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PRELIMS SAMPOORNA

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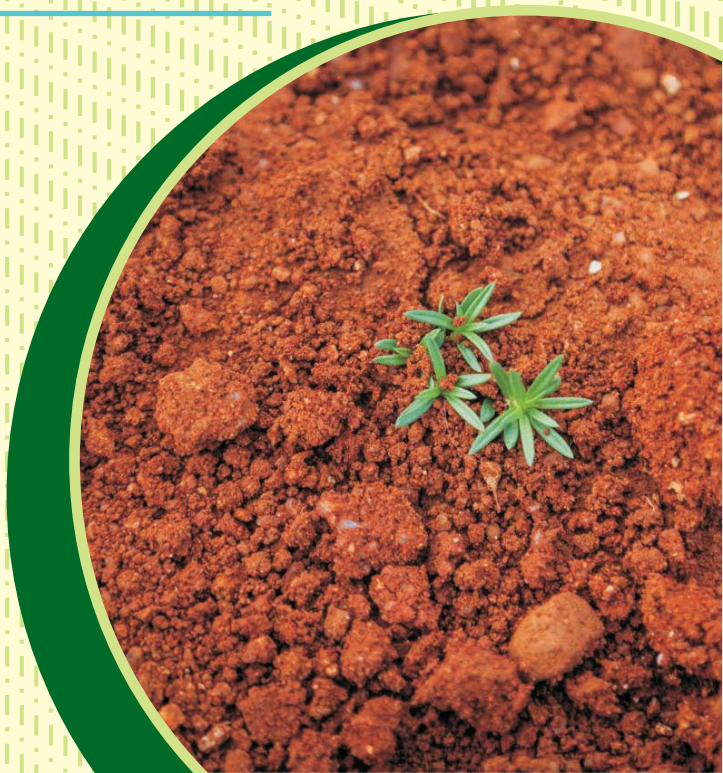
INDIAN SOIL



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INDIAN SOILS

Definition of Soil

- Soil can be defined as **the solid material on the Earth's surface** that results from the **interaction of weathering and biological activity** on the parent material or underlying hard rock.
- The naturally occurring soil is influenced by **parent material, climate, relief, and the physical, chemical and biological agents (micro-organisms) in it**.
- A soil is made up of four elements: **inorganic fraction (derived from the parent material), organic material, air and water**. The abundance of each component and its importance in the functioning of the soil system vary from horizon to horizon and from one soil to another.

What are the characteristics of Soil?

Soil Texture

- Soil texture is a term used to describe the distribution of the **different sizes of mineral particles in a soil.**
- Textures range from **clay, sand, and silt** at the extremes, to a loam which has all three sized fractions present.
- The main influence of texture is on **permeability** which generally **decreases with decreasing particle size.**
- **A clayey soil** may thus be described as **fine, a sandy soil as course**, while a **silty soil is intermediate.**

Soil Air

- The air content of a soil is vital, both to itself and to organic life within it. A certain amount of air is contained between the individual particles except for the waterlogged soils.
- The air in the soil helps in the **process of oxidation** which converts part of the **organic material into nitrogen** in a form readily available to the plants.

Soil water

- Depending on the texture of the soil, water **moves downward by percolation**.
- The amount of **water in the soil varies from almost nil in arid climates** which makes life virtually impossible for organisms, to a state of **complete water logging which excludes all air**, causes a reduction of bacteriological activity, and limits decomposition.
- **In damp climates**, especially in high latitudes where the evaporation rate is low, **water tends to move predominantly downward,** particularly in **coarse-grained sandy soils**.
- This dissolves the soluble minerals in the soil, together with soluble humus material and carries both downward, a process called leaching or eluviations.
- A **typical leached soil is known as podzol**, a Russian word meaning ash because the surface layer is often **greyish or ash-coloured**. In a hot, arid climate, evaporation exceeds precipitation for greater part of the year, so the water tends to move upward and the soil dries out.
- Consequently, in some areas, a thin salty layer is formed on the surface. This process of **Salinization.**

Soil color

- Generally, soil color is determined by the amount of **organic matter** and the state of the **iron.**
- Soil color is also related to **soil drainage, with free draining, well AERATED soils** (with pore space dominated by oxygen) having rich brown colors.
- In contrast, poorly draining soils often referred to as **gleys,** develop under **ANAEROBIC conditions** (the pore space dominated by water) and have grey or blue-grey colors.
- Such colors are the result of **oxidation-reduction**; iron is the main substance affected by these processes.
- If the iron is released in an anaerobic environment, then it stays in the reduced state giving it the **grey blue color** of waterlogged soils.

