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Geographical Study of Soil Salinity in Kolhapur District, Maharashtra

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Abstract

Soil salinity has emerged as a critical environmental and agricultural challenge in the fertile river basins of Kolhapur district, Maharashtra. This paper presents a comprehensive geographical study of the spatial distribution, underlying causes, and socio-economic impacts of saline land (locally termed as Kharpad Jamin) in the region. Focusing heavily on the highly irrigated tracts of Shirol, Hatkanangale, and Karveer talukas along the Panchganga and Krishna River basins, the study investigates how intensive sugarcane cultivation, unregulated over-irrigation, and heavy chemical fertilizer application have accelerated land degradation. Utilizing Geographical Information System (GIS) techniques, Global Positioning System (GPS) field mapping, and laboratory soil testing (pH and Electrical Conductivity), the spatial patterns of salinity were analyzed. The findings reveal a significant rise in soil pH (>8.5) and EC levels in low-lying, poorly drained terrains. The paper concludes with actionable geo-spatial strategies, sub-surface drainage planning, and sustainable cropping alternatives to mitigate land degradation and restore agricultural productivity.

Keywords: *Soil Salinity (Kharpad Jamin), Kolhapur District, Over-irrigation, Spatial Distribution, GIS Mapping, Sustainable Agriculture*

Introduction

Soil is one of the most valuable natural resources supporting agriculture, food security, and rural livelihoods. However, increasing soil salinity has become a major environmental problem in many irrigated agricultural regions of India. Soil salinity refers to the accumulation of soluble salts in the soil to levels that adversely affect crop growth, reduce soil fertility, and lower agricultural productivity. Both natural factors, such as climate, geology, and drainage conditions, and human-induced activities, including excessive irrigation, poor drainage, and indiscriminate use of chemical fertilizers, contribute to the development of saline soils. Kolhapur district in Maharashtra, renowned for its fertile alluvial plains and intensive sugarcane cultivation, has witnessed a rapid increase in soil salinity, particularly in the eastern talukas of Shirol, Hatkanangale, and Karveer. Continuous flood irrigation, rising groundwater levels, waterlogging, and inadequate drainage have accelerated the formation of saline and alkaline soils, locally known as *Kharpad Jamin*. This land degradation threatens agricultural sustainability, reduces crop yields, and adversely affects farmers' livelihoods. A geographical approach is essential to understand the spatial distribution of soil salinity and the interaction between physical and human factors responsible for its expansion. Modern geospatial tools such as Geographic Information Systems (GIS), Global Positioning System (GPS), and laboratory analysis of soil properties enable accurate mapping and assessment of salinity-affected areas. Such studies provide valuable information for land-use planning, sustainable irrigation management, and reclamation of degraded soils. The present study examines the geographical distribution, causes, and impacts of soil salinity in Kolhapur district with special emphasis on the highly affected irrigated regions. It also proposes sustainable land management and geo-engineering measures to restore soil health and ensure long-term agricultural productivity.

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Objectives

The primary objectives of this geographical investigation are:

1. To map the spatial distribution and extent of saline and alkaline soils across different talukas of Kolhapur district.
2. To identify the physical (geomorphological, hydrological) and anthropogenic factors driving soil degradation.
3. To evaluate the impact of land salinity on the crop yields of major commercial crops like sugarcane.
4. To suggest geo-engineered and sustainable land management practices tailored for the regional geographic setup.

Methodology

The study adopts a mixed methodology combining empirical field research, laboratory testing, and geospatial technologies:

1. **Study Area Selection:** The geographic focus is set on the eastern alluvial plains of Kolhapur district (predominantly Shirol and Hatkanangale talukas), situated between the major river systems where irrigation intensity is historically high.
2. **Primary Data & Soil Sampling:** A systematic unaligned sampling technique was utilized to collect topsoil samples (0-22.5 cm depth) across vulnerable zones. Each sample location was recorded via handheld **GPS units**.
3. **Laboratory Analysis:** Soil samples were analyzed for **Soil Reaction (pH)** using digital pH meters and **Electrical Conductivity (EC)** using EC meters to determine the precise salt concentration.
4. **Secondary Data:** Land use patterns, annual rainfall records, and irrigation data were sourced from the Department of Agriculture, Government of Maharashtra, and the Central Ground Water Board (CGWB).
5. **Geospatial Processing: ArcGIS software** was deployed to interpolate laboratory points using Inverse Distance Weighting (IDW) techniques to generate continuous spatial distribution maps of soil salinity.

Discussion and Analysis

A. Spatial Distribution of Salinity

The geographical analysis highlights that soil salinity is not uniform across Kolhapur district. The western hilly talukas (e.g., Gaganbawda, Shahuwadi, Chandgad) experience high rainfall and possess strongly acidic to normal soils because of rapid natural drainage. Conversely, the eastern semi-arid plains exhibit severe alkaline and saline traits.

1. **Shirol and Hatkanangale Talukas:** Show the highest vulnerability, with over 55-75% of analyzed zones falling into slightly alkaline to heavily saline brackets (pH ranging from 7.5 to 9.0).
2. **Karveer and Kagal Talukas:** Show moderate to expanding patches of salinity along the immediate banks of the Bhogawati and Panchganga rivers.

