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Assessing environmental issues in Ahmednagar district: Impacts of deforestation, water management, and agricultural practices on ecosystem sustainability

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Abstract

Ahmednagar district is situated in middle of western Maharashtra (India). Ahmednagar district northern side Nashik district, The East side Beed and Osmanabad district, Aurangabad in the North east, Pune in the west and Solapur in the southern side. Ahmednagar district is largest district in Maharashtra in terms of geographical area. The district lies between north latitudes 18°12′ and 19°54′ and east longitudes 73°54′ and 75°30′. The total area of the district is 17196 sq.km. The central and northern part of the district comes under Godavari basin and southern part under Bhima basin. The district headquarters is located at Ahmednagar town for administrative convenience, the district in Total 14 tahasils, Ahmednagar, Akole, Shrirampur, Nevasa, Shevgaon, Pathardi, Jamkhed, Karjat, Srigonda, Parner, Rahuri, Sangamner, Rahata and Kopargaon. In this district total villages 1602. This district total population of 4543159 (as per 2011 census). This District is confronting numerous environmental challenges stemming from deforestation, inadequate water management practices, and unsustainable agricultural methods. These issues significantly affect the sustainability of local ecosystems, with consequent effects on biodiversity, water resources, and soil health. This study examined the primary environmental challenges faced by Ahmednagar District, with a focus on the impact of deforestation, water mismanagement, and agricultural practices on the district's ecological equilibrium. Through field observations, secondary data analysis, and a comprehensive review of pertinent literature, this study provides a thorough understanding of the interplay among these factors in environmental degradation. Furthermore, this study proposes sustainable strategies for mitigating environmental damage and enhancing ecosystem resilience in the region. This study aims to inform policymakers, stakeholders, and local communities about effective solutions for promoting long-term environmental sustainability in Ahmednagar and comparable regions in India.

Key Words: Ahmednagar; deforestation; water management; agricultural practices; ecosystem sustainability; biodiversity; soil degradation; environmental policy.

Introduction

Ahmednagar District, situated in the rain-shadow region of Maharashtra, India, has experienced substantial environmental degradation over the past few decades. The rapid transformation of its landscape due to anthropogenic activities has resulted in the depletion of critical natural resources and the disruption of ecosystem functions. The principal environmental challenges confronting the district include deforestation, inadequate water management, and unsustainable agricultural practices, all of which contribute to declines in biodiversity, water scarcity, soil erosion, and overall ecosystem sustainability. This introduction delineates the key environmental issues in the Ahmednagar District, elucidates the consequences of these issues on the local ecosystem, and provides an overview of the factors contributing to their exacerbation.

i) Deforestation and Its Consequences

Deforestation constitutes one of the most critical environmental challenges in Ahmednagar District. The conversion of forested areas into agricultural land, in conjunction with illegal logging and urban expansion, has substantially reduced forest cover in the district. According to Saxena and Saxena (2011), forests play a vital role in maintaining ecological equilibrium by regulating climate, conserving soil, and supporting biodiversity.

However, in Ahmednagar, deforestation has resulted in habitat loss for numerous species and has contributed to increased soil erosion and decreased soil water retention. As forest cover diminishes, the capacity of the region to absorb and store water during monsoon seasons is severely compromised, leading to more frequent and intense floods and droughts.

ii) Water Management Challenges

Water scarcity is a critical issue in Ahmednagar, where agriculture depends heavily on groundwater resources. The district experiences irregular precipitation patterns, and the excessive extraction of groundwater for irrigation purposes has resulted in a significant decline in the water table levels. Research has demonstrated that groundwater depletion has reached alarming levels, with numerous wells becoming depleted, thereby affecting both agricultural productivity and potable water availability for rural communities (Shah et al., 2018). Furthermore, inefficient irrigation systems such as flood irrigation contribute to excessive water waste. A deficiency in proper water management strategies, including rainwater harvesting, watershed management, and efficient irrigation practices, exacerbates regional water crises. Inadequate management also leads to the contamination of water bodies, diminishing the quality of surface water, and negatively impacting aquatic ecosystems.

iii) Unsustainable Agricultural Practices

Agriculture is the primary economic foundation of Ahmednagar; however, conventional agricultural practices contribute to environmental degradation. The extensive use of chemical fertilizers and pesticides has resulted in soil nutrient depletion, chemical contamination of groundwater, and a decline in soil fertility (Sharma & Nair, 2014). Furthermore, monoculture farming, inadequate irrigation practices, and land overexploitation have increased soil erosion and desertification in certain areas of the district. According to Chandran et al. (2020), the absence of soil conservation measures coupled with unsustainable agricultural inputs has rendered the region vulnerable to climatic stresses such as heat waves and irregular rainfall. These agricultural practices pose a threat not only to the long-term productivity of the land but also to the biodiversity of the region, as they diminish the diversity of plant and animal species that depend on healthy soils and ecosystems.

