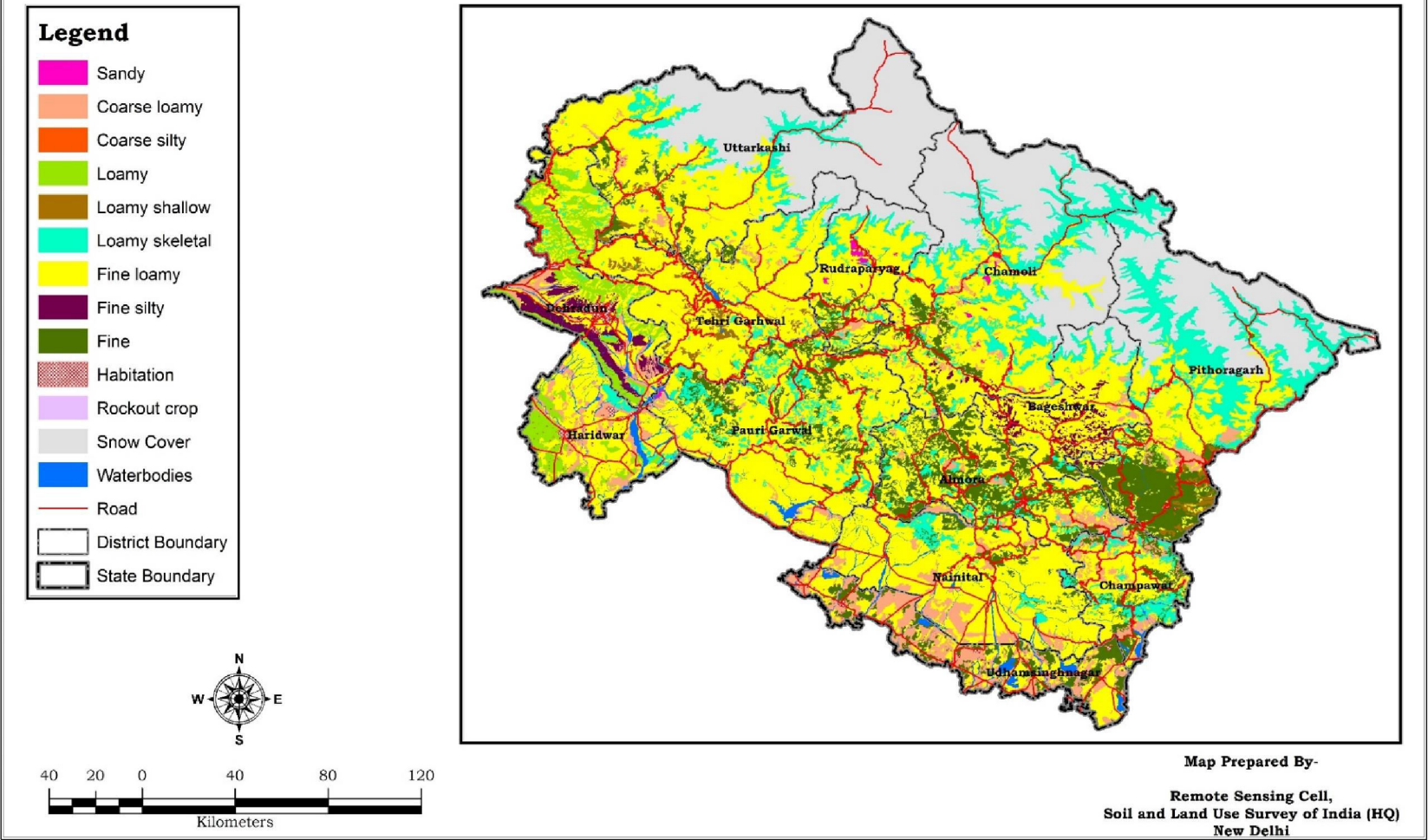
Total nine textural classes have been described in the state. Nearly 46.29 per cent of the surveyed area are having fine loamy and 9 per cent of the surveyed area are having fine textural class. These are high potential soils for biomass production. It is also to confirm that about 6.22 per cent and 2.80 per cent of the surveyed area are having coarse loamy and loamy soil type, respectively with moderate to low potential for biomass production.

The areas affected by these textural classes are given in **table 4.4** and their proportionate distribution is shown in the appended figure.

Table 4.4 Areas affected under textural classes

Sl No	Texture	Area (ha)	Percentage
1	Sandy	8332	0.16
2	Coarse loamy	332476	6.22
3	Coarse silty	1151	0.02
4	Loamy	149856	2.80
5	Loamy shallow	45855	0.86
6	Loamy skeletal	585272	10.94
7	Fine	481182	9.00
8	Fine loamy	2475523	46.29
9	Fine silty	68691	1.28
10	Habitation	25717	0.48
11	Rockout crop	1340	0.03
12	Snow Cover	1071541	20.03
13	Waterbodies	101443	1.90
	Grand Total	**5348379**	**100.00**

Soil Texture Map of Uttarakhand State



Map Prepared By-

Remote Sensing Cell,
Soil and Land Use Survey of India (HQ)
New Delhi

4.5 Soil Organic Carbon (SOC) Stock

Soil organic carbon is a measureable element of soil organic matter in soil which serve as a source and storage of nutrient in soil and it further helps in improving the physical and biological properties of soil thereby improving the overall ability of soil to support plant growth. Organic matter contributes to maintenance of soil structure, moisture retention and availability, degradation of pollutants, carbon sequestration and soil resilient.

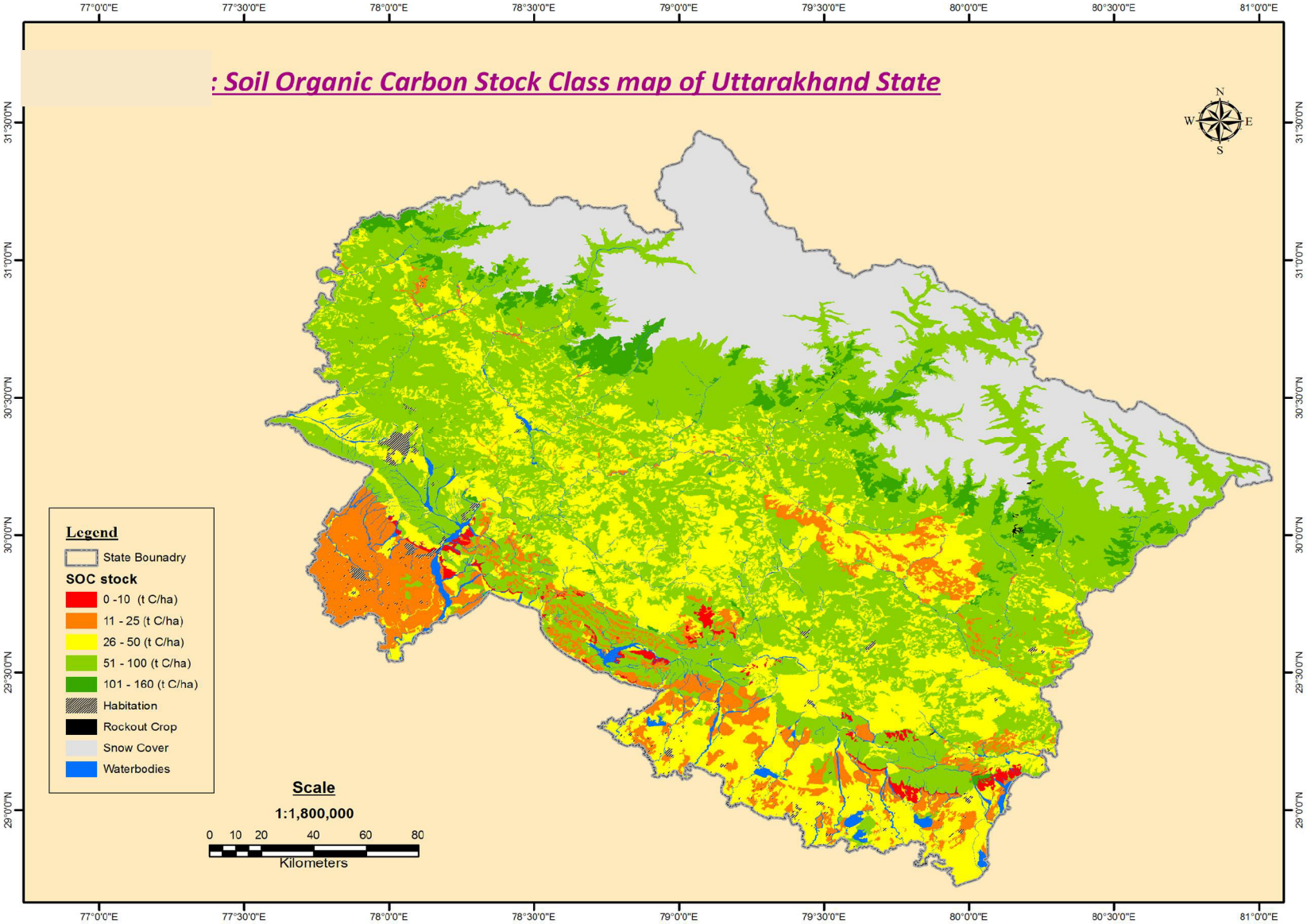
For determination of soil organic carbon stock involves quantification within a specific soil sampling depth. It consists of estimation of percent soil organic carbon content in the soil mass (< 2 mm size), coarse mineral fraction content (> 2 mm size) and, estimation of soil bulk density.

