Chapter 5 Land Resources

Nature and importance of soil

- Soil is defined as an uncemented aggregate of mineral grains and decayed organic matter with liquid and gas, occupying the void spaces between the soil particles.

Why soil is important?

It is required for plant growth

Erosion leads to environmental degradation (control it)

It is the source of sediment

It acts as filter for ground water

It serves as the bearing material for roads, pipelines etc. and act as a construction material for mud-built houses

Beneficial impact to man

- He gets all nutrient indirectly (by eating plants)
- It is a resource (for plant growth) and environmental medium
- What are the impacts of man on soil
    - Beneficial impact (by man)
        - Drainage, Fertilisation (use of fertiliser), Irrigation
    - Adverse impact (by man)
        - Soil erosion, Loss of soil fertility, Salination, Desertification, Pollution

Formation of soil

- Formed *in situ* from rocks or sediments or they may be deposited after transport

The principal factors that govern the formation and properties of the soil

1. **Climate**
    - Temperature, rainfall, wind
2. **Nature of the parent material**
    - Mineral content, relative portion of sand, silt and clay
3. **The geomorphic setting, slope and drainage**
    - Grain size of the soil
4. **Time**
    - Longer period of weathering, the greater the extent of soil formation
5. **Organism**
    - Affects/influences the soil fertility

- During weathering process, a variety of secondary mineral develop from primary mineral.
- Weathering is most intense in humid tropics
- Rapidity of weathering (Na, Ca, Mg) > (Fe, Al)
- Dissolution
    - Mineral goes into solution completely, no precipitation (congruent dissolution)
    - All or some of the ions released by weathering precipitates to form new compounds (incongruent dissolution)

$NaCl_{(c)} \Rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$ (congruent dissolution)

$Aluminosilicate_{(c)} + H_2O_{(l)} + H_2CO_{3(aq)} \Rightarrow Clay\ mineral_{(c)} + cations_{(aq)} + OH^{-}_{(aq)} + HCO_3^{-}_{(aq)} + H_4SiO_{4(aq)}$ (incongruent dissolution)

- **Hydration** is a process by which water molecules are added to a mineral

$CaSO_{4(c)} + 2\,H_2O_{(l)} \Rightarrow CaSO_4.2\,H_2O_{(c)}$

(anhydrite) (gypsum)

- **Hydrolysis** is a the decomposition of a mineral by chemical reaction with water

$KAlSi_3O_{8(c)} + H_2O_{(l)} \Rightarrow HAlSi_3O_{8(c)} + K^{+}_{(aq)}\ OH^{-}_{(aq)}$

- **Oxidation** is a the process of combining with oxygen or it is the process by which an element looses electron

$Fe_2SiO_{4(c)} + 4H_2CO_3 \Rightarrow 2Fe^{+2}_{(aq)} + 4\,HCO_3^{-}_{(aq)} + H_4SiO_{4(aq)} + 2OH^{-}_{(aq)}$

$2Fe^{+2}_{(aq)} + 4HCO_3^{-}_{(aq)} + \tfrac{1}{2}\,O_{2(g)} + 2\,H_2O \Rightarrow Fe_2O_3 + H_2CO_{3(c)}$

- **Acidification** is a the process by which minerals in the soil react with hydrogen ion in water provided by carbonic acid and inorganic acids

$CaCO_{3(solid)} + H_2CO_{3(aq)} \Rightarrow Fe^{+2}_{(aq)} + 2\,HCO_3^{-}_{(aq)}$

Soil exhibits distinctive layers with increasing depth called **horizons**

Different horizons

O horizon (organic matter)	zone of organic debris
A horizon (humus and mineral)	zone of organic accumulation
E horizon (mineral)	zone of leaching
B horizon (clay)	zone of accumulation
C horizon	zone of weathering bed rock/parent material
D horizon	Bed rock

Texture

Depends on distribution of grain size

- *Fine texture (**clays**, < 2 μ m)*
- *Medium- texture (**silt**, 2-50 μ m)*
- Coarse- *texture (**sand**, > 50 μ m)*
- *Texture of soil has profound influence on the nutrient status and moisture retention capacity of the soil*

Ion exchange capacity

- It is the ability to hold and exchange ions. Involves mostly cations (exception arsenate, selenate anions)

Cation exchange capacity (CEC)

- The content of organic matter and clays is expressed in terms of moles of positive charge absorbed per unit (cmol/kg)

CEC is also expressed as milli-equivalent of mono-valent cations that can be exchanged per 100 g of soil.

