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Soil Erosion & Water Resources Measurement in Agriculture Production

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ABSTRACT

Population growth and climate change have put a strain on the planet's limited natural resources. Soil and water are essential natural resources for the agricultural production system. Deterioration of natural resources is largely due to human and environmental activities that harm the environment. Soil erosion is one of the most important dangers to the degradation of soil and water resources among the many degradation processes. The water erosion process has eroded around 68.4 percent of India's entire geographical area. Soil erosion is accelerated by intensive farming activities. As a result of increased extraction, groundwater levels have also dropped. Soil and water resources must be managed holistically to ensure agricultural viability and the preservation of the natural ecosystem. For the preservation of soil and water, new technology, sensible use of natural resources, and good management methods are essential. To ensure long-term agricultural sustainability and soil health, this chapter examines the status of natural resource degradation, erosion processes, and soil conservation techniques.

Keywords--- Soil Erosion, Agriculture, Land, Water Resources, Production, Measurement

I. INTRODUCTION

All terrestrial life relies on soil and water for its existence and survival. There is a need for food, feed, fuel, and fibre for humans, and these are the primary resources. In order for plants to thrive, they need soil in which to grow and develop. Various types of erosion processes can quickly degrade this finite, non-renewable natural resource. Around 52% of the world's productive land has been degraded by various degradation processes, while nearly 80% of the land is affected by water erosion. Soil erosion causes about 10 million hectares (mha) of worldwide cropland to become unproductive each year at a rate of 30 t ha-1 year of soil erosion. According to estimates, water erosion contributes 28 Pg year-1 to the worldwide sediment flux. Degradation of scarce soil resources on such a scale threatens global food security and degrades environmental quality at the same time. One problem is that aquifer depletion continues to worsen, putting human life and agricultural production systems at risk under future climate change scenarios. In addition, climate change is expected to raise world water consumption by nearly 40% of the amount of water required for irrigation. Consequently, we must focus our efforts on the development and adoption of efficient soil and water conservation and agricultural sustainability measures under the future situation of acute water shortages. When it came to 2017's "World Soil Day," the focus was to promote awareness about the need to preserve healthy ecosystems and human well-being by stopping soil erosion. Use and management must be taken into consideration. As the global population continues to rise, soil and water resources are more important than they have ever been. More than one advantage of conserving soil and water can be found in agribusiness, the environment, and the bottom line. Restoring depleted nutrients, cleaning water reservoirs and pipelines, and preventing erosion are all predicted to cost $400 billion a year around the world on an annual basis.

II. THE EXTENT OF LAND DEPLETION

Changes in land use and management techniques have exacerbated soil erosion and caused irreversible land degradation, which affects 23.5 percent of the planet's surface area. Soil erosion is a severe issue that affects not only the quality of the land and water resources but also the agricultural output and the economic well-being of farm families. Through a variety of degradation mechanisms, soil erosion has deteriorated roughly 32 percent of the total land area in the United States, 30.7 percent in China, 16 percent in Africa, 17 percent in Europe, and 45 percent in India. 68.4 percent of India's land area has been degraded by water erosion, one of the several processes responsible for land degradation. Several Indian organisations have made educated guesses on the level of soil degradation (Table 1). In India, a total of

146.8 mha of land has been degraded as a result of NBSS and LUP.

Table 1: Estimates of the extent of land degradation in India by various agencies

Agency	Estimate for the year	Degraded Area (mha)
National Commission on Agriculture	1976	148
Ministry of Agriculture-Soil and Water Conservation Division	1978	175
Department of Environment	1980	95
Society for Promotion of Wastelands Development	1984	130
National Wasteland Development Board	1985	123
National Remote Sensing Agency	1985	53
Ministry of Agriculture	1985	174
Ministry of Agriculture	1994	107
National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)	1994	188
NBSS&LUP (Revised)	2004	147

III. SOIL EROSION AND THE CAUSES OF EROSION

It is the loss of topsoil by the physical pressures of eroding agents at a faster pace than it is being formed. Erosion reduces soil productivity by removing the fertile top layer, which is rich in nutrients. Accelerated erosion and geological erosion are the two types of soil erosion. Geological erosion is a natural occurrence that occurs as a result of rock weathering and disintegration at a rate that is less than that of soil development. In contrast, the rate of soil erosion accelerates as it exceeds a particular threshold. Overgrazing, deforestation, mining, and intensive and incorrect agricultural methods are all factors that contribute to increased soil erosion. When organic matter and plant nutrients are eroded from the fertile topsoil, crop productivity is eventually reduced. As a result, natural resource management and conservation are critical. Although soil erosion can't be completely eliminated, it must be controlled to the point where it doesn't have a negative influence on agricultural sustainability or output.

