Soil Erosion Control and Management

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Soil Erosion-definition

Soil erosion is defined as detachment of soil particles, their transportation from one place to another and deposition elsewhere through water, wind, coastal waves, snow, gravity and other forces. It involves three steps:

- **Detachment of soil particles from the main soil body**
- **Their transportation by splashing, floating, rolling and dragging**
- **Deposition at another place.**

Factors affecting erosion

Factors which encourage detachment of soil particles are Rainfall impact, vegetation destruction, freezing and thawing, flowing water and wind velocity.

- **Raindrop splash, flowing water and blowing wind facilitate the carrying away of soil to distant places.**
- **Soil erosion due to run-off is more on sloping and denuded lands.**
- **Soil erosion by run-off is more serious and cause loss of soil along with nutrients**
- **In deserts, the formation of sand dunes and their erosion due to high wind velocity are common phenomena.**

Factors affecting soil erosion

- Intensity of rainfall and wind velocity: soil erosion depends on the intensity, kinetic energy, amount, duration and frequency of rainfall.
- Vegetation a thick canopy of vegetation intercepts the rain water and the rooting system improves the binding capacity of soil particles as well as infiltration.
- Topography – slope of land, its nature, degree and length: If the velocity of water flow is doubled, its erosive power increases 4 times and carrying capacity 64 times.
- Physical, chemical and biological characteristics of soil: erosion is more in coarse textured soils. Organic matter and clay helps in binding of soil particles and improves water holding capacity of soils.
- Interference by human beings and animals:
- Earth quakes, landslides, flash floods etc.

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Types of erosion

Normal or Geological erosion

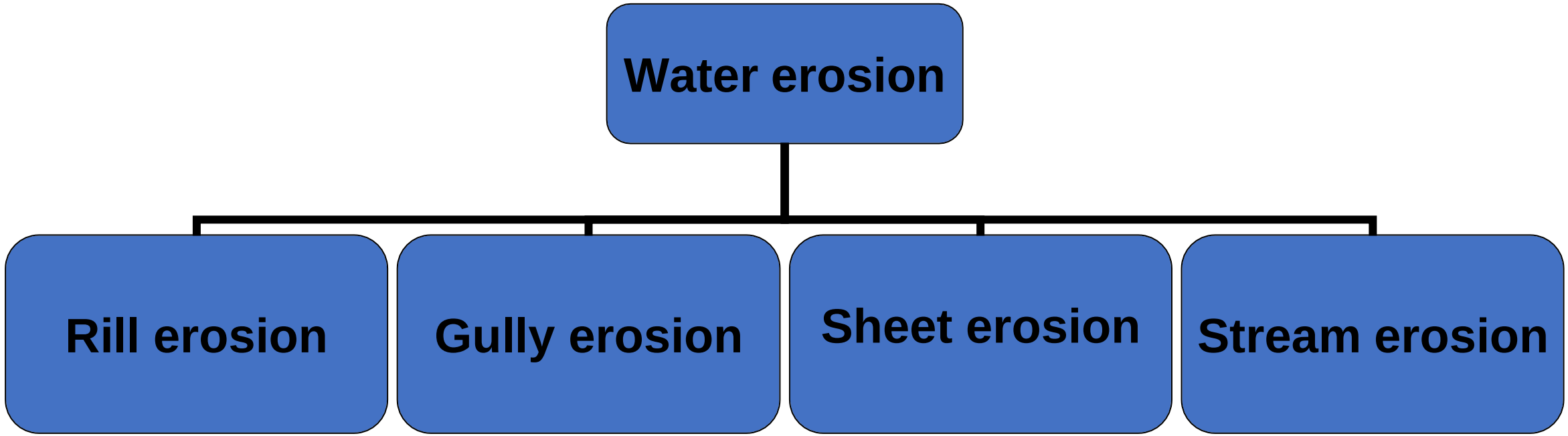
- Natural or normal erosion when the land is in natural equilibrium under the cover of vegetation. It takes place by the action of water, wind, gravity and glaciers. Its rate is so low that the loss of soil is compensated by the formation of new soil under natural weathering process. This kind of erosion does not pose any problem.

Accelerated erosion

- This is the major process in degradation of land resources and about 30 % of the cultivated land of the world and 50 % of geographical area of India is affected by soil erosion

Water erosion

Splash erosion- when raindrops fall on soil surface the soil particles become loose and splashed due to the impact force. Splashed particle remain there in level lands while in slopes they move downhill



Rill erosion - A process in which many small channels, a few centimeters deep are formed, it occurs mainly on recently cultivated soils.

- Most common form of erosion, often overlooked, effects can be easily removed by tillage
- Occurs when soil is removed by water from little streamlets that run through land with poor surface draining.
- Rills can often be found in between crop rows.

