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Soil Distribution in Nepal

Sher Bahadur Gurung
Central Department of Geography, Tribhuvan University Nepal
Email: sher.gurung@cdg.tu.edu.np

Abstract

Soil is the important natural recourse for living things of the world and regulates its ecosystem. Soil types are depending on physiographic and climatic factors. The study discussed soil types of Nepal prepared by Land Resource Mapping Project (LRMP) based on world reference base developed by Food and Agriculture Organization of the United States (FAO) and Soil and Terrain (SOTER) soil type of Nepal by ISRIC-World soil Information based on universal soil classification system developed by United State Department of Agriculture (USDA) using Geographic information system (GIS). According to LRMP the soil types of Nepal are as follow: Dystrochrepts Haplumbrepts Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs, Haplumbrepts Dystrochrepts Cryumbrepts, Udipsamments Dystrochrepts Rhodustalfs, Glaciated Mountain, Haplaquents Haplaqepts Eutrocrepts, Udorthents Ustorthents Haplaquents, Dystrochrepts Halpumbrepts Haplustalfs-calcarious Materials, Rhodustalfs Dystrochrepts Haplustalfs, Dystrochrepts Eutrochrepts Argiudolls, Dystrochrepts Hapludalfs Haplustalfs-Calcarious Materials, Haplaquents Psammaquents Ustorthents, Haplaquents Eutrocrepts Heplaquents-calcareous Materials and Haplaquepts Dystrochrepts Haplaquents covering four soil order i.e. Entisols, Inseptisols. Mollisols and Alfisols. According the SOTER map, the soil types are as follow: Gelic LEPTOSOLS, Eutric CAMBISOLS, Eutric REGOSOLS, Humic CAMBISOLS, Chromic CAMBISOLS, Dystric REGOSOLS, Eutric GLEYSOLS Calcaric, PHAEOZEMS, Gleyic CAMBISOLS, Haplic PHAEOZEMS, Calcaric FLUVISOLS and other are glacier, ice, rock croup, lake and water. These types of soils are controlled by physiography and climatic factors. The SOTER soil types are more familiar than LRMP soil map although in LRMP soil map is useful to understand the soil characteristics and soil forming processes of Nepal.. The soil degradation mitigation and adaptive strategies should consider the soil diversity types and its controlling factors such as physiography and climate.

Keywords: GIS, Natural Resource, Soil Distribution, Soil Conservation, Soil Terrain

Introduction

"Soil matters for humans and ecosystems" (Vienna Soil Declaration, 2015).

Soil is an important natural recourse for living things of the world, which connect the chain of ecosystem. Its types are variably distributes all over the earth surface which are familiar by the characteristics and various soil types are mapping units; and exist as bodies of similar soil material which eventually merge laterally with other soil types, bedrock, or unaltered sediment. It consists of

a natural body of minerals and organic matter occurring on the surface of the earth. It is an important part of the natural environment which is made up of a multitude of physical, chemical and biological entities with many interactions occurring among them for plant growth and having ever-changing properties in response to many chemical and bio-physical processes. There are different types of soil in Nepal. Various factors such as geology, physiographic, climate and vegetation types have resulted in variations in soil properties. There is very limited research about soils in Nepal (Shah, 1995 and Chalise, Kumar & Kristainsen (2019).

