Geography Year 1

SECTION 9

# METHODS OF COLLECTING GEOSPATIAL DATA

# NAVIGATING OUR ENVIRONMENT

## Geospatial Data Collection, Representation, and Interpretation

### Introduction

This section studies the types of geospatial data and the ways in which it is collected, including by people on the round, remote sensing, GPS, aerial photography, satellite imaging, and surveying. It highlights their advantages, such as accurate and efficient data collection, and their challenges, like costs and data interpretation complexities. The section emphasises the importance of these methods for applications in urban planning, environmental management, and disaster response.

**At the end of this section, you will be able to:**

- Discuss the methods of collecting geospatial data (surveying, remote sensing, and GPS).
- Assess the geospatial data collection tools.

### Key Ideas

- Geospatial data is information that includes a geographic location. It relates to the position of natural features like landforms, water bodies, and vegetation, as well as human-made structures like roads, buildings, and public transport. It is any data connected to a specific place on or near the Earth's surface.
- Raster, vector and attribute are different types of geospatial data.
- Some of the tools used to collect geospatial data are Remote Sensing (RS) using drones and, Global Positioning Systems (GPS) which uses satellites.
- Geospatial data is used by agriculture and forestry as well as for disaster monitoring, urban planning, and road building.
- Traditional geospatial data collection uses people to make field visits, take measurements and observations, complete sketches and use manually operated mapping tools for data collection.
- Modern geospatial data collection involves the use of satellites, aircraft, ships, unmanned drones, and remotely controlled vehicles data collection.
- Modern geospatial data collection tools offer accurate data and rapid data collection and processing on both local and global scales. Additionally, these tools enhance data visualisation, making it easier to interpret complex information.

# METHODS OF COLLECTING GEOSPATIAL DATA

## Meaning of Geospatial Data

Geospatial data is information that includes a geographic location. It relates to the position of natural features like landforms, water bodies, and vegetation, as well as human-made structures like roads, buildings, and public transport.

## Types of Geospatial Data

1. **Vector Data:** In vector data, points, lines, and polygons (irregular shapes) represent features. For example, houses can be represented by points, roads by lines, blocks of houses or entire towns by polygons. Here is an example of vector data to show point line and polygon representations:

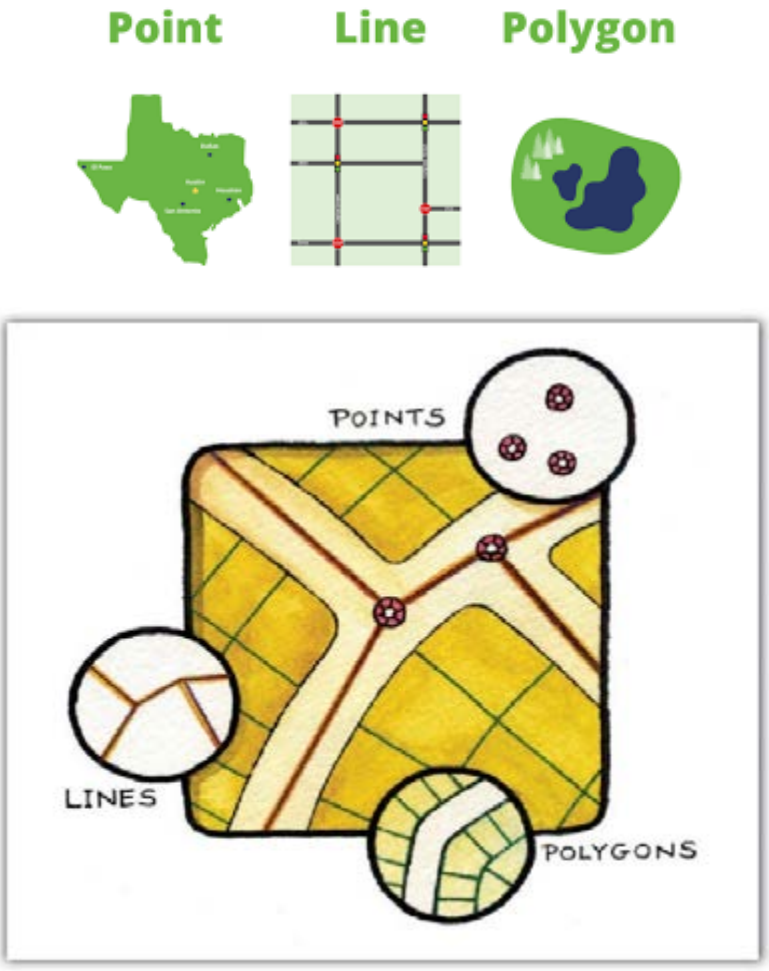



**Fig. 9.1:** Vector Data Models (saylordotorg.github.io)

2. **Raster Data**: Raster data consists of pixelated or gridded cells identified by rows and columns. It is used for more complex imagery, such as photographs and satellite images. Here is an example of raster data at three different magnifications. In the first image the human eye cannot see the pixels:

**Fig. 9.2:** Different resolutions (cell size) of the same raster image

3. **Attribute data:** Attribute data refers to information that describes the characteristics of geographic features. For example, in a map showing different types of trees, the attribute data might include the species, height, and age of each tree. This data helps provide context and details about the features represented in geospatial data, making it easier to analyse and understand the information.

## Tools for Collecting Geospatial Data

Geospatial data collection methods include both traditional and modern approaches. Traditional methods, like cartography and field surveys, rely on human input on the ground, physical maps, and tools such as tape measures and chains. Maps produced often need redrafting. Modern methods, such as GPS, remote sensing, GIS, drones, satellites, and Total Stations, use digital data for immediate updates and map creation. Modern tools are preferred for their accuracy, convenience, and efficiency. This section discusses various geospatial tools and methods, highlighting their advantages and challenges.

1. **Field Survey Methods and Ground-Based Sensing Systems:** Field surveys involve manually collecting data in the field, using both traditional surveying instruments and modern data collection technologies like total stations, theodolites, measuring tapes, mobile phones, tablets, and advanced GPS Systems. Ground-based sensors, such as weather stations or air quality monitors, theodolites, sounders, and spectrometers, gather specific environmental data.

2. **Remote Sensing:** It is the process of collecting data about an object or area without being in physical contact with it. Remote sensing data can be collected from ground-based platforms, airborne or space-borne systems. The airborne systems include the use of aircraft mounted with detectors and Unmanned Aerial Vehicles (UAVs) (Drone).

**Fig. 9.3:** Aerial Photograph (Jeffrey Milstein, 2020)

3. **Global Positioning System (GPS)**: It is a satellite-based radio navigation system used on land, sea, and air to determine the exact location, time, and velocity information on Earth, irrespective of the weather conditions. This is one of the modern ways of gathering geospatial data. They are usually linked to satellites which send the information to the GPS device. GPS systems are used in mobile phones.


**Fig. 9.4:** Handheld GPS (Copilot AI, 2024)

4. **Geographic Information System (GIS):** It is a computer-based system designed to capture, store, analyse, manipulate, and present geospatial data. GIS systems combine hardware and software to manage and analyse various types of data (spatial and attribute) tied to specific locations on the Earth's surface. GIS software includes ArcGIS, QGIS, GRASS GIS, MapInfo Pro, GeoServer and Google Earth Pro.

5. **Satellite Imagery:** This refers to images of the Earth's surface captured by satellites orbiting the Earth. It is a vital tool in geospatial data collection, providing valuable information for various applications. Satellites carry sensors that detect and record reflected and emitted energy from the Earth surface storing it as data. The captured data is then transmitted back to receiving stations on Earth, processed to create digital images, and made available for analysis.

**Fig. 9.5:** Satellite image (Burkhard Boeckem, 2020)

6. **Mobile Mapping Systems:** This involves the collection of data from a moving vehicle fitted with various sensing devices, including Global Navigation Satellite Systems (GNSS), use cameras, radar and scanners including Light Detection and Ranging (LiDAR) technology. Handheld devices like mobile phones can be used to take geospatial information while on the move in the street, along a road, beach or at the marketplace.