Rill formation in a Barren Land

Sheet Erosion

- Defined as the uniform removal of soil in thin layers from sloping land.
- This in reality is the mere runoff of the loose soil with the rain.
- Happens when rainwater flows into lower elevations, carrying sediments with it
- The water looses some of its energy of motion and it drains into the soil or slowly evaporates

The early stages of sheet erosion

Soil accumulated along fencelines could be an indicator

Sheet erosion in action displaying fine sediment runoff leaving coarser material

Stream Erosion

- Some times water continues to flow along a depression it has created. It becomes a stream
- It constantly picks up sediments from the bottom and sides of its channel.
- It carries some of the lightweight sediments, while large, heavy particles just roll along the bottom of the stream channel.
- These difference-sized materials scrape against the bottom and sides of the channel, where they continue to knock and loosen more sediments
- Because of this a stream continually cuts a deeper and wider channel

Stream Erosion

- Water flowing along a depression it has created can become a stream
- It constantly picks up sediments from the bottom and sides of the channel.
- It carries some of the lightweight sediments, while large, heavy particles just roll along the bottom of the stream channel.
- All of these difference-sized materials scrape against the bottom and sides of the channel, where they continue to knock and loosen more sediments
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Sediments and sedimentation

- Sediments include organic and inorganic particles dislodged by erosive forces and ready to be transported
- Fluvial sediment refers to the case where water is the key agent for erosion. The transported material is finally deposited when there is not enough energy to be further transported and it comes to rest

Effects of sedimentation

- Sediment plays a major role in the transport and fate of pollutants and a concern in water quality management. Toxic chemicals can become attached, or adsorbed, to sediment particles and then transported to and deposited in other areas. These pollutants may later be released into the environment
- **Deposition of sediment in rivers or lakes can decrease water depth, making navigation difficult or impossible.**
- **Affects the size and life of reservoirs and power generation**
- **Suspended sediments decrease the penetration of light into water,increase water temperature and affects the growth and survival of aquatic species**

Stream Bank Erosion

Wind erosion

- A dry weather phenomenon common in arid and semiarid regions and is accelerated when
- Soil is loose dry and finely divided
- Soil surface is smooth and relatively free or has sparse vegetation
- Areas are sufficiently large
- Wind is sufficiently strong to initiate soil movement

Wind erosion

Three processes are involved:

- **Surface creep— a wind erosion event, large particles ranging from 0.5 mm to 2 mm in diameter, are rolled across the soil surface. This causes them to collide with, and dislodge, other particles. Surface creep wind erosion results in these larger particles moving only a few metres.**
- **Saltation—occurs among middle-sized soil particles that range from 0.05 mm to 0.5 mm in diameter. Such particles are light enough to be lifted off the surface, but are too large to become suspended. These particles move through a series of low bounces over the surface, causing abrasion on the soil surface and attrition (the breaking of particles into smaller particles).**
- **Suspension—tiny particles less than 0.1 mm in diameter can be moved into the air by saltation, forming dust storms when taken further upwards by turbulence. These particles include very fine grains of sand, clay particles and organic matter**

Alley cropping with a combination of Tall trees as wind breaks and inter crops

Estimation of soil erosion

Soil loss from agricultural lands is predicted using the Universal Soil Loss Equation (USLE). The essence of the USLE is to isolate each variable and reduce its effect to a number so that when the numbers are multiplied together, the answer is the amount of soil loss

- A = RKLSCP
- where, A = Computed soil loss per unit area
- R = Rainfall factor. The number of erosion index units in a normal year's rainfall.
- Erosion index is a measure of the erosive force of specific rainfall.
- K = Soil erodibility factor. (Succeptebility of soil to erosion)
- L = Slope length factor
- S = Slope gradient factor
- C = Crop management factor
- P = Erosion control practice factor