Study Area:

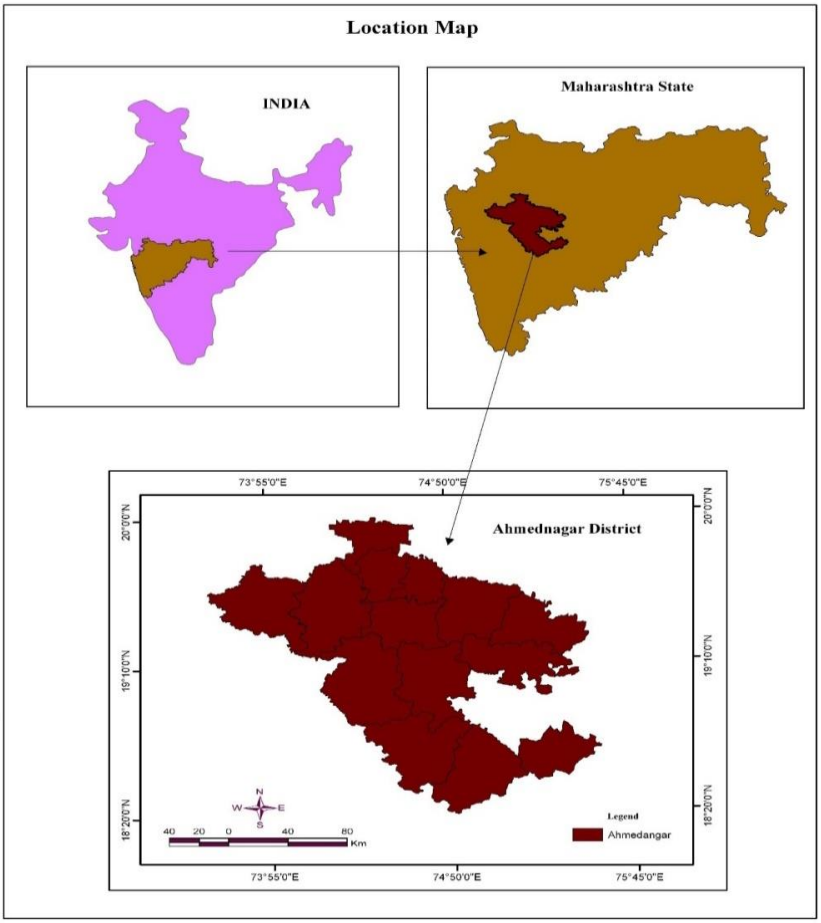
Ahmednagar District, situated in the central region of Maharashtra, India, is an agriculturally significant area characterized by diverse topography, encompassing dry semi-arid plains and hilly terrains. With an area of approximately 17,000 square kilometers, it constitutes one of the largest districts in the state in terms of geographical extent. The district has a population exceeding four million inhabitants, predominantly residing in rural areas, where agriculture serves as the primary economic activity. Despite its agricultural prominence, Ahmednagar faces numerous environmental challenges including deforestation, water scarcity, and unsustainable agricultural practices, all of which have implications for ecosystem sustainability.

i) Geographic and Climatic Features

Ahmednagar is situated in the rain-shadow region of the Western Ghats, which substantially influences its climate. The district experiences a semi-arid climate characterized by moderate to low annual precipitation, ranging between 500 mm and 800 mm annually (Rao et al., 2017). Precipitation is highly variable and results in frequent droughts, particularly in the eastern and southern regions of China. This uneven rainfall distribution, in conjunction with the region's dependence on monsoon precipitation, exacerbates the water scarcity. The topography of Ahmednagar is predominantly flat with some elevated regions in the west. The district is traversed by several rivers, including Godavari, which serve as a major water source for the region.

ii) Demographics and Socioeconomic Conditions

Agriculture constitutes the primary economic foundation of Ahmednagar, with crops such as sugarcane, groundnut, soybean, and cotton serving as principal agricultural products for local farmers (Jadhav et al., 2016). The district is characterized by irrigation-based farming systems, particularly in the regions adjacent to the Godavari River and its tributaries. However, agricultural productivity is significantly dependent on water resource availability and the absence of efficient water management systems has resulted in excessive groundwater extraction and diminished agricultural yields in certain areas of the district. Moreover, small-scale farmers and rural communities exhibit a high degree of dependence on the surrounding natural resources for their livelihoods, including forests and water bodies, rendering the region susceptible to environmental alterations.



