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A Review on Soil Conservation Issues in India

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ABSTRACT: Soil erosion is still a serious environmental issue in India and other parts of the globe, despite years of research and significant expenditure in repair and prevention. Furthermore, the issue is being exacerbated by changing climate and/or weather patterns. Our goal was to look at historical and present soil conservation programs in India to see how production, environmental, social, economic, and regulatory concerns have influenced soil and water conservation, as well as the incentives required to solve the most pressing issues. Institutions and operations must be coordinated using a comprehensive approach to ensure success in soil and water conservation programs, we discovered. Watershed programs have been shown to be one of the most successful methods for bringing socioeconomic development to India's various regions. Watershed management has quietly transformed agriculture in both dryland and rain fed regions by harmonizing different sectors via technical soil and water conservation interventions and land-use diversification. Significant outcomes from various watershed-scale soil and water conservation programs and interventions that were successful in decreasing land degradation and increasing productivity in various areas of the nation are highlighted.

KEYWORDS: Agriculture; Climates; Cropping; Soil Erosion; Water.

1. INTRODUCTION

For agroecosystems to be sustainable, soil and water are essential natural resources that must be managed in accordance with the environment. Wind and water erosion have created some of the world's most productive soils (e.g., the Indo-Gangetic Plains, Nile Delta, and Loess Plateau in China), but accelerated erosion caused by anthropogenic perturbations has had drastic effects on ecosystem services and resulted in significant landscape dissection and transformation. This study looks at catchment-scale integrated soil and water conservation practices for balancing plant nutrition and increasing production while preserving soil health and surface- and ground-water quality.

In India, soil deterioration is a widespread issue. According to the government's harmonized database, 120.7 million hectares of land have been degraded, with water erosion accounting for 70% of the total. Depending on the techniques employed, other estimates of land degradation in India vary from 53.28 Mha to 187.80 Mha. A database on acceptable erosion limits for 29 Indian states was established, and soil erosion risk was documented by overlaying geographical soil erosion rates and soil loss tolerances for various states [1], [2].

1.1. Soil Degradation in India's Himalayan Mountains:

The Northwestern Himalayan (NWHR) region, which spans 33.13 million hectares and includes the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, accounts for 10.1 percent of the country's land area and supports 2.4 percent and 4% of the country's human and cattle populations, respectively. Climates, terrain, vegetation, ecology, and land use patterns are all varied. The amount of soil erosion caused by water varies throughout the nation, ranging from 80 t ha^{-1} year^{-1} in the Shiwalik Region to 0 t ha1 year1 in the rest of the country. According to recent estimations, approximately 39% of the Indian Himalayan region has potential erosion rates of >40 t ha^{-1} year^{-1}, which is dangerously high.

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Stakeholders' and others' growing worries about the environment are connected to critical cause-and-effect debates about deforestation, landslides, large-scale downstream floods, rising poverty, and hunger. Since Independence, India has developed numerous soil conservation methods and implemented watershed development programs targeted at increasing agricultural output, particularly via soil and water conservation measures (i.e. production through soil protection). The Uttarakhand flood and landslide catastrophe in June 2013 is an extreme occurrence that is most likely linked to climate change. Under predicted climate change scenarios, existing soil conservation and watershed management systems do not have sufficient provisions to handle such severe erosion issues. As a result, attempts are being made to include these situations into watershed development plans [3], [4].

Soil acidity causes greater land degradation in India's mountainous areas (14% of TGA) than in the rest of the nation (3.7 percent of TGA). The amount of acid-affected soils in NEH (29 percent of TGA) is considerably greater than in NWH (0.8 percent of TGA). Chemical soil deterioration occurs in the Indian Himalayas, in addition to water erosion:

(i) Lower levels of soil organic matter (SOM) and biological activity in the soil;
(ii) Deterioration of soil physical characteristics as a result of lower SOM levels; and
(iii) A reduction in the availability of plant nutrients

1.2. The Indo-Gangetic Soil Degradation:

Plains Punjab, Haryana, Delhi, Union Territory Chandigarh, Uttar Pradesh, Bihar, and portions of West Bengal make up India's Indo-Gangetic plains (IGP). Water erosion is the primary source of land deterioration in this area.