Through cation exchange Ca, Mg, K metals are made available to plants. H^+ ion is exchanged. This, and leaching of metal by H_2CO_3 gives acidity to soil.

Field capacity

It is the residual moisture content after the gravity water has substantially drained out.

Wilting point

The minimal point of soil moisture the plant requires not to wilt.

Plant wilt in daytime to preserve water. If they do not get the required water they die.

Available water = field capacity – wilting point

Material	CEC (me/100g)	Field capacity (cm)	Available water (cm)	Saturated permeability (cm/day)
Clay	20	20	7	5
Silt loam	30	16	10	50
Sand	5	6	5	200
Humus	200	-	-	-

- Since the humus affects CEC to a larger extent, they control the fertility of the soil

Macronutrients

They occur in large level in plant material. (N, P, K, Ca, Mg, S)

Micronutrients

They occur in low level in plant Material. (B, Cu, Fe, Mn, Mo, Zn)

Molybdenum: slow growth, paleness

Zinc: produce auxin hormone, help in growing stem cells to elongate

Mn, Fe, V, Cl: involved in photosynthesis

Erosion *is the process by which soil particles are removed from the ecosystem, usually by wind or flowing water*

- Erosion leads to decrease in productivity
    - Physical loss of fertile top soil
    - Reduction in the rooting depth
    - Removal of plant nutrients
    - Loss of water

How soils are eroded?

- Raindrop loosen particles

- Splashing water moves them
- Turbulent water transports the loosened soil particle

It is divided in to two types

- **Sheet erosion** (un-concentrated flow in sheets)
- **Gully erosion** (concentrated flow in rills and gullies)

Erosivity is defined as *the potential ability of processes to cause erosion of soils in a certain set of environmental conditions (reduction leads to less erosion)*

Depends on

- **Rainfall** (drop size, velocity, distribution, angle and direction, intensity, frequency and duration of rain)
- **Runoff** (supply rate, flow depth, velocity, frequency, magnitude, duration and sediment content)

Erodibility refers to *the resistance of soils to erosion or its vulnerability to erosion*

Depends on

- **Soil properties** (particle size, clod forming properties, cohesiveness, aggregates and infiltration capacity)
- **Vegetation** (ground cover, vegetation type, degree of protection afforded by different kinds of vegetation)
- **Topography** (slope, inclination and length, surface roughness, flow convergence and divergence)
- **Land use properties** (contour ploughing, mulching, cover cropping, terracing, organic content, gully stabilisation rotations)

Erosion is a natural process

- **Benefits of erosion**
    - Formation of fertile alluvial soil
- **Agricultural practices responsible for erosion**
    - Farming on long slopes without terrace or runoff diversions
    - Farming in fall-line direction on steep slopes
    - Bare soil left after sowing crops
    - Bare soil left after harvest
    - Intrusive cultivation close to streams

Efforts that can reduce rate of soil erosion

- Protection of land surface from the impact of raindrops
- Increase in the infiltration of rainwater
- Decrease in the volume and velocity of overland flow
- Reduction in the erodibility of soils

Crop management

- Proper crop selection which may markedly reduce surface exposure to rainfall and bind soil particles together

- Sowing of crops in such a manner that no ground surface remains exposed to rainfall of high intensity for a long period
- Practice of intercropping and mixed cropping
- Stubble mulching
- Maintenance of soil at a high fertility level through the application of fertilizers and crop rotation

Mechanical protection

1. Contour farming; 2. Terracing; 3. Control of gulley erosion

- Construction of series of check dams;
- Plantation of vines, grasses, bushes and trees
- Development of pastures
- Plugging of gulley heads with stone-filled iron nets
- Debarring cultivation on land between two gullies

Contamination of the Soil

- **Primary source**
  - Fertilization of soil by the addition of fertilizers
- **Secondary source**
  - Addition of pollutant as a consequence of neighbouring activity (mining, smelting, aerosol deposition)

Industrialized countries have better management of pesticide related pollution than the third world countries.