Aim & Objective:

Aims:

The primary objective of this investigation was to evaluate the environmental challenges encountered in Ahmednagar District, with an emphasis on the effects of deforestation, water resource management, and agricultural practices on ecosystem sustainability. This research endeavoured to identify critical environmental issues, examine their underlying causes and ramifications, propose viable solutions to mitigate these impacts, and contribute to the long-term ecological integrity of the region.

Objectives:

i) To evaluate the extent of deforestation in Ahmednagar District:

This objective will entail identifying the historical and contemporary trends in deforestation within the region, examining the causative factors of forest degradation, and analyzing the consequent impact on biodiversity, soil quality, and local climate patterns.

ii) To assess the status of water resources and management practices in Ahmednagar district:

This objective addressed the availability, distribution, and management of water resources in the district, encompassing surface water bodies (rivers and lakes) and groundwater. This study analyzes water scarcity issues, over-extraction, and pollution, and examines existing water conservation practices.

iii) To examine the impact of agricultural practices on soil health, water quality, and local ecosystems.

This objective will involve analyzing the role of agricultural practices such as monoculture, excessive use of chemical fertilizers, and improper irrigation techniques in the degradation of soil and water resources and their impact on local ecosystems.

iv) To investigate the interlinkages among deforestation, water scarcity, and agricultural practices.

This objective was to explore how deforestation and water management issues intersect with agricultural practices, contributing to the overall degradation of the environment in Ahmednagar. It analyses the cumulative effects of these interconnected challenges on a district's ecosystem.

v) To propose sustainable solutions for environmental management and conservation in Ahmednagar

Based on these findings, this objective will focus on providing evidence-based recommendations for sustainable water management, forest conservation, and agricultural practices that could help improve the ecological health of Ahmednagar District and ensure its long-term sustainability.

Database and Methodology

Database

The study relied on primary and secondary data sources to assess the environmental issues in Ahmednagar District:

Primary Data Sources

1. **Field Surveys and Observations**:

- **Deforestation**: On-site visits to affected forest regions to document tree cover loss, species composition, and land-use changes.
- **Water Management**: Site inspections of water resources (rivers, lakes, reservoirs, and wells), irrigation practices, and impacts of drought.
- **Agricultural Practices**: Surveys were conducted among farmers to assess soil health, water usage, fertilizer/pesticide application, and crop rotation practices.

2. **Questionnaire Surveys**:

- Semi-structured interviews were conducted with stakeholders, such as local farmers, forest officials, water resource managers, and residents.
- Focus on awareness levels, sustainability practices, and perceptions of environmental degradation.

3. **Remote Sensing and GIS Data**

- Landsat and Sentinel satellite imagery from the US Geological Survey (USGS) and the European Space Agency (ESA) have been used to analyze land use/land cover (LULC) changes over the past two decades.
- Software tools such as ArcGIS and QGIS were employed for spatial analysis.

Secondary Data Sources

1. **Government Reports and Data**

- District-level environmental reports from the Ministry of Environment, Forest, and Climate Change (MoEFCC) and Maharashtra Forest Department.
- Agricultural and irrigation statistics from the Department of Agriculture, Maharashtra Government.
- Water management reports from the Central Water Commission (CWC) and regional water resource boards.

2. **Academic Studies and Journal**.

- Published research on Ahmednagar District's environmental challenges, water scarcity, and forest degradation (e.g., *Current Science, Journal of Environmental Management*).

3. **Census and Climate Data**

- Population and demographic trends in the Census of India (2011).
- Climate trends and rainfall patterns from the India Meteorological Department (IMD).

4. **Reports from Non-Governmental Organizations (NGOs)**

- Environmental conservation initiatives and case studies are documented by organizations such as WWF India, The Energy and Resources Institute (TERI), and local NGOs.