1.2.1. Exploitation of groundwater and Falling Water Tables:

Flooded rice requires a large amount of water to grow. During the growing season, traditional rice farming needs around 1500 mm of water. In addition, seedlings need around 50 mm of water to reach the transplanting stage. Farmers, on the other hand, use much more water than is required, particularly when rice is cultivated on light-textured soils in the IGP. Groundwater provides 60 percent to 65 percent of overall irrigation requirements, with canals providing the remaining 35 percent to 40 percent. Over-exploitation of groundwater is being used to meet the increased demand for water, resulting in decreasing water tables. As a result of five decades of rice-wheat cultivation, the region's water resources have been severely depleted. There is a 1.2 Mha meter water deficit in Punjab alone per year. In Haryana, around 95 percent to 98 percent of the rice-wheat land is irrigated. Because of the fast development of the tube-well network in the upper IGP, low-quality ground-water aquifers have been exploited for agricultural irrigation. The issue is particularly concerning in Punjab's central regions, where almost two-thirds of the state's total number of tube wells (1.28) are located. During the years 1993–2003, the groundwater table in this area dropped 0.55 m per year1. The water table is currently dropping at almost 1 m per year in certain parts of the upper IGP1. The percentage of places with a water table deeper than 9 meters rose from 3% in 1973 to 90% in 2004 and almost 100% in 2010. The water table has already dropped to 21 meters in over 70% of the region. Because centrifuge pumps are no longer efficient in pumping water, this is the consequence of a growing number of submersibles. The cost of constructing tube wells has risen by a factor of ten, as has the amount of energy used to pump water. Pumping water for irrigation consumes around 30% of the total energy used in the state. According to a recent NASA research (National

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Aeronautics and Space Administration, Washington, DC, USA), 13–17 km3 of groundwater is permanently lost each year from aquifers in the Punjab, Haryana, and western Uttar Pradesh.

1.2.2. Soil Health Is Getting Worse

The rice-wheat system has resulted in the extraction of key nutrients from the soil (nitrogen (N), phosphorus (P), potassium (K), and sulphur (S), resulting in nutrient imbalances and soil degradation. One gram of wheat eliminates 24.5, 3.8, and 27.3 kg of nitrogen, phosphorus, and potassium, respectively. In the IGP, SOM levels are continuously reduced. In places where water erosion is increased, the issue of soil organic carbon (SOC) loss is worsened.

1.2.3. Burning of Crop Residues:

The rice-wheat system accounts for around a quarter of India's total crop leftovers. Rice and wheat straw (other than that used as dry fodder) and leftovers from other crops have traditionally been utilized as animal bedding, thatching material for housing, and fuel, although these materials make only a tiny percentage of the overall amount of agricultural residues generated by the system. After crop harvest, the leftover rice and wheat stubble is mostly burnt or seldom integrated.

The use of combines to harvest rice and wheat is becoming more common, resulting in massive amounts of crop waste. The residues from rice-wheat cultivation are 7–10 Mg ha 1 year 1. According to a study, combine harvester's harvest 91 percent of rice fields and 82 percent of wheat fields in the Punjab, generating 37 million Mg of crop leftovers yearly. This practice is becoming more common in other parts of India where rice-wheat crops are grown. With the rise of combine harvesting, crop waste disposal (particularly rice residues) has become a significant issue. Composting of these agricultural wastes is not practical owing to a number of reasons, including transportation costs, composting time, and the absence of a viable method for fast in situ composting.

