SOIL CLASSIFICATION

Land Capability Classification

Elementary knowledge of soil taxonomy classification and soils of India

Soil Classification: Purpose of soil classification

- Soil classification is the grouping of the objects in some orderly & logical manner
  - into compartments
- Purpose of soil classification
- 1. To organize knowledge leading to economy of thoughts
- 2. To recognize properties of the objects classified
- 3. To bring out & understand relationship among individuals
  - & classes of the population being classified
- 4. To establish groups or subdivisions of the objects under study in a manner useful
  - for practical and applied purposes in :
    - Predicting their behaviour; Identifying their potential uses; Estimating their productivity; Providing objects for research and
    - Transferring agro-technology from research farm to cultivators fields.

Soil Classification: Purpose of soil classification

- The latest comprehensive classification system is known as 'Soil Taxonomy',
  - based on the properties of the soils as they are found today
- The soil taxonomy permits classification of soils rather than soil forming processes
- There are six categories of classification in Soil Taxonomy:
  - (a) Order (the broadest category)
    - (b) Suborder
  - (c) Great group
    - (d) Sub group
  - (e) Family
    - (f) Series (most specific category)
- Nature & kind of differentiating characteristics used in these six categories
  - given in the Table – 1

Table-1: Differentiating characteristics of different categories

Category	Number of taxa	Differentiating characteristics
Order	12	These are based largely on morphology, as produced by soil forming processes & indicated by the presence or absence of major diagnostic horizons
Suborder	63	Sub-division of orders according to presence or absence of properties associated with wetness, soil moisture regime, parent material, vegetational effect as indicated by key properties
Great group	240+	Sub-division of suborder, major emphasis is on the diagnostic horizon and presence and absence of diagnostic layers, base status, soil temperature and moisture regime.
Subgroup	1000+	The Typic is used to define the central concept of a great groups; the others are used to indicate integrated to great groups, suborders and orders and the extra graded to 'not soil'
Family		The soil properties that are most important for plant growth like texture, mineralogical class, soil temperature class and pH are used to differentiate families. They meet the need for making practical predictions for land use planning.
Series	200+ in India And 12000 in USA	It is the lowest category in the system. The series is collection of soil individuals essentially uniform in differentiating characteristics like colour, texture, structure, consistencey, pH and EC and in arrangement of horizons.

Soil Orders

- There are twelve soil orders
  - which are differentiated by presence or absence of diagnostic horizon (Table-2)
  - or features that are marked in the soil of difference in the degree
  - & kind of dominant sets of soil forming processes that have prevailed
- Diagnostic horizon is defined as one, formed through pedogenic processes
  - & having distinct properties or features
  - that can be described in terms of measurable soil properties
- Diagnostic surface horizon are called epipedons (Greek *epi,* over and *Pedon,* soil)
- Epipedons includes the upper part of the soil darkened
  - by organic matter, the upper eluvial horizons or both
- Diagnostic subsurface horizons are called endopedons
  - (Greek endodermis, subsurface or deep-seated and *Pedon*, soil)
- The epipedons includes the lower part of the soil materials accumulate

Designations of master horizons

Horizon Designation *New*	**Short description**
O	Organic horizon
A	Mineral horizon
E	Mineral horizon
C	Horizons or layers excluding hard bed rock
R	Hard bed rock

Horizon designation

- Once horizons are recognized & demarcated, it becomes necessary to name each horizon
- Capital letters, lower case letters and Arabic numerals are used to designate horizons
- The capital letters are used to designate master horizons e.g. A, B, C
- Lower case letters are used as suffixes to indicate specific characteristics of master horizon

Soil Orders: *Horizon designation*

- Example : A_p, B_t etc.,
  - p - tillage or other disturbance by cultivation
  - t - Accumulation of silicate clay
- Arabic numerals are used as suffixes to indicate additional vertical subdivisions within master horizon,
  - Example : B_t1, B_t2, B_t3 etc.
- Lastly Arabic numerals are also used as prefixes to indicate discontinuities in a profile
  - Example : 2C, 2BC etc.,
- Names of the orders can best be recalled by remembering a coined compound word
  - 'AVAAMIHOUSEG'
- Names of the orders along with formative elements
  - & salient characteristics are presented in Table-3