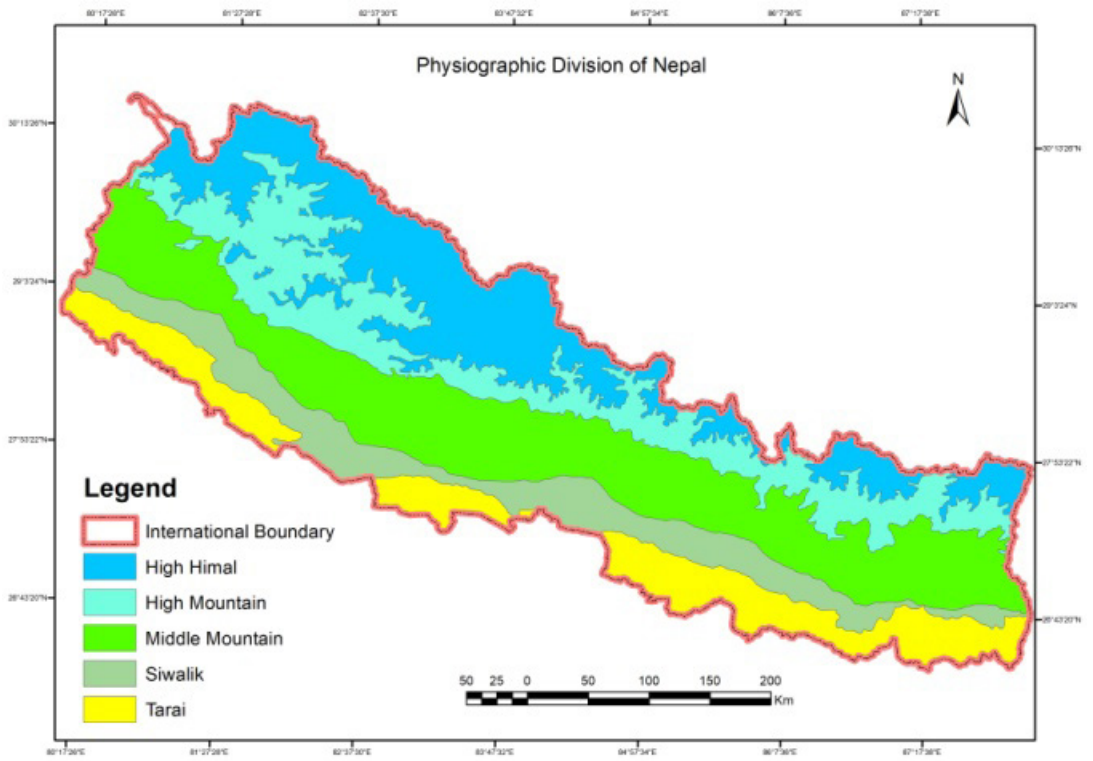
Knowledge of the distribution of soil with its types is critical to humanity's struggle for survival and well-being. This supports to identify the basic characteristics of soils as well as agricultural significance. Cropping system can be planned depending upon the types and distribution of soil. It also helps in promoting soil conservation policy. So the present paper studies visualized soil distribution and assess the soil erosion status of Nepal with large and small watershed using geographic information system and remote sensing techniques.

Material and Methods

The present research is based on published documents such as the books, reports and articles available on soil types, its classification and soil erosion of Nepal which developing the ideas regarding the soil types and soil erosion of Nepal. Similarly, most of the information related to soil types of Nepal was retrieved from websites. The study discussed soil types of Nepal prepared by Land Resource Mapping Project (LRMP) based on world reference base developed by Food and Agriculture Organization of the United States, FAO (LRMP, 1986) and Soil and Terrain (SOTER) soil type of Nepal by ISRIC-World soil Information based on universal soil classification system developed by United State Department of Agriculture, USDA (Dijkshoorn and Huting, 2009). The map scale of LRMP is 1:125000 and map scalr of SOTER soil type is 1:1000000. The soil types and its controlling factors like physiography and climate type are analyzed using Geographic information system (GIS).

Study Area

Nepal is located mostly on the Southern slope of central Himalayan in the continent of ASIA. Geographically, Nepal is elongated east to west (Mechi to Mahakali) with the length of 885 km. The North- South width varies from 145 to 241 km with the mean of 193 km. The shape of Nepal resembles roughly a narrow rectangle with an area off 147,181 sq. km. Nepal lies within the 26^{o} 12' to 30^{o}27' North latitudes and 80^{o}4' to 88^{o}12' East longitudes. It is bounded by China in the north and India in all three directions east, west and south (Buffer State). Being bounded by land on all sides Nepal is also known as Land-locked country. The physiography of Nepal has been mainly divided on the basis of river relief, structure, altitude and geographical distribution. Boaroadly, Nepal is divided into Hills and Mountain regions and Tarai and Inner Tarai regions which occupy 77 and 23 percent respectively. The can be divided into Tibetan Mrginal Range, Inner Himalayas, Great Himalaya, Midland Valley, Mahabhart Lekh and Chre Range. Similarly, Tarai and Inner Tarai regions also can be divided into Inner Terai, Bhabar zone and Main Terai (see Fig. 1).