1.3. Degradation of Soils in Dry and Arid Environments

Wind erosion affects 41% of the world's land surface, including 13.5 percent in India. Wind erosion is a major concern in the Indian Thar Desert, posing a variety of issues. Wind erosion causes nutrient-rich particles to be lost from agricultural fields, fine particles to be suspended in the air, and eroded soil particles to be deposited on railway tracks, roads, residential and commercial establishments (e.g., thermal power plants, gas and oil fields, water bodies, and irrigation canals). During extreme dust storms, suspended particles may travel hundreds of kilometers and create a dust haze blanket over the IGP and surrounding region. The Desert's current weather and topography characteristics are also highly favorable to wind erosion. Wind speed is one of the most important climatic variables, and when it surpasses the 5 m s1 threshold at 0.3 m above the ground surface, wind erosion occurs. Wind erosion is influenced by topography characteristics such as soil aggregate distribution, surface roughness, soil wetness, and plant cover. In the area, indiscriminate grazing kills more vegetation and exposes the ground surface, leaving it more susceptible to wind erosion. Wind-blown soil particles are a significant source of particle air pollution, posing severe health risks to people and animals not just in these regions, but also far beyond. In order to combat wind erosion in the wide desert, areas must be prioritized based on the severity of the issue. The purpose of this paper is to offer information on several types of wind erosion management methods based on the severity of the issues [5]–[7].

2. DISCUSSION

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Landslides/slips, mining spoil failures, and torrents are the main causes of mass erosion in the Himalayan area. On steep roads, 10–20 landslides/slips have been recorded each year on average. Landslides plague over 44,000 kilometers of India's mountainous roadways. Major landslides on steep roads cost around 50,000 man-hours and 5000 vehicle hours per kilometer per year. Mining in the Himalayan states spans more than 25,000 hectares (mainly limestone mining), resulting in significant erosion and silt discharge. River bank erosion affects 2.7 million hectares in India. Across the hill states of northern India and the Shiwaliks Hills of Uttar Pradesh, Haryana, and Punjab, 1517 km2 of land is directly beneath the path of torrents (hilly rivers with flash floods), impacting 7500 km2 of adjacent land owing to flash floods and sedimentation.

River floodplains are usually thought to be linked with flood damage. At the ICAR-IISWC in Dehradun, bioengineering technology is being developed for the management of torrents in the Shiwaliks, where mechanical methods have been employed with appropriate vegetable species for bank protection and structural vegetative reinforcement. Arundo donax (Narkul or Nada), Vitex negundo (Shimalu), Ipomoea (Besharam), Bamboo, Napier (Hathi Ghas), and Saccharum munja are all suitable plants (Munj ghas). The cost-benefit ratio of river training projects is more than 1:2.65.

Extreme rains caused a catastrophe in Uttarakhand from the 14th to the 17th of June 2013, resulting in massive loss of life and property. A survey was undertaken to examine the damage to natural resources under a collaborative effort of the National Agricultural Research System and the Uttarakhand State Government, which comprised the following:

- Agricultural fields/habitations inside high flood levels of rivers/streams were swept away, and damage to nearby flooded areas was seen.
- Damage was more severe in untreated watersheds than in treated watersheds.
- Landslides/slips were the most common cause of mass erosion, particularly near highways. Landslides/slips were more common in areas where there were no retaining walls or toe drains, and slopes were unvegetated.
- Even after 20–30 years, drainage lines (Nalas/gullies) maintained with appropriate bioengineering techniques (gabion check dams) had minimal effect.
- Some farmers built diversion drains for safe runoff water disposal on their own initiative, saving precious agricultural land and crops.
- Degraded hillslopes and landslides/slips treated with geo-jute technology 12 years ago were stable and covered with lush green flora.
- In places where excellent agroforestry practices were used, erosion was limited.