There are several types of soil erosion, and water and wind are two of the most common culprits. Around 1100 mha (56 percent of the total degraded land) is impacted by water erosion, while around 28 mha (28 percent of the total degraded land) is affected by wind erosion. Soil particles are removed by water runoff from slopes, while wind sweeps soil particles away from unprotected lands. In addition to soil compaction and flooding, other forms of land degradation include acidification, alkalinization, and salinization, all of which are influenced by factors such as parent material, climate, and crop management. Solvent erosive processes and causes, and management.

IV. WATER EROSION PREVALENT PROBLEM

Water erosion is the most devastating of the numerous forms of soil erosion. This sort of erosion is caused by rain, runoff, hail, and irrigation washing away soil particles. More susceptible to erosion are humid and subhumid agricultural systems. Heavy rains with minimal vegetation are common in dry and semi-arid locations, where the problem is magnified. The three main processes of water erosion are detachment, movement, and deposition. Soil particle movement and separation are greatly aided by rainfall. Soil particles that have been removed from the soil are to blame for decreased water penetration and discharge. The first two steps decide how much soil will be eroded, while the third phase determines how that material will be distributed. If soil particles can't be disseminated and moved, there will be no deposition. As a result, the primary mechanisms of soil erosion are detachment and transport. Understanding water erosion's mechanisms and extent can help us manage and create erosion control strategies. Splash, sheet, rill, and gully erosion are the four most prevalent types of water-induced soil erosion (Figure 1). Stream bank erosion, ravine formation, slip and tunnel erosion, and coastal erosion are all examples of water erosion. The following is a list of the several types of water erosion:

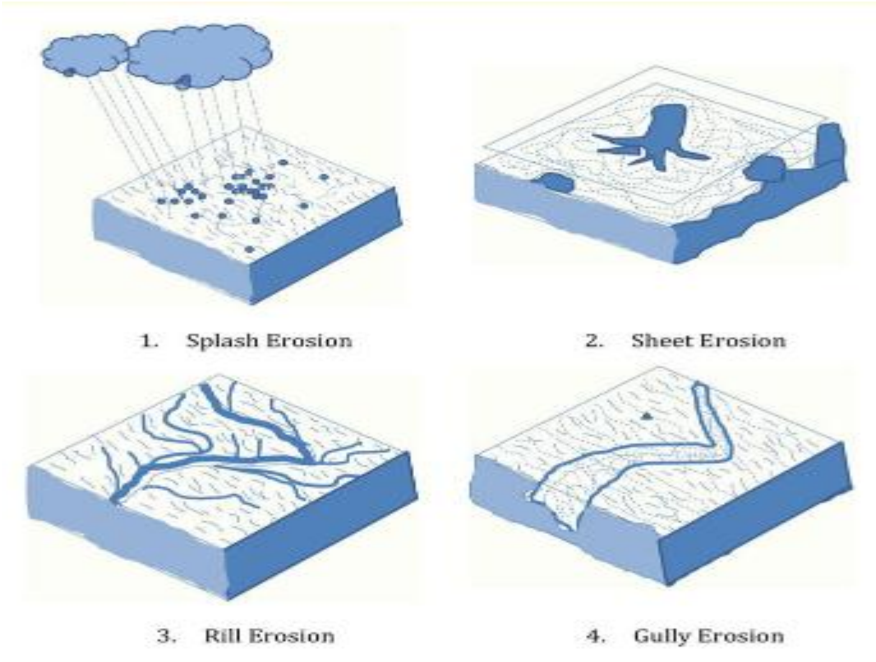

Figure 1: The four main types of soil erosion caused by water

4.1 Splashes of Erosion

Soil erosion by water begins with splash erosion. Splash erosion occurs when raindrops hit the soil surface and break up soil aggregates, dispersing and splashing soil particles away from their source. Splash erosion occurs when raindrops hit soil particles, causing a splash and craters to form. Soil particles are shattered by raindrops as they fall on the soil surface, creating a variety of voids in different shapes and sizes. A crater's size, shape, and velocity all play a role in determining the depth to which raindrops can penetrate. Soil particles can only travel a few centimetres in this state.