The SOC stock for the state has been classified in five classes. The landuse systems of forest and open scrub in high altitudes observed to have majority of area having SOC stock more than 51 t C ha^{-1} (72.65% of forest area and 77.70% area under open-scrub) as compared to agriculture where 81.44% area recorded to have less than 50 t C ha^{-1} SOC stock. This might be attributed to nutrient rich top soils of forests and high altitude area (Middle Himalayas) responsible for higher carbon sink when compared to the agricultural lands.

In case of agriculture lands, a total of 80.32% of agricultural lands observed more than 26 t C ha^{-1} having high range of percent organic carbon value (>0.75% OC).

Table 4.5 Areas affected under soil organic carbon stock classes

Sl No	Landuse	SOC stock (t C ha^{-1})					Total Area (ha)
		0 - 10	11 - 25	26 - 50	51 - 100	101 -160	
1	Agriculture	11203	208797	690352	206511	1041	1117904
2	Forest	24889	202786	413894	1541592	162687	2345847
3	Open scrub	-	4158	141117	496868	9761	651903
4	Plantation	-	7053	24235	1395	-	32683
5	Habitation						25717
6	Rockout Crop						1340
7	Snow Cover						1071541
8	Waterbodies						101443
	Total Area (ha)	**36092**	**422794**	**1269597**	**2246367**	**173488**	**5348379**


: Soil Organic Carbon Stock Class map of Uttarakhand State
77°0'0"E
77°30'0"E
78°0'0"E
78°30'0"E
79°0'0"E
79°30'0"E
80°0'0"E
80°30'0"E
81°0'0"E
31°30'0"N
31°0'0"N
30°30'0"N
30°0'0"N
29°30'0"N
29°0'0"N
N
W
E
S
Legend
State Bounadry
SOC stock
0 -10 (t C/ha)
11 - 25 (t C/ha)
26 - 50 (t C/ha)
51 - 100 (t C/ha)
101 - 160 (t C/ha)
Habitation
Rockout Crop
Snow Cover
Waterbodies
Scale
1:1,800,000
0 10 20 40 60 80
Kilometers

4.6 Land Use/Land Cover

Surface form is the resultant of the present and past climate in the areas under natural condition. Land use /land cover tends to change with human intervention resulting in deformation of terrain. Four land use and land cover types have been identified in Uttarakhand as shown in **table 4.6**. Land use and land management practices have a major impact on natural resources including water, soil, nutrients, plants and animals

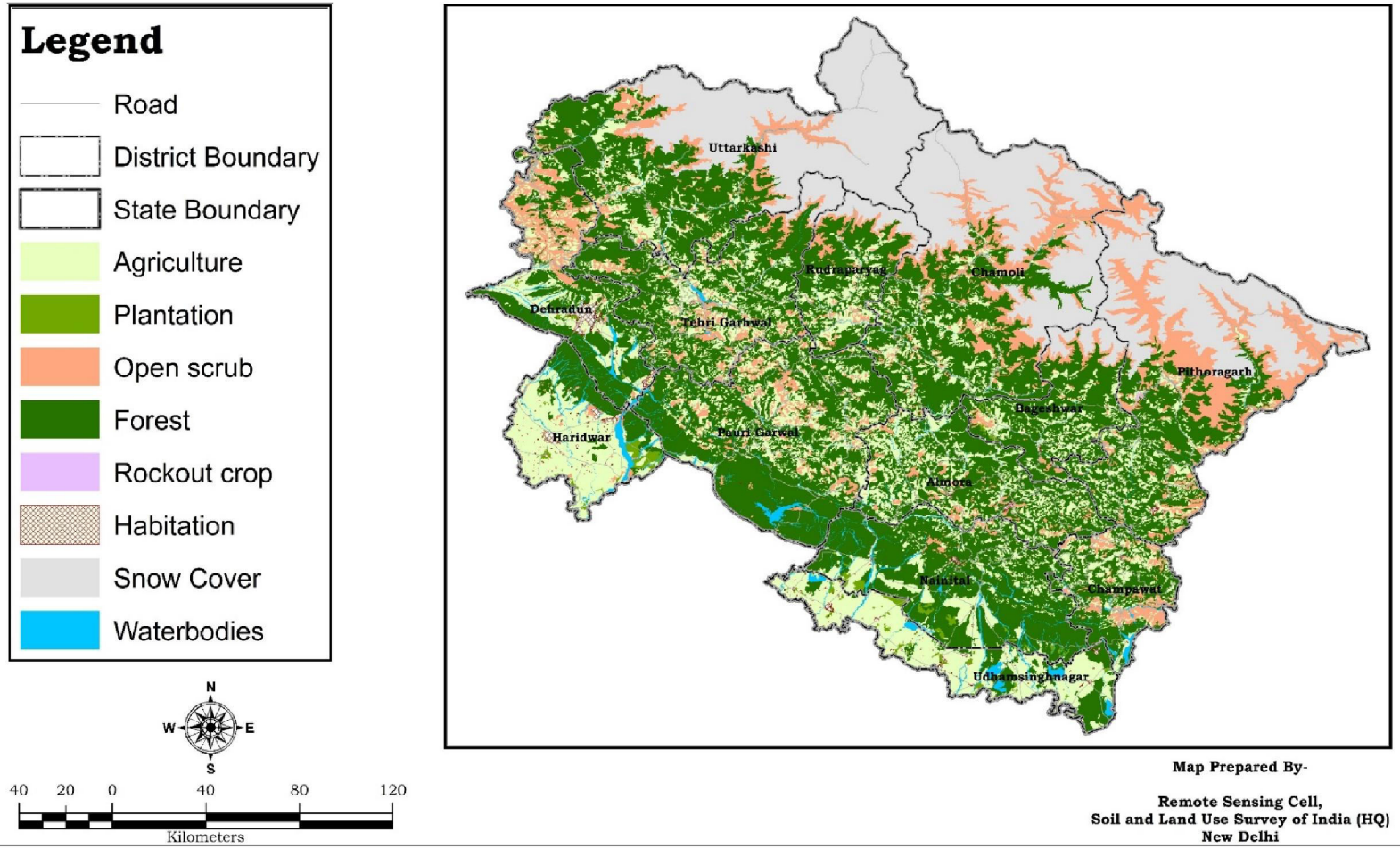
Like most other hill economies, the people of Uttarakhand state practice integrated systems of farming, forestry, horticulture, livestock and off-farm activities. The recorded forest land use constitutes 71.05% of the total reported area as per state government statistics, though the actual cover based on remote sensing and satellite imagery information is only 43.86 per cent. About 12.19 per cent of area has been mapped as degraded forest land. The net sown area for the region is a little over 20% of the total reported area, although there are wide variations in percentage from district to district. Area under cultivation in alluvial plain land is found to be 3,56,948 ha. About 22.44% of the total area in Uttarakhand is either rocky/ snow covered/ glaciated /habitation /waterbodies or otherwise unproductive and degraded land. About 12% of agricultural land is under irrigation and about 90% land is used for growing cereals, fodder (berseem) and some vegetables.