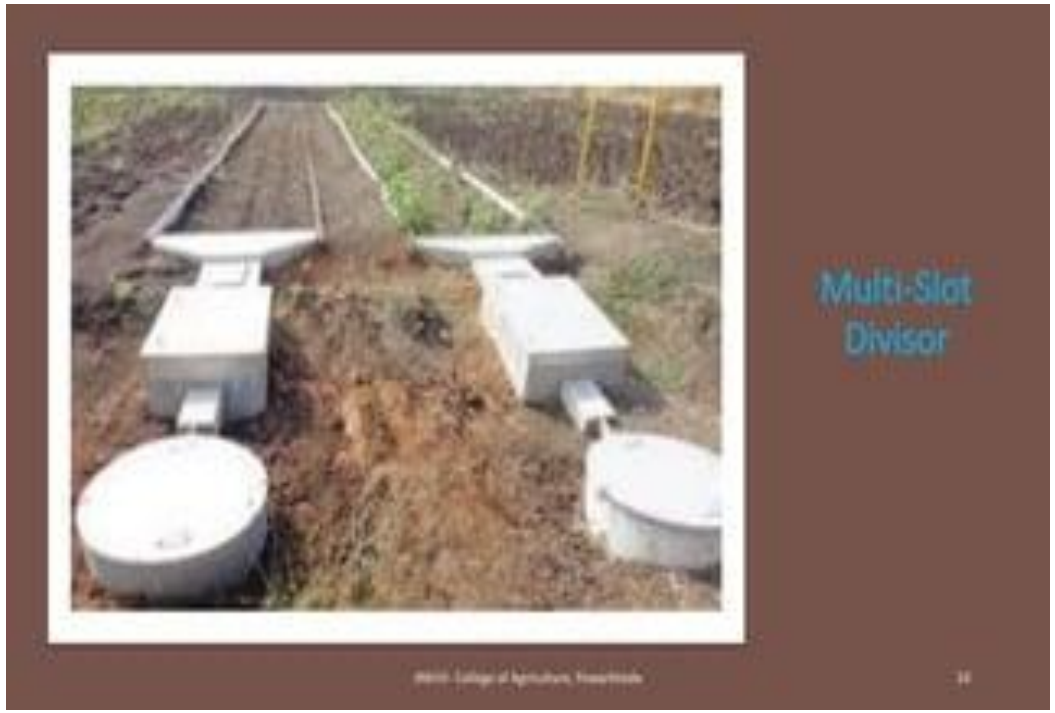
Estimation of Sediment Yield

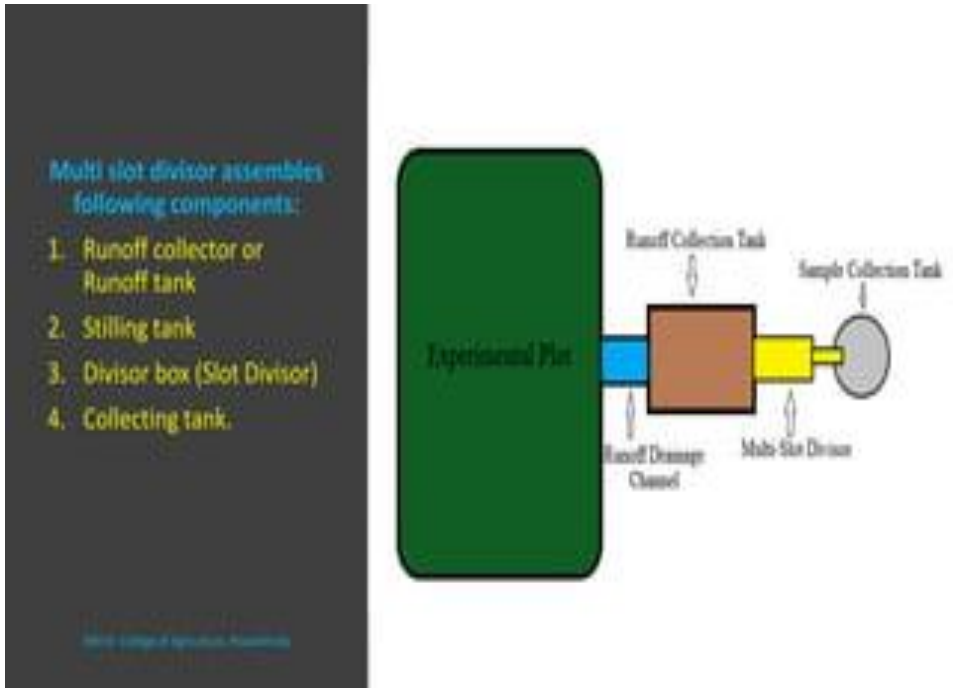
Sediment data and information are necessary in the evaluation of cropping practices and environmental planning

- First run off is measured through flumes with the help of stage level recorders.
- Flume is an open artificial water channel that leads water through gravity.
- Portion of the total run off can then be collected with the help of devices like Coshocton wheel
- Run off sample is then used for the determination of soil loss from plots or watershed.
- The runoff is calculated using the equation,
- Runoff (mm) = Run off (litres) / Area of plot (m2)
- Amount of soil is measured gravimetrically to give the soil loss in g/litre.
- Based on the total runoff volume and the area soil loss in tons/hectare is calculated

If we want to estimate sedimentation yield in run off plots / watersheds, the first run off is measured through flumes with the help of stage level recorders. Flume is an open artificial water channel that leads water through gravity

Estimating sediment Loss using Coshocton wheel





Coshocton wheel installed in field

Estimation of wind erosion

- Wind erosion can also be estimated using another equation.
- E= f (ICKLV) where
- E= average annual soil loss, t/acre
- I= Soil erodibility index, depends on soil aggregate size and slope %.
- C= Climate factor, depends on wind velocity and surface soil moisture.
- K= Soil surface roughness factor
- L= Unsheltered field width measured along the direction of prevailing wind
- V= Vegetative cover factor

Soil Conservation - Definition

Soil conservation is a combination of all management and land use practices which protect the soil against depletion or deterioration by natural or man-induced factors and improves the productivity of the natural resources on sustained basis

- The different measures adopted for soil conservation can be grouped into three;
- 1. Mechanical measures
- 2. Agronomical measures
- 3. Mechanical –cum-agronomical measures

Mechanical measures

Contour bunds

Are mechanical barriers built across the slope. along the contour

Bench terrace:

- **Flat beds constructed on hills across the slope**
- **Height of the riser should not be more than 1m**
- **Width of bench terrace depends on the degree of slope.**

Half moon terrace:

- **Semi circular beds of appropriate diameter with the shape of a half moon.**
- **Recommended for fruit trees and plantation crops on steep slopes**.

Grassed water Ways

- Most effective in moderating the flow and reducing the erosion velocity of run off
- Planting of grasses on the run off route reduces the soil and nutrient loss.

Water harvesting ponds

- Generally constructed down the slope. Earthern dams/ bunds are constructed at appropriate locations on the water shed for retaining silt loads.

Contour trench

Contour trenches are ditches dug into a hillside along the contour perpendicular to the flow of water to prevent it from flowing down the hill. They are also known as Continuous Contour Trenches (CCT)

Agronomic Measures

- Selection of proper crops and cropping patterns is important for preventing erosion
- Growing of crops with soil cover, grasses, and mulches are ideal for controlling soil erosion.
- Soil erosion can be minimized by the following crop management practices

Cropping systems:

- **Select crops which develop canopy quickly provide an early protection to soil.**

Crop geometry- Crop lay out in a field will affect soil erosion. A closer spacing across the slope can prevent erosion.

