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REMOTE SENSING APPLICATIONS IN FOREST AND WILDLIFE MANAGEMENT: A LEARNING RESOURCE FOR UNDERGRADUATE STUDENTS

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ABSTRACT

Mapping is a crucial step in managing forest and wildlife and agricultural resources. The philosophy which states that 'what cannot be mapped, cannot be measured; what cannot be measured, cannot be monitored; and what cannot be managed' underscores the importance of mapping in resource management. This paper aims to present a novel teaching and learning resource that integrates remote sensing to enhance the knowledge of 200-level agricultural sciences, forestry, and wildlife management students in Nigerian universities, in line with the National Universities Commission's (NUC) Core Curriculum Minimum Academic Standards (CCMAS). This paper methodologically introduces the principles of remote sensing, their applications in forestry and wildlife management, and their potential to address various societal problems. Developed through a structured framework of lecture notes, practical applications, case studies, and hands-on exercises, this resource provides students with the knowledge and skills necessary for sustainable forest management. In conclusion, this resource enables students to acquire the expertise needed for assessing ecosystem services, monitoring forest changes, and implementing sustainable forest management practices, thereby shaping the next generation of forestry and wildlife management professionals. After reading this article, learners and lecturers will be able to provide a definition of forest, understand Remote Sensing principles and applications in forestry, wildlife management and agricultural sciences.

Keywords: CCMAS, Nigeria, National Universities Commission (NUC), Remote Sensing, Undergraduate Forestry/Wildlife Student

INTRODUCTION

"Unarguably, *'what cannot be mapped, cannot be measured; what cannot be measured, cannot be monitored; and what cannot be monitored, cannot be managed*', This foundational philosophy is rooted in the lead author's PhD thesis research from the Department of Geoinformatics and Surveying, University of Nigeria (2018-2024), building on Martin's (2018) assertion that "if you cannot measure it, you can't manage it." This emphasizes the significant role of forest surveying and mapping for informed decision-making and sustainable forest and wildlife management. To achieve this, it is essential to gather accurate information about the Earth's resources. There are two primary methods for doing so:

1. Ground-based surveys, where researchers collect data directly in the field through observations, measurements, and surveys.
2. Remote sensing, which utilizes technology like satellites or drones with cameras to collect data from a distance. This approach enables scientists to study large areas and track changes over time, making it particularly useful for monitoring vast and complex ecosystems like forests.

Therefore, remote sensing (RS) technologies (Nandasena *et al*., 2022) are helpful tools for people who work with forests, wildlife, and on farms. It lets them see important things like where forests are, if they're damaged, and how plants are growing. This information is crucial for taking care of our planet. Old ways of mapping were expensive and took a lot of time, but remote sensing is a faster and cheaper way to get what we need. With remote sensing, we can watch how forests and crops are doing, see if people are changing how land is used, and keep forests healthy. By using remote sensing, we can learn more about our planet and how to take care of it better.

This paper aims to equip learners with foundational knowledge in forestry, remote sensing, and its applications in forestry, wildlife, and agricultural sciences. Specifically, learners will be able to define forests, understand remote sensing concepts, and explain its basics and connections to these fields. Upon completion, fresh graduates in forestry, wildlife, and agricultural sciences will be prepared to work as spatial data analysts in government and private institutions, addressing six key areas of spatio-temporal data needs, adapted from Janssen and Huurneman (2001), including:

i. **Forest Management:** Forest management can optimize timber production while maintaining tree species diversity by leveraging geospatial data on soil and existing tree stand distribution.
ii. **Agronomy**: Remote sensing methods can assess total agricultural production by obtaining spatial information on planting areas and biomass production data.

iii. **Urban Planning**: Areas with illegal construction need to be identified, including buildings situated in zones originally designated for green spaces. The evaluation data should be presented in a format that integrates with other social indicators.
iv. **Agricultural and Civil Engineering**: Optimal locations for infrastructure such as irrigation systems, buildings, mast stations in telecommunications, or electricity distribution can be determined by analyzing terrain form and obstacle locations.
v. **Agroclimatology/Climatology:** Analyzing El Niño phenomena requires data on ocean flow patterns, land surface temperatures, sea level, and energy interactions between soil and water surfaces.
vi. **Environmental Geology and Soil Hydrology:** Remote Sensing Analysts map surface mineralogy, soil suitability, and assess the impact of water flows on adjacent agroforestry soils/farmlands. Understanding topography and slope is crucial for assessing water flow and runoff patterns, identifying areas prone to erosion or landslides, determining soil stability and suitability for different land uses, and informing land use planning and management decisions**.**

This paper is structured into eight sections: Section 1 (Introduction) provides the background and objectives, followed by Section 2 (Methodology), Section 3 (Related Terminologies), Section 4 (Principles of Remote Sensing), Section 5 (Components and Types), Section 6 (Advantages and Disadvantages), Section 7 (Remote Sensing Applications), and Section 8 (Conclusion and Recommendation).

METHODOLOGY

A systematic review protocol was employed to address the first research question. A comprehensive search was conducted across Google Scholar, institutional journal websites, and online academic repositories. The search strategy utilized relevant keywords, including "Remote Sensing," "geospatial data," "Forestry and Remote Sensing," "tropical forest monitoring," and "wildlife or crop monitoring." Studies were screened against predefined inclusion and exclusion criteria at the title, abstract, and full-text levels, adhering to established Desk review guides (Hearn, 2011).

