

## Role of GIS and Remote Sensing in Wildlife Conservation

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ARTICLE ID: 53

### Abstract:

By employing GPS tracking collars and video traps, researchers and conservationists are able to gather fundamental data, including baseline information, daily movements, and behavioral patterns. This data plays a pivotal role in providing crucial insights into the spatial distribution of various species. However, Geographical Information System (GIS), satellite, aerial, and unmanned aerial vehicle (UAV) remote sensing technology, along with artificial intelligence (AI), have the potential to assist scientists and conservationists in the identification, tracking, monitoring, and assessment of wildlife across various habitats, including the most inaccessible regions worldwide, such as marine environments. The integration of satellite remote sensing and artificial intelligence (AI) technology has proven advantageous for wildlife conservation endeavors. These advanced technologies have been effectively employed to safeguard National Parks and enhance endangered wildlife monitoring inside their natural habitats. These technologies provide capability to observe ground-level information on faunal activities and animal habitats through multispectral satellite imagery and AI data analysis. By employing temporal comparisons, wildlife habitats that require protection and conservation measures can be identified. Multispectral satellite imagery generated by satellite sensors offers a heightened level of resolution, enabling the detection of sensitive regions with exceptional precision. The utilization of satellite imagery, GIS, and AI enables the acquisition of data to be utilized in the integration, analysis, modelling, and generation of satellite maps for the purposes of studying wildlife migration, mapping habitats, and conducting conservation efforts.

**Keywords:** GIS, Remote Sensing, Artificial Intelligence, Wildlife, Conservation

### Introduction:

Global biodiversity is currently facing significant challenges, such as climate change, habitat degradation, and human activities leading to rapid fall in species populations. The issue



of human impact or intrusion into diverse wildlife habitats represents significant concern. Habitat analysis and population census have emerged as crucial methodologies for wildlife managers as habitat analysis offers more comprehensive comprehension of wildlife and various types of habitats they inhabit, while census data may be utilized to assess the current condition of wildlife populations. Application of these methodologies enables assessment of the correlation between wildlife populations and their respective habitats enhancing management of wildlife resources. Utilization of remotely sensed data has potential to be employed in both habitat study and wildlife census. In past, utilization of remote sensing techniques was primarily limited to visual observations conducted from aircraft, with specific aim of conducting wildlife census or assessing habitat conditions. However, advancements in remote sensing technology have expanded the range of applications encompassing utilization of aerial photographs, computer processing of satellite data, telemetry, and thermal infrared data. The process of habitat analysis entails systematic assessment and documentation of various habitat types through use of remotely sensed data, such as color-infrared aerial images, which are employed for inventorying and mapping purpose. In recent times, there has been a notable increase in utilization of remote sensing for wildlife management purpose, specifically in areas of wildlife census, habitat mapping, inventory, and evaluation. Preservation of biodiversity is of utmost importance in order to sustain intricate equilibrium of our ecosystem. Nevertheless, process of monitoring and preserving biodiversity can present significant challenges, particularly when dealing with extensive regions. Monitoring techniques such as camera traps, acoustic sensors, and aerial imaging are widely employed methodologies for collection of comprehensive datasets across many applications. Remote sensing has emerged as a highly potent instrument for gathering wildlife conservation data, encompassing crucial aspects such as habitat characteristics, species distribution patterns, and population dynamics. Utilization of data intervention can significantly enhance conservation endeavors, particularly in facilitating informed decision-making processes. For instance, data intervention can provide valuable guidance in determining the optimal approach for connecting two cities through a roadway while minimizing the adverse impact on wildlife habitats. Additionally, it can assist in identifying strategic locations for deployment of anti-poaching tools. Significant methodologies of analysis may be achieved by diligent processing of data and extraction of



significant insights accomplished by subjecting the data to advanced AI algorithms that have been specifically developed for this purpose.

### **Geographical Information System (GIS):**

GIS is a technical instrument facilitating the understanding of geography that enables informed decision-making. GIS refers to computerized framework that encompasses acquisition, retention, administration, examination, and visualization of geospatially referenced information with processing of gathered data or information about an object or phenomena without the need for direct physical contact. This technology is an effective tool for collecting, storing, processing, manipulating, analyzing, managing, retrieving and displaying georeferenced data including wildlife data of target areas where interventional management practices are needed to monitor their effectiveness. It helps in assessing disease levels within populations, progress of management activities by accommodating large varieties of spatial and non-spatial data.