Planning land-use decision for regulating the use of land possible using digital soil and land use data on real time basis using remote sensing methods to promote more desirable social and environmental outcomes as well as a more efficient use of resources.

Table 4.6: Area covered under different Land Use classes

Sl No	Land Use	Area (ha)	Percentage
1	Agriculture	1117904	20.90
2	Forest	2345847	43.86
3	Open scrub	651903	12.19
4	Plantation	32683	0.61
5	Habitation	25717	0.48
6	Rockout crop	1340	0.03
7	Snow Cover	1071541	20.03
8	Waterbodies	101443	1.90
	Grand Total	**5348378**	**100.00**

Land Use Map of Uttarakhand State



CHAPTER 5

SOIL CLASSIFICATION

Soil particle size and mineralogical characteristics are used to distinguish families of mineral soils within sub–groups. In Soil Taxonomy, families and lower categories, particularly series, serve largely pragmatic purposes. Family differentiae for mineral soils are the classes: particle size, mineralogy, calcareous or reaction, soil temperature, soil depth, soil slope, soil consistence, coatings (sands) and cracks. The differentiae are used where relevant; soil taxonomy gives the differentiae important for each order. The family and series are the fifth and sixth categories of the system. They are distinguished by proper–tier selected to create taxa that are successively more homogeneous for practical soil uses. Families provide classes with relative homogeneity in properties important to plant growth.

Soil family guides for predicting potential constraints. Physical aspects of soil management are more or less well defined by soil names. Some physical aspects are inferable from the taxa names for the following soil orders.

5.1 ALFISOLS

Alfisols have a subsurface horizon with a clay accumulation. This argillic horizon has good moisture and nutrient storage capabilities. The surface horizons are light textured and encourage root penetration. Owing to well drained nature of these soils sustaining a land crop on these soils requires much more water because of high percolation. The most common sub order occurs in the state is Udalfs and support many types of vegetation and land use.

5.2 ENTISOLS

Entisols have no diagnostic horizons other than an ochric and mollic epipedon. Landscapes the soil material is not in place long enough for pedogenic processes to form distinctive horizons. These soils occur on steep, actively eroding slopes and on flood plains or glacial outwash plains that receive new deposits of alluvium at frequent intervals. In Entisols, suborder with greatest occurrence is Orthents. The most recent in-situ developments, which have not yet ripened, formed on erosional surfaces. They have developed in Ustic and Udic moisture regime. These soils occur on Steeper slopes and are subjected to erosion. Other group includes Arents, these are the Entisols that do not have horizons because they have been deeply mixed by plowing, spading or other methods of moving by humans, occurs on Mountain Terraces. Similarly, the sub group Fluvents showing an irregular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm, these may be stratified but the strata to have marked impact on permeability. Other important group is Pssamments, which are having very rapid permeability, and draining of these soils can create moisture stress because there is no buffering effect on moisture content. The Fluvents and Pssamments are found in one or more of the following landscape components i.e. inland valley, river fan or Piedmont slope, floodplain, and remains of a former river floodplain (uplifted river terrace).

5.3 INCEPTISOLS

These soils range from very imperfectly to excessively drain having ochric or anthropic/mollic epipedon and diagnostic subsurface horizon typically have a cambic horizon. These soils commonly occur on landscapes mountain slopes, where erosional processes are actively exposing unweathered materials, and river valleys, where relatively unweathered sediments are being deposited. The most common

suborders observed in all landforms are Ustepts and Udepts, depending upon the availability of moisture or wetness is expressed. The Ustepts suffer moisture stress often and support growth of vegetation for defined period due climate and topography, whereas the soils of Udepts remain moist in significant time in year and are having good vegetative cover in spite of biotic pressure. Leaching of bases and salts is dominant soil forming process in this area due to young nature of soil and it promotes vegetation that develops on acidic soils.

5.4 MOLLISOLS

Mollisols have a mollic epipedon. They generally have the best tilth conditions of all orders. The mollic epipedon or surface horizon cannot by definition be hard or very hard when dry, and therefore is optimal for tillage. The Ustolls and Udolls subgroups are semi-arid and moist Mollisols. The soils support variety of vegetation and densest forest found in these soil cover but these soils have few physicochemical constraints for crop production.

Total 42 soil family are identified in the thirteen districts of Uttarakhand state these families are occurring in different landscape in inaccessible terrain and remote areas. These soil families are represented in soil map of the state for sustainable land management.

Table 5.1: Temperature regime wise distribution of soils taxonomical classes

Hyperthermic Temperature Class

Entisols
Coarse Loamy, Mixed, Aquic Ustifluvents
Coarse Loamy, Mixed, Typic Ustifluvents
Coarse Loamy, Mixed, Typic Ustorthents
Fine Loamy, Mixed, Typic Ustifluvents
Loamy Skeletal, Mixed, Typic Ustorthents

Inceptisols
Coarse Loamy, Mixed, Aquic Haplustepts
Coarse Loamy, Mixed, Fluventic Haplustepts
Coarse Loamy, Mixed, Typic Haplustepts
Fine Loamy, Mixed, Aquic Haplustepts
Fine Loamy, Mixed, Fluventic Haplustepts
Fine Loamy, Mixed, Humic Haplustepts
Fine Loamy, Mixed, Oxyaquic Haplustepts
Fine Loamy, Mixed, Typic Haplustepts
Fine, Mixed, Dystric Haplustepts
Fine, Mixed, Oxyaquic Haplustepts
Fine, Mixed, Typic Haplustepts
Fine, Mixed, Vertic Haplustepts
Loamy, Mixed, Fluventic Haplustepts

Mesic Temperature Class

Entisols
Coarse Loamy, Mixed, Typic Ustorthents
Fine Loamy, Mixed, Aquic Udorthents
Fine Loamy, Mixed, Aquic Ustifluvents
Fine Loamy, Mixed, Haplic Ustarents
Fine Loamy, Mixed, Mollic Udarents
Fine Loamy, Mixed, Typic Udorthents
Fine Loamy, Mixed, Typic Ustorthents
Fine, Mixed, Haplic Ustarents
Loamy Skeletal, Mixed, Lithic Cryorthents
Sandy, Mixed, Typic Ustipsamments