RELATED FORESTRY AND REMOTE SENSING BASIC TERMINOLOGIES

FAO (2020) defines a forest to include any "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. In a more graphical definition of forest, a 'forest' also means a group of trees occupying at-least an equivalent size of a typical football pitch (FAO, 2018). Every map has a boundary. Thus, in remote sensing science, any tree community occupying a portion of land (which is less than the boundary of football pitch or 0.5 ha) is 'not a forest' land but technically regarded as 'trees outside the forest'. This is one core reason why defining your variables/parameters is very first import thing to do as a remote sensing expert.

Basically, tropical forests have numerous social, economic and ecological benefits. Forests are referenced by the United Nations Environment Programme (UNEP) as the "lungs of the earth" because, they are capable of ameliorating the Earth's climate (i.e. climate amelioration) in the following two ways: one, forests act as carbon sinks by sequestrating carbon dioxide (CO_2) into their biomass i.e. into their trunks, leaves and branches; and two, they release oxygen during photosynthesis to clean the surrounding atmosphere. In addition, forests provide tangible goods (such as timber, fuelwood, medicinal products and food) and ecosystem services (such as: natural habitat for a diverse species of fauna and flora; and amelioration of soils) for the overall benefits of humankind.

Therefore, for the above-mentioned benefits of forests to be continuously available for both present and future human generations, it therefore means that, forests should be managed sustainably. To obtain sound information for sustainable forest management, undergraduate students, either studying for the award of Bachelor of Science (B.Sc.) Degree (forestry, wildlife and range management) or B.Sc. (Agriculture) in a contemporary Nigerian university will need to be trained on how to effectively deal with geographically referenced data. Such knowledge will equip the young forestry to (especially during their students' project) collect, process, analyze or skilfully use spatial data to making sound decisions. Later in life, after graduation, they could be involved in data acquisition and analyses that can assist in providing useful information from inventorying, mapping and monitoring of earth resources such as forest biodiversity, wildlife, land degradation, watershed management, *etcetera*).

Two keywords are mentioned from the foregoing statements, viz: **data and information**. What do these two words really mean in this Course, titled: Introduction to Remote Sensing Applications?

a. **Data:** Data simply means representations that can be operated upon by a computer. Generally, data are collected in space (spatial) and time (temporal).
b. **Information**: means data that is already interpreted by humans. Therefore, researchers use a wide range of

approaches to achieve the information required by environmental resource management: interviewing, land surveys, lab measurements for samples, interpretation of aerial photographs, images taken using *in-situu* satellite sensors, numerical simulations, etc.

c. **Image:** Remote sensing images create a permanent record of the Earth's surface features, including natural and man-made features. These images, captured through visual or non-photographic means, serve as valuable data inputs. Understanding image resolution is crucial, as it determines the level of detail apparent in the images (University of Wisconsin and University of Washington, 2010). Image resolutions refer to the potential detail visible in remotely sensed images. There are four types of image resolutions (University of Wisconsin and University of Washington, 2010) as follows:

i. **Spatial Resolution:** Spatial resolution refers to the smallest feature that can be detected by a satellite sensor or displayed in a space-borne image. It is typically represented as the length of one side of a square, with a single value denoting the resolution. For instance, a spatial resolution of 250m means that a 250m x 250m area on the ground is represented by a single pixel.

ii. **Spectral Resolution:** Spectral resolution is like a special power that helps satellites see different colours in the world. Imagine looking at a rainbow - some satellites can see all the colours, while others can only see a few. The ones that see more colours can tell us more about the Earth and what's on it. In other words, spectral resolution describes a satellite sensor's ability to detect specific wavelengths of the electromagnetic spectrum. It is defined by the precision of the wavelength bands, with higher spectral resolution corresponding to narrower bands. Satellite sensors can capture data across multiple bands, including visible spectrum (red, green, and blue) and beyond, such as infrared, ultraviolet, and x-rays. Unlike aerial photographic sensors, which are limited to a single band, satellite remote sensors can image across numerous bands of the electromagnetic spectrum.

iii. **Temporal Resolution**: Temporal resolution in remote sensing refers to the frequency at which a remote sensor captures data of the same location. It's about how often a satellite revisits an area. High temporal resolution means frequent revisits, sometimes daily or multiple times a day, ideal for tracking rapid changes. Low temporal resolution means less frequent revisits, perhaps every few weeks or months, suitable for monitoring slower changes. Therefore, temporal resolution refers to the time interval between successive images of the same geographical area. With advancements in satellite technology, there has been a significant increase in the frequency of image acquisition, enabling more regular monitoring of the Earth's surface.

iv. **Radiometric Resolution**: Radiometric resolution is a measure of how well a satellite sensor can detect small differences in the energy it receives from the Earth. Think of it like shades of gray - can the sensor see just a few shades or many different shades? Sensors with higher radiometric resolution can see more shades, which means they can capture more detail in an image. In other words, radiometric resolution refers to an imaging system's ability to detect subtle differences in energy. Higher radiometric resolution enhances sensor sensitivity, allowing it to capture slight variations in energy levels, thereby providing more detailed information.

