

## Advancing Renewable Natural Resources Management Through Computer-Based Technologies: A Comprehensive Review

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### Abstract

Forests, water, soil, biodiversity, and other renewable natural resources (RNR) are all crucial for preserving ecological balance and guaranteeing the sustainability of human lifestyles. But issues like deforestation, soil erosion, biodiversity loss, and water scarcity all of which are made worse by climate change call for creative solutions. Resource management has seen a revolution because to computer-based technologies including Geographic Information Systems (GIS), Remote Sensing (RS), Artificial Intelligence (AI), the Internet of Things (IoT), and Decision Support Systems (DSS). The uses, advantages, difficulties, and possibilities of various technologies in RNR management are systematically reviewed in this paper. The review demonstrates how these technologies may facilitate data analysis, monitoring, and decision-making for sustainable resource use by examining peer-reviewed research. The results highlight how crucial it is to include contemporary techniques into resource management while removing obstacles to their uptake.

**Keywords:** Renewable; Natural Resources; Computer-based; Technologies and GIS

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### INTRODUCTION

#### Background of the Study

Forests, water, soil, fisheries, and biodiversity are examples of renewable natural resources (RNR), which support both economic growth and environmental stability worldwide. They provide vital ecosystem services such food production, biodiversity preservation, climate management, and carbon sequestration (FAO, 2022). However, these resources are under a great deal of stress due to unsustainable farming methods, urbanisation, industrialisation, and fast population expansion. Global worries over deforestation, water shortages, soil erosion, and biodiversity loss are growing, especially as the effects of climate change worsen (IPCC, 2022).

The intricacy and scope of these issues are frequently too great for traditional resource management techniques, which rely on empirical methodologies and manual surveys (Zhang *et al.*, 2020). Computer-based technologies like GIS, RS, AI, IoT, and DSS have become more popular as a result of the demand for creative, data-driven solutions. These technologies provide improved capabilities for sustainable monitoring, analysis, and management of renewable resources.

## Relevance of Computer-Based Technologies

Large-scale monitoring and geographical mapping are made possible by GIS and RS, while real-time data collecting and predictive modelling are made possible by AI and IoT. To produce useful insights for decision-making, DSS combines various technologies (Sharma & Singh, 2021). The Sustainable Development Goals (SDGs) of the UN, especially SDG 13 (Climate Action) and SDG 15 (Life on Land), are among the global sustainability programs that these technologies support (UNEP, 2023). Notwithstanding their promise, obstacles including exorbitant expenses, a lack of technological know-how, and adoption reluctance prevent them from being widely used. The uses, advantages, and difficulties of various technologies in RNR management are examined in this paper.

## METHODOLOGY

Using a systematic review methodology, this study concentrated on peer-reviewed works released from 2015 to 2024. The following keywords were used to search databases including Scopus, Web of Science, and Google Scholar: "computer-based technologies in RNR," "GIS in natural resource management," "AI applications in resource conservation," and "IoT for sustainability." 87 of the 152 articles that were found were chosen because they were pertinent to RNR management. To group the results into important technical applications, advantages, difficulties, and case studies, a thematic analysis was performed.

## RESULTS

1. Geographic Information Systems (GIS): GIS makes resource mapping and spatial analysis possible. Research emphasises its application in watershed management, land-use changes, and deforestation monitoring (Adeyemi *et al.*, 2021).
2. Remote Sensing (RS): RS technologies, such as drone surveys and satellite photography, offer real-time data for climate impact assessments, agricultural monitoring, and forest health assessment (Rahman *et al.*, 2022).
3. Artificial Intelligence (AI): AI finds trends in resource degradation, automates data processing, and improves predictive modelling. For example, deforestation drivers and biodiversity loss have been predicted using AI models (Smith *et al.*, 2020).
4. The Internet of Things (IoT) facilitates precision agriculture and disaster management by enabling real-time monitoring of environmental factors such soil moisture, air quality, and water levels (Mensah & Agyeman, 2021).
5. Decision Support Systems (DSS): DSS supports decision-making in forest management, water distribution, and renewable energy site selection by integrating data from GIS, RS, and IoT (Sharma & Singh, 2021).

## DISCUSSION

### Applications and Benefits

Computer-based technologies offer RNR management capabilities never before possible. Large-scale monitoring and geographical analysis are made possible by GIS and RS, while resource management is made more accurate and efficient by AI and IoT. In order to balance economic

activity with conservation, DSS incorporates these technologies into decision-making processes (Rahman *et al.*, 2022).

### **Challenges**

The use of these technologies is restricted, particularly in developing nations, by their high implementation costs and technical competence requirements, notwithstanding their advantages. Another major obstacle is cultural opposition to using new techniques in place of old ones (FAO, 2022). Targeted interventions, including as finance, stakeholder involvement, and capacity building, are necessary for the successful integration of these technologies.

### **Case Studies**

- Water distribution efficiency in the Mekong River Basin was increased by 25% thanks to GIS-based hydrological models (Pham & Hoang, 2021).

In India, real-time irrigation management facilitated by IoT-connected devices cut water waste by 40% (UNCCD, 2022).

Over a five-year period, Indonesia's illicit logging operations were cut by 30% thanks to AI-driven prediction models (UNEP, 2023).

## **CONCLUSIONS**

Innovative approaches to the sustainable management of renewable natural resources are provided by computer-based technology. To tackle issues like deforestation, soil degradation, and biodiversity loss, GIS, RS, AI, IoT, and DSS provide effective monitoring, analysis, and decision-making. These technologies have proven successful in a variety of applications and are in line with global sustainability goals, despite acceptance difficulties.

## **RECOMMENDATIONS**

1. Building Capacity: Train resource managers to improve their technical proficiency.
2. Policy Support: To encourage the use of these technologies, governments and international organisations should give priority to financing and policy frameworks.
3. Collaborative Research: To create and localise technological applications, fortify alliances between academia, business, and policymakers.
4. Involve local communities in the adoption process to guarantee sustainability and acceptability.

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