Table 2. Major features of diagnostic horizons

Diagnostic Horizon	Major features
Surface Horizons (Epipedons)- 9	
Mollic	Thick, dark coloured, high base saturation, strong structure
Umbric	Same as Mollic except low base saturation
Ochric	Light coloured, low organic content, may be hard and massive when dry
Histic	Very high in organic content, wet during some part of the year
Anthropic	Man modified Mollic like horizon, high in available P
Plaggen	Man made sod like horizoncreated by years of manuring
Folistic	Organic soil materials that remain saturated for less than one month
Melanic	A thick black horizon (>4.0 % OC) at or near, but within 30 cm of the soil surface
Grossarenic	A sandy horizon , 100 cm or more thick over an Argillic horizon

Table 2. Major features of diagnostic horizons

Diagnostic Horizon	Major features
Subsurface Horizons(Endopedons)- 19	
Argillic	Silicate clay accumulation
Natric	Argillic, high in sodium, columnar or prismatic structure
Spodic	Organic matter, Fe and Al oxide accumulation
Cambic	Changed or altered by physical movement or by chemical reactions
Agric	Organic and clay accumulation just below plough layer due to cultivation
Oxic	Highly weathered, primarly mixture of Fe, Al oxides, and 1:1 type minerals
Duripan	Hard pan, strongly cemented by silica
Fragipan	Brittle pan, usually loamy textured, weakly cemented
Albic	Light coloured, clay and Fe, Al oxides mostaly removed

Table 2. Major features of diagnostic horizons

Diagnostic Horizon	Major features (Subsurface Horizons(Endopedons)- 19)
Calic	Accumulation of $CaCO_3$ or $CaCO_3.MgCO_3$
Gypsic	Accumulation of gypsum
Salic	Accumulation of salts
Sombric	Draining horizon, formed due to illuviation of humus and not of aluminium or sodium
Kandic	Low activity clayswith or without clay skins, it has CEC of < 16 c mol(p+) kg-1 soil
Sulphuric	A mineral or organic soil horizon that has a pH <3.5
Glossic	Albic horizon characteristics gradually intruding in to an argillic, a kandic or nitric horizon
Petrocalcic	An indurated calcic horizon that has hardness of 3 or more(Mho's scale)
Petrogypsic	Astrongly cemented gypsic horizon whose dry fragments do not slake in water
Placic	A thin , slowly permeable, dark reddish brown to black coloured Fe or Mn pan
Of these Argillic, Natric, Cambic, Kandic, Oxic, Calcic and Gypsic are commonly observed in India	

Table 3: Soil orders with soil characteristics

SN	Soil Order	Derivation	Pronunciation Soil	Characteristics
1	Entisol	Nonsense symbol	Recent	Soils with little horizon development or beginning of soil formation
2	Inceptisol	L. *inceptum*, beginning	Inception	Soils with altered horizons, but no illuvial horizon containing clay or Fe, Al oxides, may have umbric, ochric or cambic horizon
3	Gelisols	Gk, gel, ice	Frost churning	Soils that have permafrost within 100cm or gelic material with permanent frost within 2m of the surface
4	Histosols	Gk. Histos, tissue	Histology	Soils containing > 30 % organic matter to a depth of 40 cm

Table 3: Soil orders with soil characteristics

SN	Soil Order	Derivation	Pronunciation Soil	Characteristics
5	Spodosols	Gk. Spodos, ash	Podzol; odd	Soils with spodic horizon with in 2 m
6	Andisols	Jap. And	Ando	Soils that have andic soil properties in 60% or more of the thickness between the soil surface and 60 cm or lithic or paralithic contact
7	Oxisols	Fr. Oxide, oxide	oxide	Highly weathered soils of tropical and subtropical regions with oxic horizon
8	Vertisols	L. verto, turn	Invert	Soils with more than 30% clay in all horizons and crack when dry