PRINCIPLES OF REMOTE SENSING

The Basics

If you can read the wordings of this Chapter, it means that you are sensing the content herein with your natural eyes. As you can read with your normal eyes, the words contained in this Chapter, you are experiencing the principle of remote sensing. Your human eyes are sensing the written words on this page, your brain processes that information and interprets the logical meaning. Hence, the reason as to why you are understanding this sentence that are now reading. Interesting, the capability of the human eyes to observe and record things around us, without coming into direct contact with the things we see. Have you ever taken a photograph with either a phone camera or any other camera? Photographic system (see Figure 1) uses the similar approach for observing and recording objects on Earth's surface as do the human eyes. However, within a minute portion of the energy that is absorbed and reacted by an object surface, both human eyes and camera systems respond to light. The other natural remote sensors that every fully normal person has, are the human sensor for sight (eye), hearing (ear) and smell (nose). However, the present day remote sensing devices can react to a much wider range of radiations: reflected/emitted, absorbed and transmitted, by all object surfaces at certain temperatures above 0 Kelvin. As you read on, you will learn about the **visible range at which your human** eyes and ground-based cameras can sense the trees, buildings and other things around us. Furthermore, you will also learn about those portions of electromagnetic spectrum where human eyes and camera cannot be sensed except through the use of advanced remote sensors on-board aerial or satellite platforms.

As such, remote sensing is what we have been focusing on in this part of the Chapter. From the beginning of the 1960s, a remote sensing terminology has been applied. By definition, the term 'Remote Sensing' is concept which means an overall process of obtaining and measuring information on objects and phenomena on the Earth Surface by a recording device that does not come into physical contact with those objects or phenomena. In a more academic sense, the Canadian Centre for Remote Sensing (CCRS) defines "Remote sensing as the science and art of acquiring data (typically from satellite, aircraft or drone) about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information." In the above two definitions, it is apparent that there are four main characteristics of a remote sensing system; in particular: (i) an **object surface**, (ii) the **recording device (sensor)**, (iii) the **information carrying energy waves** (Figure 1) and (iv) an **electromagnetic energy source** (the sun or propagated energy). Based on the **energy source**, there are two main classes of remote sensing: passive and active systems[7]; as explained hereunder:

Figure 1: The sun emits light. First, light passes through the atmospheric window. Then, it reflects off the Earth to a satellite sensor orbiting the Earth.

i. **Passive remote sensing sensors** (GISGeography, 2022): These systems detect radiation from the sun that is reflected and/or emitted from the surface features of Earth (Figure 1). Therefore, the sun provides a very convenient source of energy for remote sensing. Sun is the most important source of energy used in passive remote sensing. In passive remote sensing, the sun's energy is either reflected (as it is for visible wavelengths), or absorbed and then re-emitted (as it is for thermal infrared wavelengths). Remote sensing systems which measure energy that is naturally available are called passive (optical) sensors. Only when naturally occurring energy is available can **passive sensors** be used to detect energy. Passive sensors are only able to detect reflected energy. In other words, reflected energy can only be possibly detected by passive remote sensors only when the sun is shining on Earth. The solar radiation cannot be reflected in the night.

ii. **Active sensors**: provide their own energy source for illumination, Figure 2. The active remote sensor usually emits its radiation directed at the target that needs to be examined. The sensor will detect and measure the radiation coming from this target. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors are ideal for observing Earth's surface features that require specific wavelengths, such as microwaves. They generate their own energy to illuminate targets, enabling data collection. Examples include LiDAR (Light Detection and Ranging) and Radar (Radio Detection and Ranging), which use artificial energy to gather information. Radar technology is commonly used for tracking aircraft from control towers, like those at Nigerian airports. LiDAR, on the other hand, can observe forests similarly to humans, detecting details like bare tree branches. However, the effectiveness of LiDAR systems in vegetation depends on the sample point length and density, with dense vegetation or insufficient sample length reducing the probability of generating accurate pulses.

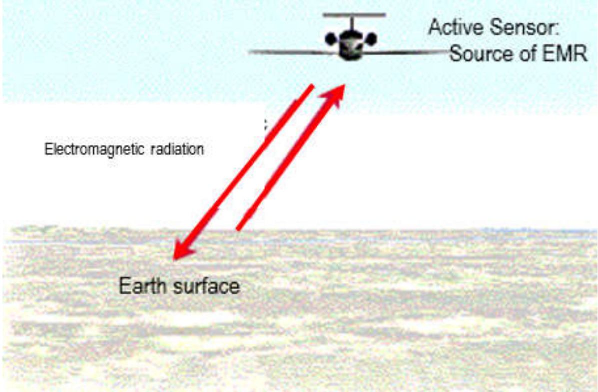

Figure 2: Active system of remote sensing

Remote sensing data originates from electromagnetic radiation emitted or reflected by objects, enabling the identification and classification of Earth's surface features. According to the United States Geological Survey (USGS), aerial and satellite imagery can reveal valuable information about landforms, vegetation, water bodies, and other features. These remotely sensed images facilitate accurate mapping of land-cover features at local, regional, continental, and global scales, enhancing our understanding of the Earth's surface.

