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## THE USE OF REMOTE SENSING IN GHANA TO SUSTAINABLY MANAGE THE ENVIRONMENT

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### ABSTRACT

A prerequisite for achieving the objectives of sustainable development is knowledge of the nature, extent, geographical distribution, along with the potentials and limits of natural resources. The mapping, monitoring, measuring, and management of many elements of the built, natural, and biophysical environments are all made possible through satellite remote sensing. Remote sensing is a crucial tool for advancing solutions and offers useful insights into urgent environmental concerns. Thus, data collection for efficient resource management in Ghana has shown to be greatly aided by remote sensing, which may also be used for environmental monitoring and management. Because of this, it is crucial for remote sensing technology to progress in order to acquire data more effectively and efficiently, which helps with rapid change detection, sustainable environmental management, and sustainability. This review's goal was to provide a thorough analysis of the literature on Ghana's use of remote sensing for environmental management and sustainability. Wiley, Taylor & Francis, Science Direct (Elsevier), and Scopus (Elsevier) were a few of the databases used for the review. The findings indicate that there are numerous remote sensing applications for sustainable environmental management in Ghana, including environmental impact assessments of various projects, analyses of changes in land use and land cover, mapping of watersheds and hydrologic features, estimation of soil loss, management of water resources, management of forestry

resources, and management of natural disasters. The outcomes also demonstrate that natural, biophysical, and constructed ecosystems might be appropriately monitored and sustainably managed for the benefit of both the present and future generations with the use of remote sensing technology. Governments, municipal managers, environmentalists, and planners may develop useful plans and strategies for sustainable development and effective environmental management with the aid of the information supplied by remote sensing.

**Keywords:** Ghana, Sustainable Management, Environment, Remote Sensing.

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## INTRODUCTION

The process of learning about an interesting feature without making physical touch with it is called remote sensing. Images of the Earth's surface taken by sensors deployed on airborne and space borne platforms are common types of remote sensing utilised in the environmental sciences. Globally, remote sensing has been utilised for environmental management, sustainability, and monitoring. Over the past century, there has been a significant evolution in the breadth and diversity of sensing systems as well as the variety of applications. Images that disclose details that could be unseen to the human eye, such as the physical structure and chemical composition of the Earth's surface, are utilised in addition to more common aerial pictures that record views comparable to those seen by the human eye. The Earth's surface may be seen on remotely sensed imaging in a form that makes it possible to recognise, identify, and classify its characteristics. Additionally, even if each photograph captures the environment in a single moment, it is frequently feasible to gather images across time. In order to map invasive species, monitor land-cover changes, such as habitat fragmentation, and estimate the biophysical and biochemical features of forests, to name a few, remote sensing has been employed in a wide range of environmental management applications.

### The Remote Sensing Concept

Ramachandran et al. (1997) defined remote sensing as the science and art of gathering data (spectral, spatial, and temporal) about physical items, areas, or phenomena without actually coming into touch with those things, those areas, or those phenomena. Remote sensing technology has been increasingly significant in recent years for obtaining data in a more efficient manner, which is helpful in quickly detecting changes and efficient resource management. Another way to categorise remote sensing technology is into three stages: Data is gathered from a sensor installed on a platform, handled, and interpreted before being used to create some thematic maps of the surfaces under investigation. GIS software is used to evaluate data obtained through remote sensing.

Consequently, a variety of options for environmental monitoring and management, particularly in the field of natural resource management, are provided by remote sensing and geographic information systems (forest ecology). Therefore, it is impossible to overstate the role that remote sensing plays in sustainability and environmental management. This is why environmentalists need to adopt and apply remote sensing to their work (Ukpere et al., 2018). The majority of human decisions and actions regarding exploration and exploitation operations first appear to have significant economic rewards, but in the long term, these choices have had disastrous effects on the ecosystem. It is undeniably true that human activities designed by human ingenuity are continuously altering the biophysical or biogeochemical makeup of the

world, leading to environmental pollution and deterioration. The use of remote sensing technology is the only way to fully analyse and map out the impacts of both to identify potential mitigations (Ukpere, 2016). It's critical to have knowledge about the world's topography in order to establish a sustainable environment for current and future generations. The goal of this paper is to empirically examine studies on remote sensing's uses in Ghana for sustainability and environmental management.