1. Manure is the safest fertilizer
2. Phosphate fertilizer pollute more than nitrogen fertilizer
3. Sewage sludge needs to be cleaned of its toxic component before being used for irrigation and fertilization.

Contamination

1° Source	Element	1° Source	Element
Fertiliser	Cd, Pb, As	Sewage sludge	Cd, Pb, As
Lime	As, Pb	Irrigation	Cd, Pb, Se
Pesticide	Pb, As, Hg	Manure	As, Se

2° Source	Element	2° Source	Element
Auto aerosol	Pb	Coal burning	As, Se, Sb
Smelter	As, Pb, Cd	Marine	Se
Tyre wear	Cd	Rubbish	Pb, Cd, As

Description	Pb	Cd	Hg	As
1. Phosphate fertiliser	4-1000	0.1-190	0.01-2	>1-1200
2. Nitrogen fertiliser	2-120	>0.05-0.1	0.3-3	2-120
3. Limestone	20-1250	>0.05-0.1	---	0.1-24
4. Sewage sludge	2-7000	>1-56	>1-56	2-30
5. Manure	0.4-16	>0.1-0.8	>0.01-0.2	>1-25
6. Irrigation water	<20	<0.05	---	<10
7. Pesticides	11-26	---	0.06-6	3-30

Lead

- Typical value 1-888 µg/g ; mean 29.2 µg/g (29.2 X 10^{-3} X 10^{-3} g/g) or 10-20 ppm
- When Pb increases to **>100 ppm** it is called **contamination**
- Possible area of contamination
    - Metal working units, high traffic roads (TEL, Tetra Ethyl Lead)
- Half-life of Pb is 800 – 6000 yrs
- Adverse effects
    - Pb reduces the enzymatic activity of biota
    - Incomplete decomposition of organic materials

Cadmium

- Typical value 0.1-1.0 µg/g ; mean 0.62 µg/g
- When Cd increases to **>3 ppm** it is called **contamination**
- Possible area of contamination
    - Soil with high organic content
- Adverse effects
    - Food grown in contaminated soil unfit for human consumption

Mercury

- Typical value 0.01-0.06 µg/g
- When Hg increases to **>400 ppm** it is called **contamination**
- Possible reason of contamination
    - Mining of sulphide ore, production of Cl2, caustic soda, fungicides
- Maximum absorption occurs in soil occurs in clay or organic matter
- Adverse effects
    - Lethal to marine population
    - If it enters food chain will affect all the species

Arsenic

- Typical value 5-10 µg/g
- Pesticide used area may have 600 µg/g of As

- Under toxic condition As occurs as arsenate $(AsO_4)^{3-}$
- Arsenite {As(III)} is more toxic form
- Soil bacteria oxidises As(III) to less soluble As (V) form
- Methylation produces As(III) methyl derivatives

Land is *the solid cover of earth on which human beings depend for sustenance (food)*

- Total land area around 29 % of Earth (148,950 X 10^3 km^2)
- Human beings use 30 % of total land
- Over a period of time Population increases but the available land area does not. So the *per capita* available land space decreases when the population increases.
- India has 17% of world population living in 2.3% of world area. So we are severely affected