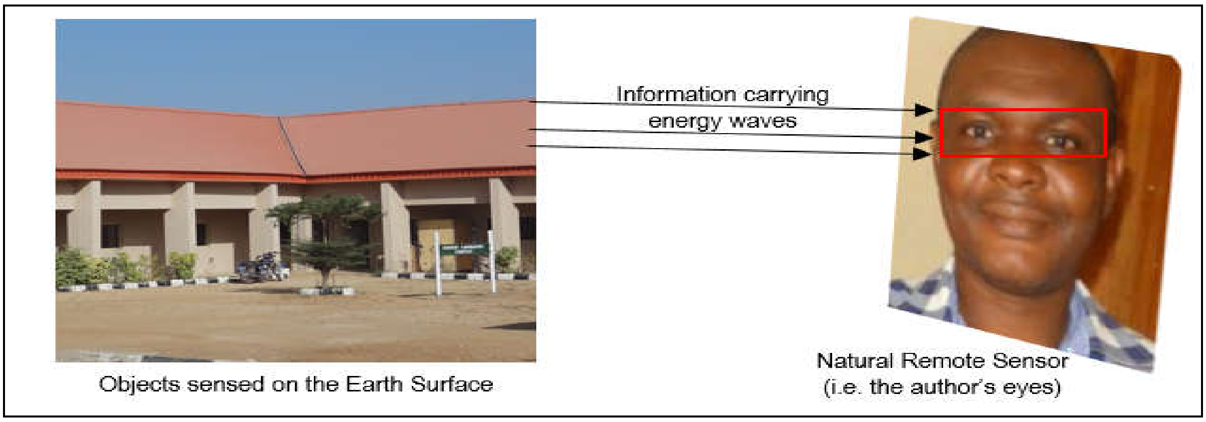

Figure 3: Conceptual Framework of the Remote Sensing Principle

The comparison of remote sensing images obtained at different times may be used to examine transient phenomena, such as seasonal vegetation growth and contaminant discharges. A standard photograph (Figure 3) is an image of a scene, phenomenon or object which resembles direct observations with our naked eyes. From Figure 3, we can see that the sky is blue; the tree is green and the roof, red. The colour sensation is as a result of the physics of Electro-Magnetic Radiation (EMR). Blue, green and red are a form of light energy. Light is an EMR that is visible to the human eye. In nature, the Sun emits light; the features on the surface of the Earth, reflect it; and the *cones* and *rods* (photo-sensitive cells of human eye), detect the reflected light. This is exactly the reason behind the differentiation of colours in Figure 3 (left), above. It is the light that is reflected from the building that lets us observe the roof to be red and the paint of the building to be beige (light brown). Furthermore, the Sun is not only the source of light but of heat, also. The heat that radiates from the sun warms and stimulates the production of Vitamin D in human bodies according to literature. In reality, the photograph (left) in Figure 3 was produced from the analogue and a record of reflected electromagnetic energy of the sky, laboratory building and the tree within a very narrow spectral range: The features (sky, building, etc.) become visible to us between 380 and 760 nm.

Electromagnetic Spectrum

As the objects/events being observed are located far away from the eyes, the information needs a carrier to travel from the object to the eyes (Figure 3). The visible light, a part of the electromagnetic spectrum, is the information carrier in this case. Consequently, without first understanding the electromagnetic spectrum, it is not possible to interpret the features captured on remotely sensed images, Figure 4. The CCRS asserts that, the electromagnetic spectrum consists of a range from short wavelengths, namely gamma and x rays to long wavelengths such as microwaves and broadcast radio waves. Electromagnetic Spectrum (EMS) is represented by electromagnetic waves. The electromagnetic spectrum is represented by electric waves. It is characterized by a wavelength or frequency which corresponds with its speed of light, as Figure 4 (right) shows. All radio waves, ranging from the low to the highest frequency of electromagnetic spectrum, such as those of radio and television, microwave, radar, infrared radiation, visible light, ultraviolet rays, X-ray and gamma ray are included. Nearly all frequencies and wavelengths of electromagnetic radiation can be used for spectroscopy.

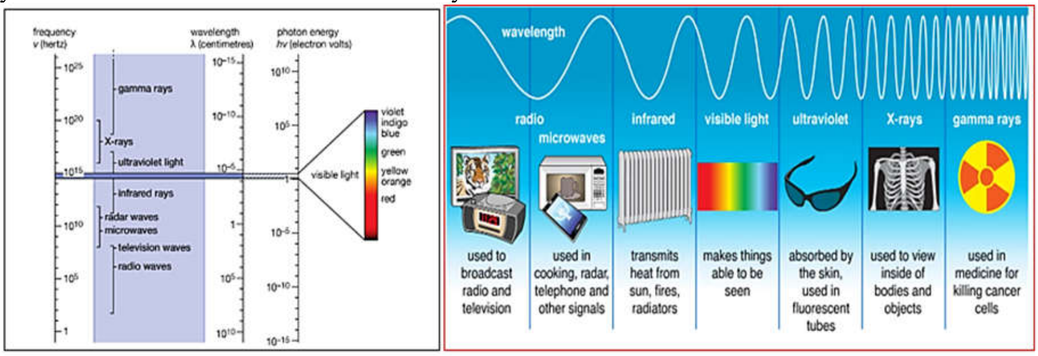

Figure 4: Electromagnetic spectrum, (left) and types of electromagnetic radiation (right) (Britannica, 2024)

One major advantage is that, electromagnetic spectrum enables the study of spectral bands. Again, a band[3] is defined as a portion of the electromagnetic spectrum sensed by a satellite. One can think of it as a colour, but often some of the bands will be in the infrared and invisible to the human eye. Figure 4 depicts the rainbow colour of blue light (occurring at a wavelength around 450nm), green light (600 nm) and red light (650 nm).