The main climates of Nepal are sub-tropical, warm temperate, cool temperate, alpine or cold and tundra or cold desert. The subtropical climate found up to 1200m from the sea level. It is hot and moist climate. The temperature ranges from 15^0 c to 35^0c and rainfall occur from 1000mm to 2000mm in this climatic zone. Warm temperate climate is a healthy climate, it is found from 1200m t0 2100m from the sea level. The temperature ranges from 10^0c to 30^0c and rainfall occur from 1000mm to 2000mm. The cool temperate climate also healthy climate but it is little bit cool which elevation ranges from 2100m to 3300m. The temperature is in between 5^0c to 20^0c and rainfall take place nearly 1000m with snowfall in winter. The characteristic of alpine or cold climate is short summer and long winter where the elevation ranges from 3300m to 5000m. Temperature falls in between 0^0c to 10^0c and rainfall occurs less than 500mm mostly in the form of snow but only 250mm in rain shadow area. The tundra or cold desert climate region found above 5000 m is permanently snow region. Temperature is always 0c all the year round and only snowfall take place and occasionally occur snow storm in this region. This region is also known as the third pole of the world (see Fig. 2).

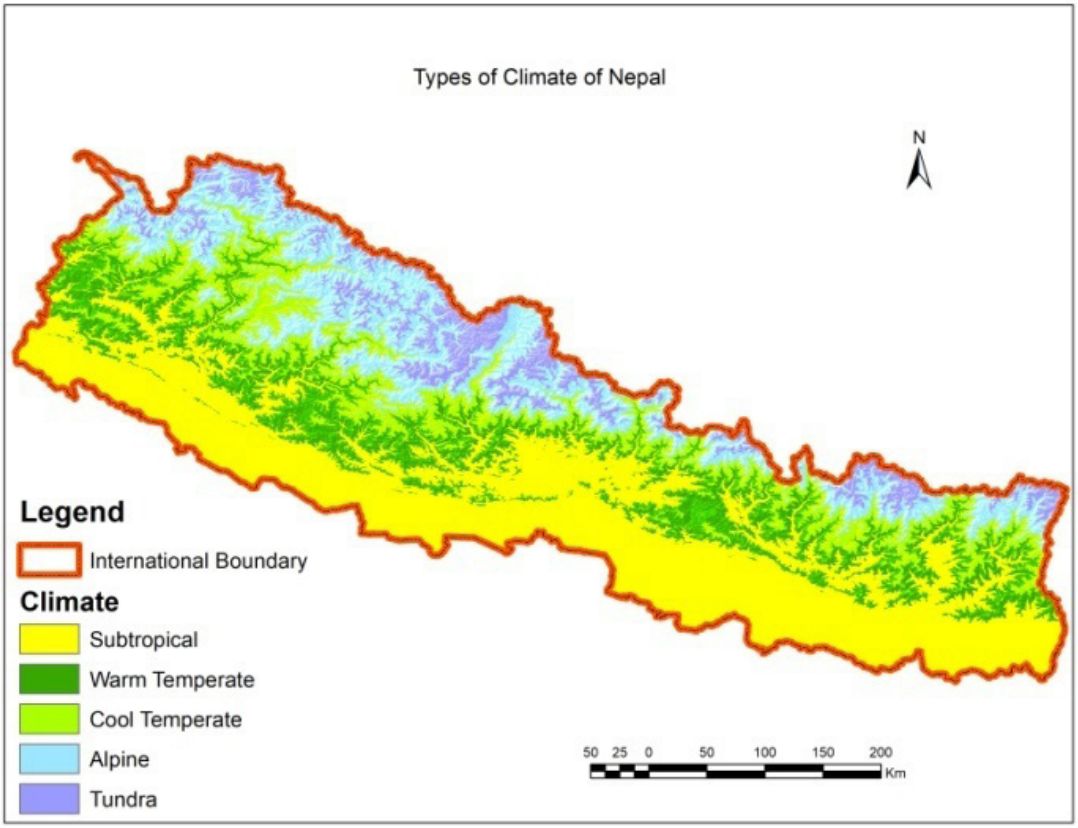


Fig. 2: Climatic Zone of Nepal

Results

Traditional soil classification of Nepal

Traditionally, Nepali people classify soil based on soil colour and texture (Shah, 1995). *Kalo* (black) soil is10 YR 3/1–4/1 –dark greyish brown-very dark greyish brown in munsell soil colour chart. *Rato* (red) means 2.5 YR 4/6–5/6 – red. *Haluko rato* (light red) denotes 5 YR 5/6–6/6-yellowish red-reddish yellow. Similarly, *Khair* (brown), *Phusro* (grey), *Kharani* (light grey) and *Jogi* (yellow) soils are 7.5 YR 4/2–5/2- brown-dark brown, 10 YR 5/1–5/2- grey –greyish brown, 7.5 YR 7/10 YR 7/7-light grey and 10 YR 6/6-7/6–8/8 – brownish yellow-yellow in munsell soil colour chart respectively. The local terms *Pango* denotes silty loam/silt of USDA texture class. Simmilarly, *Balaute, Domat, Balaute Domat, Balaute Chimte, Domat Chimte, Chim, Gagren, Masino and Chimte* means sand, loam, sandy loam, sandy clay loam, clay loam, clay, Gravelly, fine and very find clay soil of USDA texture class respectively.