**Fig. 9.6.:** Mobile mapping system (Sameer Khan, 2023)

Visit the link below to watch a video on the use of mobile mapping

https://youtu.be/16QfEZX2Uz4

If you cannot access the link, visit your school or community library for assistance

## Uses of different types of Geospatial Data:

1. **Satellite Imagery**: Derived from satellites orbiting or going around the Earth. This data provides detailed views of the planet's surface like the images found on Google Maps or Google Earth. Satellite data are used in monitoring clouds, rainfall, navigation, photography, and other environmental-related features.
2. **GPS Data**: Collected from global positioning systems, it helps track locations accurately. Smartphones use this technology by processing three signals from a satellite to work out positions on the Earth's surface and a fourth to work out height above sea level. GPS helps in determining a position, getting from one location to another, monitoring objects or personal movement, creating maps and making it possible to take precise time measurements.
3. **Remote Sensing Data**: Captured by sensors on aircraft or satellites, it provides information about land cover, including vegetation, crop production, ice masses, and volcanic lava flows. For example, large forest fires can be mapped from space for easier management, can be used to track clouds to help predict the weather, and also, monitor and watch erupting volcanoes to issue early warnings to those who are likely to be affected.
4. **Address Point data**: Captured by satellites and remote sensing methods. Specific locations are represented by coordinates (latitude and longitude). Provides information on exact locations on roads and streets, for example, digital address systems in Ghana. It is also used by international postal services.
5. **Map data:** Captured by satellites, and remote sensing methods. Geospatial data is fundamental for creating digital and paper maps that visualise spatial relationships and patterns. Map data helps to locate features, as a reference to show political boundaries, landforms, water bodies, and the positions of settlements. Map data also helps us to know the routes of an area, landmarks, location (latitudes and longitudes) of a building and spatial spread of features.

## People, Organisations and Geographical Fields that make use of Geospatial Data:

1. **Mapping and Cartography:** Geospatial data forms the foundation of digital maps and cartographic products, enabling accurate representation of geographical features and their attributes. Previously, maps were manually drawn by cartographers. With the emergence of modern geospatial data tools, most maps are now digitally produced.
2. **Environmental Monitoring:** With rapidly changing geographical phenomena, geospatial data helps environmentalists in countries to monitor changes in the environment. These changes may be caused by different land use, variations in vegetation cover, urban and agricultural land use, and natural disasters.
3. **Urban Planning:** Geospatial data assists urban planners with urban development by providing insights into population density, infrastructure, transportation networks, and land use patterns. As the population increases and settlements

expand, it becomes necessary to plan well to make sure the population growth keeps pace with the growth of towns and cities, geospatial data is needed to manage the direction of the city growth about the location of essential facilities.