Inceptisols
Coarse Silty, Mixed, Typic Haplustepts
Fine Loamy, Mixed, Humic Eutrudepts
Fine Loamy, Mixed, Humic Haplustepts
Fine Loamy, Mixed, Typic Haplustepts
Fine Loamy, Mixed, Typic Humudepts
Fine Loamy, Mixed, Typic Humustepts
Fine Silty, Mixed, Aquertic Haplustepts
Fine Silty, Mixed, Oxyaquic Humustepts
Fine Silty, Mixed, Typic Fragiudepts
Fine Silty, Mixed, Typic Haplustepts
Fine, Mixed, Typic Dystrustepts
Loamy Skeletal, Mixed, Typic Haplustepts
Loamy, Mixed, Typic Haplustepts
Sandy, Mixed, Humic Haplustepts

Mollisols
Coarse Loamy, Mixed, Udorthentic Haplustolls
Fine Loamy, Mixed, Entic Hapludolls
Fine Loamy, Mixed, Typic Hapludolls
Loamy Skeletal, Mixed, Entic Hapludolls

Thermic Temperature Class

Alfisols
Fine Loamy, Mixed, Typic Hapludalfs

Entisols
Coarse Loamy, Mixed, Typic Udifluvents

Coarse Loamy, Mixed, Typic Ustifluvents Coarse Loamy, Mixed, Typic Ustorthents Fine Loamy, Mixed, Aquic Ustorthents Fine Loamy, Mixed, Haplic Ustarents Fine Loamy, Mixed, Humic Ustorthents Fine Loamy, Mixed, Oxyaquic Ustifluvents Fine Loamy, Mixed, Typic Ustorthents Loamy shallow, Mixed, Typic Ustorthents Loamy shallow, Mixed, Udic Ustorthents Loamy Skeletal, Mixed, Lithic Udorthents Loamy Skeletal, Mixed, Typic Ustorthents Loamy, Mixed, Udic Ustorthents Sandy, Mixed, Typic Psammaquents

Inceptisols
Coarse Loamy, Mixed, Dystric Eutrudepts Coarse Loamy, Mixed, Typic Eutrudepts Fine Loamy, Mixed, Aquic Haplustepts Fine Loamy, Mixed, Dystric Eutrudepts Fine Loamy, Mixed, Dystric Haplustepts Fine Loamy, Mixed, Fluventic Haplustepts Fine Loamy, Mixed, Typic Calciustepts Fine Loamy, Mixed, Typic Eutrudepts Fine Loamy, Mixed, Typic Haplustepts Fine Loamy, Mixed, Typic Humustepts Fine Silty, Mixed, Dystric Eutrudepts Fine, Mixed, Dystric Haplustepts Fine, Mixed, Typic Haplustepts Fine, Mixed, Vertic Haplustepts Loamy Skeletal, Mixed, Dystric Eutrudepts Loamy Skeletal, Mixed, Typic Haplustepts

Mollisols
Fine Loamy, Mixed, Typic Hapludolls Fine, Mixed, Udic Haplustolls Loamy Skeletal, Mixed, Lithic Hapludolls Loamy Skeletal, Mixed, Typic Hapludolls Loamy, Mixed, Lithic Hapludolls Loamy, Mixed, Typic Hapludolls

Table 5.2: Distribution of different Soil Taxonomic classes

Order	Sub order	Great group	Sub group
Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs
Entisols	Aquents	Psammaquents	Typic Psammaquents
	Arents	Udarents	Mollic Udarents
		Udorthents	Aquic Udorthents
			Lithic Udorthents
			Typic Udorthents
		Ustarents	Haplic Ustarents
	Fluvents	Udifluvents	Typic Udifluvents
		Ustifluvents	Aquic Ustifluvents
			Oxyaquic Ustifluvents
			Typic Ustifluvents
	Orthents	Cryorthents	Lithic Cryorthents
		Ustorthents	Aquic Ustorthents
			Humic Ustorthents
			Typic Ustorthents
			Udic Ustorthents
	Psamments	Ustipsamments	Typic Ustipsamments
Inceptisols	Udepts	Eutrudepts	Dystric Eutrudepts
			Humic Eutrudepts
			Typic Eutrudepts
		Fragiudepts	Typic Fragiudepts
		Humudepts	Typic Humudepts
	Ustepts	Humustepts	Oxyaquic Humustepts
			Typic Humustepts
		Calciustepts	Typic Calciustepts
		Dystrustepts	Typic Dystrustepts
		Haplustepts	Aquertic Haplustepts
			Aquic Haplustepts
			Dystric Haplustepts
			Fluventic Haplustepts
			Humic Haplustepts
			Oxyaquic Haplustepts
			Typic Haplustepts
			Vertic Haplustepts
Mollisols	Udolls	Hapludolls	Entic Hapludolls
			Lithic Hapludolls
			Typic Hapludolls
	Ustolls	Haplustolls	Udic Haplustolls
			Udorthentic Haplustolls

CHAPTER 6

SOILS OF THE AREA

Soil formation is influenced by differences in physiography and age of landform. It is therefore logical to base a first inventory of soils on properties that are a recognizable consequence of soil formation in a certain physiographic setting. As taxonomic discriminators, such inherent soil properties are not very selective. Rather, they are diagnostic of soil taxa with considerable internal variation. Such taxa can be further subdivided by attributing diagnostic value to profile characteristics that reflect dominant soil forming processes.

As discussed, the Uttarakhand state is divided into nine numbers of broad physiographic units. The relationship between these physiographic units and their soil type established in this study, as the topography is often used in soil studies as it is overwhelmingly influences most of the other soil forming factors (Jenny, 1980) and there is a close relationship between the soil properties and soil forming factors in the soils in mountainous areas (Gessler *et al.*, 1995; Gobin *et al.*, 2001). The physiographic position on landscape indicate the stage of soil development and thus helpful in extrapolating the soil properties on map.

However, this variation is not random because the properties of soil vary from place to place. Natural soil bodies are the result of climate and living organisms acting on parent material, with topography or local relief exerting a modifying influence and with time required for soil-forming processes to act (Soil Survey Division Staff, 1993). The soils are typified using Soil taxonomy, which classifies soils by inherent and stable properties. Land use–induced spatial distribution of soil properties and regional distribution of soils are discussed in terms of typical physiographic settings.

6.1 Alluvial soil

The Indo-Gangetic plain is bound from the northern side by the abruptly rising Himalayas, which feed its numerous rivers and are the source of the fertile alluvium soil which deposited across the region by two river systems. The Indo-Gangetic Plain is a large and fertile alluvial plain encompassing most of northern and eastern India, the most populous parts of India.

Topographically, the plain is relatively homogeneous. Two terrain belts are observed in the area. The Tarai region which constitute narrow northern boundary of the Indo-Gangetic Plain, where the foothills of the Himalayas meets the plain, have been formed by coarse sands and pebbles deposited by mountain streams and the second terrain is great alluvial plain of river Ganges.

The soils of Tarai area is dominated by piedmont physiography. The abrupt transition from a narrow inland valley stream to a wide or complex braided stream channels results in sudden drop in river flow velocity and transportable bed load capacity. Thus, induce sediment deposition from regularly shifting stream/channels to forms alluvial fan with coarse–textured sediments at pediments, which becoming gradually finer toward the base as slopes become gentle. The piedmont plain forms where

adjacent fans overlap. The piedmont plain physiography exist in the area of Siwalik range. These soils are used for growing variety of food grains/ cash crops. These soils are very deep, loam/ clay loam in texture in low topographic plain. The soils have moderate base saturation and organic carbon content.