Soil Type Land Resource Mapping Project (LRMP)

LRMP (1986) scientificlly reported dominate 14 soil grouping i.e. *Dystrochrepts Haplumbrepts*

Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs, Haplumbrepts Dystrochrepts Cryumbrepts, Udipsamments Dystrochrepts Rhodustalfs, Glaciated Mountain, Haplaquents Haplaqepts Eutrocrepts, Udorthents Ustorthents Haplaquents, Dystrochrepts Halpumbrepts Haplustalfs-calcarious Materials, Rhodustalfs Dystrochrepts Haplustalfs, Dystrochrepts Eutrochrepts Argiudolls, Dystrochrepts Hapludalfs Haplustalfs-Calcarious Materials, Haplaquents Psammaquents Ustorthents, Haplaquents Eutrocrepts Heplaquents-calcareous Materials and *Haplaquepts Dystrochrepts Haplaquents covering four soil order i.e. Entisols, Inseptisols. Mollisols and Alfisols*. Parent rocks of the soils are phyllite, quartz, sandstone, granites, gness and shisct. The characteristics of soil are high porosity, poor slope instability; shallow soil depth, course texture and acidic reaction (see Fig. 3). Soil orders *Spoddosol, histosol, Ultisol* and *Aridic* are occasionally found in Nepal.

Table 1: LRMP Soil Type

Soil Types	**Area in SQKM**	**Percent**
Dystrochrepts, Haplumbrepts, Haplustalfs	29746.48	20.21
Dystrochrepts, Haplustalfs, Rhodustalfs	23930.94	16.26
Haplumbrepts, Dystrochrepts, Cryumbrepts	22024.88	14.96
Udipsamments, Dystrochrepts, Rhodustalfs	17572.20	11.94
Glaciated Mountain	16872.91	11.46
Haplaquents, Haplaqepts, Eutrocrepts	10312.95	7.01
Udorthents, Ustorthents, Haplaquents	9177.09	6.24
Dystrochrepts, Halpumbrepts, Haplustalfs-calcarious Materials	7839.13	5.33
Rhodustalfs, Dystrochrepts, Haplustalfs	2900.84	1.97
Dystrochrepts, Eutrochrepts, Argiudolls	2127.31	1.45
Dystrochrepts, Hapludalfs, Haplustalfs-Calcarious Materials	1942.40	1.32
Haplaquents, Psammaquents, Ustorthents	1586.40	1.08
Haplaquents, Eutrocrepts, Heplaquents-calcareous Materials	780.87	0.53
Haplaquepts, Dystrochrepts, Haplaquents	366.61	0.25
	147181.00	100

Source: LRMP, 1986

Table 1 shows the dominant soil order i.e. *Dystrochrepts Haplumbrepts Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs, Haplumbrepts Dystrochrepts Cryumbrepts, Udipsamments Dystrochrepts Rhodustalfs, Glaciated Mountain, Haplaquents, Haplaqepts, Eutrocrepts, Udorthents, Ustorthents, Haplaquents* and *Dystrochrepts, Halpumbrepts, Haplustalfs-calcarious Materials* which occupy 20.21, 16.26, 14.96, 11.94, 11.46, 7.01, 6.24 and 5.33 percent respectively. *Heplaquents-calcareous Materials* and *Haplaquepts Dystrochrepts Haplaquents* are rare soil group.