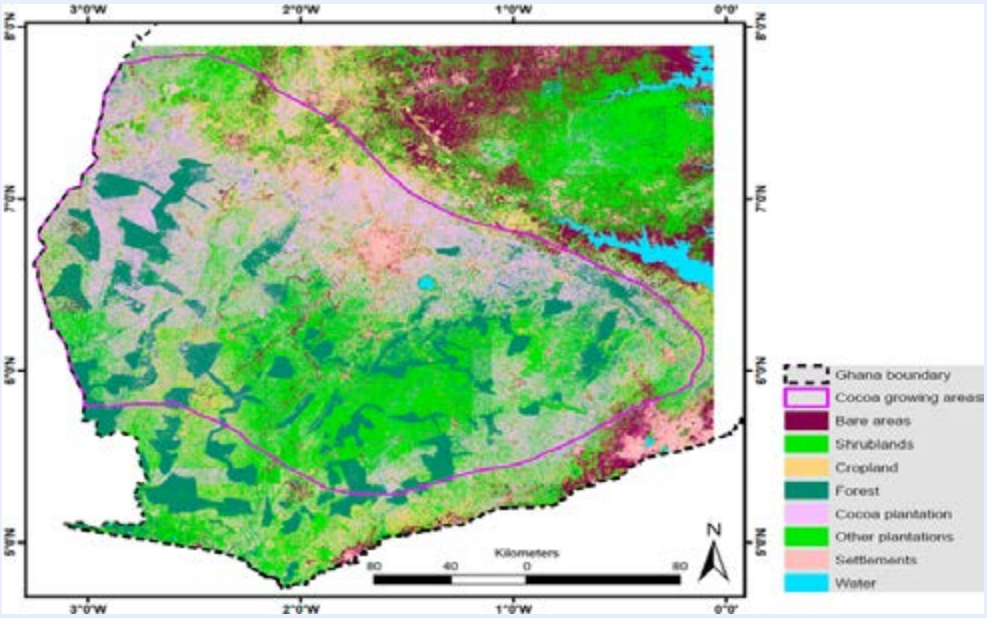
4. **Agriculture:** Geospatial data is used by farmers in agriculture. In this regard, the location of farms and other agricultural activities are based on specific field conditions and environmental factors. Geospatial data can assist in making decisions on such issues.
5. **Natural Resource Management:** Geospatial data helps governments and private organisations in managing and monitoring natural resources like forests, water bodies, minerals, and wildlife. Ghana's natural resources can be harnessed with the help of geospatial data, it helps to locate these resources, their quantities, spread and distribution, including environmental factors.
6. **Emergency Response and Disaster Management:** Geospatial data aids emergency services in assessing the impact of disasters, planning evacuation routes and coordinating relief efforts. When there is a disaster, geospatial data is used to find the location and distribution of such disasters to help manage them.
7. **Transportation and Logistics:** Geospatial data is vital for route planning, location-based services and optimising transportation and logistics operations. It is used in aviation and navigation as well as other means of transport.
8. **Utilities and Infrastructure:** Geospatial data assists companies and governments in managing utility networks such as electricity, water, and telecommunications, and in planning infrastructure development projects. In Ghana, geospatial data is used by utility companies like Ghana Water Company, Electricity Company of Ghana, and Telecommunications companies.
9. **Decision Support System:** Geospatial data allows simulation of the future outcome of today's decisions, using '*what if scenarios*'. An example might 'how much forest can be cut down without having a serious impact on river flows and flooding?' Based on observed outcomes of different scenarios, decision-makers chose the one with the least impact.

## Activity 9.1

1.
   a. Measure the perimeter of a sports field, classroom or a local park with either of the following traditional geospatial tools.
      i. Tape measure
      ii. Paces when walking
   b. Make a map or plan using your measurements. Add the distances.
   c. Share the plan with a friend and discuss how accurate it is.

2. Using a mobile phone, record the coordinates of some of the features like large trees or buildings near your school or home. You will need to have a map app like Google Maps. If you have the Google Maps app follow these instructions:
   a. Open the Google Maps app.
   b. Tap and hold on the location you want to find coordinates for until a red pin appears.
   c. Swipe up from the bottom to see the coordinates in the search bar.

3. The image below is a digital aerial photograph of Cocoa growing areas in Ghana. Use it to do the following activities.




   i. Identify any three human features or activities using the latitude and longitudes as coordinates.
   ii. Identify any three natural features using the latitude and longitudes as coordinates.

4. Here are three modern geospatial data tools:
   a. GPS (Global Positioning System)
   b. LiDAR (Light Detection and Ranging)
   c. GIS (Geographic Information System)

Either on your own, with a friend, or in a small group which your teacher has selected, research what data each of these methods/tools can collect. Present your information digitally using images or clips from the Internet. Your teacher will guide you on ways to collect and present information.

# ASSESSING THE GEOSPATIAL DATA COLLECTION TOOLS

In the earlier part of the section, you found out what geospatial data was, the tools employed to collect it and how it can be used by people and organisations. In part of the section, you will discover the advantages and disadvantages of the methods and tools for collecting geospatial data.

## The Advantages and Disadvantages of Geospatial Data Collection Methods/Tools

### Traditional Geospatial Data Collection Methods

Traditional geospatial data collection involves physical measurements and observations using long-established tools and techniques although modern handheld devices like Total Stations (advanced surveying instruments that combine electronic distance measurement and angle measurement to provide precise location data. They are commonly used in construction and land surveying). Key steps include field visits, measurement, and observation, sketching and mapping, and data compilation and analysis. Modern geospatial tools, such as GPS and remote sensing, offer greater accuracy, efficiency, and wider area coverage, making them preferred methods for data collection today.