Contour cultivation - Cultivation of crops along contour

- **Tillage - Follow low intensity tillage.**
- **Agro forestry - Growing of trees along with agricultural crops prevents soil erosion.**

  Multipurpose trees like Subabul, Eucalyptus etc. are recommended.
- **Grasses: Low and evenly distributed canopy and fibrous root systems make grasses highly effective in controlling soil erosion.**

Mechanical – cum – Agronomical Measures

Depending on the needs of the land and intensity of erosion, bio-engineering measures are sometimes preferred as compared to either mechanical or agronomical measures alone. In black soils with 45-50% clay, both agronomical and mechanical measures have been found to be very effective to reduce run off and soil losses

Controlling wind erosion:

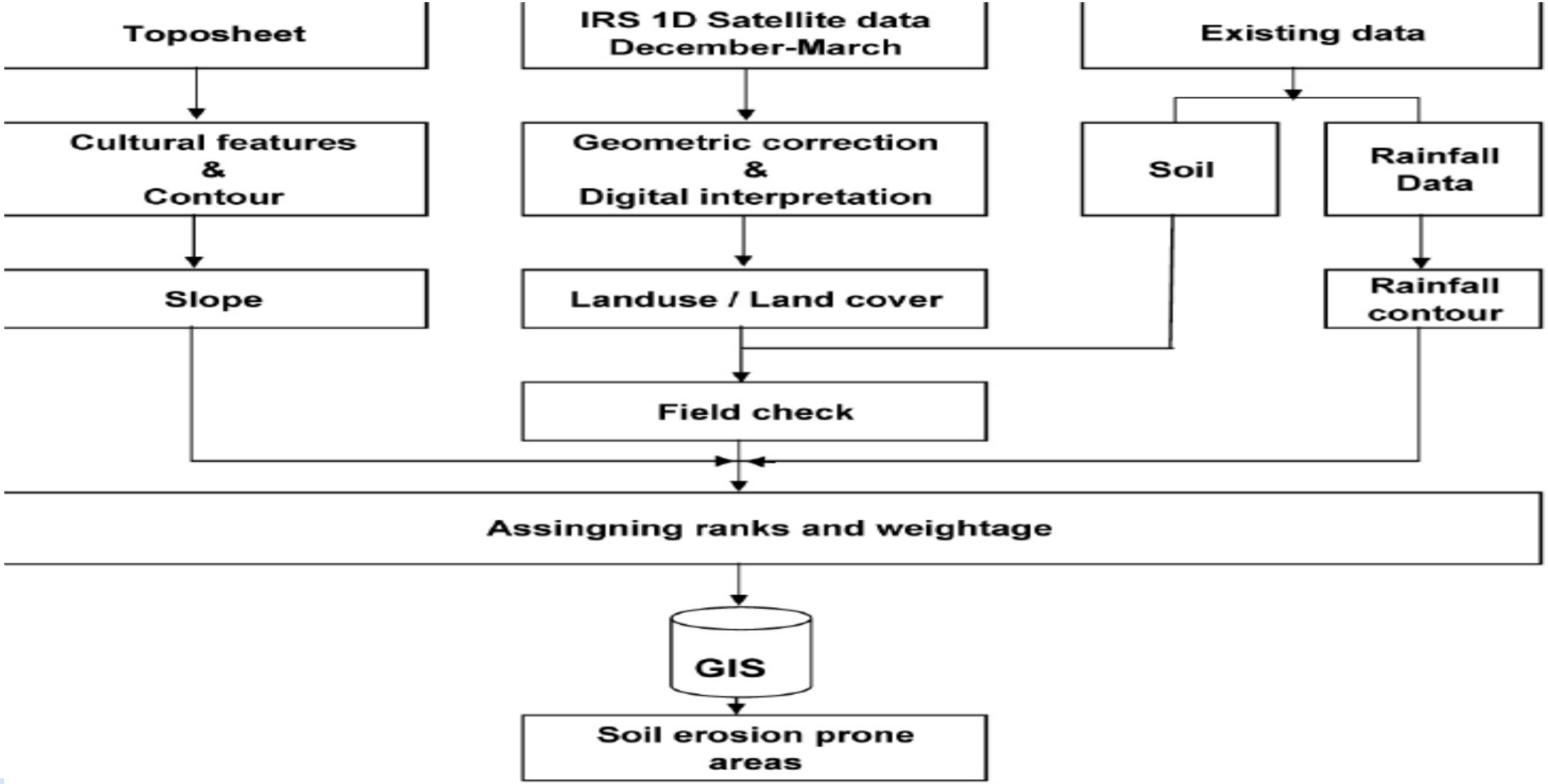
- Maintain a vegetative cover, either growing plants or crop residues,
- Reduce cultivated fallow,
- Reduce or eliminate tillage,
- For tilling, choose a tillage implement that buries less residue and reduce tillage speed,
- Plant and maintain field shelterbelts.
- Avoid overgrazing.