Table 3: Soil orders with soil characteristics

SN	Soil Order	Derivation	Pronunciation Soil	Characteristics
9	Aridisols	L. aridus	Arid	Dry soils, ochric epipedon, some have argillic, nitric or salic horizon
10	Ultisols	L.ultimus, last	ultimate	Soils in warm humid regions with argillic horizon and low base saturation(<35% at 2 m depth below the surface
11	Mollisols	L. mollis, soft	mollify	Dark colored, base rich soils of grass land areas, mollic epipedon, many with argillic, nitric, or calcic horizon
12	Alfisols	Nonsense symbol	Pedalfer	High base status (>35%) soils of the humid and sub humid regions with an ochric epipedon and argillic (or nitric) horizon

Land Capability Classification

- Land capability classification (LCC) may be defined as
  - a system of grouping land in to various classes
  - based on inherent limitations imposed on sustained use
  - by soil attributes, topography, drainage and climate
- Guiding principle underlying LCC is "use land according to its capability
  - & treat it as per its need"
- Capability classes falls in 2 groups:
  - one suited for cultivation
  - & other not suited for cultivation
- Each group is further sub-divided in to 4 capability
  - based on intensity of hazards and limitations of use
- Subclasses are further divides in to unit based on a specific management practice

Land Capability Classification

- Thus land is classified in to eight land capability classes under 2 broad groups as:
  - Land suitable for agriculture and other uses which include class I to class IV lands
  - Land not suitable for agriculture but very well suited
    - for forestry, grass land & wild life which include class V to class VIII lands
- On map, the capability classes are indicated in different colours as:
  - Green (I), Yellow (II),
  - Pink (III), Blue (IV),
  - Dark green (V),
  - Orange (VI),
  - Red (VII),
  - Purple (VIII)
- Detailed characteristics of each class are given in Table 4

Table 4: Salient features of Land Capability Classes (LCC)

LCC	Characteristics
	Land Suitable for Cultivation
I	Very good cultivable, deep, nearly level productive land with almost no limitation or very slight hazard. Soils in this class are suited for a variety of crops, including wheat, barely, cotton, maize, tomato and bean. Need no special practices for cultivation
II	Good cultivable land on almost level plain or on gentle slopes, moderate depth, subject to occasional overland flow, may require drainage, moderate risk of damage when cultivated, use crop rotations, water control system or special tillage practices to control erosion
III	Soils are of moderate fertility on moderate steep slopes subject to more sever erosion and severe risk of damage but can be used for crops provided adequate plant cover is maintained, hay or other sod crops should be grown instead of row crops.
IV	These are good soils on steep slopes, subject to severe erosion, with severe risk of damage but may be cultivated occasionally if handled with great care, keep in hay or pasture but a grain crop may be grown once in 5 or 6 years.

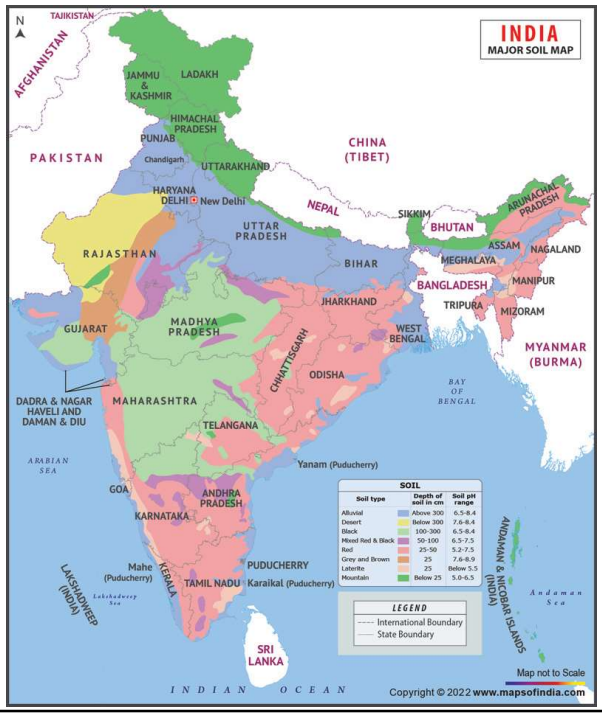
Table 4: Salient features of Land Capability Classes (LCC)

