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WATERLOGGING AND SALINITY: BARRIERS AND DIFFICULTIES IN THE REHABILITATION OF LAND RESOURCES

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Abstract - One-third of agricultural land is currently grappling with issues of salinity and waterlogging. In various regions of Haryana, including Hisar, Sirsa, Rohtak, Jhajjar, and certain villages in the Charkhi Dadri district, the water table has risen to varying depths. This phenomenon has rendered a significant portion of the land unsuitable for agricultural use.

Agricultural ecosystems are managed environments designed for the cultivation of crops and fodder for livestock. In some villages within the study area, the primary crops include mustard, bajra, rice, and wheat. However, in recent years, there has been a substantial increase in rice cultivation. This shift can be attributed to enhanced canal-based irrigation and the seepage of water from earthen canals, which have elevated water levels. Consequently, the growth of traditional crops has been hindered, while the cultivation of wheat, rice, and other water-loving weeds has been promoted. Additionally, due to the potential for greater economic returns, farmers have chosen to grow wheat and rice out of preference rather than necessity. These crops require significant irrigation, leading to severe waterlogging issues in some low-lying areas. The extensive irrigation practices in these villages have contributed to both waterlogging and soil salinity.

The survey revealed that the soil's underlying strata, beneath the A-horizon, contains a clay layer that obstructs the natural drainage of surface water. Moreover, there is adequate recharge of groundwater from canals and monsoon rains. This paper aims to explore various strategies for managing water salinity and reclaiming waterlogged lands, as well as to propose an effective model for water drainage. Agroforestry regions appear to be less impacted by waterlogging and salinity, suggesting that such practices could be beneficial in addressing these challenges.

Keywords: bio-drainage, water logging, salinity, evapotranspiration, seepage.

1 INTRODUCTION

Water logging occurs when the upper layers of soil become completely saturated with water, leading to a lack of oxygen for plant roots. This phenomenon is not solely caused by a rising water table; it can also result from inadequate drainage in the soil's root zone. Effective soil and water management are essential for maintaining a sustainable agricultural ecosystem. Various strategies exist to address water logging, with agroforestry being a particularly cost-effective solution that addresses both water management and soil health.

Agroforestry involves cultivating trees alongside crops, either through bunding or intercropping methods. This approach serves multiple purposes: it aims to achieve short-term crop yields while also providing long-term forest products. In addition to its economic advantages, agroforestry offers numerous ecological benefits.

The relationship between crops and trees is mutually beneficial, fostering an environment conducive to the growth of soil microorganisms and helping to mitigate the greenhouse effect. It enhances the physical, chemical, and biological characteristics of the soil. A critical issue to consider is the cooperative survival of forests and crops concerning their shared use of water and soil nutrients. Agroforestry can enhance soil quality by replenishing nutrients and reducing nutrient leaching into the underlying water table.

Another significant concern is the issue of water logging. In Haryana, the rural economy and agricultural sector face challenges due to the mismanagement of water and land resources. Over-irrigation and inappropriate cropping practices have rendered substantial areas of land barren and unsuitable for agricultural use. Consequently, low-lying regions are

increasingly experiencing water logging due to excessive irrigation and inadequate natural drainage.

The rice-wheat cultivation system has led to excessive water usage, resulting in significant issues such as soil salinity and waterlogging. According to the Haryana Kissan Ayog's working group report on Natural Resource Management (2013), out of a total area of 44,021 lakh hectares in Haryana, over 50,000 hectares have a water table that is less than 1.5 meters deep. In waterlogged regions, salinity levels reach 35-40 Deci Siemens per meter (ds/m), compared to a normal level of 2 ds/m. Despite notable advancements in agriculture, the area under cultivation is declining, soil salinity is on the rise, and the water table is either decreasing or fluctuating across different locations. In Haryana, nearly 50% of the land is experiencing issues with a rising groundwater table and salinity, with approximately 10% of the area (0.44 million hectares) already classified as waterlogged (Expert Committee 1998). Consequently, the total cultivated area is diminishing while the demand for crop products continues to grow. This situation is particularly critical in arid and semi-arid regions, such as the southern parts of Haryana, where groundwater quality is already poor. There is immense pressure on canal systems to meet the agricultural, livestock, and domestic water needs, including drinking water. The study area lacks natural freshwater lakes, and the village ponds are primarily replenished with water from these canals.

The Working Group of the Ministry of Water Resources on "Waterlogging, Soil Salinity, and Alkalinity (1991)" established criteria for identifying waterlogged, saline, and alkaline regions. According to these criteria, an area is classified as waterlogged if the water table is within 2 meters of the land surface. An area is considered potentially waterlogged if the water table is between 2 and 3 meters from the surface, while an area is deemed safe if the water table is below 3 meters. Waterlogging has several detrimental effects, some of which are outlined below.