Factors Responsible for Soil Formation

Soil formation is the combined effect of physical, chemical, biological, and anthropogenic processes on soil parent material.

Parent material

- This is the material from which the soil has developed and can vary from solid rock to deposits like alluvium and boulder clay. It has been defined as **'the initial state of the soil system'.**
- The parent material can influence the soil in a number of ways**: color; texture; structure; mineral composition and permeability/drainage.**

- Soil may form directly by the **weathering of consolidated rock in situ** (a residual soil), saprolite (weathered rock), or it may develop on **superficial deposits**, which may have been transported by ice, water, wind or gravity.
- These deposits originated ultimately from the **denudation and geologic erosion** of consolidated rock.
- Consolidated material is not strictly parent material, but serves as a source of parent material after some physical and /or chemical weathering has taken place.
- Soils may form also on **organic sediments** (peat, muck) or **salts** (evaporates).
- The **chemical and mineralogical compositions** of parent material determine the **effectiveness of the weathering forces**.

Climate

- Temperature varies with **latitude and altitude**, and the **extent of absorption and reflection** of solar radiation by the atmosphere.
- Solar radiation (direct radiation and diffuse radiation) **increases** with **elevation, differs seasonally**, and is influenced by **cloud cover or other atmospheric disturbance** (e.g. air pollution).
- The absorption of the solar radiation at the soil surface is affected by many variables such as **soil color, vegetation cover, and aspect.**
  - In general, the **darker the soil color, the more radiation is absorbed and the lower the albedo.**
  - The **effect of vegetative cover** on absorption varies with density, height, and color of the vegetation.
- Hence the absorption differs in areas with deciduous trees (soil surface is shaded by trees most of the year) and arable land (soil surface is not shaded throughout the year).
- Light, or whitish-colored, soil surfaces tend to **reflect more radiation**. When incoming solar radiation is reflected, there is less net radiation to be absorbed and heat the soil.
- Snow is especially effective in **reflecting the incoming solar radiation**.
- Temperature affects the **rate of mineral weathering and synthesis**, and the **biological processes of growth and decomposition.**
- Weathering is intensified by **high temperatures**; hence weathering is stronger in the tropics than in humid regions.
- Biological processes are intensified by rising temperatures.
- Reaction rates are roughly doubled for each 10°C rise in temperature, although enzyme-catalyzed reactions are sensitive to high temperatures and usually attain a maximum between 30° and 35°C.

Biological Factors

- The soil and the organisms living on and in it comprise an ecosystem. The active components of the soil ecosystem are the **vegetation, fauna, including microorganisms, and man**.

Vegetation

- The primary succession of plants that colonize a weathering rock culminates in the development of a **climax community**, the species composition of which depends on the **climate and parent material**, but which, in turn, has a profound influence on the soil that is formed.
- Deciduous forest seems to **accelerate soil formation** compared to grassland on the same parent material under similar climatic conditions.

Meso-/Macrofauna

- Earthworms are the **most important of the soil forming fauna** in **temperate regions**, being supported to a variable extent by the small arthropods and the larger burrowing animals (rabbits, moles).
- Earthworms are also **important in tropical soils**, but in general the activities of **termites, ants, and beetles** are of greater significance, particularly in the sub humid to semi-arid savannah of Africa and Asia.

Micro-organisms

- The organic matter of the soil is colonized by a variety of soil organisms, most importantly the micro-organisms, which derive energy for growth from the oxidative decomposition of complex organic molecules.
- During decomposition, essential elements are converted form **organic combination to simple inorganic forms (mineralization).**
- Types of micro-organisms comprise **bacteria, actinomycetes, fungi, algae, protozoa, and soil enzymes.**

Man

- Man is perhaps now the **most influential of all organisms**. He affects the soil by such activities as: ploughing, irrigating, mining, clearing, disposing and leveling.