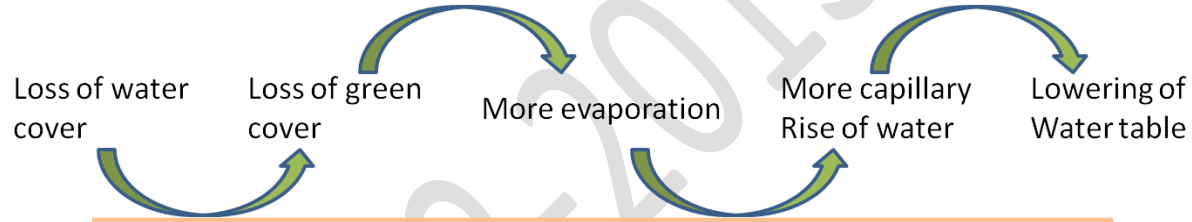
Man-made uses of land

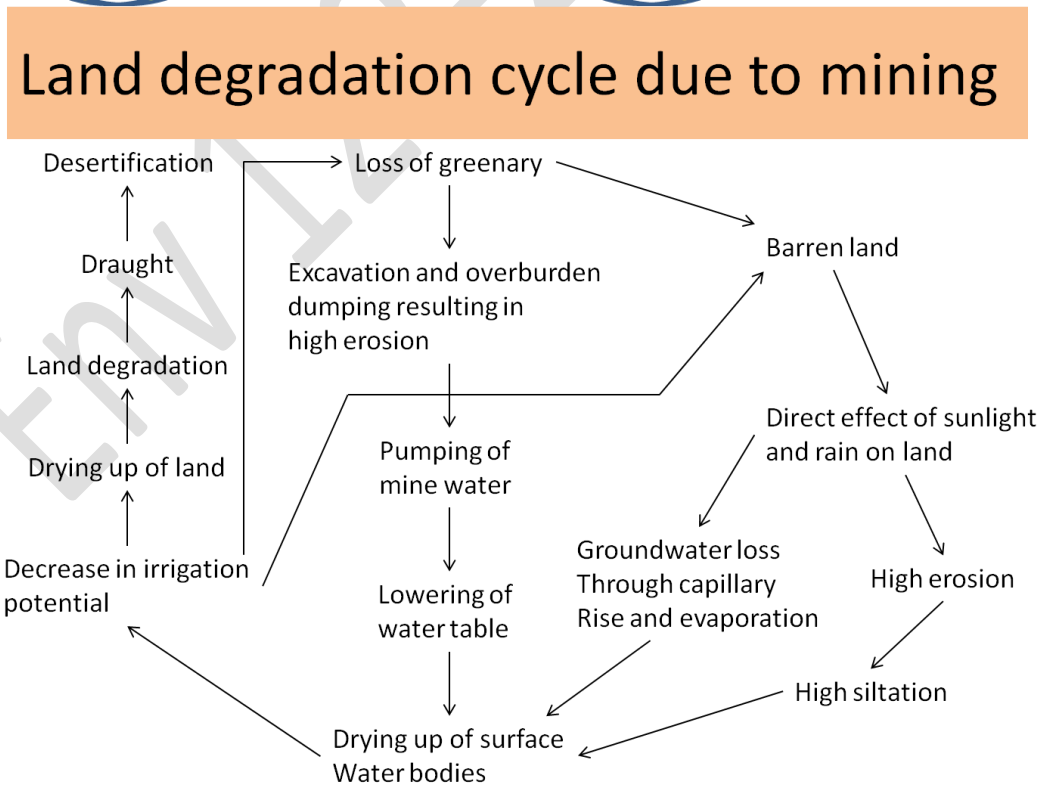
- Habitat, agriculture, artificial water bodies, sports ground, mining

This may not suit the land. It leads to waste land.

Due to mining many land area is damaged.

- Felling of trees, overburden dumps, making quarries
- Gradual filling up of surface water bodies, lowering of water table





Impact of human activities on land

Activity	Impact
1. Agriculture 2. Urbanisation	Reduction of forest cover, damage to groundwater resource, damage to land-forms, historical artifacts
3. Development of communication system (road/rain)	Irretrievable damage to wet-land, loss of forest, agriculture land, alteration of natural drainage, creation of flooded burrow pits, impoundment of water
4. Dams and hydropower plants	Loss of forest, bush, reduction in agriculture land, overgrazing, deforestation; affects navigation, fishing, cultivation (downstream)
5. Industry	Exposure of land and uncovered area lead to erosion, silt run off, stress on forest, wetlands. Landscape altered
6. Mining	Removal of huge amount of rock and soil and deposition of the same somewhere else, introduction of spoil or slag, loss of farmlands, altering drainages

Nature-synchronous land use planning should focus on (i) requirement of the society, (ii) technical feasibility, (iii) economic viability

Wasteland is defined *as land which is degraded and is presently lying unutilized except as current fallow, due to different constraints*.