2.1. Watershed Development Programs' Effects:

The Government of India sponsors and implements watershed development initiatives in India. These programs are supported by a number of state agencies, non-governmental organizations (NGOs), and self-help groups (SHGs). Some of the important development programs include the "Drought-Prone Area Programme" (DPAP), "Desert Development Programme" (DDP), "National Watershed Development Project for Rainfed Areas" (NWDPRA), "Watershed Development in Shifting Cultivation Areas" (WDSCA), and the "Integrated Watershed Development Project" (IWDP). Soil conservation was the goal of the first generation of watershed initiatives. The second generation, on the other hand, was focused on preserving damaged land regions. The third-generation watershed initiatives, which stress participatory methods, were introduced. The new strategy focuses on increasing agricultural production while also enhancing livelihoods [8], [9].

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2.2. Watershed Management's Effects

Rain-fed agriculture accounts for 60% of India's agriculture, thus development of rain-fed regions is a major issue. Watershed development programs are often used to solve the issues of rain-fed regions. Meta-analysis was used to assess the macro-level of 636 micro-watersheds (100 to 1000 ha). Higher income, rural job creation (151 person days ha1), increased crop yields and cropping intensity (36 percent), reduced runoff (45 percent) and soil loss (1.1 t ha1 year1), supplemented groundwater, and decreased poverty) are all advantages of watershed programs [41]. Watershed development programs had a cost-benefit ratio (C: B) of 1:2 on average, while 0.6 percent of watersheds failed to produce returns on investment (C: B ratio 1). A mean cost-benefit ratio of >1:2 was found in 32% of watersheds, and an internal rate of return (IRR) of >30% was found in 27% of watersheds. In drylands, community watersheds should be implemented using comprehensive, participative, and business-oriented methods. In the 700–1100 mm rainfall agro-ecoregions, newer technologies and interventions had better effects in terms of C: B ratios and IRR, but not in the 1100 mm rainfall zones. As a result, specialized watershed development methods for 1100 mm rainfall zones must be found and implemented [10].

2.3. Sand Dune Stabilization:

Wind erosion management has received a lot of scientific attention in India's Thar Desert. The checkerboard technique of sand-dune stabilization by plant cover was reported in the majority of these studies, and it became a prominent wind erosion control technology in the area. Planting appropriate vegetation on denuded dune surfaces reduces surface wind speeds, avoids scouring, and improves soil conditions, all of which help to enhance microclimatic conditions. Because dry areas have little water, high percolation rates, high ambient temperatures, and high potential evapo-transpiration rates, it's critical to choose plants that can thrive in such harsh conditions. The ones that need the greatest care in sand-dune stabilization are those that must be able to live in:

- weather conditions that are very hot or cold;
- a wide range of salinity levels;
- wind with varying speed and direction;
- sandstorms with high winds;
- very low soil moisture (i.e. xerophytes); and
- biotic stress situations

3. CONCLUSION

In India, soil erosion is the most common kind of land degradation. Due to the forecasting of high-intensity storms and the denudation of forest cover, such issues (wind and water erosion) are anticipated to worsen in a changing climate scenario. As a result, remediation of such problem regions must be included into watershed programs. Various management methods have been developed in response to the causative causes of soil erosion, with the primary goal of reducing the erosive energy of wind and water or decreasing soil erodibility by changing surface soil properties, surface cover, or roughness. Watershed development, which may be accomplished by maintaining permanent grass cover on rangelands, is the most appropriate holistic approach for controlling soil erosion among the many methods. Increased earnings are a result of watershed programs (more so in the poor income regions compared with higher income regions). Benefits from existing technology were greater in areas with annual rainfall of 700–1000 mm. With public involvement, the advantages of watershed improvements grew.

Watershed programs would be unsustainable without user participation. So far, the emphasis of watershed programs has been on resource conservation and agricultural production improvement. More emphasis is needed on elected institutions' involvement, good local leadership, and the community's readiness for collective action, as well as the establishment of effective linkages between watershed institutions and other institutions such as input delivery systems, credit sectors, and technology transfer systems.

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