NO PREP

GIS and Digital Mapping

Archaeology Meets Big Data

Includes: Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

GIS and Digital Mapping: Archaeology Meets Big Data

What Is GIS and Why Archaeologists Love It

Geographic Information Systems, universally known as GIS, have transformed how archaeologists record, analyze, and share spatial data. At its core, a GIS is a computer system that stores, manages, and analyzes data linked to geographic locations. Think of it as a smart map that knows not just where things are, but what they are, when they existed, and how they relate to other features in the landscape. Every artifact, structure, soil layer, and environmental feature recorded during an excavation can be entered into a GIS as a data point with its precise coordinates, description, and associated information. Before GIS, archaeological

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Building a Digital Map of the Past

The process of creating an archaeological GIS begins with georeferencing, which means assigning real-world geographic coordinates to every data point. During excavation, the position of every significant find is recorded using instruments like total stations or GPS units, which can measure positions to within a few centimeters. This data is then imported into the GIS along with associated information: what was found, what layer it came from, its condition, its date, and any other relevant details. The result is not just a map but a database that can be queried and analyzed. An archaeologist might ask the GIS to show all bronze objects from a particular century, or all hearths within fifty meters of a water source, or all sites where a specific pottery type has been found. The GIS retrieves the relevant data points and displays them on the map, allowing the researcher to see spatial patterns that might not be apparent from looking at the raw data in a spreadsheet. GIS also enables spatial analysis, which uses mathematical and statistical methods to identify meaningful patterns in geographic data. Nearest-neighbor analysis can determine whether artifacts are clustered, dispersed, or randomly distributed. Viewshed analysis can calculate what was visible from any given point in the landscape, which is useful for understanding why defensive sites were placed where they were. Cost-surface analysis can model the easiest routes through a landscape, helping archaeologists predict where ancient roads and trails might have run. These analytical capabilities make GIS far more than a fancy mapping tool. It is a research instrument that generates new hypotheses and answers questions that could not have been asked before the technology existed. When archaeologists say that GIS has changed their discipline, they do not just mean that their maps look nicer. They mean that GIS has changed the kinds of questions they can investigate and the kinds of answers they can find.

Predicting Where Sites Are Hidden

One of the most powerful applications of GIS in archaeology is predictive modeling. By analyzing the locations of known archaeological sites in relation to environmental features like water sources, soil types, elevation, slope, and vegetation, GIS can identify areas with similar characteristics where undiscovered sites are likely to exist. This approach, sometimes called predictive modeling or archaeological sensitivity mapping, helps archaeologists and land managers focus their survey

efforts on the areas most likely to contain sites. Predictive models have proven remarkably effective. In the Netherlands, GIS models predicted the locations of buried Neolithic and Bronze Age sites in the Rhine-Meuse delta with accuracy rates above 80 percent. In the American West, predictive models have guided survey crews to previously unknown pueblo sites by identifying terrain with the right combination of water access, arable soil, and defensive position. Even in urban settings, predictive models have helped city planners anticipate where construction projects are likely to encounter archaeological remains. The approach is not without controversy. Some archaeologists argue that predictive models are inherently biased because they are based on the locations of already-known sites, which may not represent the full range of past human activity. If ancient people sometimes settled in unexpected locations, those sites would never be predicted by a model trained on typical settlement patterns. There is also a concern that over-reliance on predictive models could lead to under-surveying areas that the model rates as low probability, potentially missing important sites. Despite these debates, predictive modeling has become an essential tool in cultural resource management, the branch of archaeology that deals with protecting sites from destruction by development. When a highway, pipeline, or housing development is planned, CRM archaeologists use GIS models to identify which portions of the project area are most likely to contain archaeological sites, allowing them to target their limited survey time and budget where it will do the most good.

Data That Saves Sites

Beyond research, GIS plays a critical role in archaeological site management and heritage protection. Many countries and states maintain GIS databases of known archaeological sites, which are consulted whenever development projects are proposed. In the United States, State Historic Preservation Offices maintain digital inventories of tens of thousands of sites, and developers are required by law to check these databases before breaking ground. This system has prevented the destruction of countless archaeological sites that would otherwise have been bulldozed without anyone knowing they were there. GIS data is also used to monitor the condition of known sites over time. By comparing GIS records from different years, heritage managers can detect erosion, encroachment by development, looting, and other threats. When combined with satellite imagery and aerial photography,

GIS provides a comprehensive monitoring system that covers vast areas more efficiently than periodic on-the-ground inspections. The digitization of archaeological records into GIS has also transformed how knowledge is shared. Researchers anywhere in the world can access digital site databases, download spatial data, and conduct analyses without traveling to the site or the archive. Open-access GIS projects, such as the Digital Archaeological Record (tDAR) and Open Context, make archaeological data freely available to researchers, students, and the public. This democratization of archaeological data is one of the most significant developments in the field in recent decades, breaking down the barriers that once kept archaeological knowledge locked away in obscure reports and institutional archives.