LCC	Characteristics
Land unsuitable for cultivation but suitable for permanent vegetation	
V	Land is too wet or stony which make it unsuitable for cultivation of crops, subject to only slight erosion if properly managed, should be used for pasture or forestry but grazing should be regulated to prevent cover from being destroyed
VI	These are shallow soils on steep slopes, used for grazing and forestry; grazing should be regulated to preserve plant cover; if the plant cover is destroyed, use should be restricted until cover is re-established
VII	These are steep, rough, eroded lands with shallow soils, also includes droughty and swampy land, severe risk of damage even when used for pasture or forestry, strict grazing or forest management must be applied
VIII	Very rough land, not suitable even for woodland or grazing, reserve for wild life, recreation or wasteland consideration

Soils of India: Introduction

The major soil groups of India and their properties

- India situated b/n the latitude of 08° 4' & 37° 06' N & longitudes of 68° 07' to 97° 25'E,
  - has a geographical area of 329 Mha
- India with a variety of landforms, geological formations & climatic conditions,
  - exhibits a large variety of soils
- Variety is so diverse that except few soil orders,
  - India represents all the major soils of the world
- Major soil group of India,
  - according to the Genetic approach can be classified in to following soil groups:
    - 1. Alluvial Soils, 2. Black(Cotton) Soils, 3. Red Soils,
    - 4. Laterite and Lateritic Soils, 5. Desert (Arid) Soils, 6. Forest and Hill Soils
    - 7. Podsolic Soils, Brown, 8. Forest Soils, 9 Salt Affected Soils



Alluvial Soils – (Soils of India)

- The name of Alluvial Soils is given to soils
  - which have developed on parent materials transported by different agencies
  - viz. water, ice, gravity and wind
- They are by far the largest and the most important group of soils for crop production
- They are extensively distributed in the states:
  - Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, West Bengal, Assam
  - & coastal regions of India & occupy an estimated area of 75 Mha
    - in the Indo-Gangetic Plains and Brahmaputra valley alone
- These soils are variable in texture,
  - depending on the source of parent material & their place of deposition
- They are coarser near the source and become finer near to sea
- They are stratified and irregular distribution of organic matter with depth

Alluvial Soils – (Soils of India)

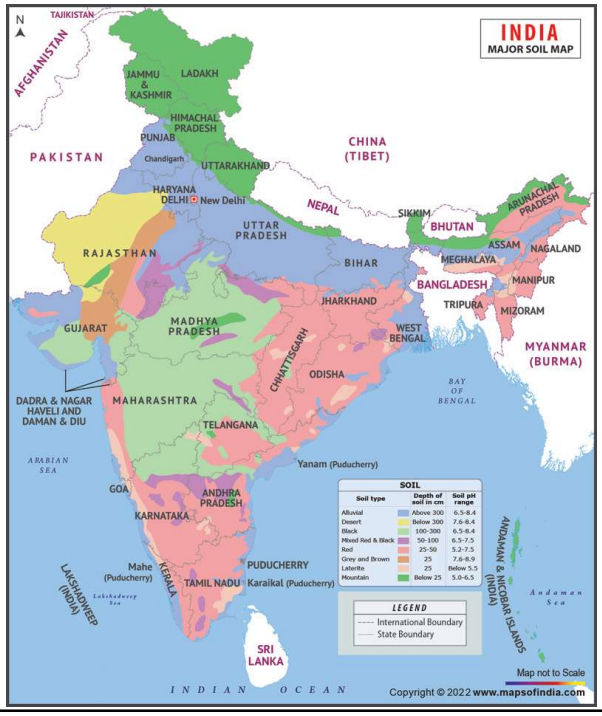
- They are either alkaline or acidic
- Profile development varies
  - from undeveloped (A-C) to very developed (A-B-C) profiles
- They are inherently rich in plant nutrients
- In general, they are fairly sufficient in phosphorus & well supplied with potassium,
  - but are deficient in nitrogen and organic matter
- These are the best agricultural soils used for growing most agricultural crops
- Because of injudicious use of irrigation water
  - some soils have been rendered waterlogged & pose problem of soil salinity
  - &/ or sodicity