Time

- Time is a factor in the interactions of all the above factors as they develop soil.
- Over time, soils evolve features dependent on the other forming factors, and soil formation is a **time-responsive process** dependent on how the other factors interplay with each other.

Relief

- Relief is not static; it is a dynamic system (its study is called geomorphology). Relief influences soil formation in several ways:
- It influences soil profile thickness i.e. as angle of slope increases so does the erosion hazard. Gradient affects run-off, percolation and mass movement.
- It influences aspect which creates microclimatic conditions

Stages of Soil Formation

Soil formation is a **long slow process.** It's estimated that an inch of soil takes 500 to 1000 years to form. Soil is constantly being formed.

Stage One

- This is the **rock pulverizing stage.** Here the forces of wind, rain, freezing and thawing water, earthquakes, volcanoes all work to slowly pulverize rocks into smaller particles that can make up a soil. **At the end of**

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this stage a combination of sand, silt and clay sized particles forms. These form a mineral soil like substance but are unable to support life.

- They are **missing nitrogen**. It may seem nitrogen should be the least of a being's worries. After all the air we breathe is made up of about 78% nitrogen. The problem is that plants cannot use nitrogen in this form. For them it needs to be converted to either ammonia which is a combination of nitrogen and hydrogen or nitrates - a combination of nitrogen and oxygen.

Stage Two

- This is the early stage of soil formation. Here life is added specifically by lichens.
- **Lichens are a symbiotic relationship of algae and fungus**. The algae have the very important role of fixing the nitrogen, changing it from nitrogen gas to a form, the plant can use. It also captures the sunlight and creates sugars and oxygen. The fungus provides a place for the algae to live, along with water and the mineral nutrients it needs.

Stage Three

- At this time the little pockets of soil have formed to the extent that some larger plants, plants with roots can have a go at growing.
- The first pioneers will be short lived but as their bodies are added to the layers of soil forming; the soil becomes more capable of supporting life. Humus builds and soil horizons begin to form.

Stage Four

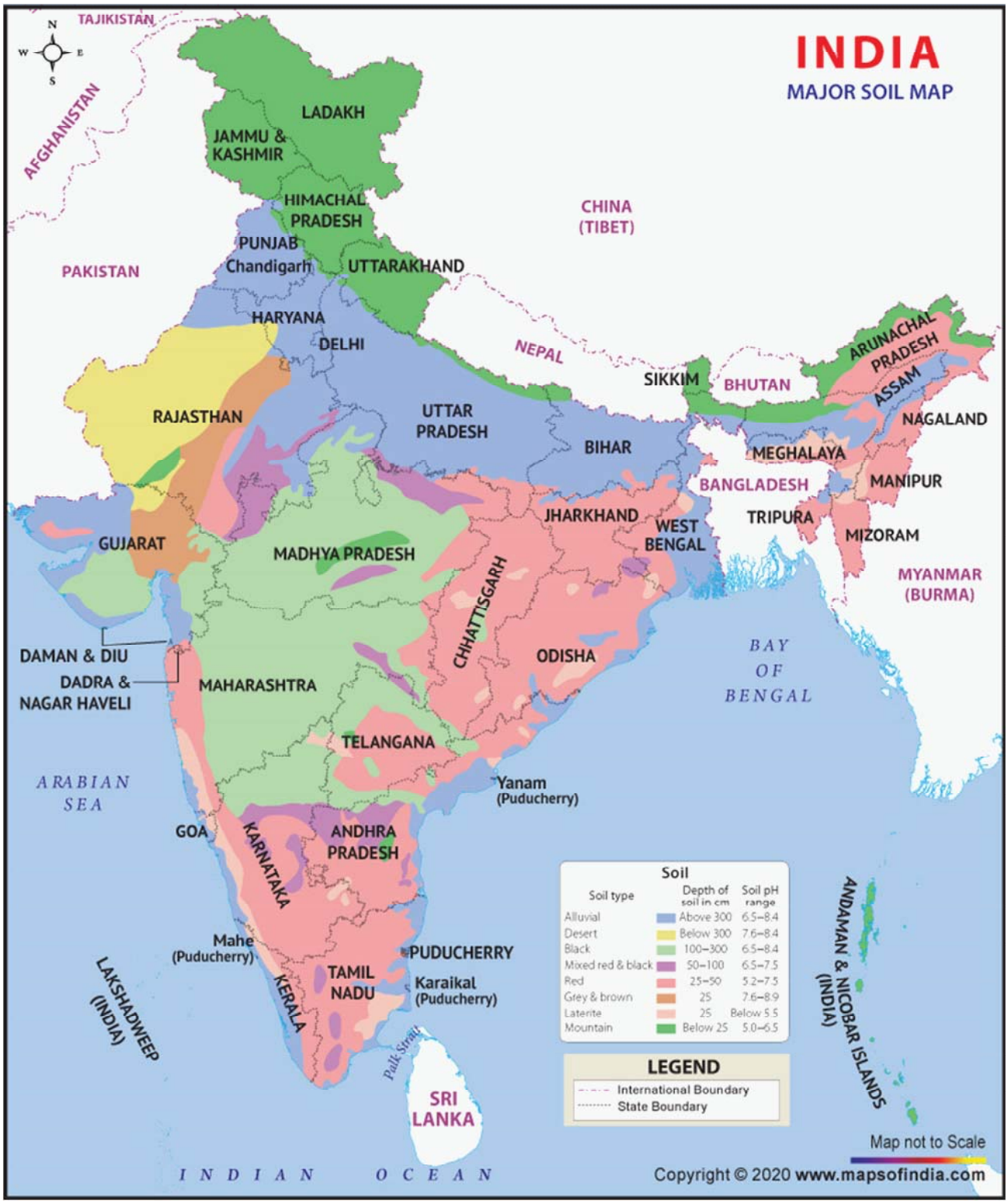
- The soils are developed enough to support thick vegetation.