Types of electromagnetic energies useful in remote sensing

Remote sensing technology makes it possible to see the Earth's surface in a new way that reveals patterns which are normally invisible, thereby expanding our ability to detect electromagnetic energy beyond its visible band. The electro-magnetic radiation regions used in remote sensing are near UV (ultra-violet) (0.3-0.4 m), visible light (0.4-0.7 m), near shortwave and thermal infrared (0.7-14 m) and micro wave (1 mm - 1 m). Within this thermal infrared region are the middle wave infrared wavelength (MWIR) and longwave infrared wavelength (LWIR). Warm objects such as the Earth's surface are the source of these radiations. They are used for the measurement of Earth's land and sea surface temperature by satellite remote sensing.

Basically, electromagnetic radiation (consists of an electrical field (E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. These two fields travel at the speed of light (c). EM radiation occurring before the light wavelength of 380 nm is Ultra-violet (UV) which stimulates our bodies to generate Vitamin D through heat i.e. warmth (by thermal emission). EMR beyond the range of 760 nm is not visible to the human eye (i.e., the range within near-infrared).

COMPONENTS AND TYPES OF REMOTE SENSING

Components of Remote Sensing

i. **Platform:** A platform is the carrier of remote sensors. There are three main types:
   a. Ground-based platforms: Towers and cranes.
   b. Airborne platforms: Helicopters, low-altitude airships, and aircraft.
   c. Spaceborne platforms: Satellites, including space shuttles, polar-orbiting satellites, and geostationary satellites.

ii. **Remote Sensor**: A remote sensor is an electronic device that detects electromagnetic radiation and converts it into a recordable signal, which can be displayed as numeric data or images. In essence, any device that captures electromagnetic radiation (EMR) and turns it into an image —like a photograph or picture—is considered a remote sensor. Remote sensors are classified based on how they capture and output data:

a. **Photographic (analogue) sensors**: These record images as a whole at the moment of exposure, such as traditional cameras.

b. **Non-photographic (digital) sensors**: These capture images bit-by-bit, often referred to as scanners. Satellite remote sensing typically uses non-photographic sensors, and the interpreted data can be used to create maps.

iii. **Elements Involved In Remote Sensing:** The Seven Elements of Remote Sensing are illustrated in Figure 5.

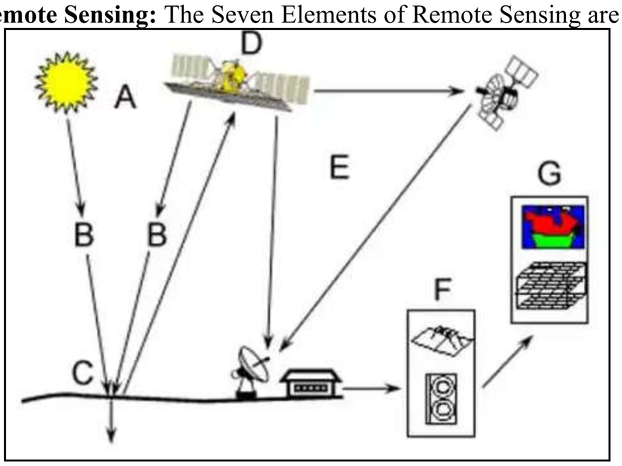

Figure 5: Elements Involved in Remote Sensing

Figure 5 is interpreted as follows:

1. **Energy Source or Illumination (A):** Remote sensing requires an energy source to illuminate the target.
2. **Radiation and the Atmosphere (B):** Energy interacts with the atmosphere as it travels to and from the target.
3. **Interaction with the Target (C):** Energy interacts with the target, depending on its properties.
4. **Recording of Energy by the Sensor (D):** A detector collects and records the electromagnetic radiation scattered or emitted by the target.
5. **Transmission, Reception, and Processing (E):** The recorded energy is transmitted to a processing station where it's converted into an image.
6. **Interpretation and Analysis (F):** The image is interpreted to extract information about the target.
7. **Application (G):** The extracted information is applied to better understand the target, reveal new insights, or solve a specific problem.

A. General Types of Remote Sensing Systems

i. **The Human Visual System: A Remote Sensing Example**

The human eye (Figure 6) is a natural remote sensing system. It has two types of sensors in the retina: cones and rods. **Cones** help us see colours and are sensitive to red, green, and blue light. This is why computer monitors use these same primary colours to display images. On the other-hand, **Rods** are more sensitive to light intensity and take over in low-light conditions. However, rods don't detect colours, which is why everything appears in shades of gray in dim light.