The second being alluvial plains of river Ganga. It consists of very deep, fine loamy to fine type soils covered under Haridwar, Nainital and Udham Singh Nagar districts.

Paleo channel has been mapped with Stream bank in soil association. The soils of stream bank are moderate to severely eroded and having relatively impermeable subsurface results in high runoff and deep gully formation similarly the soils of Paleo channel are well drained, sandy to fine loamy texture and are most responsive to the management.

These soils are weak to moderately developed. And are very deep, loamy textured and are responsive to the management

Land Use: The area is largely prime land of state under agriculture. In the area under cultivation for cereals and cash crop like sugarcane and agro-forestry plantation is also observed.

Potential Limitations: The alluvial plains are having slight to moderate water erosion hazard, prone to flooding during rainy season and are areas of low strength. Soil health issues such as stagnant or lowering of productivity even after increased use of water and chemical inputs have been noticed results in building up soil salinity and sodicity in soils significantly.

6.2 Soils of Valleys

The narrow valleys in the mountains which are located in the North part of state are transformed by glaciers. The massive snow mass and ice slowly creep downhill along the path of least resistance. The valleys cut by rivers and streams. As the glaciers melts, they pick up rocks and grind away at the valley floor and sides.

Apart from "V" shape Narrow mountain valley two physiographic units occurs here are River terrace and River/stream bank. The river terraces are observed along the river wherever the main channel is carved deeper than the adjoining plain due to high velocity of streams results in formation of uplifted River terraces, noticed in middle Himalayan mountain range.

These valleys are narrow with very gentle sloping to gentle sloping (1-5 %) having Thermic and Mesic soil temperature regime. The two landforms constitute part of mountain valley are River terraces and River/ Stream banks having a geographic area of 50,422 ha and 19,282ha respectively. These areas support crop/ vegetables productivity in the state.

These landforms were of Alluivio-colluvial origin, formed due to fluvial action of stream water and gravitational action at high sloping land surface on mountain. These soils are deep to very deep, sandy to coarse silty and fine silty in nature showing weak structural development.

6.2.1a Thermic temperature regime

Soils under Thermic soil temperature regime varied in depth from very deep to deep having coarse loamy to fine loamy texture. The land covers found here are agriculture, forest and open scrub. The forest lands covered with well drained, medium textured & developed soil structured soils whereas, the agricultural lands are well to somewhat excessively drained, sandy to coarse loamy/ silty soils with low organic carbon content.

The agriculture lands are showing soils with evidence of an ochric epipedon, an argillic horizon and moderate to high base saturation having soil moisture control section dry 90-180 cumulative days. Thyse soils ae very deep depth, fine loamy to fine textured soils.

Land Use: The area is mainly under agriculture and forest type. In the area under cultivation for millets and cereals is also observed along with open scrub/ dense scrub and mixed deciduous forest vegetation.

Potential Limitations: The narrow valleys and stream bank are prone to moderate to severe water erosion hazard and are susceptible to flooding. These are areas of low strength owing to shallow depth of rock, and the presence of large stones and prone to accumulation of debris due land slide. Similarly, agriculture lands on area being mountain river terraces, suffering from moderate erosion and these are the area of moderate strength.

6.2.2b Mesic temperature regime

Soils under Mesic soil temperature regime vary in depth from very deep to deep, having fine loamy to fine silty textural family. The soils in term of physiography are of Alluvial-colluvial in origin and have agriculture, open scrub and forest land use. The River terraces in valley area occupy **around 16,240** ha and in Stream /River bank is having an area of **7,022 ha** in the valley area of mountains. These are productive areas in middle Himalayas. The narrow valleys merged to the broad valleys where soils with high base saturation and fragipan structure in stream bank are encountered. These soils are deep, fine textured, calcareous in nature and are susceptible to moderate to high sheet erosion. The stream /river banks often filled with rocky exposures and soils of sandy & fragmental soil texture, been observed. Agriculture lands showing presence of Udic moisture regime where the soil moisture control section remains dry for <90 consecutive days.

Land Use: The area is largely under agriculture and forest types based on canopy cover of forest vegetation are observed. The area under cultivation for cereals, medicinal/spices and plantation is also observed along with open scrub and scrubby forest vegetation.

Potential Limitations: The narrow valleys and stream banks having moderate to severe water erosion hazard and prone to flooding during rainy season. Shallow depth of soils, presence of large stones and accumulation of debris due to landslide are the feature of mountain valleys. Similarly, River terraces areas are mostly under agriculture, suffering from moderate water erosion and these areas of moderate strength.

6.3 Soil of Mountain top

Soil variation on summits and ridges is influenced by degree of slope and climate. The climate of the area is characterized by mild summer and cool winter. The mean annual rainfall is around 1500 mm in most of the part in the state. The Soil moisture is Udic, Ustic and Temperature regime is Mesic.

Ridges and summits with moderately to strongly sloping slope landforms spread in few patches. Soil develop in these areas is deep somewhat excessively drained, loamy surface. The soils on ridges and summits are deep to very deep, coarse silty to fine loamy. These soils are having high to medium organic carbon and medium base saturation with medium/low buffering capacity. These soils occupy the area representing 0.02 % of the total geographic area. These soils cover the part of Chamoli, Uttarkashi.

Land Use: Area is predominantly under scrub recreation and under occasional cultivation in patches.

Potential Limitations: Moderate sheet water erosion hazard, strongly slope, and deep to very deep depth to weathered parent material, prone to landslide activity, and areas of low strength.

6.4 Soil in Undifferentiated mountain side slopes

Formation of soils on side slope is influenced by degree and length of slope as it controls the surface runoff and soil erosion. The area is experiencing wide variation in climate. In the extreme north, most of the areas are covered with snow and precipitation is received through snowfall.

Soil temperature is identified as Mesic and Isofrigid, areas above 3500 m in altitudes are nearer to Isofrigid region, experiencing cool climate. The variations in temperature and soil moisture regime are related to the altitude of the area. The Uttarakhand state is experiences mild summer and cool winter in general. The soil moisture regime in subtropical area is Ustic and in temperate area is Udic type and soil temperature regime is Thermic and Mesic in areas having < 2500 m above MSL.

These soils cover an area of 33,91,325 ha representing 63.41% of total geographic area with soil temperature regime Thermic, Mesic and parts of Isofrigid (areas < 3500 m above MSL), whereas the soil moisture regime is Ustic and Udic-Ustic and Udic type.

6.4.1 Moderately to Strongly Sloping (5-15%)

6.4.1a Thermic temperature regime

These landforms are found in mountain foots which constitute the part of lower Himalaya and in residual hills of Siwalik range.

Theses soils are moderately deep to deep & very deep having coarse loamy to fine loamy, fine silty and fine having medium to high organic carbon content as per the parent material type. These landforms are suffering from slight to moderate & severe erosion classes at different places. The different land use observed were agriculture, forest and open scrub.

Under agriculture land use soil with low to medium organic matter content, clay enriched subsurface horizon with moderate to high base saturation are observed. The soil moisture control section

dry 75-150 cumulative days. Apart from these soils with soils showing minimal to moderate soil development found in association. Soils having sandy texture with redox depletion was also mapped in lower topographic plains in patches.