### **Remote Sensing:**

Remote sensing is a technological approach that utilizes sensors to gather and acquire informative data pertaining to the environment from a considerable distance. This method has demonstrated its efficacy as a potent and emerging instrument for the preservation and protection of biodiversity. The utilization of remote sensing in conservation encompasses a wide range of applications, including the monitoring of ecological alterations and the identification of instances of wildlife poaching. In remote sensing different types resolution exist, which are relevant for biodiversity conservation application:

- 1) **Spatial resolution:** Spatial resolution the size of pixel inside an image. The spatial resolution of a satellite image depends on sensor have very high-resolution data set by Quick bird, WorldView-2 etc. provide spatial resolution upto half a meter. Other like have a spatial resolution of 30m which is available in Landsat imagery. When the spatial accuracy decreases, the extent of imagery increase.
- 2) **Spectral resolution:** It refers to ability of distinguishing between different objects based on their unique spectral signatures, which may be quantified using a portable spectrometer. This measurement process yields separate signals for each object type. Spectral remote sensing data encompasses the breadth and quantity of bands that span several spectral ranges.

- 3) **Thematic resolution:** It refers to a characteristic of a collection of rules employed to delineate a hierarchical structure of land cover categories, the criteria employed to differentiate them, and the interconnections between these categories.
- 4) **Temporal resolution:** The temporal resolution is not directly related to sensor. It corresponds to frequency of revisits and is therefore dependent on the orbitography of platform or satellite on which sensor is hosted.

Biodiversity conservation categories using remote sensing and GIS: It can be grouped into three categories:

- ✚ Biodiversity mapping
- ✚ Biodiversity monitoring
- ✚ Biodiversity modeling.

**A. Biodiversity mapping for individual species, species assemblages and habitats:**

Satellite based data combined with field-based habitat data, land scape structure and species abundance information to identify the habitat boundaries and biophysical characteristics to map species assemblage. The utilization of remote sensing technology to generate habitat maps and gather data on species habitat associations is commonly employed in order to obtain insights into species distribution patterns.

**B. Biodiversity monitoring:** It plays a crucial role in assessing and enhancing biodiversity conservation efforts with meticulously planned and executed biodiversity monitoring program aiming to (i) provide insights into the changing patterns of key biodiversity elements, (ii) serve as an early indicator of potential issues, and (iii) yield measurable evidence of both successful and unsuccessful conservation endeavors. (iv) for enhancing management practices effectiveness and (v) to furnish pertinent details regarding the return on investment in conservation efforts.

**C. Biodiversity modelling:** Remote sensing and GIS have been used to predict species distribution and risk to biodiversity to aid visualization, exploration and modeling of data on species distributions, modelling, ecological niche modeling and habitats suitability modeling has been growing at a striking rate in the recent years. Species distribution or ecological niche models (ENMs) offer a valuable approach to solve the issue of insufficient data on species distribution. These models can effectively



bridge knowledge gaps by projecting habitats in areas that have little or no occurrence records, thereby providing a means to enhance our understanding of species distributions. The process of species distribution modelling involves the integration of geographically referenced occurrence data points with various environmental data sets that provide information about the habitats in which the focal species are found. The sets are merged and examined with the objective of constructing a depiction of the ecological needs of the focal species.

### **Applications of GIS and Remote Sensing in biodiversity conservation:**

GIS and Remote sensing technology has revolutionized the way we study and conserve biodiversity via various ways in which this technology is being used to develop conservation plans to protect critical habitats and species that depend on them.

- 1. Habitat Mapping and Monitoring:** Habitat mapping is process of identifying the spatial distribution of habitats in a specific area. Remote sensing technology can provide high-resolution images of study area that enables identification of different types of vegetation and land cover. This information is useful for developing habitat maps that can be used to identify and manage critical habitats for various species. In addition to habitat mapping, remote sensing can be used for habitat monitoring. By regularly monitoring changes in habitat, conservationists can detect any threats to biodiversity and implement necessary actions. These can detect changes in land cover and vegetation, which may indicate habitat degradation or fragmentation.
- 2. Species Distribution Modeling:** Remote sensing can also be used to develop species distribution models, which can be used to predict the spatial distribution of species based on environmental variables. This information is valuable for biodiversity conservation efforts because it enables conservationists to identify areas that are important for specific species survival. By combining remote sensing data with field data on species occurrence and environmental variables, conservationists can develop accurate species distribution models to develop conservation plans that target critical habitats for specific species.
- 3. Monitoring of Invasive Species:** Invasive species are a major threat to biodiversity, and remote sensing can be used to monitor their spread and distribution. Remote sensing technology can detect changes in vegetation patterns and identify areas where invasive species are becoming established.