1. Water logging provide suitable place for growth of methanogens that produce methane and add to greenhouse effect.
2. Consistent low soil temperature
3. Crop yield is measurably lowered
4. Water logging create anaerobic conditions which may kill the beneficial aerobic bacteria of the soil.
5. High salt conc. and less aerated soil Inhibit seed germination and growth of plants.
6. Promote growth of water loving weeds which compete with the crops for nutrients.
7. A large part of Agriculture land is transformed into marshes

Thus, there is an urgent need to deal with increasing water logging and salinity conditions in Haryana. Conventional methods of water drainage are not only costly but also cause eco- degradation and leaching of nutrients. Various methods of minimising water logging and salinity are

1. Bio-drainage method
2. Proper surface and subsurface drainage system
3. Crop Rotation

Biodrainage refers to the cultivation of trees in areas prone to waterlogging. These trees typically possess larger leaves, deeper root systems, and rapid growth rates. They coexist well with other crops, as they do not release allelopathic substances that could hinder crop development. A prime example of such a tree is Eucalyptus, which has an impressive transpiration rate of approximately 1250 liters per day. Other notable species include Populus and Casuarina. The biodrainage process encompasses the absorption of water, its upward movement through the xylem, and the subsequent transpiration of the absorbed water. Approximately 98% of the water taken up is transpired, while only 2% is retained by the plant to maintain turgidity. The biodrainage model can serve as a control strategy in waterlogged areas with water levels reaching up to 3 meters and can also act as a preventive measure in regions where the water table is between 3 to 9 meters deep, thereby mitigating the risk of waterlogging.

Advantages of Bio-drainage

a) It is a cost effective model
b) Trees absorb excess of Co2 from air thus nullifying the excess greenhouse effect.

c) Improve the soil fertility by improving the soil texture, micro flora and fauna.
d) The fallen leaves and twigs from trees undergo decomposition and thus enrich the soil with mineral nutrients and humus.
e) Prevent water lodging of crops due to heavy winds.
f) Provide suitable home for birds and insects many of which are friendly and help in pollination and dispersal of seeds/fruits.

Surface and subsurface drainage represent traditional techniques for managing water drainage. Surface drainage entails the removal of excess water from the surface, directing it into lower-lying furrows via slopes. Open channels are constructed to gather surface water, which is then directed into canals or ponds. In contrast, subsurface drainage systems utilize a network of tiles or buried pipes. However, these methods can be expensive and demand a high degree of technical expertise.

Another strategy to alleviate waterlogging issues is crop rotation. By alternating the cultivation of crops that require less water with the continuous planting of water-intensive crops like wheat and rice, farmers can effectively manage water levels in the soil.

Aims of the study

Effective management of soil and water is essential for achieving sustainable agricultural practices. A significant portion of fertile land is deteriorating into unproductive areas as a result of waterlogging and salinity issues. The restoration of these lands can only be accomplished by understanding the underlying causes and subsequently creating appropriate, practical, and economical solutions. The primary objectives of this paper are

a) To find out the reasons for water logging and salinity.
b) To know the impact of agroforestry on the water table.
c) To understand the water management practices adopted at regional level to reclaim the water logged and saline lands.
d) To suggest the possible best model for reclamation of salinity.

2 METHODOLOGY

This research paper presents findings from a survey conducted in the agricultural fields of villages within the Charkhi Dadri district. A comprehensive survey was carried out in the villages of the study area, which are significantly impacted by waterlogging and salinity issues. During the field survey, farmers were interviewed to gather information on how waterlogging affects crop productivity, the role of tree planting in mitigating waterlogging, and the management of water resources. Additionally, questions were posed to assess the socio-economic impacts of waterlogging on farmers over the past two to three decades. Elderly farmers were chosen as participants to determine whether changes in crop patterns are a consequence of or a response to waterlogging. Soil samples were collected and analyzed, comparing their texture to that of typical unlogged soils.

Importance of study

The agricultural sector serves as the foundation for both farmers and the national economy. Effective management of water and soil resources is essential for sustainable agriculture. In recent years, there has been a shift from traditional cropping methods to a focus on wheat and rice cultivation. This change, along with other contributing factors, has led to issues such as waterlogging and soil salinity. Consequently, these problems have negatively impacted crop yields and have also resulted in various socioeconomic challenges. This study aims to identify the causes, effects, and potential solutions to these significant issues. The results of this research will provide farmers with a practical, cost-effective, and scientifically sound approach to mitigate the detrimental effects of waterlogging and salinity on their vital water and soil resources.

Study area

Charkhi Dadri is situated in southern Haryana at a latitude of 28.600 and a longitude of 76.267. It has been designated as the 22nd district of Haryana and is approximately 110 kilometers from the national capital, New Delhi. According to the 2001 census, the population of Charkhi Dadri was recorded

at 44,892. This study focuses on specific waterlogged areas within the Charkhi Dadri district, particularly the agricultural lands of the villages of Jaishree, Misri, and Kamod, which are located to the north of the city. In these villages, the water table typically ranges from 10 to 20 feet but rises to just 2 to 3 feet during the rainy season, leading to waterlogging conditions.