These areas are mostly covered in Almora, Bageshwar, Champawat, Dehradun, Haridwar, Nainital, Pauri and Tehri Garhwal distrcts.

Land Use: The area is largely under varied forest cover and forest types are observed. In patches the area under cultivation for millets and cereals were also observed along with open scrub and scrubby forest vegetation.

Potential Limitations: Moderately to strongly sloping mountain slopes mostly remains dry for 75 to 150 days under dense forest vegetation are having slight water erosion and are areas of moderate strength. The potential landslide activity and severe to very severe erosion areas of low strength are observed in area of thin (0-20%) canopy forest and in open scrub land use. The agriculture lands are mountain terraces, suffering from moderate erosion and these are the area of moderate to low strength.

6.4.1b Mesic temperature regime

This regime constitutes part of middle Himalayan structural mountains. Theses soils are moderately deep to very deep having contrast in textural class ranging from coarse loamy to fine loamy, fine and sandy textural family. The different land use namely agriculture, forest and open scrub are associated with different soils types. The content of soil organic carbon varies with land cover type in forest and influence the availability of moisture in agricultural terraced lands. These soils show predominance of coarse fragments in forest & open scrub whereas, the agriculture terraces under crops and plantations are relatively stable.

The agriculture lands are showing two soil types, i.e. soils showing development in subsurface features responsible for increased soil moisture in soil series control section. At places presence of fragipan within series control section are base-rich soils. The other type being soils with no diagnostic horizons with sandy, fragmental soil texture class, well drained drained with excessive permeability and having soil moisture control section remains moist for ¾ part of year.

These areas are mostly covered in Bageshwar, Chamoli, Pithoragarh, Uttarkashi, Rudraprayag and Tehri Garhwal districts.

Land Use: The area is largely under varied forest cover and forest types based on canopy cover of forest vegetation are observed. In patches, the area under cultivation for millets and cereals is also observed along with open scrub and scrubby forest vegetation.

Potential Limitations: Moderately to strongly sloping mountain slopes mostly remains remains moist for ¾ part of year i.e. 9 months sunder dense forest vegetation are having slight water erosion and are areas of moderate strength. The lands suffer severe to very severe erosion are the areas of low strength are observed in area of thin (0-20%) canopy forest and in open scrub land use. The agriculture lands are mountain terraces, suffering from moderate erosion and these are the area of moderate to low strength.

6.4.2 Steep slope (15-33%)

6.4.2a Thermic temperature regime

These landforms are found in structural hills of Phyllite, Schist, Gneiss and Sand Stone type parent material that are constitute the part of lower Himalaya and in residual hills of Siwalik range, respectively.

The soils are deep to very deep developed on undifferentiated mountain slope. These soils are excessively drained to well drained, fine loamy to coarse loamy texture with slight surface stoniness and gravelliness suffering from slight to severe sheet and gully erosion and are found in the forest land use.

Based on canopy cover two types of soil associations are observed in Thermic temperature regime. The moderately dense to dense forest (20-60 percent canopy) covered landforms dominantly covers with soils having medium to high organic carbon content, moderate to well-developed structure, offsets the soil loss shows only moderate erosion. Whereas the scrubby forest / Open scrub land, soils with low per cent organic carbon, relatively coarser texture with weak structural development covered by Pinus sp. and suffers from moderate to severe erosion.

Apart from these, two other land use i.e. agriculture and open scrub were also observed. The soils in this area are moderately deep to deep, fine loamy to coarse loamy and loamy skeletal textural class. These soils are suffering from moderate erosion.

These areas are mostly covered in Almora, Bageshwar, Champawat, Haridwar, Nainital, Pauri and Tehri Garhwal distrcts.

Land Use: These areas are largely under forest cover and forest types of moderate canopy cover. In patches the area under cultivation for millets and cereals are also observed along with open scrub and scrubby forest vegetation.

Potential Limitations: Moderately steep to steep sloping mountain slope remains dry from 90 to 150 days under thin to moderately dense forest vegetation are suffering with moderate water erosion and are inferred to be areas of moderate to low strength. The severe to very severe erosion are confirmed to be the areas of low strength is observed in area of thin (<10%) canopy vegetation and in open scrub land use. The agriculture lands are mountain terraces, suffering from moderate erosion and these are the area of moderate to low strength.

6.4.2b Mesic temperature regime

These landforms are found in Structural hills of Phyllite, Schist, Gneiss and Granitic gneiss which forms the part of lower Himalaya and also among residual hills of Siwalik range.

The soils of under lower Himalayan landscape are deep to very deep and shallow to moderately deep in Middle Himalayan region having textural class coarse loamy to fine loamy, fine silty and fine, developed on steeply sloping hill side. These soils are having high proportion of per cent organic carbon,

favourable texture & structure to suspect mixed vegetation. The land use found are agriculture, forest and open scrub. The dominant landuse being agriculture. Whereas, others are under open scrub, 40-60 % canopy forest and 20-40 % canopy forest.

Whereas, under Middle Himalayan Region, the soils are having agriculture and forest. These soils are very deep, deep to moderately deep, fine loamy texture, favourable structure to promote mixed forest and double crop and remains moist in all or some parts for > 270 days.

The agriculture lands are showing two soil types, i.e. soils with evidence of cambic horizon and an ochric epipedon having ½ to ¾ soil moisture control section. These have fragipan within its upper boundary, have base-rich soils in some areas and presence of mollic epipedon was observed in the area.

And also showing soils with no diagnostic horizons other than an ochric epipedon with sandy & fragmental nature and having soil moisture control section dry <90 cumulative days.

These areas are mostly covered in Bageshwar, Chamoli, Pithoragarh, Uttarkashi, Rudraprayag and Tehri.

Land Use: On the basis of canopy cover, the area is largely observed varying in forest cover and forest types of forest vegetation. This leads in maintaining soil functions such as regulation of soil nutrients, water and temperature. It also affected soil-related ecosystem services such as soil nutrient availability or erosion control by water. In patches, the area under cultivation for millets and cereals is also observed along with open scrub and scrubby forest vegetation.

Potential Limitations: Moderately steep to steep sloping mountain slope remains moist for 210 to 270 days under dense forest vegetation are having moderate strength accompanied with Slight water erosion. The potential landslide activity with severe to very severe erosion areas of low strength were observed in area of thin (0-20%) canopy forest vegetation and in open scrub land use. The agriculture lands are mountain terraces, suffering from moderate erosion and these are the area of moderate to low strength.

6.4.3 Very-Very steeply sloping (33 - >50% sloping)

6.4.3a Thermic temperature regime

These landforms are found in Structural hills of Phyllite, Schist, Gniessic-complex and Sand stone which constitutes lower Himalaya areas of middle Himalayas.

These soils are moderately deep to very deep, developed over sloping high mountain slopes. These soils are excessively drained, Coarse loamy to fine loamy with slight surface stoniness and rockiness at places and suffers from moderate to very severe erosion. The soils are moderately acidic in nature, dark brown to dark yellowish brown and moderately rich in organic carbon content. These soils have moderate to high base saturation. The soil shows none-slight to moderate profile development.

In these landforms soil associations varies with altitude and also land use/land cover wise are reported as under. The soil association with deep, fine loamy soils with slight surface stoniness and rockiness and moderate to severe erosion having high to medium soil organic carbon values with densely covered forest (40-60% canopy). Whereas, other soil association of moderately deep depth, coarse loamy

to fine loamy & loamy skeletal type with low soil organic carbon status are observed in thin to moderately dense forest vegetation (0 to 40%).