4. **Assessment of Forest Cover Change:** Remote sensing can be used to monitor changes in forest cover over time. By comparing satellite images from different time periods, conservationists can assess the extent and rate of forest cover change useful for developing conservation plans to protect forest habitats and species that depend on them.
5. **Monitoring of Wetland Ecosystems:** Wetland ecosystems are important habitats for many species, but they are also threatened by human activities such as land use change and pollution. Remote sensing can be used to monitor changes in wetland ecosystems, including changes in vegetation, water quality, and water levels that can be useful for developing conservation plans to protect wetland habitats and species that depend on them.
6. **Monitoring of Coral Reefs:** Coral reefs are important habitats for many marine species, but they are also threatened by climate change and human activities such as pollution and overfishing. Remote sensing can be used to monitor changes in coral reefs, including changes in coral cover and water temperature for developing conservation plans to protect coral reef habitats and species that depend on them.
7. **Detection of Wildlife Poaching:** Remote sensing can also be used to detect illegal activities such as wildlife poaching. By monitoring changes in vegetation patterns, conservationists can identify areas where poaching may be occurring to target anti-poaching efforts and prevent further damage to wildlife populations.
8. **Assessment of Land Use Change:** Human activities such as agriculture and urbanization can have a significant impact on biodiversity. Remote sensing can be used to assess changes in land use over time, including changes in vegetation patterns and urbanization extent for developing conservation plans to mitigate negative impacts of human activities on biodiversity.
9. **Monitoring of Water Bodies:** Water bodies such as lakes, rivers, and oceans are important habitats for many species. Remote sensing can be used to monitor changes in water quality, water levels, and vegetation patterns in and around water bodies for developing conservation plans that aim to protect aquatic habitats and the species that depend on them.
10. **Monitoring of Grassland Ecosystems:** Grassland ecosystems are important habitats for many species, including large herbivores such as bison and pronghorn. Remote sensing can be used to monitor changes in grassland ecosystems, including changes in vegetation

patterns, land use, and water availability useful for developing conservation plans that aim to protect grassland habitats and depending species.

**11. Detection of Forest Fires:** Forest fires can have a significant impact on biodiversity, and remote sensing can be used to detect and monitor forest fires. By monitoring changes in vegetation patterns and temperature, conservationists can identify areas where forest fires may be occurring or are at risk of occurring with early warning systems and responding to forest fires quickly, thereby minimizing their impact on biodiversity.

### **Challenges in Biodiversity Conservation by GIS and Remote Sensing**

Remote sensing has benefits for biodiversity conservation, but challenges include data quality and availability, lack of standardization, technical limitations, and limited expertise. Addressing these challenges can lead to effective use of remote sensing in conservation. Some of the challenges are:

- a) **Data Availability and Quality:** Remote sensing relies heavily on data, and availability and quality of data can be a major challenge. In some cases, the data may be incomplete or outdated, making it difficult to accurately assess changes in biodiversity over time. Additionally, the quality of data may vary depending on source and method of collection, which can impact analysis accuracy.
- b) **Lack of Standardized Methods:** Another challenge in using remote sensing for biodiversity conservation is the lack of standardized methods. Different organizations and researchers may use different techniques and approaches, which can make it difficult to compare and analyze data across different studies. A lack of standardization can also make it difficult to replicate studies and ensure consistency in the results.
- c) **Technical Limitations:** Remote sensing technology is advancing rapidly, but there are still some technical limitations that can impact its effectiveness for biodiversity conservation. For example, some remote sensing techniques may not be able to accurately detect small or hidden species, which can limit their usefulness for monitoring biodiversity in certain ecosystems. In addition, some techniques may be limited by weather conditions, such as cloud cover or rain, which can impact the quality of the data.
- d) **Limited Knowledge and Expertise:** Lack of knowledge and expertise can be a challenge in using remote sensing for biodiversity conservation. Remote sensing is a highly specialized field, and many conservation practitioners may not have the necessary



training or experience to effectively use and data interpretation. This can lead to data misinterpretation and inaccurate or ineffective conservation strategies. Additionally, there may be a limited pool of experts who are able to provide guidance and support remote sensing projects in biodiversity conservation.

**Conclusion:**

To tackle global crisis of biodiversity loss, we need innovative and effective solutions. Artificial intelligence and remote sensing, when used in tandem greatly increases the scale and effectiveness of wildlife metrics. GIS, Remote sensing and AI in combination is used in biodiversity conservation to map biodiversity, monitor endangered species, detect and manage invasive species, and identify ecological hotspots that can be used to monitor wildlife populations and track their movements, allowing for effective wildlife management strategies. These techniques are also used to monitor changes in climate, allowing scientists and researchers to develop effective strategies for mitigating its impact on biodiversity. By providing high-resolution images of study areas, remote sensing technology can be used for habitat mapping, species distribution modeling, and monitoring of invasive species, forest cover change, wetland ecosystems, coral reefs, wildlife poaching, land use change, water bodies, grassland ecosystems, and detection of forest fires. This information is useful for developing conservation plans with aim to protect critical habitats and the species that depend on them.