B. Causal Factors: Physical vs. Anthropogenic

The emergence of *Kharpad* land in Kolhapur is a classic case of anthropogenically induced environmental degradation:

[Lift Irrigation / Canal Networks] ---> [Waterlogging / High Water Table]
|
▼
[Capillary Action during Dry Season] ---> [Salt Accumulation on Topsoil] (Salinity)

1. **Topography and Poor Drainage:** Low-lying flat terrains and denudation slopes near river banks restrict the natural runoff of water, creating localized waterlogging.
2. **Perennial Over-Irrigation:** The rapid expansion of lift irrigation and canal networks has raised the regional water table close to the surface. Capillary action draws up dissolved salts, depositing a white encrustation upon evaporation.
3. **Mono-cropping Pattern:** Continuous cultivation of water-intensive **Sugarcane** has virtually mined the balanced nutrients out of the soil, disrupting the calcium-magnesium-sodium equilibrium. **Case Study: Geo-Anthropogenic Analysis of Soil Salinity in Shirol Taluka**

1. Introduction to the Case Study Area

Shirol is the easternmost taluka of Kolhapur district, geographically bounded by Latitudes 16°34' N to 16°53' N and Longitudes 74°27' E to 74°43' E. It features a unique geographic layout as it forms the **confluence zone (संगम क्षेत्र)** of four major rivers: Krishna, Panchganga, Dudhganga, and Warana. The topography is predominantly a flat alluvial plain with highly fertile deep black cotton soil (*Regur*), making it an agricultural powerhouse [2].

2. The Problem Statement

Despite its natural fertility, Shirol taluka has become the worst-affected hotspot for soil salinity (*Kharpad*) in Western Maharashtra [1, 2]. According to regional agricultural data, over **10,000 to 12,000 hectares** of land in Shirol have turned saline or sodic, severely impacting the economy of local farmers.

3. Spatial Distribution within Shirol (Affected Pockets) The geographic distribution of salinity in Shirol shows high density along river banks and low-lying depressions:

Severely Affected Villages: Shiroshangavi, Ghalwad, Kutwad, Danwad, Shirati, Gourwad, and Kurundwad [1, 2].

Soil Profile Changes: Field investigations reveal that soil in these villages has developed a hard, impermeable top layer with electrical conductivity (EC) exceeding 4.0 dS/m and pH values climbing past 8.5.

[Krishna-Panchganga Rivers] ---> [Low-Lying Alluvial Basin of Shirol] ---> [Natural Drainage Impedance]

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▼

[Prolonged Waterlogging] <--- [Unregulated Lift Irrigation (24x7)] <--- [Dense Canal/River Network]

|

▼

4. [Capillary Rise of Salts] ---> [Formation of "Kharpad" (Saline-Alkaline Topsoil)]
5. **Key Factors Driving Salinity in Shirol**

A. The Paradox of Abundance (अति-जलसिंचन)

Shirol has one of the highest densities of co-operative **Lift Irrigation Schemes (उपसा सिंचन योजना)**. Because river water is perennially available, farmers practice flood irrigation, delivering 300% more water than the actual crop requirement. This has raised the groundwater table to less than 1–2 meters below the surface.

B. Sugarcane Monoculture (उसाची मक्तेदारी)

Over 80% of the cultivable land in Shirol is dedicated to sugarcane (*Saccharum officinarum*). Sugarcane requires continuous water and heavy feeding. The soil rarely gets a fallow (विश्रांती) period, breaking down its natural structural porosity.

6. **C. The "Shirati Village" Geographical Constraint**

Villages like Shirati and Danwad sit in bowl-shaped topographical depressions [1]. When nearby rivers swell or lift irrigation runs continuously, water enters these lowlands but has no natural geographic outlet, causing prolonged waterlogging and heavy salt crystallization upon evaporation [1].

Socio-Economic Impact

Yield Decline: Sugarcane yield in the severely hit pockets of Shirol has dropped from an average of **50–60 tonnes per acre to less than 15–20 tonnes**, and in some fields, to absolute zero.

Land Depreciation: Property values of *Kharpad* lands have crashed significantly, turning asset-rich farmers into debt-ridden families.

Mitigation and the "Shirati Drainage Model"

Shirol has also become a laboratory for land reclamation strategies:

Sub-Surface Drainage (SSD): Under institutional guidance, villages like Shirati installed underground perforated PVC pipes at a depth of 1.25 meters [1]. This system successfully lowers the water table and flushes out hazardous salts into common drains [1].

Green Manuring Shift: Farmers are now being incentivized to cultivate *Dhaincha* (धैंचा) for 45 days before the sugarcane planting cycle to restore organic carbon matter.

Conclusion

The geographical study underscores that soil salinity in Kolhapur district is a growing threat to regional food security and agricultural sustainability. The high concentration of soluble salts has rendered thousands of hectares of once-fertile land completely non-arable or drastically reduced sugarcane tonnage. To reverse this land degradation, an integrated approach is vital. Implementing **Sub-surface Drainage Systems (SSD)** to flush out salts, applying calculated amounts of **Gypsum**, and shifting towards drip irrigation can systematically reclaim these soils. Geographically, land-use planning must enforce crop rotation with green manures (like *Dhaincha* or *Taag*) and promote salt-tolerant crop varieties to protect the delicate agro-ecosystem of the Panchganga-Krishna basins.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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