Methodology

The methodology involves a multidisciplinary approach to assess the impacts of deforestation, water management, and agricultural practices on ecosystem sustainability in Ahmednagar district.

1. Research Design

The research followed a **mixed-methods approach** that integrated qualitative and quantitative data collection.

- **Qualitative Methods**: Interviews, focus group discussions (FGDs), and case studies.
- **Quantitative Methods**: Data were collected using GIS tools, field measurements, and statistical analysis.

2. Study Area Selection

- Ahmednagar district, located in Maharashtra, was selected because of its susceptibility to deforestation, water scarcity, and heavy reliance on agriculture.
- Specific talukas (sub-districts) with significant environmental concerns, such as Akola, Sangamner, and Shrigonda, are analyzed.

3. Data Collection Methods

A. Land Use and Deforestation Analysis

- **Remote Sensing**:

- Satellite imagery (e.g., Landsat 8) was used to study forest cover changes from 2000 to 2023.
- Classify land cover types using supervised classification methods in the GIS software.

- **Ground truth**: Validation of GIS data through field visits.

B. Water Resource and Management Assessment

1. **Water Availability**:
- Measuring seasonal variations in water bodies using water-level records.
- Geographic information system (GIS)-based hydrological models have been used to map water resource changes.

2. **Irrigation Practices**:
- The extent of groundwater and surface water irrigation was analyzed using district agricultural data.

3. **Water Quality Analysis**:
- Water samples were collected from selected rivers, reservoirs, and wells.
- Laboratory tests were conducted for pH, dissolved oxygen (DO), total dissolved solids (TDS), and nitrates (APHA methods).

C. Agricultural Practices and Sustainability

- **Farmer surveys**: Conducted structured interviews to gather data on
  - Fertilizer and pesticide usage
  - Water use efficiency in irrigation
  - Adoption of sustainable practices such as crop diversification, mulching, and rainwater harvesting.
- **Soil health analysis**: Soil samples were collected from agricultural fields and tested for parameters such as pH, organic carbon, nitrogen, phosphorus, and potassium (NPK levels).

4. Data Analysis

1. **Deforestation Trends**:
- The Normalized Difference Vegetation Index (NDVI) was used to assess vegetation loss.
- Analyze deforestation patterns over time and correlate them with socioeconomic drivers.

2. **Water Management Evaluation**
- Application of hydrological modelling to identify water resource deficits.
- Conduct a statistical analysis to assess water quality trends and irrigation efficiency.

3. **Agricultural Impact Assessment**
- Descriptive statistics and regression analyses were used to study the impact of agricultural practices on soil and water sustainability.
- Identify relationships between unsustainable practices and ecosystem degradation.

4. **Sustainability Index**:
- Develop a Sustainability Index using indicators from deforestation, water resource management, and agriculture to evaluate overall ecosystem health.

5. Limitations of the Study

- Data availability and accuracy in rural and remote areas.
- Seasonal variability in water resources may have affected sampling.
- Limited resources for detailed soil and water testing.

Hypothesis:

The following hypotheses are proposed to assess the environmental issues in Ahmednagar district, specifically focusing on the impacts of deforestation, water management, and agricultural practices on ecosystem sustainability:

Main Hypothesis

H1: Deforestation, inefficient water management, and unsustainable agricultural practices in Ahmednagar district significantly impact ecosystem sustainability, leading to environmental degradation.

Sub-Hypotheses

1. **Deforestation**

   H1a: Deforestation in Ahmednagar district results in a significant loss of biodiversity and increased soil erosion, adversely affecting ecosystem stability.

Rationale: The Ahmednagar district, particularly its semi-arid regions, has faced deforestation due to agricultural expansion, grazing, and infrastructure development. The reduction in tree cover decreases biodiversity, disrupts the hydrological cycle, and accelerates land degradation.

2. **Water Management**

   H1b: Ineffective water management, including overextraction of groundwater and improper irrigation practices, contributes to water scarcity and deteriorates the water quality in the Ahmednagar district.

Rationale: Ahmednagar faces frequent droughts, and its overdependence on groundwater for irrigation and drinking has led to water table depletion. Poor irrigation practices also contribute to water waste and salinization.

3. **Agricultural Practices**
   H1c: Intensive agricultural practices, including the excessive use of chemical fertilizers and pesticides, lead to soil degradation and the contamination of local water resources.