The study area also includes small patches of forest known as "Bani," which are managed on social forestry lands overseen by local gram panchayats. Among all natural resources, water is vital for humanity, as well as for plant and animal life. It serves not only as a direct resource for human use but also as a catalyst for significant economic development. Additionally, water plays a crucial role in enhancing human aesthetic experiences and is a key factor shaping the physical and biological environment that supports various activities. The primary sources of water supply in the Charkhi Dadri district include canals, ponds, and tube wells; however, the district lacks a river system.

It is estimated that approximately 50 percent of the villages in the district are located near ponds. These ponds collect water during the rainy season, which is then used for secondary domestic purposes and as drinking water for livestock. However, most ponds tend to dry up during the summer months. The surface water from these ponds is utilized for irrigation in the district via canals. Water is a crucial component of agriculture; without it, seeds, soil, and fertilizers are ineffective. Sufficient water availability enables the cultivation of double or multiple crops, thus increasing the total area under cultivation. In the study area, the soil lacks fertility, particularly in the sandy regions of the state, including Charkhi Dadri District, which is characterized by light grey sandy soils. This soil is influenced by the high-speed warm winds from Rajasthan and is not conducive to fertility. The sandy and domut soil found in Charkhi Dadri and Bhiwani Tehsil is particularly poor in nutrients. Over the past two decades, excessive irrigation has led to land degradation, resulting in a logging problem. The underlying clay strata in these villages hinder proper percolation, while high evaporation rates during the summer lead to the accumulation of salts on the surface. Consequently, the saline and waterlogged soils in many villages within the study area have transformed once-fertile lands into barren landscapes.

3 RESULTS AND DISCUSSIONS

The current survey indicates that waterlogging poses a significant challenge in the study area. Continuous cultivation of rice and wheat has led to an increase in water percolation through soil capillaries. The findings show that over the past decade, the number of tube wells has remained unchanged, while the installation costs have significantly decreased, primarily due to the rising water table. The volume of water recharged through rice-wheat cultivation surpasses the amount extracted by tube wells. This surplus water is made accessible to the soil via canals, resulting in a consistent accumulation of groundwater year after year.

The bio-drainage model presents an economically viable solution, requiring only an initial investment in afforestation. Once established, it can yield economic benefits through the provision of fodder, fuelwood, and timber. Eucalyptus has demonstrated effective results in reclaiming waterlogged soils through bio-drainage, producing biomass at no additional cost and contributing positively to farmers' economies.

In India, bio-drainage remains in the experimental phase, with no established guidelines or suitable models available. Further research is needed to assess the bio-drainage potential of various plant species across different agro-climatic conditions, as well as to explore effective plantation geometries, appropriate spacing, and the botanical interactions between crops and trees.

Some farmers have noted the negative impacts of certain trees, particularly Acacia nilotica, which hinder the germination of seeds for traditional crops. In contrast, Eucalyptus does not exhibit this effect. Various factors contribute to waterlogging, including seepage from unlined earthen canal systems, insufficient surface water drainage, ineffective water management practices, and the use of low-quality groundwater, which is often highly saline

in the studied region, for irrigation. While water availability is crucial for enhancing productivity, excessive water in agricultural fields poses a significant challenge to agricultural output. It also leads to adverse ecological consequences, such as the emission of greenhouse gases, specifically methane, from waterlogged areas and marshy rice fields.

4 CONCLUSION AND SUGGESTIONS

The water table can be significantly reduced by limiting the area dedicated to rice cultivation and promoting the growth of low-water-demand crops such as guar, brassica, and pulses. Additionally, adopting an agroforestry approach, specifically biodrainage, can alleviate waterlogging issues. This method is cost-effective and encourages community involvement at the individual farmer level. It is essential to implement irrigation techniques that minimize surface flooding. Proper leveling of the land can also prevent water accumulation in certain areas. Enhancing soil texture can be achieved by incorporating manures and gypsum. Waterlogging is closely linked to salinity, as summer evaporation can lead to salt buildup in the surface and root zones. Therefore, a multifaceted strategy is necessary to address this challenge.

Furthermore, more stringent measures may be required at the governmental level, such as subsidizing low-water-demand crops and establishing accessible marketplaces for their products.

The management of underground water resources from the basin must be conducted carefully, taking into account regional variations and changing conditions over time. There is a need to develop improved tree varieties, such as Eucalyptus and Casuarina, that possess higher evapotranspiration potential and are compatible with economic crops and local climate conditions. However, the area designated for agroforestry will differ from one region to another, depending on factors such as rainfall, soil types, and salinity levels of underground water.

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