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Indian Soil Degradation: Causes, Significant Threats and Management Options

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INTRODUCTION

The term "soil degradation" describes a loss in the productivity of the soil brought on by unfavourable changes in the nutritional status, soil organic matter, structural characteristics, and concentrations of harmful compounds and electrolytes. The process of soil deterioration reduces the land's ability to provide commodities and services in the present as well as the future. It has also been described as the pace of unfavourable change in soil characteristics leading to a loss in the land's capacity for production as a result of processes primarily caused by human interference. As a result, it suggests a loss in soil productivity, a decline in plant cover, a qualitative and quantitative decline in water resources, soil degradation, and air pollution.

Degradation is a stage of evolution that lowers the potential of resources. 7.40 million hectares of arable land. Every year, due to climate change and deforestation, people around the world migrate to degraded regions. Since the beginning of land farming, soil degradation has been an issue. However, it has become significantly worse in recent decades as a result of India's population growth, which is expanding at a pace of roughly 1.8% and necessitating the plow-up of marginal regions to fulfil the rising food demand. These marginal soils are especially susceptible to deterioration, which lowers their quality and general production. In order to prevent soil degradation in India, the current paper briefly describes degraded and wastelands, their origins, significant threats, and management solutions.

Why Soil Degradation Occurs?

The overuse of the land to supply conflicting demands for food, fibre, and fodder from the expanding population is what is causing the destruction of the environment. Salinization, flooding, drought, erosion, and waterlogging are only a few of the human activities that exacerbate soil deterioration.

Other activities include the construction of large-scale irrigation canals, deforestation, and improper land use. In turn, these processes lower agricultural yield, which causes social insecurity.

The main cause of soil deterioration may be greenhouse gas emissions into the atmosphere, which cause global warming. Deforestation and removal of natural vegetation, excessive grazing, agriculture-related activities, and excessive domestic use of the vegetation are the causes of degradation brought on by direct and indirect human interference.

Major Threats and Management Options

Soil Erosion: -Soil erosion is a significant contributor to the depletion of the environment's natural resources. Soil erosion is typicallymore severe than in plain and undulating places where there are mountains. Improper soil management, unsuitable forAccelerated soil erosion is caused by things like tilling along a slope, not covering crops during heavy rains, etc.Land productivity is lost because of erosion. More than 85 M hectares of TGA are thought to be subject to this. Erosion caused by wind and water. Mechanisms of soil structural decay result from a variety of processes, including slaking and dispersion.Climate and soil types affect how quickly things collapse and degrade.In the context of India, one of the most catastrophic degradations is caused by water eroding soil. Existing data on soil loss wereevaluated It was determined that an average of 16.35 t ha-1 yr-1, or 5334 M t yr-1, of soil erosion was occurring. Natural vegetation being removed because of excessive grazing and expanding agriculture. The primary human-induced variables contributing to rapid wind erosion in marginal locations. This sort of erosion involves the movement of soil particles caused by wind.

Salinization and Alkalization: -One of the primary tactics for reaching self-sufficiency in food production has been the extension of irrigation. From roughly 22 M hectares in 1950 to more than 51 M ha today, India's net irrigated area has risen. The majority of the development involves increasing the area irrigated by canals, which raises the groundwater table and causes the soil to degrade due to salt build-up. However, the area of 6 million ha of salinized or alkalinized soils has decreased due to reclamation operations from 7 million ha.

(Fig-1: White Saline Soil Patches)

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Crop yields and output are affected by the high amounts of soluble salts, exchangeable sodium, or both present in these soils. The physiochemical characteristics and salt composition of the soils determine whether it is saline, sodic, or saline-sodic. In the GIS format, salt-affected soils were simply reclassified into two classes: saline and sodic/alkali soils. Alkali soils typically exhibit high soil pH (up to 10.8), high exchangeable sodium percent (ESP) (up to 90), low organic carbon, poor infiltration and poor fertility status and other properties. Salts of sodium carbonate and sodium bicarbonate make up the majority of these soils. The electrical conductivity of salty soils is higher (> 4dS m-1), their ESP is lower (15), and their pH is lower (8.5). Chlorides and sulphates of Na, Ca, and Mg are the main salts in saline soils.