### Modern Geospatial Data Collection Methods

Modern geospatial data collection uses various technologies to observe and measure locations. These technologies include:

- GPS (Global Positioning System): Helps determine exact locations on Earth.
- Drones and UAVs (Unmanned Aerial Vehicles): Fly over areas to capture images and data.
- Remote Sensing Imagery: Uses satellites and sensors to take pictures and gather information from a distance.

These tools have become common in collecting data about places.

## Advantages of Modern Geospatial Data Collection Tools

1. **Accuracy:** Provides precise location information for better mapping and analysis.
2. **Speed:** Enables rapid data collection and processing for real-time monitoring and quick decision-making.
3. **Coverage:** Gathers information over large areas efficiently, useful for land management and geological studies.
4. **Integration:** Combines data from various sources for a comprehensive understanding of places and problems.

5. **Affordability:** More accessible to a wider range of organisations, including small businesses and charities.
6. **Enhanced Detection:** Uses technologies like drones and UAVs to detect details invisible to the human eye.
7. **Monitoring:** Regularly checks the same areas to track changes over time, such as deforestation or urban growth.
8. **Accessibility:** Provides information about hard-to-reach places, like remote wilderness areas.
9. **Availability:** Offers images of any part of the world on demand.
10. **Efficiency:** Simplifies and accelerates the creation and updating of maps for better understanding and interpretation.

## Disadvantages of modern geospatial data collection tools

1. **High cost of equipment**: The cost of some geospatial data collecting tools like LiDAR, Drones and satellites is high, which can make it hard for smaller companies or individuals to get access to them.
2. **Lack of technical knowledge**: Modern geospatial data collection tools need some technical knowledge or the training to operate them. A mobile phone with a map app is easy to learn how to use while GIS software needs a high level of skill.
3. **Short lifespan hand-held accessories**: Handheld geospatial data collection tools need batteries, particularly those used in remote locations without electricity supply. The life span of these batteries without points for charging them can be limited, making data collection unreliable.
4. **Poor Internet facilities**: Most modern geospatial tools need to be connected to the Internet for synchronising, sending or storing data to the cloud, this is a problem if you are in a remote area which has no Internet provider service.
5. **High-resolution geospatial data**: Data volumes can be large and require substantial storage capacity and complex management solutions.
6. **Privacy:** Some governments and environmental organisations have concerns about the misuse of the data which has been collected.

### Activity 9.2

1. Carefully read through the ten advantages of modern geospatial data collection tools.

   **Select the Top Five Advantages:** Choose the five advantages you believe are the most impactful or beneficial.

**Rank the Advantages:** Assign a rank from 1 to 5 to each of the selected advantages, with 1 being the most important and 5 being the least important among the top five.

**Explain the Ranking:** Provide a brief explanation for each ranking, detailing why you believe one advantage is more important than another.

2. The local environmental protection community group has asked your advice on the advantages and disadvantages of using geospatial data collection tools to map land use to identify areas where protection schemes need to be set up. Write an email explaining to them what tools are available, how they can produce the type of images which would help them and outline their advantages and disadvantages.

**What did I learn?**

# Review Questions

## REVIEW QUESTIONS 9.1: METHODS OF COLLECTING GEOSPATIAL DATA

1. Name and describe three types of geospatial data.
2. Name and describe three modern methods of collecting geospatial data.
3. Describe two uses of geospatial data.
4. How do the following people or organisations make use of geospatial data?
    a. Cartographers
    b. Farmers
    c. Urban Planners
    d. Governments
5. Identify any uses for geospatial data which could benefit your community.

## REVIEW QUESTIONS 9.2: ASSESSING THE GEOSPATIAL DATA COLLECTION TOOLS

1. Explain why modern geospatial tools are preferred over traditional tools to collect data from wide geographical areas.
2. List three important advantages of modern geospatial data collection tools
3. List three important disadvantages of modern geospatial data collection tools
4. What steps would you take when collecting geospatial data using handheld tools in a remote area of Ghana?