Fallow - plowed and left unseeded for a season or more; uncultivated. not in use; inactive

Impact of human activities on land

Level 1	Level 2
1. Cultivable wasteland	1.1. Gullied and/or Ravenous land 1.2. Undulating upland with or without scrub 1.3. Surface waterlogged land and marsh 1.4. Salt affected land 1.5. Shifting cultivation area 1.6. Degraded forest land 1.7. Degraded pastures/grazing land 1.8. Degraded non-forest plantation land 1.9. Strip land 1.10. Sands 1.11. Mining/industrial wasteland
2. Uncultivable wasteland	2.1. Barren rocky /Stony waste/ sheet rock area 2.2. Steep sloping area 2.3. snow covered and or Glacial area

1. **Gullied/Ravenous land**

- The gullies are formed as a result of localised surface runoff affecting the friable unconsolidated material in the formation of perceptible channels resulting in undulating terrain. The gullies are the first stage of excessive land dissection followed by their networking which leads to the development of ravenous land. The word 'ravine' is usually associated not with an isolated gully but a network of deep gullies formed generally in thick alluvium and entering a nearby river, flowing much lower than the surrounding high grounds. The ravines, are extensive systems of gullies developed along river courses.

2. **Undulating uplands with or without scrub**

- They occupy (relatively) higher topography like uplands or high grounds with or without scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain.

3. **Waterlogged land and Marshy/Swampy land**

- Waterlogged land is that land where the water is at/or near the surface and water stands for most of the year. Such lands usually occupy topographically low-lying areas. It excludes lakes, ponds and tanks. Marshy land is that which is permanently or periodically inundated by water and is characterised by vegetation, which includes grasses and weeds. Marshes are classified into salt/brackish or fresh water depending on the salinity of water.

4. **Lands affected by salinity/alkalinity- Coastal or inland**

- The salt-affected land is generally characterised as the land that has adverse effects on the growth of most plants due to the action or presence of excess soluble or high exchangeable sodium. Alkaline land has an exchangeable sodium percentage (ESP) of about 15, which is generally considered as the limit between normal and alkali soils. The predominant salts are carbonates and bicarbonates of sodium. Coastal saline soils may be with or without ingress or inundation by seawater.

5. **Shifting of cultivation areas**

- Such land is the result of cyclic land use like felling of trees and burning of forest areas for growing crops. This results in extensive soil losses leading to land degradation.

6. **Degraded notified forest lands**

- It is described as a forest where the vegetative (crown) density is less than 20% of the canopy cover. It is the result of both biotic and abiotic influences. Scrub is a stunted tree or bush/shrub.

7. **Degraded pastures/Grassland/Grazing land**

- All those grazing lands in non-forest areas, whether or not they are permanent pastures or meadows, which have become degraded due to lack of proper soil conservation and drainage measures fall under this category.

8. **Degraded land under plantation crop**

- These are degraded lands containing plantations outside the notified forest area.

9. **Sandy area (costal and desertic)**

- These are the areas, which have stabilised accumulations of sand in-site or transported in

coastal riverine or inland (desert) areas. These occur either in the form of sand dunes, beaches, channel (river/stream) islands, etc

10. **Mining/Industrial wastelands**

- Lands where large-scale mining operations bring about degradation of land and resultant mine dumps are known as mining wastelands. Industrial wastelands are areas which are subjected to degradation caused by large scale industrial effluent discharges.

Uncultivable wasteland

1. **Barren rocky/Stony waste/Sheet rock area**

- It is defined as the rock exposures of varying lithology often barren and devoid of soil cover and vegetation and not suitable for cultivation. They occur amidst hill forests as openings or scattered as isolated exposures or loose fragments of boulders or as sheet rocks on plateau and plains. It includes quarry or gravel pit or brick kilns

2. **Steep sloping areas**

- Land with very steep slopes (> 35%) are prone to erosion and mass wasting (land slide).

3. **Snow-covered /Glacial area**

- It is snow-covered areas defined as a solid form of water consisting of minute particles of ice. It includes permanently as on the Himalayas. Glacier is a mass of accumulated ice occurring amidst permanently snow-covered areas.