Soils of India

- The **National Bureau of Soil Survey and the Land Use Planning** an Institute under the control of the **Indian Council of Agricultural Research (**ICAR) did a lot of studies on Indian soils.
- In their effort to study soil and to make it comparable at the international level, the ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.
- On the basis of **genesis, colour, composition and location**, the soils of India have been classified into:

Alluvial Soil

- Alluvial soils are widespread in the **northern plains and the river valleys**.
- These soils cover about **40 per cent** of the total area of the country.
- They are **depositional soils,** transported and deposited by rivers and streams.
- Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat.
- In the Peninsular region, they are found in **deltas of the east coast** and in the **river valleys**.
- In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. **Khadar and Bhangar**.
  - **Khadar** is the new alluvium and is deposited by floods annually, which enriches the soil by depositing fine silts.



- **Bhangar** represents a system of older alluvium, deposited away from the flood plains. **Both the Khadar and Bhangar soils contain calcareous concretions (Kankars).**

- These soils are **more loamy and clayey in the lower and middle Ganga plain** and the **Brahmaputra valley**.
- The **sand content decreases from the west to east**.
- They yield splendid of rice**, wheat**, **sugarcane tobacco, cotton, jute, maize, oilseeds, vegetables and fruits.**

Black Soil

- Black soil covers most of the **Deccan Plateau** which includes parts of **Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu.**
- In the upper reaches of the **Godavari and the Krishna**, and the north western part of the Deccan Plateau, the black soil is very deep.

- These soils are also known as the '**Regur Soil' or the 'Black Cotton Soil'.**
- The black soils are generally **clayey, deep and impermeable**.
- They swell and become **sticky when wet and shrink when dried.**
- Chemically, the black soils are rich in **lime, iron, magnesia and alumina.**
- They also contain **potash**. But they lack **in phosphorous, nitrogen and organic matter**.

- The colour of the soil ranges **from deep black to grey.**
- **Cotton, maize, jowar, linseed, Virginia tobacco, castor, sunflower, and millets** are some of the major crops grown on the black soils.