- Remote Sensing and GIS for Soil Erosion Prone area Assessment: Case study from Kalrayan hills, Eastern Ghats, Tamil Nadu

Methodology

- **The IRS 1D, satellite data of December,2001 (Path101-Row65) has been geometrically and radiometically corrected , land use and land cover have been digitally interpreted and classified using ERDAS software.**
- **Limited field check has been undertaken for the correctness of the interpreted data.**
- **Monthly rainfall data from State government departments have been collected and isohyets map prepared using Arc GIS – Spatial analyst software 5**
- **Suitable ranks and weightage given to interpret the erosion prone areas based on the thematic layers parameters.**
- **Vector overlay has been performed using the Arc-GIS software**
- **Based on the above, the integrated output on high soil erosion prone areas have been identified for implementing soil conservation activities**

Flow chart on methodology adopted

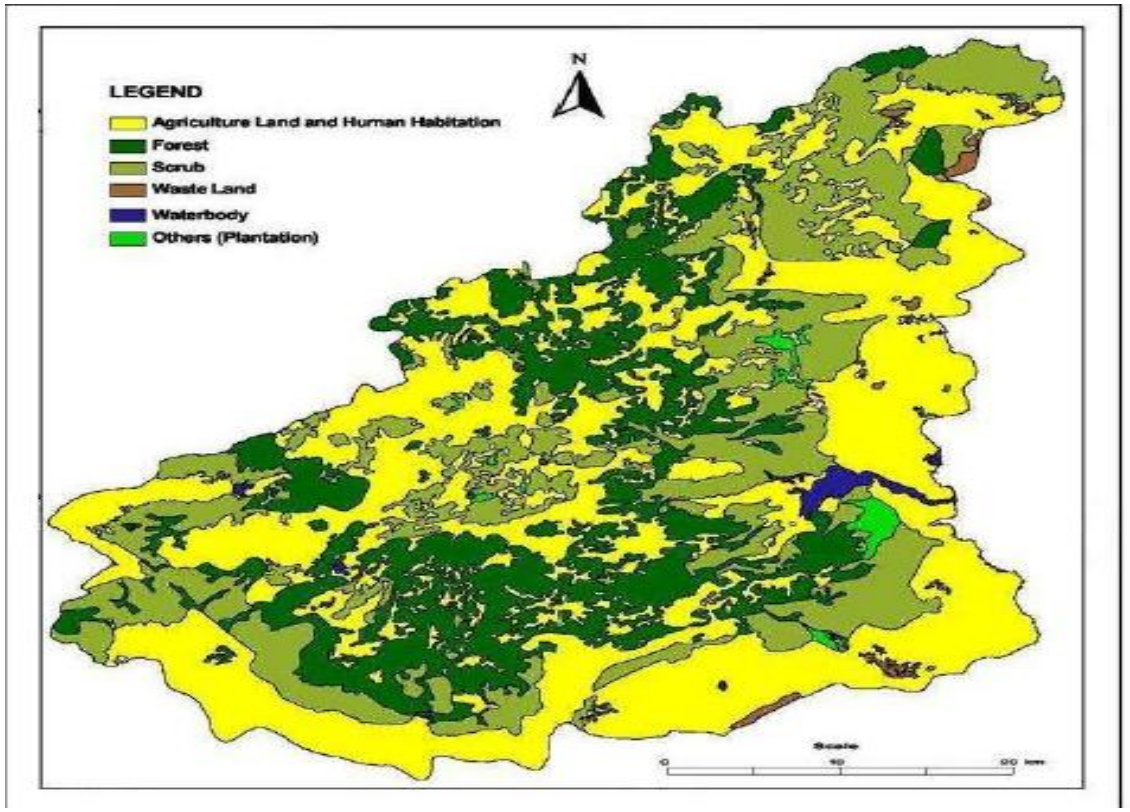


Parameters	Weightage
Forest Cover	
Agriculture	5
Scrub	4
Wasteland	3
Forest & Plantation	2
Waterbody	1
Slope in Degrees	
> 32	5
24 – 32	4
16 – 24	3
8 – 16	2
< 8	1