### **Review Techniques**

An extensive search of the English-language internet was done for this review with an emphasis on published journal papers. The goal of the search was to locate peer-reviewed literature discussing remote sensing applications for Ghana's sustainable environmental management.

### **Environmental Management and Sustainability in Ghana Using Remote Sensing (RS)**

#### **Analysis of Changes in Land Use and Land Cover**

Changes in land use have an impact on the composition of the atmosphere, which leads to changes in temperature and weather at the local and global levels, according to Huang et al. (2021). The formulation of solutions for environmental management and sustainability now frequently includes remote sensing. Huang et al. (2021) claim that remote sensing has the potential to instantly collect spectral fingerprints over vast amounts of data. Information on the surface temperature, plant cover, and land cover may be extracted using the spectral signatures (Stocking & Murnaghan, 2010). Anderson (1976), Treitz and Rogan (2004), Ahmad, K., and Laituri (2017) hypothesised that combining Landsat Multispectral Scanner (MSS) data and Landsat Thematic Mapper (TM) data via image classification algorithms, land cover and land use changes could be analysed over time. The extent of land usage and land cover change through time has been thoroughly described using the remote sensing approach, which also provides precise and timely information. It investigates fresh approaches to identify, describe, and track changes in forests (Kumar et al., 2013). According to Lausch et al. (2016), forest loss in the Woreta watershed has been evaluated using change detection methodology, which makes use of both GIS and remotely sensed data.

Compared to field survey, remote sensing provides a practical and affordable way to map vegetation, other types of land cover, and land use across huge regions. To monitor long-term and widespread forest cover, moderate spatial resolution satellite systems like Landsat provide almost worldwide coverage of multi-spectral images going back to the middle of the 1980s (Tsai et al., 2019). The characteristics of the land cover detected by remote sensing techniques can be used to infer the land use, especially when combined with auxiliary information or priority knowledge. The management of natural resources, preservation of wildlife habitats, baseline mapping for GIS input, urban growth, logistics planning for seismic/exploration/resource extraction activities, damage delineation (windstorms, flooding, seismic, fire, etc.), legal boundaries for tax/property evaluation, target detection, and identification of landing strips, roads, clearings, bridges, and land/water interface are just a few examples of the land use applications of remote sensing.

#### **Environmental Impact Assessment**

The systematic identification and evaluation of the potential impacts (effects) of proposed projects, plans, programmes, or legislative actions with regard to the physical, chemical, biological, cultural, and socioeconomic components of the entire environment is known as environmental impact assessment (EIA). The environmental impact assessment identifies ways

to lessen negative effects and increase project feasibility. In terms of time and money compared to the time and budgets allotted for EIA preparation and notably for scoping studies, the use of remote sensing in the EIA process is typical for scoping. The majority of environmental challenges may be effectively treated by using the remote sensing technology (Lechner et al., 2020).

Satellite remote sensing is a contemporary method that enables systematic and thorough data collection using space-based sensors. The most important factors in selecting this kind of data to conduct environmental impact assessments are its high geographical resolution, which spans several minutes to several other days, as well as its high temporal resolution between a number of minutes and other days. Monitoring and modelling of Earth surface processes and their interactions with the atmosphere are among the goals of remote sensing in EIA studies. Other goals include measuring and estimating geographical, biological, and physical variables, identifying details and materials on the Earth's surface, and analysing the spectral signatures captured by satellite sensors. These objectives are feasible due to the fact that the features captured in a picture, depending on the shape and chemical composition, absorb, emit, and reflect electromagnetic radiation at various wavelengths (Lechner et al., 2020). Remote sensing is useful in identifying the origin of desertification, landslides, volcanoes, pollution, and other natural dangers while studying the environment and its surroundings. This investigation yielded significant findings that could subsequently be applied to stop the emergence of another natural calamity.

### **Watershed Mapping and Hydrologic Features**

Watershed management is important for managing the environment sustainably. The foundation for environmental management and sustainability is the mapping of watersheds and their hydrologic features using remote sensing and GIS technologies because it helps to identify soil erosion-prone areas based on the estimated soil loss and designs appropriate soil and water conservation structures while taking their cost effectiveness into account (Ottah Chinyere, 2018). When adopting intervention strategies like soil and water conservation measures, environmentalists first define the watershed via community-based participatory watershed management planning (Tsai et al., 2019).