4.2 Erodibility of Sheets

Next comes splash erosion, which sets the stage for sheet erosion immediately. Runoff water removes a consistent thin layer of fertile topsoil from the field's entire sloping surface area. Detachment of particulate matter from the soil surface, rainfall intensity, and the slope of the land all influence sheet erosion. Soil erosion in the form of little rills is caused by the shallow flow of runoff water. The nutrient-rich top layer of soil is lost in this process, which is the most prevalent and most severe type of soil erosion in agriculture. Splash and sheet erosion account for 70% of overall soil erosion.

4.3 Erosion of the rill

"Rill erosion" is a term used to describe the movement of soil and organic matter-laden runoff water through finger-like, tiny channels. In this case, the soil is lost in the most advanced form of sheet erosion. Soil is eroded more quickly by water flowing in narrow channels than by large sheets of water. In terms of water erosion, rill erosion is the second-most prevalent. Heavy rainfall can increase soil erosion. Tillage operations can easily control these rills. Runoff transit capacity, land slope, and hydraulic shear of water flow are all elements that contribute to rill erosion.

4.4 Erosion Ravine

In the most advanced form of rill erosion, a gully has developed. During periods of heavy rainfall, concentrated runoff water causes rills to deepen and widen, forming gullies. In the valleys, linear incision channels with a width of 0.03 metres and a depth of 0.03 metres are found in the valleys. Gullies are formed when runoff is concentrated in a narrow area. The entire soil profile is lost as a result of continuous gully erosion. Gully erosion can lead to crop failure, exposing plant roots, lowering groundwater levels, and affecting landscape stability in an extreme form. Field tearing can exacerbate non-point source contamination (sediment, chemicals, etc.) to nearby waterbodies. It's impossible to fix gullies with normal agricultural practises. The shear stress of flowing water and soil critical shear stress are the most important elements in gully erosion. As gullies continue to erode, ravines begin to form. Gullies can be divided into a number of different types based on their dimensions, depth, and drainage area.

V. SOIL EROSION'S IMPACT ON AGRICULTURAL PRODUCTION

Soil quality, agricultural output, and nutritional quality are all negatively impacted by the increased rate of soil erosion. Agricultural yields are lower, land is degraded, and the landscape is deformed as a result of increased soil erosion. As a result of these factors, the rate of soil erosion can be influenced by factors such as parent material, soil texture, and slope steepness. We lose 5334 million tonnes (m t) of soil each year and 8.4 million tonnes (m t) of nutrients due to soil erosion, on average, according to known statistics on soil loss in the United States. However, the average annual soil loss permitted per hectare is 12.0 tonnes per ha1. Around 29% of all eroded soil is lost to the sea, while 61% is carried by runoff from one location to the next, and the final 10% is directly deposited in reservoirs. Soil samples taken from agricultural fields show a higher nutrient concentration than soil samples taken from other areas. In July, degraded soil contained approximately 45.9 kg C ha^{-1} and 4.3 kg N ha^{-1}.

To improve soil biophysical and chemical properties, soil organic matter (SOM) is essential. SOM has roughly 95% nitrogen and 25–50% phosphorus. Soil and tiny organic particles are lost at a higher rate of erosion. Erosion removes 1.5–5 times more SOM from the soil than it does from the soil that is left behind. SOM availability affects soil biodiversity and biological activity in a given agro-ecosystem. It's also more likely that soil erosion will occur because of the more intense and unpredictable rainfall. This means that there is less water available for vegetation. According to a study conducted by Sharda et al., water erosion decreased national crop production by 13.4 Mt in 2008–2009 due to the severity of the erosion. All ecosystems are negatively impacted by the loss of soil due to water and wind erosion. As shown in Figure 2, agricultural productivity is likely to decline as a result of soil and water erosion.