(**Fig-2: Alkaline Soil**)

Acidity: -The laterites and different latosolic soils, such as ferruginous red soils, ferruginous gravelly red soils, mixed red and black, or red and yellow soils, make up the greatest areas in India covered by acid soils. According to reports, acid soils affect 6.98 million hectares of land, or 9.4 percent of total grazing area (TGA). Assam, other North Eastern states, West Bengal, Bihar, Odisha, Andhra Pradesh, Kerala, Madhya Pradesh, Karnataka, Maharashtra, and Tamil Nadu are some of the humid and per-humid places where acid soils can grow. The acid sulphate soils of Kerala are unusual in their features and associated issues. These soils developed because of extensive cation leaching brought on by heavy rainfall, which lowered the pH and reduced soil fertility. The classification of acidic soils as extremely acidic (pH 4.5), moderately acidic (pH 4.5-5.5), mildly acidic (pH 5.5-6.5), and non-acidic (pH > 6.5) soils is based on the pH range.Acid soils present the normal water management issues that are mostly related to the physical and chemical characteristics of the soil. Acidic light-textured soils with a kaolinite dominance have extremely high-saturated hydraulic conductivity, which causes significant percolation losses. Compaction can be used to stop this. The adoption of light, frequent irrigation practises helps these soils absorb water and nutrients more effectively. By mulching the agricultural lands with available paddy straw, issues with high evaporative demands on crusting soils can be handled.

Soil Organic Carbon Losses:-Due to nutrient depletion brought on by pedogenic processes for soil growth, Alfisols, Ultisols, and Oxisols are vulnerable to chemical degradation. These soils' base saturation is significantly lower than that of Alfisols, especially in Ultisols and Oxisols. In India, the degradation of about 3.7 M hectares is caused by the loss of organic matter. These places are widely dispersed throughout the nation and range from subtropical belt farming to locations with revolving agricultural practises. The main causes of the depletion of soil organic carbon include intense farming, removal or in-situ burning of crop leftovers, and minimal or no input of organic manures. To sequester organic carbon in soils, ideal choices include managing agricultural wastes, using inorganic and organic materials in a balanced and integrated manner, etc.

Nutrient Imbalance:- High agricultural yields require a balanced nutrient supply, yet too much or too little of a given nutrient can have negative effects on ecosystems, human health, and the environment. There are several different ways that nutrients can be lost, including through runoff, leaching, erosion, and emissions of NH3, N2O, NO, and N2 into the air and discharges into water. Between Indian states and regions, nutrient inputs differ significantly. The economic development is tied to the nutritional balances, which vary amongst states. In agriculturally developed areas like Punjab, Haryana, and Orissa after the 1980s, fertiliser was more commonly used than manure. The extensive use of fertiliser and the rapidly expanding animal industry have both contributed to significant N losses to the environment. Both the N inputs and outputs demonstrated. Large differences amongst crops were also seen in the N inputs and outputs. It has been noted that the development of cash crops demands larger nutrient inputs and accumulation. The issue of nutrient loss and/or organic matter depletion will get worse in the future due to rising food demands to support a growing population. This issue of soil health exhaustion has already been noted in a number of case studies, particularly in highly intensively farmed areas of the rice-wheat cropping system in the Indo-Gangetic Plains.

Socio-Economic Impacts and Future Challenges:-

The effects of soil deterioration on society and the environment are extensive. With over three-quarters of the poor and food insecure living in rural areas and depending on the natural resources for employment and income, it is now widely acknowledged that poverty in South Asia has historically been primarily a rural phenomenon. About 520 million people (40 percent of the world's poor) live in South Asia, which has a poverty incidence of 43 percent. Additionally, the majority of people who live on badly degraded soils are marginal farmers and tribal groups, who are underprivileged and illiterate. In contrast to farmers who cultivate superior fields, these folks lack infrastructure and services related to the land. Due to nutrient depletion caused by soil erosion and other processes of soil degradation, the quality of the soil has decreased. People are forced to look for more land to farm because of poverty and the destruction of the environment. As a result, people are compelled to farm in woods, cultivate steep slopes, and further deteriorate marginal lands. Therefore, preserving natural resources and revitalising wastelands and degraded areas present significant opportunities for reducing poverty and providing sustainable means of subsistence.

For soil scientists and environmentalists, determining the exact extent of soil deterioration and how it affects the environment presents significant hurdles. Managing soil resources even degraded ones, to supply food, fibre, and fuel for basic human requirements is still a big problem. Further improvements should be achievable in the cutting-edge database analytical systems as we embrace new high-tech research methods and as fresh data from remote sensing satellites that are pertinent to natural resources become accessible. It is impossible to produce more food to fulfil the duties to leave a better legacy for future generations unless urgent efforts are done to stop the degradation process and to restore productivity of damaged soils. Characterization of fundamental resources including soil, water, climate, and biodiversity is necessary to provide livelihood

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and environmental security to the nation's growing population. This necessitates a thorough understanding of soils, including their size, distribution, types, issues, and possibilities for improving land use. To accomplish this, innovations in science and farming methods are urgently required, and both the public and policymakers must make an effort.

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