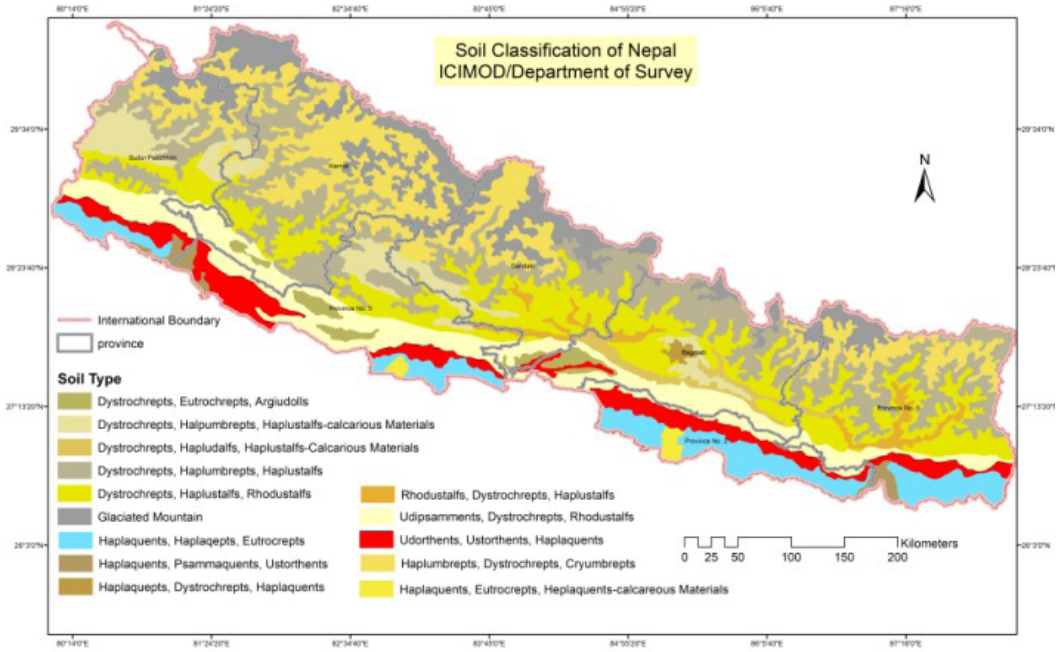


Fig. 3: Soil Classification of LRMP

Glaciated mountain soil and *Haplumbrepts Dystrochrepts Cryumbrepts* are dominant soil in High Mountain. *Haplumbrepts Dystrochrepts Cryumbrepts, Dystrochrepts Haplumbrepts Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs* and *Dystrochrepts, Halpumbrepts, Haplustalfs-calcarious Materials* are dominant soil in Mid-hill. *Haplaquepts Dystrochrepts Haplaquents* soil group found in Kathmandu valley. *Udipsamments Dystrochrepts Rhodustalfs* is dominant soil in Chure and Bhabar zone. *Udorthents, Ustorthents, Haplaquents* and *Haplaquents, Haplaqepts, Eutrocrepts* are dominant in Tarai and Inner Tarai region.

Soil and Terrain (SOTER) Soil Type

Dijkshoorn and Huting (2009) classified soil of Nepal based on the conversion of the soils and landscapes from the land system classification of Land Resource Mapping Project (LRMP, 1986). *LEPTOSOLS* is a very shallow soil and it is *Orthents* in Soil Taxonomy. *CAMBISOLS* is product of colluviums deposition and it is Eutric *Dystrudepts* in Soil Taxonomy. *REGOSOLS* or *Entisols* has no diagnostic sub-soils and it is *Psamments or Fluvents* in Soil Taxonomy. *Luvisols* or *Ultisols* is a clay accumulation in sub-soils and it is *Udults* in Soil Taxonomy. In paddy field, these are *Aquults* and in ancient alluvium and it is classified as *Hapludults* in Soil Taxonomy.

In table 2 show *Gelic LEPTOSOLS, Eutric CAMBISOLS, Eutric REGOSOLS, Humic CAMBISOLS, Chromic CAMBISOLS, Dystric REGOSOLS, Eutric GLEYSOLS Calcaric, PHAEOZEMS* and Gleyic CAMBISOLS are dominant soils which occupy 20.85, 18.83, 12.91, 9.69, 9.29, 9.25, 7.9, 5 and 2.34 percent area.