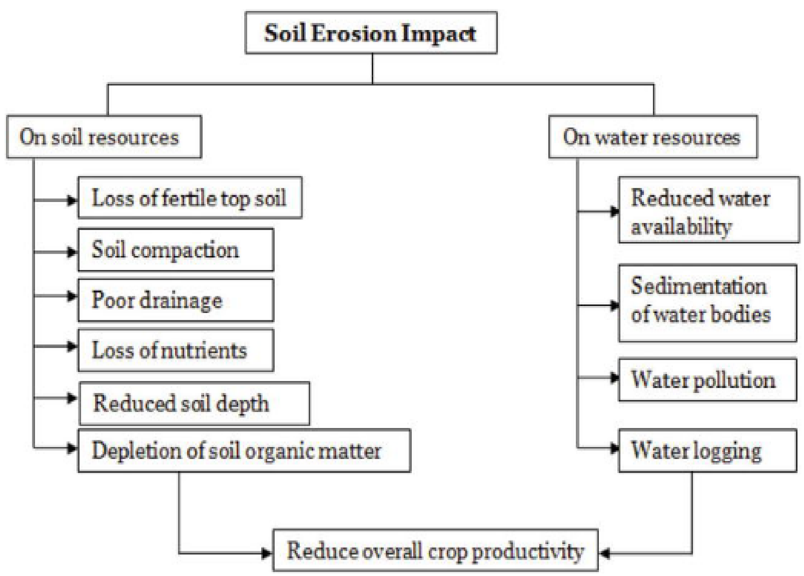

Figure 2: Soil and water resources

Agricultural land's surface runoff and water erosion are greatly reduced when they are covered in plants. The kind of vegetation, canopy cover, slope gradient, and rainfall features all have a significant impact on runoff, soil erosion, and nutrient loss. In addition to reducing surface runoff, increased canopy cover and crop residue mulching on the soil surface minimise the impact of rainfall erosivity and soil erodibility. In addition to protecting the soil surface from heavy rains, vegetation minimises soil particle dissociation. In addition, it keeps soil moisture, silt, and organic elements in place. Soil loss and nutrient loss by water erosion must be reduced in order to maintain agricultural output.

VI. CONSERVATION OF SOIL AND WATER

There are two kinds of actions that can be taken to protect soil and water: mechanical/engineering/structural actions and biological actions. Mechanical measures include permanent and semi-permanent structures like terracing, bunding, trenching, check dams, gabion structures, loose/stone boulders, crib walls, etc. Biological measures include forestry, agroforestry, horticulture, and agricultural and agronomic practises.

6.1 Agronomy, or Agriculture and Agroforestry

Agronomic measures can be used on slopes of less than 2%. Raindrops hit the ground less hard because the surface of the soil is covered and the soil can absorb more water. This reduces runoff and soil loss from erosion. These measures are cheaper, will last longer, and may sometimes work better than structural measures.

6.2 Protect Crops

Cover crops are close-growing plants with dense canopies that are grown to protect soil from erosion. Legume crops have better biomass than row crops to protect the soil. The effectiveness of cover crops depends on the shape of the crop and how well the canopy grows to catch raindrops and protect the soil from erosion. It has been said that, compared to cultivated fallow and sorghum, legumes provide better cover and protection for land against runoff and soil loss. Cowpea, green gramme, black gramme, groundnut, etc., are some of the best cover crops.

Advantages

- Soil erosion is caused by raindrops, water runoff, and wind.
- Acts as a barrier to the flow of water, slowing it down. This reduces runoff and soil loss.
- Increase the amount of organic matter in the soil by incorporating the plant's waste and giving it deep roots.
- Biological nitrogen fixation makes more nutrients available to the component crop and the crops that come after it.
- Improve the quality of the water and the soil's ability to hold water.
- Change the way the soil works, stop weeds from growing, and make crops more productive.

6.3 Intercropping

Intercropping is when two or more crops are grown in the same field at the same time, either in a set row pattern or in alternating rows. It can be done in a row, a strip, or a relay, depending on the crops, soil type, topography, and weather. Intercropping takes into account both time and space. Erosion-friendly and erosion-resistant plants should be grown together. The plants should grow roots in different ways. Intercropping gives the soil surface more coverage, lessens the direct effect of raindrops, and keeps the soil from washing away.

Advantages

- High total production of biomass.
- Use of soil and water resources in an effective way.
- Because different kinds of products are made at different times, marketing risks are lessened.
- Intercropping can help reduce the effects of drought.
- Reduce the number of weeds and insect pests or diseases that are spreading like wildfire.
- It makes the soil more fertile.

VII. CONCLUSION

The amount of land is limited, and the amount of land that can be farmed is getting smaller over time because of different types of land degradation. There is no other way to get more land that can be farmed. The only way to do this is to either make farming more productive per unit of resource or fix up the land that has been damaged. All types of terrestrial ecosystems need healthy soil and water to be productive. This is because plants need fertile soil with good biophysical and chemical properties and good quality water to grow and develop. It is important to use biological (agroforestry and agricultural) soil and water conservation methods to reduce runoff and soil erosion and improve soil quality, water quality, moisture retention, and overall crop productivity in a way that is sustainable. Biological measures are both affordable and good for the environment. They also improve the soil's properties and help save soil and water resources. Also, using both biological and mechanical methods together will help boost and keep up agricultural productivity.

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