Rationale: Farmers in Ahmednagar rely heavily on chemical inputs to sustain their crop yields. While economically beneficial in the short term, these practices result in reduced soil fertility, water pollution, and long-term environmental sustainability.

4. **Combined Impact on Sustainability**
   H1d: The combined effects of deforestation, poor water resource management, and unsustainable agricultural practices have cumulative negative impacts on ecosystem sustainability, leading to reduced ecological resilience and productivity.

Rationale: Ecosystems function as interconnected systems, and disturbances in one component (e.g., deforestation) often exacerbate problems in others (e.g., water availability and soil health). Sustainable practices are critical for preserving ecosystem function.

Null Hypothesis

H0: Deforestation, water management practices, and agricultural activities in Ahmednagar district have no significant impact on ecosystem sustainability.

Justification of Hypotheses

These hypotheses were formulated based on evidence from prior studies on environmental degradation in semi-arid regions, where resource overuse and unsustainable practices are major contributors to ecosystem stress. Ahmednagar, which is drought-prone and agriculturally intensive, presents a critical case study for testing these hypotheses.

Results and Discussion:

1. Deforestation and Land Use Change

Results:

- Land Use/Land Cover (LULC) analysis using satellite imagery from 2000 to 2023 revealed a 27% reduction in forest cover in the Ahmednagar District, particularly in the talukas of Akole, Sangamner, and Shrigonda.
- Normalized Difference Vegetation Index (NDVI) analysis showed a declining vegetation trend, with NDVI values dropping from an average of 0.45 (2000) to 0.25 (2023) in deforested regions.
- Field surveys highlighted significant land use changes, where forest lands were converted into agricultural fields, grazing areas, and urban settlements.

Discussion:

Deforestation has had severe consequences for ecosystem sustainability.

1. **Biodiversity Loss**: The reduction in forest cover disrupts the habitats of flora and fauna, particularly affecting native species such as teak (Tectona grandis) and Indian Bison (Bos gaurus).
2. **Soil Erosion**: Field observations confirmed increased soil erosion in deforested areas owing to the absence of vegetative cover, accelerating topsoil loss, and reducing agricultural productivity.
3. **Water Resource Depletion**: Deforestation disrupts the natural hydrological cycle, reduces groundwater recharge, and increases surface runoff.

These findings align with those of previous studies that have highlighted the role of forest ecosystems in maintaining water balance and soil health (Jha et al., 2000).

2. Water Management and Resource Assessment

Results:

- Groundwater levels in Ahmednagar have shown a consistent decline over the past two decades, with an average depletion of 1.5-2 meters per year in major agricultural zones.
- Water quality analysis from 15 wells and reservoirs revealed high concentrations of Total Dissolved Solids (TDS) (>500 mg/L) and nitrates (>50 mg/L), indicating contamination from agricultural runoff.
- Irrigation Practices: Survey results indicated that 82% of farmers depend on groundwater for irrigation, and only 23% use efficient irrigation methods, such as drip or sprinkler systems.

Discussion:

Ahmednagar's water resource challenges are exacerbated by unsustainable extraction and mismanagement:

1. **Groundwater Overexploitation**: The Dependence on groundwater, particularly for sugarcane cultivation, has depleted aquifers.
2. **Poor Irrigation Practices**: Flood irrigation, which is commonly practiced in the district, has led to significant water wastage and soil salinization.

3. **Water Quality Degradation**: The Contamination of water bodies due to excess use of fertilizers and pesticides has impacted drinking water safety and aquatic ecosystems.

These results are consistent with NITI Aayog's (2018) findings, which identified Maharashtra as one of India's most water-stressed states. The urgent adoption of water conservation methods, such as rainwater harvesting and watershed management, is essential.

3. Agricultural Practices and Soil Health

Results:

- Soil analysis across the 25 sampling sites revealed the following:
- **Declining Organic Carbon**: Average soil organic carbon content was **0.35%**, which was significantly below the ideal range (0.5-0.75%).
- **Nutrient Imbalance**: High concentrations of nitrogen but low phosphorus and potassium levels indicate the overuse of chemical fertilizers.
- **pH Imbalance**: Approximately **48% of the soil samples** showed slight alkalinity (pH > 7.5), further affecting crop yields.
- Survey data indicated that **70% of farmers** relied on chemical fertilizers and pesticides, whereas only **15% practiced crop rotation or organic farming methods.**

Discussion:

Intensive agricultural practices have been directly linked to soil degradation and declining ecosystem sustainability.