Black(Cotton) Soils – (Soils of India)

- The name black is given to soils that are very dark in colour
  - & turn extremely hard on drying & sticky & plastic on wetting,
  - & hence are very difficult to cultivate & manage.
- These soils are dominantly distributed in central, western & southern states of India
- They occupy an estimated area of 74 Mha
- Soils developed on gneisses & schist
  - moderately shallow (50 - 80 cm) to moderately deep (80-120 cm),
  - while those developed on basalt are very deep (>150cm)
- They are highly clayey (30-80 %)
- The pH ranges from 7.8 to 8.7, which may go up to 9.5 under sodic conditions
- They have high exchange capacity because of smectite clay minerals
- These have high water and nutrient holding capacity

Black(Cotton) Soils – (Soils of India)

- These soils do not exhibit eluviation & illuviation process, because of churning
- These have high bulk density because of the swelling & shrinking nature of the soil
- Dark colour of the soil is due to clay-humus complex
  - & presence of titaniferous magnetite minerals
- They are highly sticky & plastic
  - & pose problems in both agriculture & nonagricultural crops
- These soils are poor in some available plant nutrients
  - especially N, P, S & micronutrients.
- Main constraints to crop production are due to low workability, low infiltration,
  - poor drainage and occasional moisture stress
- These soils are used for growing cotton, millet, sorghum
  - in Madhya Pradesh, Andhra Pradesh, Gujrat and Maharashtra states of India
- Under irrigated conditions they can be used for a variety of other crops
  - like sugarcane, wheat & citrus plantations.



Red Soils – (Soils of India)

- These soils are generally red or reddish brown
  - & derived from granites, gneiss and other metamorphic rocks
- These soils are formed under well drained conditions
- Eluviation & illuviation of clay, iron, aluminum
  - & bases are the main soil forming processes
- These soils are predominantly observed in the southern parts of Indian Peninsula,
  - comprising the states of Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra,
  - Orissa and Goa & in North Eastern States
- These soils are highly variable in texture, ranging from loamy sand to clay loam
- They are shallow & poor gravelly in uplands to very deep,
  - fertile in plains & valley
- They are, in general, neutral to acidic in nature

Red Soils – (Soils of India)

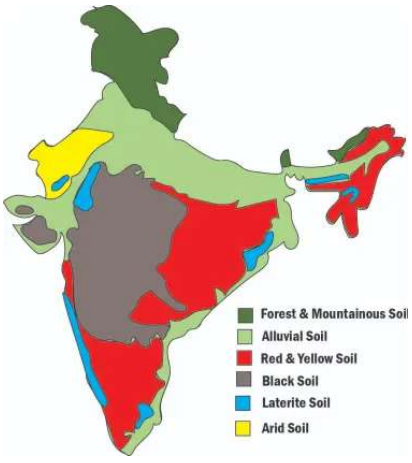
- The CEC (Cation Exchange Capacity) & base saturation of these soils
  - relatively lower than those of black & alluvial soils
- These soils are generally deficient in N, P and K
  - They are also poor in organic matter and lime contents
- These soils show common presence of kaolinite clay minerals
- Soils pose limitations of soil depth, poor water and nutrient holding capacity,
  - surface crusting and hardening, excessive drainage and runoff
- Under good management practices, these soils can be profitably used
  - for variety of agricultural, horticultural and plantation crops,
  - such as millets, rice, groundnut, maize, soybean, pigeon pea, green gram,
  - jute, tea, cashew, cocoa, grapes, banana, papaya, mango etc.