Red and Yellow Soil

- Red soil develops on crystalline igneous rocks in areas of **low rainfall** in the eastern and southern part of the Deccan Plateau.
- The soil develops a reddish colour due to a **wide diffusion of iron in crystalline and metamorphic rocks.** It **looks yellow when it occurs in a hydrated form**.
- The **fine-grained red and yellow soils are normally fertile**, whereas coarse-grained soils found in dry upland areas are poor in fertility.
- They are generally **poor in nitrogen, phosphorous and humus**.
- **Rice, wheat, sugarcane, maize/corn, groundnut, ragi (finger millet) and potato, oil seeds, pulses, millets and fruits such as mango, orange, citrus, and vegetables** can be grown under ideal irrigation.

Laterite Soil

- Laterite has been derived from the Latin word **'Later' which means brick.**
- The laterite soils develop in areas with **high temperature and high rainfall**.
- These are the **result of intense leaching** due to tropical rains.
- With rain**, lime and silica are leached away**, and **soils rich in iron oxide and aluminium compound are left behind.**
- **Humus content of the soil is removed fast by bacteria** that thrive well in high temperature.
- These soils are **poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess.**
- Hence, laterites are **not suitable for cultivation**; however, application of manures and fertilizers are required for making the soils fertile for cultivation.
- Laterite soils are **widely cut as bricks for use in house construction**.

Arid Soils

- Arid soils range from **red to brown in colour**.
- They are generally **sandy in structure and saline in nature.**
- In some areas, the salt content is so high that common salt is obtained by evaporating the saline water.
- Due to the dry climate, high temperature and accelerated evaporation, they **lack moisture and humus.**
- **Nitrogen is insufficient and the phosphate content is normal.**
- Lower horizons of the soil are occupied by **'kankar'** layers because of the increasing **calcium content downwards.**

Saline Soils

- They are also known as **Usara soils.**
- Saline soils contain a larger proportion of **sodium, potassium and magnesium**, and thus, they are infertile, and **do not support any vegetative growth.**
- They have more salts, largely because of **dry climate and poor drainage**.
- They occur in **arid and semi-arid regions**, and in **waterlogged and swampy areas**.
- Their **structure ranges from sandy to loamy.**
- They **lack in nitrogen and calcium**.

Peaty Soils

- They are found in the **areas of heavy rainfall and high humidity**, where there is a good growth of vegetation.
- Thus, **large quantity of dead organic matter** accumulates in these areas, and this gives a rich humus and organic content to the soil.
- Organic matter in these soils may go even up to **40-50 per cent**.

Forest Soils

- As the name suggests**, forest soils are formed in the forest** areas where sufficient rainfall is available.
- The soils vary in **structure and texture** depending on the **mountain environment where they are formed.**
- They **are loamy and silty on valley sides** and **coarse-grained in the upper slopes**.
- In the snow-bound areas of the Himalayas, they **experience denudation**, and are acidic with low humus content.
- The soils found in the **lower valleys are fertile**.

Soil Degradation

- In a broad sense, soil degradation can be defined as the **decline in soil fertility**, when the nutritional status declines and depth of the soil goes down due to erosion and misuse.
- Soil degradation is **the main factor leading to the depleting soil resource** base in India.
- The degree of soil degradation varies from place to place according to the **topography, wind velocity and amount of the rainfall.**

Soil Erosion

- The **destruction of the soil cover** is described as soil erosion.
- The **soil forming processes and the erosional processes** of running water and wind go on simultaneously. But generally, there is a **balance between these two processes**.
- The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer.

- Sometimes, such a balance is disturbed **by natural or human factors, leading to a greater rate of removal of soil.**
- Human activities too are responsible for soil erosion to a great extent.
- As the human population increases, the demand on the land also increases.
- Forest and other natural vegetation are removed for human settlement, for cultivation, for grazing animals and for various other needs.
- Soil erosion is **a serious problem for Indian agriculture** and its negative effects are seen in other spheres also.
- Eroded materials are **carried down to rivers** and they lower down their **carrying capacity, and cause frequent floods and damage to agricultural lands. Deforestation is one of the major causes of soil erosion.**
- Plants keep soils bound in locks of roots, and thus, prevent erosion.
- They also add humus to the soil by shedding leaves and twigs.
- Forests have been denuded practically in most parts of India but their effect on soil erosion are more in hilly parts of the country.