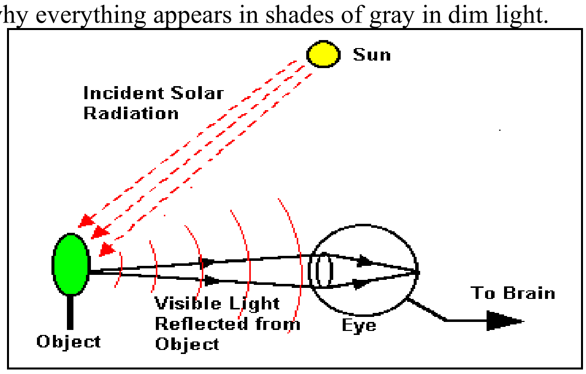

Figure 6: Visual System: The eyes passively senses the radiation reflected or emitted from the object. The sensing system depends on an external source of illumination.

ii. **Optical Remote Sensing**

Optical remote sensing uses sensors to detect reflected sunlight from the Earth's surface, creating images based on how different materials reflect light. Since materials reflect and absorb light differently at various wavelengths, we can identify them by their unique spectral signatures in the images. There are four types of optical remote sensing systems, classified by the number of spectral bands they use:

a) **Panchromatic**: Uses a single band to capture broad-spectrum images (e.g., Ikonos Pan).
b) **Multispectral**: Uses multiple bands to capture images in specific wavelengths (e.g., Landsat Operational Land Imager (OLI)).
c) **Super-spectral**: Uses many bands to capture detailed spectral information (e.g., MODIS).
d) **Hyper-spectral**: Uses hundreds of bands to capture very detailed spectral signatures (e.g., Hyperion).

iii. **Infrared Remote Sensing**

Infrared remote sensing uses infrared sensors to detect infrared radiation emitted from the earth's surface. The medium-wave infrared (MWIR) and the long-wave infrared (LWIR) are in the thermal infrared range. This radiation is emitted by warm objects such as the earth's surface.

iv. **Microwave Remote Sensing**

Microwave remote sensing uses wavelengths of about 1-100 centimeters to observe the Earth's surface. This technology can penetrate clouds and rain, enabling it to collect data in all weather conditions.

v. **RADAR (RAdio Detection And Ranging) Remote Sensing**

RADAR uses radio waves to detect and locate objects, and it's commonly used in remote sensing applications. For example, a satellite radar remote sensor uses long-wavelength energy that penetrates clouds and is sensitive to changes in the physical structure of vegetation. These properties represent great advantages for monitoring forest dynamics, especially in tropical regions with persistent cloud cover.

vi. **Satellite Remote Sensing**

Satellite sensors collect data from a distance by detecting energy reflected or emitted by the Earth. This includes various wavelength ranges, such as:

a) Microwave
b) Ultraviolet
c) Infrared
d) Visible light

These sensors are onboard satellites orbiting the Earth (Figure 7), distinguishing them from those on aircraft. They capture data without direct contact, thus, enabling us to monitor the Earth surface from space.

Figure 7: Types of Optical satellites in Orbit

vii. **Airborne Remote Sensing**

Airborne remote sensing uses sensors on aircraft to capture images of the Earth's surface, offering high-resolution imagery (20 cm or less) but with limited coverage and high costs, making it less suitable for large-scale mapping compared to satellites, which enable continuous monitoring.

viii. **Acoustic and Near-Acoustic Remote Sensing**

Acoustic waves carry information about their source and surroundings as they travel. Acoustic remote sensing covers a wide range of frequencies (0.01 to 10 million Hz) and distances (1 cm to 10,000 km), with applications in:

i. Biomedical imaging
ii. Non-destructive testing
iii. Oil and gas exploration
iv. Military systems

v. Nuclear monitoring

1. ADVANTAGES AND DISADVANTAGES OF REMOTE SENSING

Remote sensing has some great benefits and some drawbacks. Let's take a look:

i. **Advantages:**

2. **Ground Coverage**: Remote sensing can collect data from large areas on the ground surface.
3. **Easy and efficient**: It's a fast and simple way to gather information.
4. **Reaches remote areas**: We can collect data from places that are hard to reach area such as valleys and mountain tops.
5. **Saves money**: It's often cheaper than sending people to collect data.
6. **Creates maps quickly**: We can make maps fast using remote sensing data.

ii. **Advantages:**

1. **Requires expertise**: You need someone with special skills to understand the data.
2. **Too much data:** Having too much information can be confusing.
3. **Needs ground checks**: We have to verify the data on the ground to make sure it's accurate.
4. **Image problems**: Sometimes the sensor's movement can distort the images.

REMOTE SENSING APPLICATIONS

Brief Overview: Researchers have shown that remote sensing technology can be used in many important areas, such as tracking changes in urban trees (Ogbodo *et al*., 2020), monitoring forest health (Ogbodo *et al*., 2015), understanding how drought affects crops and prices (Ogbodo et al., 2019; Shuaibu *et al*., 2016), and measuring carbon emissions from deforestation (Ogbodo et al., 2024). These applications of remote sensing help achieve environmental management goals that align with global sustainability objectives (Ogbodo *et al*., 2021). Remote sensing tools also provide innovative solutions for monitoring agricultural crops (Zhai et al., 2025), tracking wildlife movement (Ascagorta *et al*., 2025; Craft, *et al*., 2025), and managing forages (Rapiya *et al*., 2025), effectively. Other applications of remote sensing include the following:

i. **Land Use Mapping**: Remote sensing data is useful for obtaining up-to-date land cover and land use patterns of large areas, as well as monitoring changes over time. This information can be used to update road maps, assess asphalt conditions, and delineate wetlands, ultimately informing policy decisions for regional development.