Wasteland in India

No.	Category	Total waste land (km^2)	% of Total geographical area covered
1.	Gullied and/or Ravenous land	20,533.35	0.65
2.	**Undulating upland with or without scrub**	**1,94,014.29**	**6.13**
3.	Surface waterlogged land and marsh	16,568.45	0.52
4.	Salt affected land	20,477.38	0.65
5.	Shifting cultivation area	35,142.20	1.11
6.	**Degraded forest land**	**1,40,652.31**	**4.44**
7.	Degraded pastures/grazing land	25,978.91	0.82
8.	Degraded non-forest plantation land	5,828.09	0.18
9.	Sands	50,021.65	1.58
10.	Mining/industrial wasteland	1,252.13	0.04
11.	Barren rocky /Stony waste/ sheet rock area	64,584.77	2.04
12	Steep sloping area	7,656.29	0.24
13.	Snow covered and or Glacial area	55,788.49	1.76
	Total wasteland area	**6,38,518.31**	20.17

Basic requirement for Wasteland development

1. **Skills and training**

i) Horticulture and forest nurseries as revenue source
i) Horticultural development
ii) Tusser silk production
iii) Bee-keeping
iv) Fodder production and processing
v) Wood-based crafts

> Did you know?
> Govt. of India had created the **Department of Wasteland Development** during July, 1992 under the Ministry of Rural Development, which has been subsequently reorganized and renamed as **Department of Land Resources**, with a broader mandate.

2. **Forestry**

i) Survey and preparation of plantation sites
ii) Selection of suitable species
iii) Plantation programme planning
iv) Working out section wise plantation schedule and actual plantation operation
v) Protection of reforested area with volunteers

3. **Health Education**

i) Dissemination of basic knowledge about human anatomy, body functions, diseases
ii) Education about public sanitation and personal hygiene
iii) Ante natal and child care
iv) Propagation of home remedies
v) Dental care based on traditional medicine

4. **Nutrition Education**

i) Dissemination of information about the nutritional needs of the human body
ii) Informing people about nutritional value of food
iii) Ensuring adequate milk consumption by expectant and nursing mothers, children

5. **Animal husbandry** (agricultural practice of breeding and raising livestock)

i) Promoting ecologically sound and economically beneficial livestock policy
ii) Genetic upgradation of cattle, goat, sheep so as to bring switch –over from grazing economy to stall-fed economy
iii) Usage of modern technology to accelerate upgradation of livestock

6. **Conservation**

i) Educating the formers about all the aspects of nature conservation
ii) Promoting economical use of water

7. **Agricultural extension**

i) Evolution of scientific land use pattern
ii) Identification of rotation cropping patterns for micro-ecosystem
iii) Experiments in genetic engineering by a carefully selected avant-garde group of local formers

Desertification

Desertification refers to loss of productivity of the land**.** Desertification is the persistent degradation of dryland ecosystems due to human activities and variations in climate.

- Moderate loss (25 %)
- Severe (25 - 50 %)
- Very severe (> 50 %)
- End result is creation of desert where there had once been thriving agriculture

Major desert zones

1. The desert basins that run from northwestern Mexico to the southwestern USA.
2. The **Atacama desert** in the southwestern South America.
3. The great desert belt running from the **Sahara** in Africa. through the deserts of Iran, erstwhile USSR, Pakistan, India, Mongolia and China.
4. The **Kalahari desert** in southwestern Africa.
5. Most of the continent of **Australia**.

Reasons for desertification

1) Over cultivation
2) Deforestation
3) Overgrazing
4) Unskilled irrigation

Increase of population also compounds the issue

- **The Dust Bowl**, or the Dirty Thirties, was a period of severe dust storms causing major ecological and agricultural damage to American and Canadian prairie lands in the 1930s. The phenomenon was caused by **severe drought** combined with farming methods that did not include crop rotation, fallow fields, cover crops, soil terracing and wind-breaking trees to prevent wind erosion.

Area susceptible to desertification

- **Range lands** (grazing for livestock) 80 % affected by desertification
- **Croplands watered by rain** 60 % affected by desertification
- **Cropland watered by irrigation** 30 % affected by desertification

Effects of desertification

- Survival depends on success of few crops or the sale of few animals
  - Productivity of the land falls
  - Living conditions worsen
  - Crops fail
  - Water source dry up
  - Animals die
  - Fuel-wood become scarce

The only solution is migration