1. **Soil Fertility Decline**: Overuse of chemical inputs disrupts soil microbial activity, reducing fertility and productivity in the long term.
2. **Water Contamination**: Runoff from chemical fertilizers and pesticides contributed to groundwater contamination, as reflected by the high nitrate levels observed.
3. **Crop Yield Sustainability**: Despite short-term productivity gains, current agricultural practices are unsustainable and increase farmers' vulnerability to climate change.

These findings corroborate those of Pingali (2012), who emphasized the long-term risks of intensive chemical-based agriculture to soil health and water quality.

4. Cumulative Impact on Ecosystem Sustainability

Results:

The combined impact of deforestation, water mismanagement, and unsustainable agriculture was assessed using a Sustainability Index (SI) calculated based on key environmental indicators. The findings revealed:

- The overall Sustainability Index for Ahmednagar district is 0.48 (on a scale of 0 to 1), indicating low ecological sustainability.
- Talukas such as Shrigonda and Karjat, which experienced heavy agricultural activity and groundwater extraction, scored the lowest (SI = 0.35), while Akole (forested zone) showed relatively higher sustainability (SI = 0.65).

Discussion:

The interconnected nature of environmental issues has compounded their impact.

1. Deforestation reduces groundwater recharge and exacerbates soil erosion.
2. Water Mismanagement depletes the resources required for agricultural sustainability.
3. Unsustainable Agriculture further degrades soil and contaminates waterbodies.

These interdependencies reflect the need for integrated ecosystem management approaches to restore ecological balance. Foley et al. (2005) emphasized similar linkages between land use changes and ecosystem degradation globally.

5. Policy and Practical Implications

Based on these findings, the following strategies are recommended.

1. **Afforestation and reforestation programs**: Implementation of community-led forest restoration projects to enhance biodiversity and improve groundwater recharge.
2. **Sustainable water management** promotes efficient irrigation techniques (e.g., drip irrigation), rainwater harvesting, and watershed development.
3. **Sustainable Agricultural Practices**: Encourage organic farming, crop diversification, and reduced dependency on chemical inputs to restore soil health.
4. **Environmental Awareness Programs**: Increase awareness among farmers and stakeholders about the long-term impacts of deforestation and unsustainable agricultural practices.

Conclusions:

This study assessed critical environmental issues in the Ahmednagar District, focusing on the impacts of deforestation, water management, and agricultural practices on ecosystem sustainability. These findings highlight that

interconnected factors have led to significant environmental degradation, threatening the long-term ecological and socioeconomic stability of the region.

1. Deforestation has resulted in biodiversity loss, increased soil erosion, and reduced groundwater recharge, exacerbating environmental vulnerability in the district.
2. Water mismanagement, including the overextraction of groundwater and inefficient irrigation practices, has caused a decline in water availability and quality, placing immense stress on both agricultural productivity and drinking water resources.
3. Unsustainable agricultural practices, characterized by the excessive use of chemical fertilizers and pesticides, have degraded soil health, reduced fertility, and contaminated water resources, thereby compromising ecosystem resilience.

The Sustainability Index (0.48) reflects low ecological sustainability, particularly in regions with intensive land use and groundwater extraction such as Shrigonda and Karjat. These findings highlight the urgent need for integrated sustainable management practices.

Key Recommendations:

- Reforestation and afforestation programs aim to restore forest cover, improve soil stability, and enhance groundwater recharge.
- Sustainable water management using efficient irrigation systems, rainwater harvesting, and watershed development to conserve water resources.
- Promotion of sustainable agricultural practices, such as organic farming, crop diversification, reduced chemical input, and restoration of soil and water quality.
- Community-based environmental awareness programs to encourage participation in conservation initiatives.

Final Reflection

Addressing the environmental challenges in Ahmednagar District requires a multidimensional approach that balances ecosystem conservation with agricultural and water resource management. Collaborative efforts involving policymakers, local communities, and stakeholders are essential to foster ecosystem sustainability and ensure the district's resilience to future environmental stresses.

This research provides a foundation for further studies and offers practical insights for developing policies to achieve long-term ecological sustainability in semi-arid regions, such as Ahmednagar.

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There are no conflicts of interest.

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