ii. **Classification of Forest Type**: Remote sensing offers a way to quickly identify and delineate different forest types, a task that would be difficult and time-consuming with traditional soil surveys. Data is available in various scales and resolutions to suit local or regional needs, enabling large-scale species identification and small-scale cover type delineation.

iii. **Agriculture**: Satellite and aerial imagery are used as mapping tools to classify crops, study their health and viability, and monitor agricultural practices. Remote sensing applications in agriculture include crop species classification, crop health assessment, yield estimation, soil property mapping, and monitoring of agricultural practices.

iv. **Surveying Wild Animals with Remote Sensors:** Remote sensing-based cameras are efficient and non-invasive tools for wildlife research and management (Figure 8). These cameras detect moving objects with different temperatures than the background, making them suitable for detecting mammals and birds. Satellite imagery (Figure 8) can also be used to track and monitor wildlife species in national parks or game reserves, allowing researchers to identify and analyze wildlife habitats for conservation and management purposes.

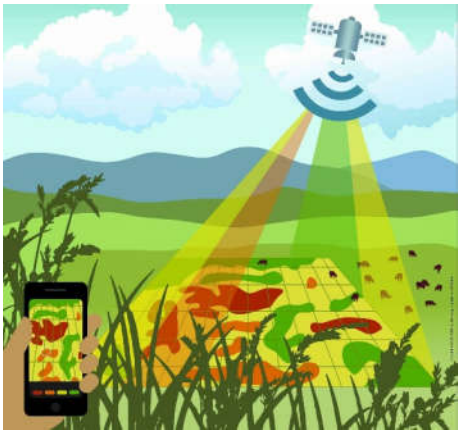

Figure 8: Example of remote sensors in form of cameras used in capturing wild animals in their natural habitat. Photo source: as indicated on the RHS

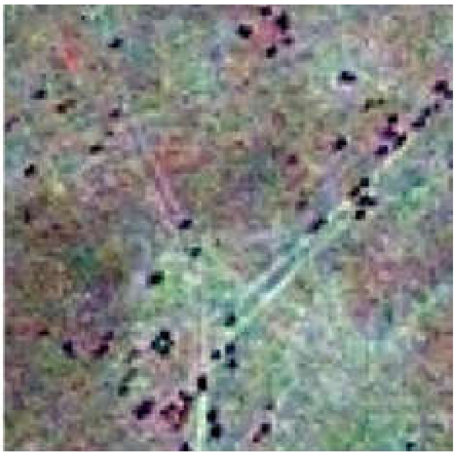

Figure 9: Migrating zebras (*Equus quagga*) as captured on a GeoEye-1 satellite image

CONCLUSION AND RECOMMENDATION

CONCLUSION

Remote sensing is a valuable technology that enables the gathering of information about the Earth's surface without physical contact. Its diverse applications in forestry, agriculture, hydrology, ecology, and geography underscore its importance in understanding our environment. By leveraging special cameras and remote sensors to collect and analyze remotely sensed images, researchers can gain valuable insights into the Earth's physical properties, ultimately supporting informed decision-making.

RECOMMENDATIONS

This paper serves as a comprehensive resource for educators and learners in forestry, wildlife, and agricultural sciences in Nigerian universities, supporting the achievement of the Centre for Continuing Management and Academic Services (CCMAS) goals and relevant objectives in the Nigerian university system.

REFERENCES

Ascagorta, O., Pollicelli, M. D., Iaconis, F. R., Eder, E., Vázquez-Sano, M., and Delrieux, C. (2025). Large-Scale Coastal Marine Wildlife Monitoring with Aerial Imagery. *Journal of Imaging,* 11(4), 94. https://www.mdpi.com/2313-433X/11/4/94

Britannica, (2024). Electromagnetic spectrum. Retrieved on April 24, 2025 from https://www.britannica.com/science/electromagnetic-spectrum

Craft, T. B., Piersma, T., Hooijmeijer, J. C., Zhu, B. R., D'Souza, M., O'Reilly, E., ... and Howison, R. A. (2025). Remote sensing and GPS tracking reveal temporal shifts in habitat use in nonbreeding Black-tailed Godwits. *Journal of Applied Ecology*, 62(1), 119-131. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.14827

FAO - Food and Agriculture Organization, (2018). World’s Forests, the Natural Inquirer. Retrieved on April 24, 2025 from https://www.fao.org/3/i0105e/i0105e.pdf

FAO - Food and Agriculture Organization, (2020). Terms and Definitions. Retrieved on April 24, 2025 from https://www.fao.org/3/I8661EN/i8661en.pdf

FAO– Food and Agriculture Organization, (2018). World’s Forests, the Natural Inquirer. Retrieved on April 24, 2025 from https://www.fao.org/3/i0105e/i0105e.pdf

FAO – Food and Agriculture Organization, (2020). Terms and Definitions. Retrieved on April 24, 2025 from https://www.fao.org/3/I8661EN/i8661en.pdf

GISGeography, (2022). Passive vs Active Sensors in Remote Sensing. Retrieved on April 24, 2025 from Example of Passive remote sensing: https://gisgeography.com/passive-active-sensors-remote-sensing/

Hearn, G. J. (2011). B2 Desk studies. Geological Society, London, Engineering Geology Special Publications, 24(1), 71-101. https://www.lyellcollection.org/doi/full/10.1144/egsp24.6#