Laterite and Lateritic Soils – (Soils of India)

- The lateritic soils are those in which laterization is the dominant soil forming process
- It is a compact to vesicular rock like material
  - composed of a mixture of hydrated oxides of iron
  - & aluminum with small amounts of manganese oxides and Titania
- They are generally observed
  - on hill tops & Plateau landforms of Orissa, Kerala, Tamil Nadu etc.
- These are deeply weathered soils with high clay content
- Lateritic soils are more widely distributed
  - & occupy about 25 Mha of the total geographical area of India
- Kaolinite is the dominant clay mineral of these soils
- These soils lose bases & silica due to pronounced leaching
  - with accumulation of sesquioxides & the soils are rendered acidic

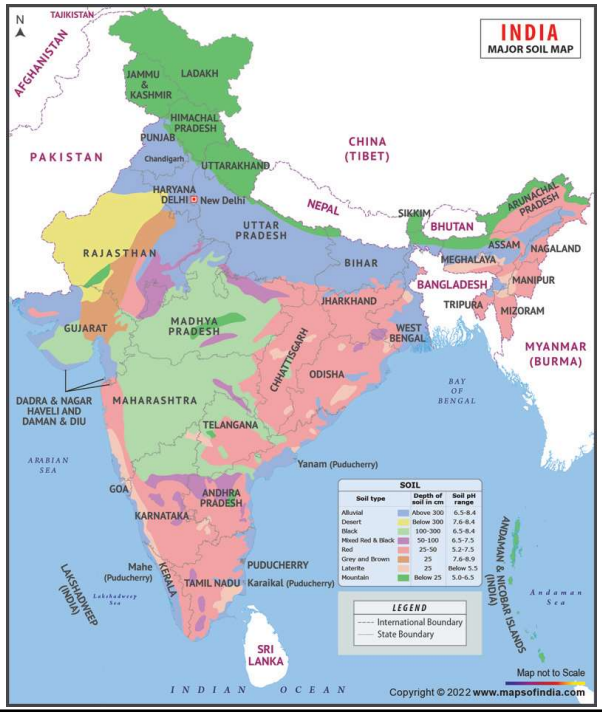
Laterite and Lateritic Soils – (Soils of India)

- These are low in CEC and base saturation
- The major limitations posed by these soils are deficiency of P, K, Ca, Zn, B, etc
  - & high acidity and toxicity of aluminum and manganese
- The laterites of lower topographic positions are used
  - for growing rice, banana, coconut, areca-nut
- & higher topographic positions
  - for cocoa, cashew, tea, coffee, rubber etc.



Desert (Arid) Soils – (Soils of India)

- A large part of the arid region belonging to western Rajasthan, southern Haryana
  - & S-W Punjab, lying b/n the Indus river & Aravalli hills,
  - covering an area of 29 Mha
- Soils of hot arid belts are comparable with those of Alluvial soils,
  - but have an aridic moisture regime
- Sandy material, under arid conditions, results in poor profile development
- These are sandy to loamy fine sand in texture
  - with clay content varying from 3.5% to less than 10%
- Pale brown to yellowish brown in colour & have weak subangular blocky structure
- Poor in nutrient (N, P, K, S and Zn) and water holding capacity
- These are slightly to moderately alkaline in reaction (pH 7.8-9.2)
  - because of calcareous nature