A watershed may be mapped or delimited manually, automatically, utilising top sheets and manual digitization, or both (DEM). Even though manual procedures take more time and are less precise, professionals still prefer them over DEM. This could be brought on by a lack of proficiency with GIS and remote sensing technology (Tsai et al., 2019). Because it precisely and effectively determines the fundamental watershed properties, such as drainage pattern, topography, land use kinds, soil types, degraded land, and soil erosion, this method is more sophisticated and essential in large-scale watersheds (Entekhabi et al., 2010; Barrett, 2013). For watershed delineation, both quantitative and quantitative data are absolutely essential (Breuste et al., 2013). According to Cheng et al. (2011), remote sensing is crucial for comprehending topography factors such bedrock type, infiltration rate, and watershed surface runoff.

### **Managing Water Resources**

In order to survive, humans need water. The effects of urbanisation, industrialization, and climate change on water resources are all significant. Increased groundwater resource extraction is inevitable since surface water is susceptible to contamination. In addition to supplying clean drinking water, groundwater also nourishes the rivers, wetlands, and lakes that

are crucial for both ecological sustainability and agricultural productivity in both developing and developed nations (Lausch et al., 2016).

To manage water resources sustainably and sustainably, the water system needs a holistic approach that integrates ideas and ideas from various disciplines. An in-depth understanding of the various processes of the water cycle can be developed with the help of a field study that is conducted at a larger scale. A potential technique to include the models for acquiring continuous water is remote sensing technology. As a result, the satellite remote sensing for hydrological applications includes, but is not limited to, rainfall (Global Precipitation Measurements (GPM) and Tropical Rainfall Measuring Mission (TRMM)); soil moisture (Soil Moisture Active Passive (SMAP) and Soil Moisture Ocean Salinity (SMOS)); actual evapotranspiration (Surface Energy Balance System); mapping evapotranspiration with internalised calibration (METRIC) and surface energy balance (Sandhu et al., 2020).

### **Forest Resources**

Forest cover can regenerate through sustainable management, claim Pettorelli et al. (2011). Therefore, a forest manager can produce information about forest cover, forest area present in a neighbourhood of interest, human encroachment extent into forest land/protected areas, encroachment of desert-like conditions, to name a few, using remote sensing data and GIS techniques. This information is essential for the development of forest management plans and for the process of determining which policies should be implemented to control and regulate the management of forest resources (Forkuor et al., 2020).

In Ghana, RS has been utilised to monitor the forest cover changes in different sections of the nation by several studies. In a study conducted by Tsai et al., 2019 on the forest cover changes within different reserves types in Ghana in southern Ghana using Land sat 7 and images from 1999-2018 (on a fully protected reserve Kakum National Park and less protected reserve – Subri River), results provided a highly accurate and effective means to monitor land-use changes in forested and cloud-prone regions with great promise for application to improved monitoring of moist tropical and other forests characterised by high cloud cover. The investigation was able to pinpoint the reason of the alterations and offer advice on the way forward.

### **Natural Disaster Management**

Extensive multi-temporal spatial data is necessary for the management of natural disasters like flooding, earthquakes, volcanic eruptions and landslides. In this context, satellite remote sensing is a perfect tool that gives information over large areas and at short time intervals, which may be utilised in various phases of disaster management, such as prevention, preparedness, relief, reconstruction, early warning and monitoring (Ukpere et al., 2018). (Ukpere et al., 2018). The remote sensing approach is used to identify disaster-causing causes and mitigation measures. It provides disaster managers, in particular the Ghanaian Fire Service, with the pertinent information required for managing and controlling fire.

### **Estimating Soil Losses**

For calculating potential soil loss related with the RUSLE soil erosion model, GIS and remote sensing techniques are also employed (Lechner et al., 2012). Remote sensing is primarily used and being used for this purpose in various regions of Ghana. The applications of remote sensing in soil loss estimation for proper planning of soil and water conservation, which has a great advantage of sustainable environmental management, are essential (Li et al., 2020).



## CONCLUSION

Growing environmental pressure is a result of urbanisation. Remote sensing technology should be utilised to sustainably manage our environment in an effective and efficient manner. Such technology is applied and still being applied globally specifically Ghana in different research areas related to sustainable environmental management including watersheds and hydrologic features mapping, land use and land cover change analysis, environmental impact assessment of different projects, estimating soil loss, water resources management, forest resource mapping and management and natural disaster management etc. As a result, remote sensing technology should be used to ensure environmental management and sustainability that meets the needs of current and future generations.

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