Table 2: SOTER Soil Type

Dominant Soils	Area in SQKM	Percent
LPi - *Gelic LEPTOSOLS*	30689.87	20.85
CMe - *Eutric CAMBISOLS*	27715.37	18.83
RGe - *Eutric REGOSOLS*	18996.25	12.91
CMu - *Humic CAMBISOLS*	14264.29	9.69
CMx - *Chromic CAMBISOLS*	13678.78	9.29
RGd - *Dystric REGOSOLS*	13610.11	9.25
GLe - *Eutric GLEYSOLS*	11626.43	7.90
PHc - *Calcaric PHAEOZEMS*	7358.79	5.00
CMg - *Gleyic CAMBISOLS*	3451.34	2.34
PHh - *Haplic PHAEOZEMS*	2264.60	1.54
FLc - *Calcaric FLUVISOLS*	2065.67	1.40
Glacier, inland ice	499.46	0.34
Rock outcrop	34.04	0.02
Lake, inland water	10.49	0.01
Total	147181	100

Source: Dijkshroom and Hunting, 2009

Gelic LEPTOSOLS and *Eutric REGOSOLS* are dominated soil group in the high Himalaya. *Eutric REGOSOLS, Humic CAMBISOLS, Eutric CAMBISOLS, Chromic CAMBISOLS* and *Gleyic CAMBISOLS* are dominated soil group in mid ill. *Dystric REGOSOLS* is dominating soil group in Chure and Bhavar zone. *Calcaric PHAEOZEMS* and *Eutric GLEYSOLS* are dominated in Tarai and Inner Tarai region in Nepal (See Fig. 4).

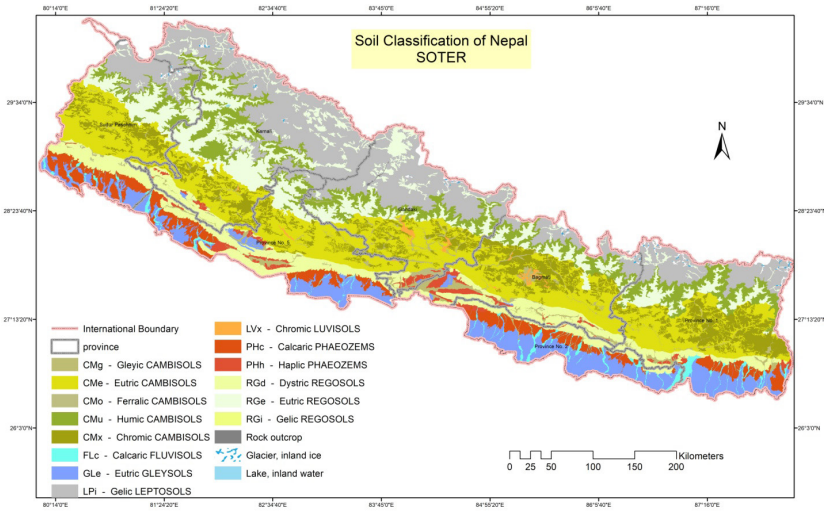


Fig. 4: SOTER Soil Classification

Soils of Nepal are highly variable and derive mainly from young parent which were classified into the following categories of FAO (Singh, Kharel, Joshi and Mathema, 2004):

Alluvial soils: These are found in the Terai valleys and the Dun valleys2 of the middle hills. Alluvial soils are divided into three broad groups: i) new alluvial soils deposited in the floodplain areas along river courses, which contain more sand and silt than clay; ii) less recent alluvial soils, which cover the greater part of the Terai; and iii) older alluvial soils, which are deficient in nutrients.

Sandy and alluvial soils: Relatively fertile sandy and silty alluvial soils are found in the Kathmandu and Pokhara valleys, together with some deposits of peat mare (diatomaceous clay). The Kathmandu valley is also a source of dark clay/silt clay soil, which is rich in humus and potash (with limited calcium) and is collected from deep underground pits and used to fertilize vegetable crops.

Gravely soils: A mixture of gravel and pebbles constitutes the coarse-textured gravely soils, which retain little moisture and are not useful for agriculture. Deposited by the rivers that originate in the Churia hills, these soils have high lime contents. Some coarse-textured soils are also found in the high mountain area.

Residual soils: These are found mostly on mountain ridges and slopes. Those of the Churia hills are very young, coarse and dry for most of the year. Residual soils on the middle hills have medium to low nutrient contents and are less productive owing to moisture and climatic limitations.

Glacial soils: These are found in the high Himalayas and are mainly rocky and covered with snow and/or ice for most of year.

Organic matter (OM) on cultivated soils below 2000 m asl range from 0.5 to 3.0 percent (average <1.0 percent). Forest soils have 1 to 2 percent higher OM contents. Over 2000 m asl, OM contents for both cultivated and forest soils (2 to 3 percent higher). New forest clearings in the Terai may have 4 to 5 percent OM contents, but these drop to less than 2 percent after a few years of cultivation.