# Answers to Review Questions

## ANSWERS TO REVIEW QUESTIONS 9.1: METHODS OF COLLECTING GEOSPATIAL DATA

1. Types of Geospatial Data:
   **Vector Data:** Represents geographic features using points, lines, and polygons. Examples include maps showing cities (points), roads (lines), and boundaries (polygons).

   **Raster Data:** Consists of pixelated or gridded cells, often used for images like satellite photos and aerial imagery. Attribute data refers to information that describes the characteristics of geographic features. For example, in a map showing different types of trees, the attribute data might include the species, height, and age of each tree.

2. Modern Methods of Collecting Geospatial Data:
   - **GPS (Global Positioning System):** Uses satellites to provide precise location data anywhere on Earth.
   - **LiDAR (Light Detection and Ranging):** Uses laser pulses to create detailed 3D maps of the Earth's surface.
   - **Drones:** Equipped with cameras and sensors, drones capture high-resolution images and data from above.

3. Uses of Geospatial Data:
   - **Urban Planning:** Helps planners design and manage urban spaces by analysing spatial data on land use, infrastructure, and population density.
   - **Environmental Management:** Monitors natural resources, tracks changes in ecosystems, and manages conservation efforts.

4. Uses of Geospatial Data by Different People/Organisations:
   - **Cartographers:** Use geospatial data to create accurate and detailed maps, incorporating various geographic features and attributes.
   - **Farmers:** Utilise geospatial data for precision agriculture, optimising crop yields by analysing soil conditions, weather patterns, and crop health.
   - **Urban Planners:** Rely on geospatial data to plan and develop urban areas, ensuring efficient land use, transportation networks, and public services.
   - **Governments:** Use geospatial data for policy making, disaster management, infrastructure development, and public service delivery.

5. Uses for Geospatial Data Benefiting the Community:
    - **Emergency Response:** Enhances the efficiency of emergency services by providing accurate location data for incidents and resources.
    - **Public Health:** Helps track disease outbreaks and plan healthcare services by analysing spatial patterns of health data.
    - **Infrastructure Development:** Assists in planning and maintaining public infrastructure like roads, utilities, and public facilities.

## ANSWERS TO REVIEW QUESTIONS 9.2: ASSESSING THE GEOSPATIAL DATA COLLECTION TOOLS

1. Why Modern Geospatial Tools are Preferred

    Modern geospatial tools are preferred over traditional tools for collecting data from wide geographical areas because they offer:

    - **Higher Accuracy:** They provide precise and reliable data.
    - **Faster Data Collection:** They enable real-time data gathering and processing.
    - **Broader Coverage:** They can efficiently cover large and remote areas.
    - **Integration Capabilities:** They combine data from multiple sources for comprehensive analysis.
    - **Cost-Effectiveness:** They have become more affordable and accessible.

2. Three Important Advantages are:
    - **Accuracy:** Provides precise location information, essential for detailed mapping and analysis.
    - **Speed:** Allows for rapid data collection and real-time monitoring, crucial in emergencies.
    - **Coverage:** Efficiently gathers data over large areas, useful for land management and environmental monitoring.

3. Three Important Disadvantages are:
    - **Cost:** Initial setup and maintenance can be expensive.
    - **Technical Expertise:** Requires skilled personnel to operate and interpret data.
    - **Data Privacy:** Potential concerns over the misuse of collected data.

4. Steps for Collecting Geospatial Data in Remote Ghana

**Preparation:** Ensure all equipment (GPS devices, handheld tools) is charged and functional.

**Safety Measures:** Carry essential supplies (water, food, first aid kit) and ensure communication devices are operational.

**Data Collection:** Use handheld GPS devices to collect location data. Take notes and photographs for additional context.

**Data Verification:** Regularly check data accuracy and completeness. Backup data frequently.

**Post-Collection:** Analyse and process the collected data. Share findings with relevant stakeholders and local communities.

## Extended Reading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