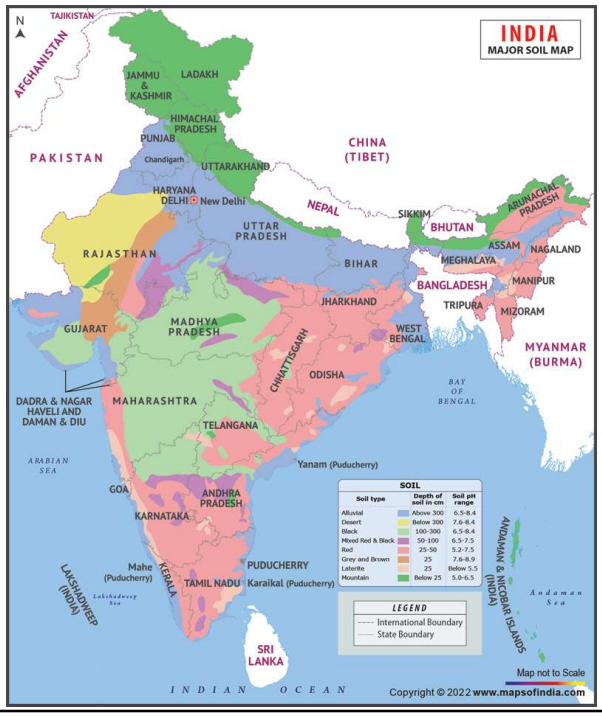


Desert (Arid) Soils – (Soils of India)

- These soils may form gypsic horizon
- Such gypsi-ferrous soils need special attention to avoid formation of sink holes,
  - if irrigated
- The built up of organic matter is very low
- Major constraints of these soils are less water which restricts their use
  - for raising agricultural crops
- However, some areas are used for growing millet and pulses
- If irrigated, they can be profitably used for growing two crops in a year

Forest and Hill Soils – (Soils of India)

- These soils developed under forest cover
- In India , the total area under forest is estimated to be 75 Mha
- Observed dominantly in the states of Himachal Pradesh, Jammu and Kashmir,
  - Uttar Pradesh, Uttarakhand, Bihar, Madhya Pradesh, Maharashtra,
  - Kerala and North-East region
- The climatic conditions and & altitude control the kind of forest species,
  - the kind of forest & topography control the kind of soils
  - & their degree of profile development
- The major soils observed in different areas are:
  - Brown forest and Podsolic: In Northern Himalayas,
    - developed on sand lime stone, conglomerate, granite, gneisses & schists
    - under cool/cold humid climate (acidic environment)
- Red and Lateritic: In Deccan Plateau,
  - developed on igneous & metamorphic rocks(basalt, granite, gneisses)
  - under tropical climatic conditions(slightly acidic, neutral or basic environments)

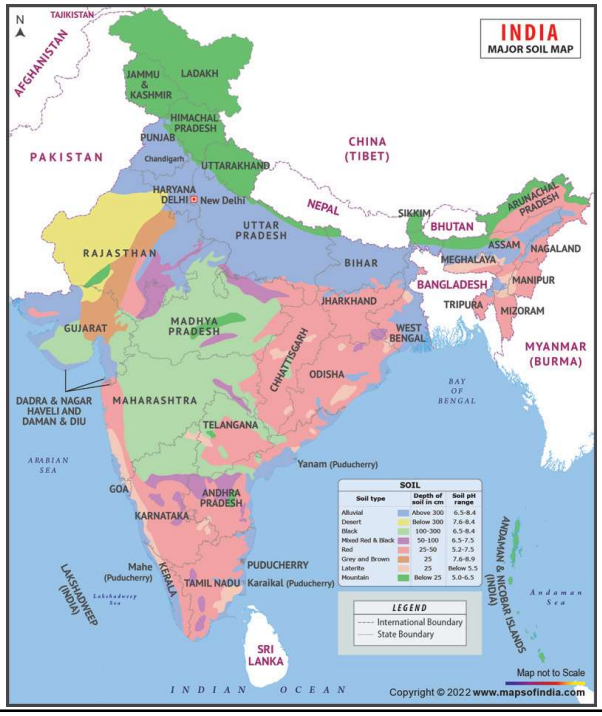


Podzolic Soils – (Soils of India)

- Soils found under coniferous vegetation in presence of acid humus & low base status
- These soils are moderately to strongly acidic in reaction (pH 4.5-6.0)
- These soils are high in organic matter content (3.0-3.5%)
  - &, in general, low (<50%) in base status
- These soils are variable in exchange capacity [10-15 cmol (p +) kg-1] (centimoles)
- The clay content varies from 20-30%
- These soils are deficient in P (phosphorus)
- These soils face a major problem of erosion by water
- They are used for growing a variety of crops – rice, maize, soybean etc. on terraces
  - & tea and other fruit crops on slopes