Discussion

The physiographic condition of the earth surface create various physio-chemical soil types LIu, Pan, Bao, Liang, Jiang, Tu, Nong and Huang (2020) and climatic factor also play a vital role to develop various soil properties Nwosu and Okon (2020). The table 3 shows the soil variation according to various physio climatic conditions.

Table 3: Physio-climatic Distribution of Soil

Elevation in m.	Physiography	Climate	LRMP	SOTER
Above 5000	High Himalaya	Tundra or cold desert	Glaciated mountain soil and *Haplumbrepts Dystrochrepts Cryumbrepts*	*Gelic LEPTOSOLS* and Eutric *REGOSOLS*
3300 – 5000	Trans Himalaya and Inner Himalaya	Alpine	*Haplumbrepts Dystrochrepts Cryumbrepts*	*Gelic LEPTOSOLS* and Eutric *REGOSOLS*

2100 – 3300	Mid-Hill and Mahabharat	Cold Temperate	*Haplumbrepts Dystrochrepts Cryumbrepts, Dystrochrepts Haplumbrepts Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs* and *Dystrochrepts, Halpumbrepts, Haplustalfs-calcarious Materials*	*Eutric REGOSOLS, Humic CAMBISOLS*, *Eutric CAMBISOLS, Chromic CAMBISOLS* and *Gleyic CAMBISOLS*
1200 - 2100	Mid Hill	Warm temperate	*Haplumbrepts Dystrochrepts Cryumbrepts, Dystrochrepts Haplumbrepts Haplustalfs, Dystrochrepts Haplustalfs Rhodustalfs* and *Dystrochrepts, Halpumbrepts, Haplustalfs-calcarious Materials*	*Eutric REGOSOLS, Humic CAMBISOLS, Eutric CAMBISOLS, Chromic CAMBISOLS* and *Gleyic CAMBISOLS*
60 - 1200	Chure, Tarai and Inner Tarai	Sub-tropical	*Udorthents, Ustorthents, Haplaquents* and *Haplaquents, Haplaqepts, Eutrocrepts*	*Calcaric PHAEOZEMS* and *Eutric GLEYSOLS*

Source: After LRMP, 1986 and Dijkshroom and Hunting, 2009

There is interrelation between soil formation or types and geomorphological processes (Bouza, Ríos, Rostagno, & Saín, 2017) soil physio-chemical properties also play a important role to develop various landforms of the earth surface. So that in Nepal, High mountiona and inner mountain region glacier lake out brust flood, avalanche and snow blizzard are major geomorphological events, in the mid hill, Landslides, debris flow, flash flood - landslide dam outburst flood, cloud burst etc. fluvial process take place and in Tarai region flood and channel shifting are major geomorphic processes which determine the sol formation of the region. Consequently, as a mountainous country Nepal is prone to soil erosion and degraded the soil and environs Ojha & Chalise (2016). Their study found that the annual soil loss in Nepal ranges from 2-105 t ha-1 with 34% water induced erosion and 60% mass wasting (geological erosion). Other forms of land degradation like flooding (6%) and water logging (5%) are present in bottom hills and plain areas of Nepal. In total, 28% of land is under degradation. As climate change impacts, soil degradation issues needed to be equally raised in Nepalese context.

Land degradation management policy is essential to address the current degradation problems and the soil conservation adaptive strategies are also essential to restore the ecosystem. Government took initiation to address soil and watershed degradation problems by promulgating 'soil and watershed conservation act' in 1983. Recently launched 20 years Agriculture Development Strategy envisioned reducing degraded land to 14%.

Conclusion

Soil is one of the important natural resource of the nation. The understanding of soil types and its controlling factors like physiographic and climatic condition are essential to measure soil degradation

and formulate scientific adaptive strategies. The study visualize the soil types of Nepal of LRMP based on world reference base developed by Food and Agriculture Organization of the United States (FAO) and SOTER map based on universal soil classification system developed by United State Department of Agriculture (USDA) and its controlling factors physiographic and climatic type using Geographic information system (GIS). There is fourteen types of soil group found in Nepal which is controlled by physiography and climatic factors. The SOTER soil types are more familiar than LRMP soil map although in LRMP soil map is useful to understand the soil characteristics and soil forming processes of Nepal. The soil degradation mitigation and adaptive strategies should consider the diversification of soils its controlling factors like physiogrphy and climate.

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