Key Information: GIS in Archaeology

Feature	Details
What GIS stands for	Geographic Information Systems
Core function	Stores, manages, and analyzes data linked to geographic locations
Georeferencing	Assigning precise real-world coordinates to every data point
Spatial analysis	Mathematical methods to identify patterns in geographic data (clustering, viewsheds, cost-surfaces)
Predictive modeling	Uses known site locations and environmental data to predict where undiscovered sites may exist
CRM application	Cultural Resource Management uses GIS to protect archaeological sites from development
Data sharing	Open-access platforms like tDAR and Open Context make archaeological GIS data freely available
Key advantage	Combines multiple data layers (artifacts, geology, surveys, imagery) into one analyzable system

Case Study: Rerouting the Highway

City planner Tomoko Hayashi stared at the GIS screen displaying the proposed route for Highway 47, a four-lane bypass intended to relieve congestion around the growing city of Riverside. The red line of the proposed route cut directly through a zone highlighted in orange on the archaeological sensitivity map, an area that the GIS predictive model rated as having a high probability of containing buried archaeological sites. The model had flagged the zone because of its proximity to a documented creek confluence, its well-drained soil, and its gentle south-facing slope, all factors associated with prehistoric settlement in the region. "We need to survey this area before we break ground," Tomoko told the highway commission. "If there are buried sites here, we are legally required to mitigate the impact." A CRM team spent three weeks surveying the flagged area and found exactly what the model predicted: a previously unknown prehistoric village site with stone tools and pottery fragments scattered across two acres. "We can shift the route 300 meters east and avoid the site entirely," Tomoko proposed. "It adds two million dollars to the project but avoids the legal and ethical costs of destroying a significant archaeological site." The commission approved the change.

1. Based on the reading, explain how the GIS predictive model identified the area near Highway 47 as likely to contain archaeological sites. What specific environmental factors did it use?

2. How does Tomoko's situation demonstrate the practical value of GIS for cultural resource management? What might have happened if the predictive model had not existed?

Multiple Choice

1. What makes GIS more than just a digital map?

    a) It uses satellite imagery exclusively

    b) It stores data linked to locations that can be queried and analyzed computationally

    c) It replaces the need for physical excavation and other systematic site survey methods

    d) It only works with archaeological data

2. What is georeferencing in the context of GIS?

    a) Assigning precise real-world geographic coordinates to every data point

    b) Drawing maps by hand using geographic reference books and site field notes

    c) Referencing geographic textbooks when writing site reports

    d) Using Google Earth to find archaeological sites

3. Why is GIS predictive modeling controversial among some archaeologists?

    a) It requires access to classified satellite data

    b) It has never correctly predicted any site location in a real archaeological study

    c) It is too expensive for most research projects

    d) Its models are based on known sites and may miss sites in unexpected locations

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ GIS	A) Mathematical methods used to identify meaningful patterns in geographic data
2. ___ Spatial Analysis	B) Numerical values that specify the exact position of a point on the earth's surface
3. ___ Predictive Model	C) The process of assigning real-world geographic positions to data points in a digital system
4. ___ Coordinates	D) A computer system that stores, manages, and analyzes data linked to geographic locations
5. ___ Georeferencing	E) A tool that uses known site locations and environmental factors to predict where undiscovered sites may exist

Fill-in-the-Blank

1. GIS stands for Geographic _____ Systems, a technology that stores and analyzes data linked to locations.

2. The branch of archaeology that uses GIS to protect sites from destruction by development is called _____ resource management.

3. Open-access platforms like tDAR and _____ make archaeological GIS data freely available to researchers and the public.

Short Answer

Answer each question in 2-4 complete sentences.

1. How has GIS changed the way archaeologists study spatial patterns at sites? Give a specific example of a question that GIS can answer that would be difficult to answer using traditional paper maps.

2. Explain the concept of predictive modeling in archaeology. Why is it useful, and what are its limitations?

3. The reading describes GIS as a tool that democratizes archaeological knowledge. What does this mean, and why is it important for the field of archaeology?