Soil Conservation

- Nature has its own **laws of maintaining balance**. Nature offers enough opportunities for humans to develop their economy without disturbing the ecological balance.
- Soil conservation is a **methodology to maintain soil fertility, prevent soil erosion and exhaustion, and improve the degraded condition of the soil.**
- Soil erosion is essentially aggravated by faulty practices.
- The first step in any rational solution is to check **open cultivable lands on slopes** from farming.
- Lands with a **slope gradient of 15 - 25 per cent should not be used for cultivation.**
- If at all the land is to be used for agriculture, terraces should carefully be made.
- **Over-grazing and shifting cultivation** in many parts of India have affected the natural cover of land and given rise to extensive erosion.
- It should be regulated and controlled by educating villagers about the consequences.
- **Contour bunding, Contour terracing, regulated forestry, controlled grazing, cover cropping, mixed farming and crop rotation** are some of the remedial measures which are often adopted to reduce soil erosion.
- The **Central Soil Conservation Board**, set up by the Government of India, has prepared a number of plans for soil conservation in different parts of the country.
- These plans are based on the **climatic conditions, configuration of land and the social behaviour of people**.
- Even these plans are fragmental in nature. **Integrated land use planning**, therefore, seems to be the best technique for proper soil conservation.
- Lands should be classified according to their capability; land use maps should be prepared and lands should be put to right uses.
- The final responsibility for achieving the conservation of land will rest on the people who operate on it and receive the benefits.

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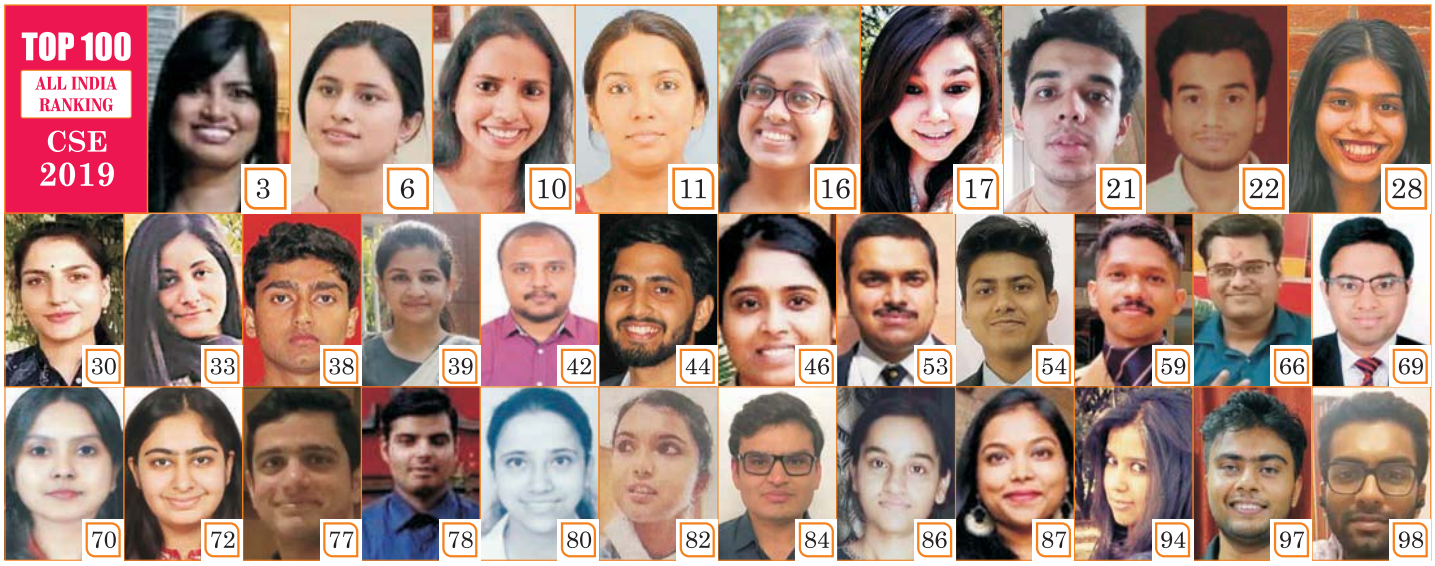

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