Similarly, the association of soils are moderately deep depth, fine loamy to fine silty with low to medium soil organic carbon content under Stable Mountain terraces are having agriculture land use. The remaining are under open scrub land use.

These areas are mostly covered in Almora, Bageshwar, Champawat, Haridwar, Nainital, Pauri and Tehri.

Land Use: The area is largely under forest cover having variety of forest vegetation and partly under cultivation for millets and cereals. This area is moderately suitable for deciduous evergreen forest vegetation, shrubs, medicinal and aromatic species.

Potential Limitations: Prone to moderate water erosion and remain partly dry for more than 150 days under dense forest vegetation are the areas of moderate strength. The lands show potential landslide activity and very to very severe erosion areas of low strength attributed mainly to loss of vegetation cover under thin vegetation canopy, forest area suffering from moderate to severe, rill/ gully sheet erosion and the area under agriculture, open scrub land use as well.

6.4.3b Mesic Temperature regime

These soils are deep to very deep and developed on undifferentiated mountain slope on the middle to greater Himalaya region. These soils are excessively drained; fine loamy to coarse loamy texture with surface rockiness, stoniness and gravelliness with moderate to very severe erosion are having moderate per cent organic carbon in the forest land use.

Three types of soil associations are observed in mesic temperature regime based on per cent canopy cover of forest vegetation, i.e. dense forest (40-60 % and above canopy) having slight to moderate erosion, moderately dense (20-40% canopy) forest suffering from moderate erosion and thin forest vegetation suffering from severe to very severe erosion.

Apart from forest other two land use viz. Agriculture and open scrub grassland are also observed in this type. These soils are moderately deep to deep, fine loamy to coarse loamy & loamy skeletal textural class and are rich in organic carbon thus suitable for organic farming. These soils are suffering from moderate to very severe erosion.

The soil association on the area of altitude of 2500 m and above are of shallow to moderately deep, gravely coarse loamy to loamy skeletal of Typic Udorthents and Lithic Cryorthents are found in scrubby uncultivable waste land on zones of glacial drifts and Moraines.

The agricultural lands are having the soils of deep and fine loamy texture. These areas are mostly covered in Bageshwar, Chamoli, Pithoragarh, Uttarkashi, Rudraprayag and Tehri.

Land Use: On greater Himalaya, very steep to extremely steep mountains slopes are dominantly occupied with soils of shallow depth, excessively drained, sandy-skeletal to loamy-skeletal, neutral to slightly acidic with low available water holding capacity. Such soil covers 406842 ha area of which 35-40 per cent area are found under the unit rock-out crop in patches and non- divisible being the part of extremely steep sloping escarpment in most part. Remaining part of area under both altitude zone (greater and middle Himalayas) is under forest cover and, some patches under cereals and millets cultivation, similarly the land on altitudes of 2500 m and above is under mountain cliffs are under perpetual snow/barren uncultivable waste land and lower part of the near stream under cultivation of millets.

Potential Limitations: Moderate water erosion and soil in some or all parts remains moist for 9 months i.e. 270 days and under moderately dense to dense forest are the areas of moderate to high strength. Severe to very severe erosion was observed in the areas of thin forest and open scrub/deforested lands. These lands are bearing low strength for soil erosion/land slide. The agricultural lands having Steep faces of terraces that border bottomlands having moderate water erosion hazard are the areas of lower to moderate strength.

CHAPTER 7

Geo-spatial Soil database in future strategic Planning for land use

Uttarakhand State is well endowed with forest and water resources. More than 12,000 glaciers and 8 major river catchments act as the lifeline for the entire hydrological system of Indo-Gangetic plain. The Himalayan Watersheds are under constant threat of mass wasting and erosion caused by depletion of forest cover, unscientific agronomic practices, hydrologic imbalances and natural calamities.

Under current scenario of increasing population, need to provide a better quality of life to the people and the pressure on natural resources is further compounding the problem. Considering the magnitude of the problems and demand of state, there is a need to provide the hydrologic framework for taking up watershed based planning. **Soil and Land Use Survey of India** has delineated and codified the state in 4 Catchments (2B3, 2B6, 2B7 and 2C7), 14 Sub catchments, 72 watersheds, 1,502 sub watersheds and 8,382 Microwatersheds with **unique national code** in the state which can be taken up for regeneration and sustainable development, in phased manner.

The distinct geographical features of Uttarakhand with dominantly mountainous part, coupled with Tarai and Ganges alluvial plain regions makes it a unique region where it is possible to grow varieties of fruits, flowers and other horticultural crops. With altitude wise gradient varying from 250 meters above sea level to 7,187 meters above sea level, different altitude. The study reveals spatial distribution of geographical area under different altitude determines the climatic condition favorable for various fruit crops, consequently, fruits orchards ranging from tropical to temperate fruit plants can be grown as per the location of area under various altitudes. The identification of areas of expansion should be taken up in accordance to the topography, agro climatic zone and soil conditions. **The Soil Resource Database developed by Soil and Land Use Survey of India using RS and GIS** of the state with the watershed **and micro watershed atlas** can be used for sustainable agricultural development.

Variation in altitude, microclimate and soil types offers natural advantage for crop diversification. Less remunerative crops can be replaced/alternated with more remunerative crop on a rotational basis. This will take care of sustainability as well as economic viability. The Soil resource databases identify and demarcate the areas of potential and promise.

Environmental heterogeneity and ecological fragility favored evolution of subsistence production system sustained with organic matter and nutrients derived from the forests. The forests cover 63.44 per cent of the total area of Uttarakhand. Though the actual cover based on remote sensing and satellite imagery information is only 43.06 per cent. The forests constitute the most important natural resource have in state. The forest eco-system and the protection of forest have remarkable contribution in the process of economic development and environmental stability. The locals of the region are dependent on forests for employment and resources like fuel wood, timber, fodder, medicinal herbs etc. But rising population and increasing needs have led to indiscriminant

exploitation of forest resources and leads to depletion of forests. About 13.46 per cent of area has been converted to degraded forest land.

The Soil Resource database at 1:50,000 useful in developing strategies or action plan to ensure fulfillment of both ecological and economic needs as it has locational and spatial extent of the forest wastelands and forest areas suitable for agro forestry which should be utilized for agriculture to increase the revenues and the employment opportunities for the states rural population.

Uttarakhand has the advantage of very fertile Tarai region, which contributes maximum of its cereal production. This region also, comprising of districts Dehradun, Nainital, Hardwar and Udham Singh Nagar, which have high productivity. This area has been categorized under alluvial plain (4,60,600 ha) and under piedmont plain (29,272 ha) out of TGA. However, the area in around stream/river bank subjected to flooding and severe erosion (3,856.09 + 18,781.69 ha) needs to be treated for soil erosion control /flood control measures. However, the production and productivity in hill districts of Uttarakhand is relatively quite low due to small land holdings, adverse geo-climatic condition and non-availability of agricultural inputs (both in terms of quantity and quality). The technology transfer to these areas is also very difficult. The soil Resource database can be helpful in developing the strategy in the plain area for;

- **Identifying niche areas for developing specific crops**
- **Acidic soils and soil degradation due to soil erosion**
- **Decreasing humus content in soils in plains due to high use of chemicals**

For optimizing the land use in the state of Uttarakhand the assessment of climate and soil resources for alternative land use is essential prerequisite. This may help us to select the suitable and alternative cropping systems that are economically feasible, ecologically viable and socially acceptable for sustainable development. The Soil Resource Map does provide such information, which could be used for rationalizing land use.