Janssen, L.L.F., and Huurneman, G.C. (2001). Principles of Remote Sensing, Faculty ITC, University of Twente in Enschede, Netherlands. http://www.gdmc.nl/oosterom/PoRSHyperlinked.pdf

Martin, Prince (2018). "If you can't measure it, you can't manage it" - essential truth, or costly myth? World Psychiatry. 17(1):1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5775130/

Nandasena, W.D.K.V., Brabyn, L., Serrao-Neumann, S. (2022). Using Remote Sensing for Sustainable Forest Management in Developing Countries. https://link.springer.com/referenceworkentry/10.1007/978-3-030-38948-2_35-1#citeas

Ogbodo, J. A., Bichi, A. U. H., and Ogbodo, J. I. (2021). Analyzing the progress, pitfalls and prospects for attaining environmental-related sustainable development goals in Nigeria. Animal Research International, 18(1), 3990-4004. https://www.ajol.info/index.php/ari/article/view/206768

Ogbodo, J. A., Obimdike, L. M., and Benison, Y. (2020). Remote sensing for urban tree canopy change detection with Landsat satellite data in Nnamdi Azikiwe University Awka, Nigeria. *Indonesian Journal of Forestry Research*, 7(2), 99-112. http://ejournal.forda-mof.org/ejournal-litbang/index.php/IJFR/article/view/5759

Ogbodo, J. A., Obimdike, L. M., and Benison, Y. (2020). Remote Sensing For Urban Tree Canopy Change Detection with Landsat Satellite Data in Nnamdi Azikiwe University Awka–Nigeria. *Indonesian Journal of Forestry Research*, 7(2), 99-112. https://ejournal.aptklhi.org/index.php/ijfr/article/view/463

Ogbodo, J. A., Oke, D. O., and Dagba, B. I. (2015). The potential of synthetic aperture radar (SAR) imagery in automated detection of forest degradation features using visual and semi-automated analyses. Landuse, Landuse Change and Forestry, 57-77. https://www.researchgate.net/profile/John-Ogbodo-3/publication/293891400_The_Potential_of_Synthetic_Aperture_Radar_SAR_Imagery_in_Automated_Detection_of_Forest_Degradation_Features_Using_Visual_and_Semi-Automated_Analyses/links/56bcd86808ae6cc737c674d0/The-Potential-of-Synthetic-Aperture-Radar-SAR-Imagery-in-Automated-Detection-of-Forest-Degradation-Features-Using-Visual-and-Semi-Automated-Analyses.pdf

Ogbodo, J. A., Okeke, F. I., and Odey, P. O. (2024). Open-Source Remote Sensing Determination of Carbon Emissions from Tropical Deforestation Scenarios in Southeast Nigeria. Qeios. https://www.qeios.com/read/JZ21C6

Ogbodo, J. A., Wasige, E. J., Shuaibu, S. M., Dube, T., and Anarah, S. E. (2019). Remote sensing of droughts impacts on maize prices using SPOT-VGT Derived Vegetation Index. Climate Change-Resilient Agriculture and Agroforestry: Ecosystem Services and Sustainability, 235-255. https://link.springer.com/chapter/10.1007/978-3-319-75004-0_14

Okeke, F. I. (2006). InSAR operational and processing steps for DEM generation. *Promoting Land Administration and Good Governance*, 1-13. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=8kKfXrUAAAAJ&citation_for_view=8kKfXrUAAAAJ:IjCSPb-OGe4C

Parra, Lorena. (2022). "Remote Sensing and GIS in Environmental Monitoring" Applied Sciences 12, no. 16: 8045. https://www.mdpi.com/2076-3417/12/16/8045#:~:text=Remote%20sensing%20and%20GIS%20in%20the%20urban%20area%20can%20be,where%20to%20build%20new%20structures

Rapiya, M., Ramoelo, A., and Truter, W. (2025). Seasonal monitoring of forage C: N: ADF ratio in natural rangeland using remote sensing data. Environmental Monitoring and Assessment, 197(2), 137. https://link.springer.com/article/10.1007/s10661-024-13579-x

Shuaibu, S. M., Ogbodo, J. A., Wasige, E. J., and Mashi, S. A. (2016). Assessing the impact of agricultural drought on maize prices in Kenya with the approach of the SPOT-VEGETATION NDVI remote sensing. Future of Food: Journal on Food, Agriculture and Society, 4(3), 8-18. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Assessing+the+impact+of+agricultural+drought+on+maize+prices+in+Kenya+with+the+approach+of+the+SPOT-VEGETATION+NDVI+remote+sensing&btnG=#d=gs_cit&t=1745483778084&u=%2Fscholar%3Fq%3Dinfo%3AVIaVLFAE10QJ%3Ascholar.google.com%2F%26output%3Dcite%26scirp%3D0%26hl%3Den

University of Wisconsin and University of Washington, (2010). Resolutions in remote sensing. Accessed on April 24, 2025 from https://cimss.ssec.wisc.edu/sage/remote_sensing/lesson3/concepts.html

Zhai, W., Cheng, Q., Duan, F., Huang, X., and Chen, Z. (2025). Remote sensing-based analysis of yield and water-fertilizer use efficiency in winter wheat management. Agricultural Water Management, 311, 109390. https://www.sciencedirect.com/science/article/pii/S0378377425001040