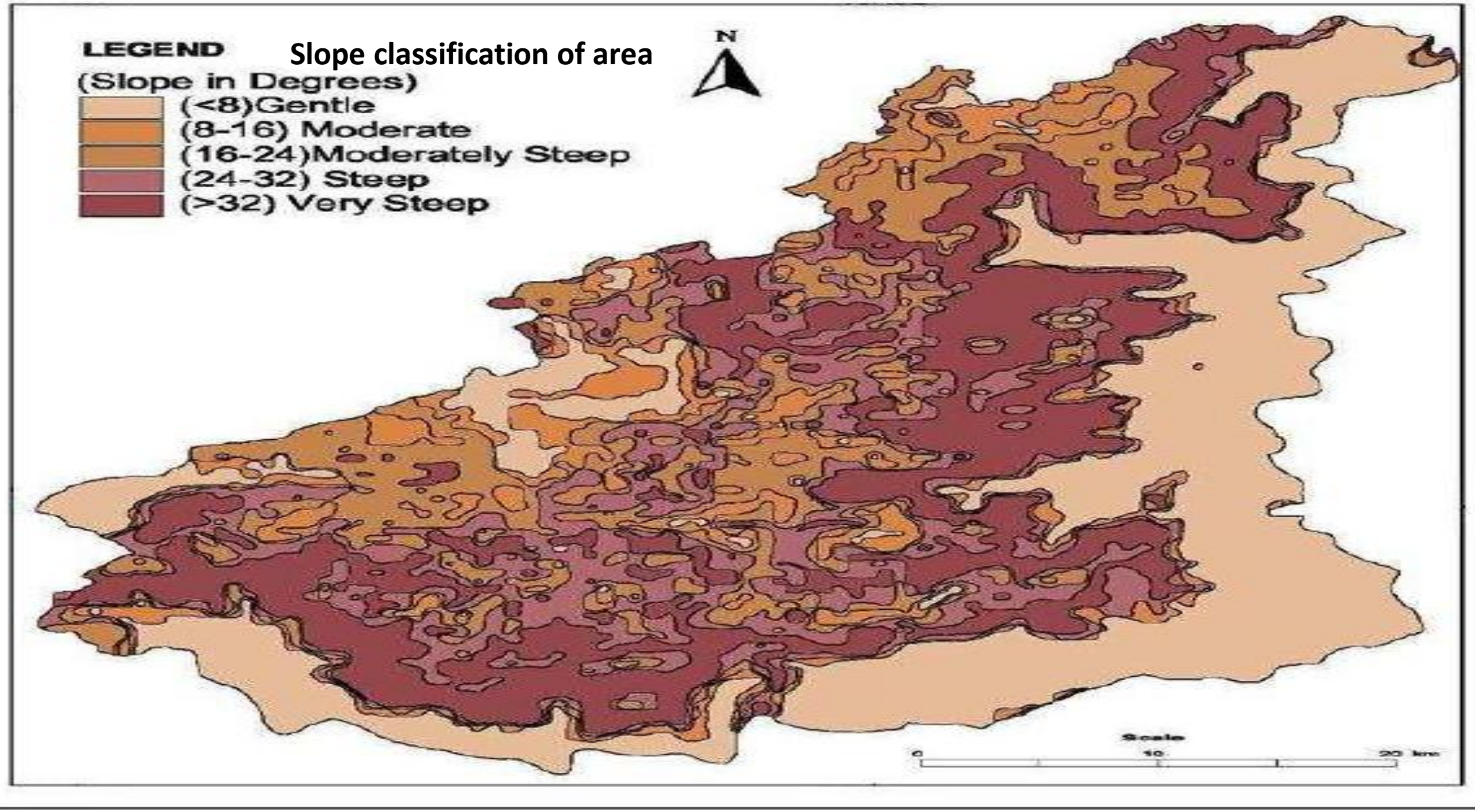
Parameters	Weightage
Rainfall	
> 1600	5
1400 – 1600	4
1200 – 1400	3
1000 – 1200	2
< 1000	1
Soil Type	
Gravelly loamy	5
Loamy	4
Gravelly clay	3
Clay	2
Calcareous clay	1