METHODOLOGY ADOPTED IN THIS STUDY

Soil Resource Mapping in the state has been undertaken using latest technology, which includes remote sensing database i.e. Satellite imagery together with Survey of India Toposheets, geology and vegetation map of the region. A three-tier approach viz. visual image interpretation, Field Surveys and Laboratory investigation, Soil Map generation using digital cartography and printing was adopted.

Pre field interpretation

Monoscopic visual interpretation technique has been followed to prepare the soil resource map of Uttarakhand state. LISS-III (IRS-1D) satellite imageries on 1:50,000 scale having spatial resolution of 23.5 m were used for image interpretation to delineate the Landscape, Physiography, slope boundary to develop geomorphic units. Landscape, Physiography, and slope boundaries were drawn on the base map using SOI toposheet. The information and boundary delineation were transferred to satellite imagery to update the land use /land cover information and preparation of soil map units based on discernible variation in of image elements i.e. tone, texture, size, shape, pattern, location etc. An interpretation key was developed to segregate image units for each soil map units. A valid correlation between image elements and soil landscape characteristic was established and interpretation was carried accordingly.

The mapping unit is an association of dominant and co-dominant soil families with inclusion, if any. The dominant soil occupies the 50% or more area and co-dominant soil occupy 20% or more but less than 50% of total polygon area. The rest of area in the unit or polygon, if any, is covered by soil inclusion occupying less than 20% unit or polygon area.

Soil map unit composition

The map unit have been assembled in five tier approach as may be observed in the legend of soil map (1:50,000 scale) considering that there is a close relationship between the soil properties and soil forming factors in the soils in mountainous areas (Gessler *et al.*,1995; Gobin *et al.*, 2001).Thus, understanding the soil distribution pattern in relation to the soil forming factors is very important for the prediction of soil types in mountainous areas that helpful in extrapolating the soil properties on map.

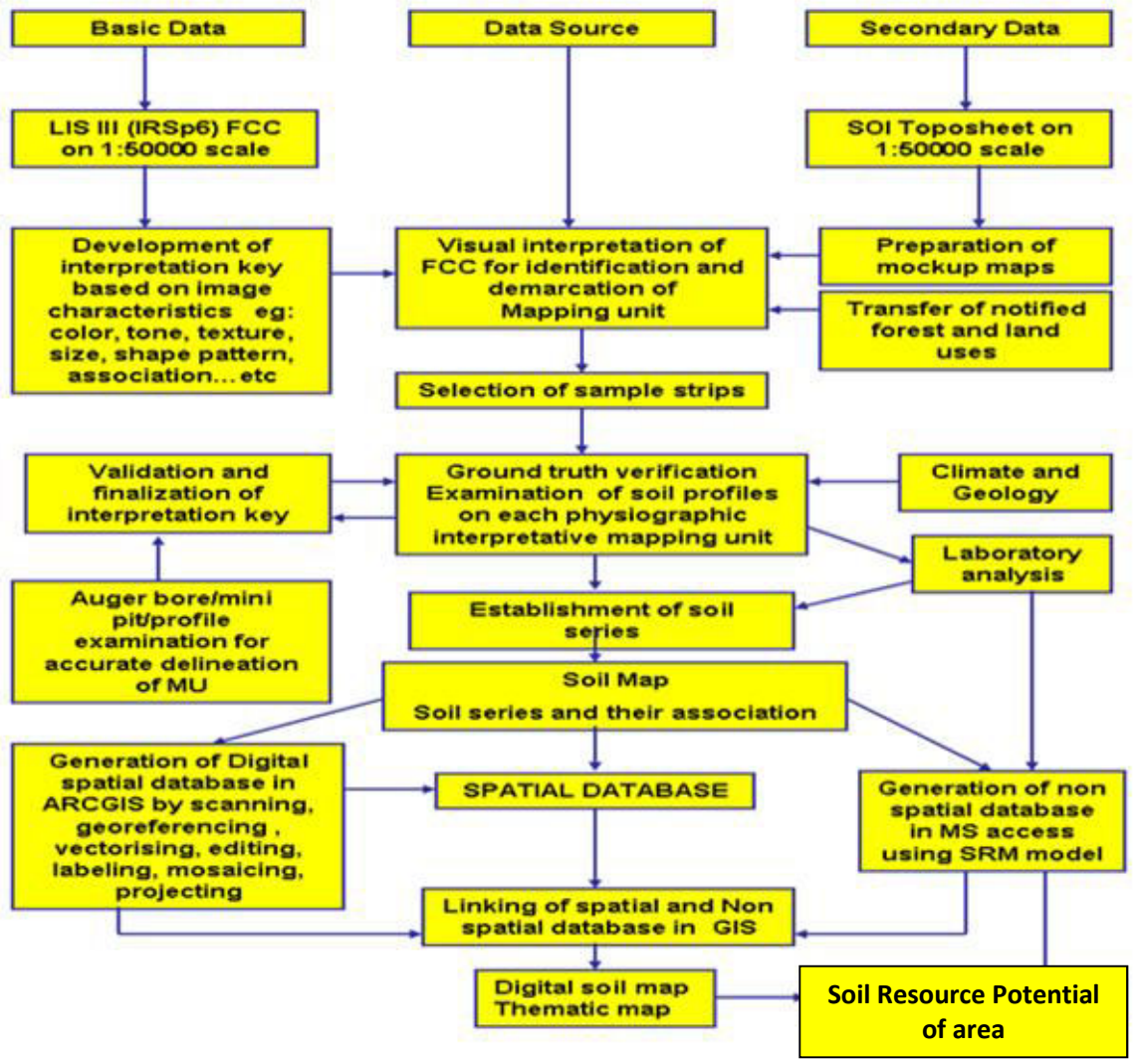
The upper tier shows the Landscape or Parent material, second tier shows the Physiography, third tier shows the slope class range, forth tier shows the present land use and the lower tier gives us the soil family association number qualifying a map unit.

Selection of Sample strips for Soil Studies in ground truth verification

The soil mapping unit is combination of the derived landform and geological formation was used to stratify the soil sampling units and to allocate soil sample sites sample strips covering all landscape and physiographic units were selected for intensive study in order to establish soil series and their association. Field survey includes the ground truthing of selected sample points in order to establish correlation between spectral signature of the image with soil and its associated land

features. Selection of area for detailed field investigation was made keeping the number of tentatively defined soil classes, traffic ability of the area and the total area under study. All the tentatively identified and defined soil classes are studied in the field through soil profile examinations and auger bore observations to identify and record the morphological characteristics of the soils and to correlate them with image characteristics. Around 35 to 40 per cent of the total area was studied for all the tentatively identified soil classes. Soil samples were collected from soil profiles for detailed physico-chemical analysis. Soil series and their association have been mapped as mapping units.

The soil profile and auger bore observations have been correlated with its image characteristics for preparation of final legend and accordingly post field interpretation has been done.



Flow chart showing the Methodology for Soil Resource Mapping

Post field interpretation, validation and finalization of maps

Soil samples collected in the field horizon wise during ground truth were analyzed for various physical and chemical such as mechanical analysis, pH, EC, Organic carbon, cation exchange capacity, base saturation etc. and classification of soil series is finalized according to Soil Taxonomy (USDA, 2010) in the light of soil morphological and analytical data.

To ensure correct identification of soil class and their accuracy in delineation of soil boundaries, validation of the soil resources mapping have carried out by undertaking random ground checks. Based on validation findings, improvement in identification and mapping was made wherever necessary. Thus, image analysis undertaken prior to the field survey is thoroughly examined and adjusted in light of ground observations.

PROJECT TEAM

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