Brown Forest Soils – (Soils of India)

- These soils developed on sedimentary rocks/ or alluvium
  - under sub-humid to humid climate & mixed vegetation are Non Calcic Brown
  - or Brown Forest soils
- They are neutral to slightly acidic in reaction (pH 6.0-7.0)
- The calcareous members under sub-humid conditions may have a pH around 8.2
- These are moderate to high in organic matter content (2-3%)
  - which decreases with depth
- These are moderate in cation exchange capacity [15-20 cmol (p+) kg-1]
  - & exchange complex is almost saturated with bases (70-90%)
- Soils have great potential for growing agricultural crops
  - such as rice, maize & fruit plants such as apple, almond, pear, apricot etc

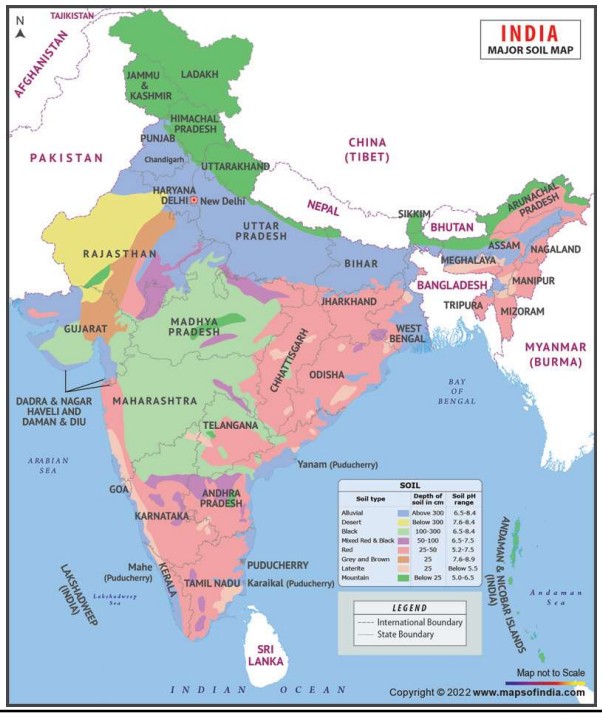


Salt Affected Soils – (Soils of India)

- Soils occurring in the arid & semi arid regions
  - & occupy about 10 Mha area of which 7Mha is sodic
- These soils occurs in the Indo-Gangetic planes followed by the Deccan (Peninsula)
- Plateau supporting black soils, the rest in the arid & coastal regions are saline
- Sodic soils of the Indo-Gangetic plain, occupy relatively lower topographic positions
  - where products of weathering accumulate during the monsoon rains
  - by surface runoff
- Saline soils of coastal region result from rise of brackish ground water
  - due to capillary action under excessive evaporation
- Sodic soils pose serious problem of high sodium on the exchange complex,
  - poor physical conditions, especially soil structure & drainage,
  - nutrient & water availability and micronutrient deficiency

Salt Affected Soils – (Soils of India)

- Another problem is of receding ground water in the central sectors
  - & the south-west sectors of Punjab, Haryana & some parts of Rajasthan
- The rise in ground water causes salinization of soils
- Sodic soils once ameliorated by applying gypsum,
  - used for growing rice followed by wheat



Soil Orders (as per Soil Taxonomy) representing different soil groups

S. No.	Genetic System	Soil Taxonomy	
		Mainly	Occasionally
	Alluvial Soils	Entisol, Inceptisol	Alfisol, Aridisol
2	Black(Cotton) Soils	Vertisols	Inceptisols, Entisols
3	Red Soils	Alfisol, Ultisols	Inceptisols, Entisols
4	Laterite and Lateritic Soils	Ultisols	------
5	Desert soils	Aridisol	Entisols
6	Forest and Hill Soils	Alfisols, Ultisols	Inceptisols
7	*Podsolic Soils* *Brown Forest Soils*	Inceptisols, Mollisols, Alfisols	Entisols
8	Salt Affected Soils	Aridisols, Inceptisols,	Alfisols and Vertisols