Maps prepared from data of stdy area

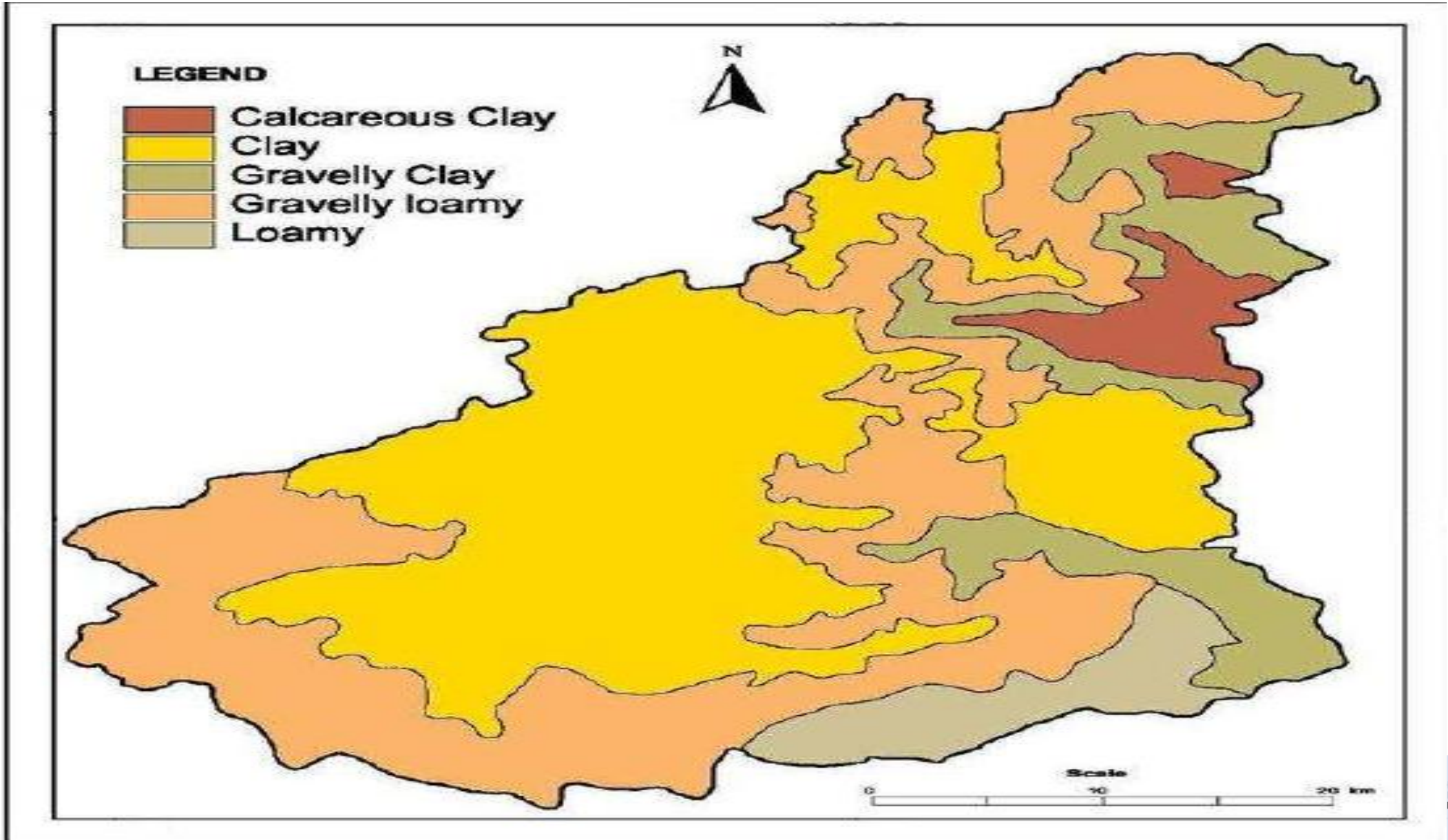
Forest cover2001



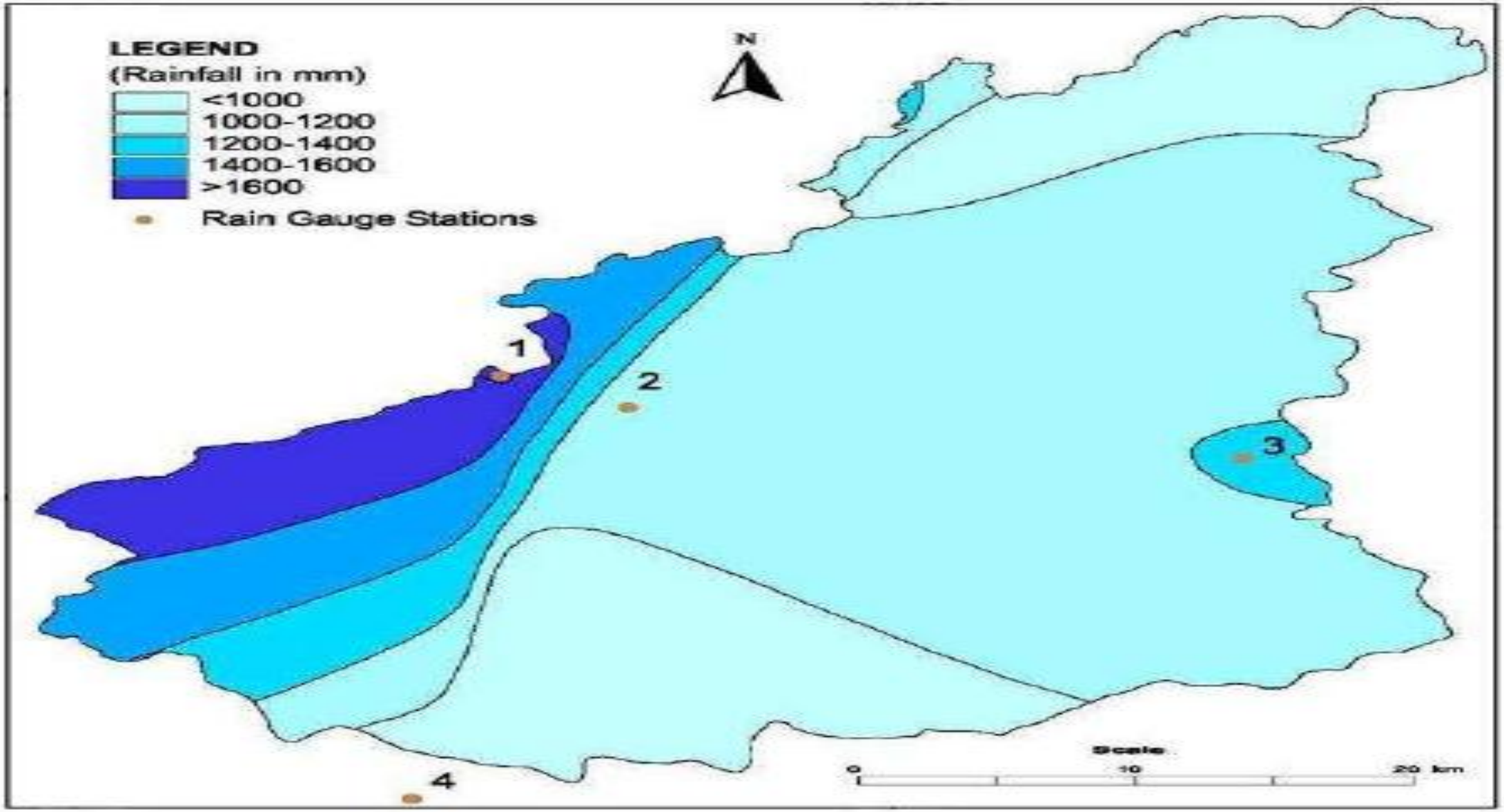
Slope classification of area



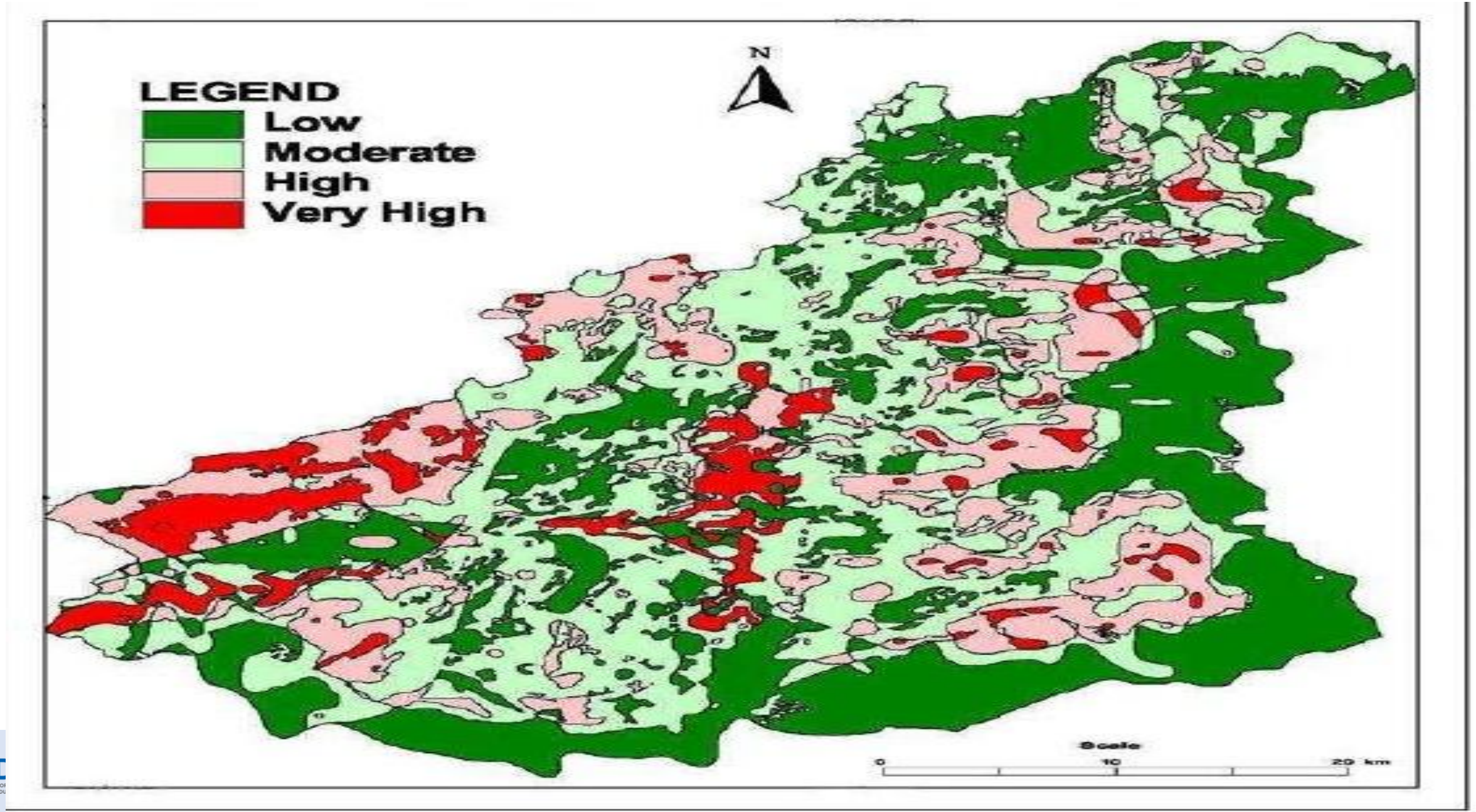
Soils


LEGEND
Calcareous Clay
Clay
Gravelly Clay
Gravelly loamy
Loamy
N
Scale
0
10
20 km

Annual Rainfall



Rainfall and Soil erosion prone areas



Conclusions

- **Very high soil erosion hazard zones are found at the inner slopes of the plateau portion and these areas represent the steep slopes in the human habitation where agricultural activities are practiced.**
- **Very high soil erosion prone areas are found at the higher outer slopes of Tumbal extension reserved forest area of western side of the study area which is due to agricultural practices.**
- **Areas highly prone for soil erosion are Pattimedu, Jadayagaundan (Southern portion), Kanai and Puttai reserved forests (Eastern portion) are due to deforestation and human interferences.**
- **Area with moderate soil erosion hazard zones area confined to the lower outer slopes occurred in the reserved forest and more confined to, the plateau portions of the study area, Vellimalai, Kariyalur and Innadu .**
- **Areas with low soil erosion hazards are found to the foothills and plain regions of the study area.**

Severely eroded barren hill slope

sevre damage due to water erosion

Severely eroded barren hill slope


Eroded slope with exposed subsoil laterite

Scene of land slide after heavy downpour

Sea erosion control using Tetrapods

Barren hillock with cropped valley


Thank You