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Applications of Modern Geospatial Technologies (GTs) in Archaeology: Global and Sri Lankan Practices

U. Jinadasa[1*], N. Senarath[2], S. Subasinghe[3] and K. Asanga[4]
[1]*Department of Archaeology, Faculty of Arts, University of Peradeniya, Peradeniya, Sri Lanka*
[2]*Department of Indigenous Social Sciences, Faculty of Indigenous Social Sciences and Management Studies, Gampaha Wickramarachchi University of Indigenous Medicine, Yakkala, Sri Lanka*
[3]*Department of Geography, Faculty of Arts, University of Peradeniya, Peradeniya, Sri Lanka*
[4]*Department of Archaeology, Sir Marcus Fernando Mawatha, Colombo 7, Sri Lanka*
**Corresponding author: ujinadasa@arts.pdn.ac.lk*

Abstract: Geospatial technologies (GTs) have revolutionized the field of archaeology by providing archaeologists with powerful tools to analyze, manage, and visualize spatial data. These advancements have enabled a more detailed and accurate understanding of the human past. In particular, technologies such as remote sensing (RS), drone technology (DWT), three-dimensional (3D) mapping, and real-time data analysis (RTDA) have made significant contributions to archaeological research—especially when integrated with geospatial technologies. These tools make it possible to locate archaeological sites and monuments, analyze their spatial patterns, and reconstruct ancient monuments with greater ease and precision. However, there are also limitations in the use of these technologies. Alongside global advancements in geospatial technologies, their application has also progressed within Sri Lankan archaeology. The primary aim of this article is to highlight the benefits, challenges, and limitations of using geospatial technology in archaeological research. It aims to analyze the practical applications of geoinformation technologies in archaeology by drawing on a range of scientific studies from both global and local contexts.

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INTRODUCTION

Archaeology is a diverse and interdisciplinary field of study that intersects with multiple disciplines including history, anthropology, linguistics, geography, geology, economy, information technology, and medicine. In general terms, archaeology is studying past human cultures through the material remains. As archaeology is grounded in the analysis of material remains, it enables interpretations that extend beyond periods of human history documented by written records. As Renfrew and Bahn note, archaeology is partly the discovery of the treasures of the past, partly the meticulous work of the scientific analyst, and partly the exercise of the creative imagination (Renfrew and Bahn 2016). As a Western discipline, archaeology was introduced to colonial territories through the excavation, collection, and preservation of antiquities and ruins—a process institutionalized by the establishment of government departments such as the Archaeological Survey of India in 1861 and the Archaeological Survey of Ceylon in 1890 under British colonial rule.

The transformation of archaeology from treasure hunting into a professional discipline grounded in scientific and interdisciplinary approaches was a gradual process. Gorden Childe in his influential essay *The Urban Revolution* identified the social surplus as the key concept to the fundamental shift of human societies from primitive to complex urban ones (Childe 1950). By interpreting the societal transformations that occurred in river valley civilizations from an economic perspective—particularly through the development of agriculture and trade—Childe also emphasized the need for archaeology to integrate other disciplines for more comprehensive interpretations. Processual Archaeology, or the New Archaeology, which emerged in the United States during the 1960s, was instrumental in promoting a more scientific and systematic approach to archaeological research, marking a paradigm shift in the field. Binford—a pioneer in the Processual Archaeology movement—in his foundation paper *Archaeology as Anthropology*, argued archaeology to be treated as a scientific discipline akin to anthropology (Binford 1962). Clarke (Clarke 1968), in *Analytical Archaeology*, introduced analytical methods and models for interpreting archaeological data, aligning with the principles of New Archaeology. The use of emerging computer technology for analysis processes in archaeology can be framed within the context of the theoretical and methodological shifts in the discipline, alongside the advances in mainframe computing during the 1950s and 1960s and the subsequent rise of personal computers in the 1970s. By 1958 and 1959, archaeologists were using computer technology for archaeological research in France (Cowgill 2019). Subsequently, 5 to 10 major archaeological projects in the United States also incorporated this evolving technology (Cowgill 2019).

The emergence of Geographic Information Systems (GIS) was closely linked to advancements in information technology during the early 1960s (Tomlinson 2007). GIS emerged in 1963 when geographer Roger Tomlinson initiated a national land-use management programme for the Canadian government, focusing on the inventory of natural resources. The period from the 1960s to the 1990s witnessed rapid theoretical, technological, and organizational advancements in GIS (Maguire 1991). Over the years, modern geospatial technologies (GTs)—including Geographic Information Systems (GIS), remote sensing (RS), and Global Positioning Systems (GPS)—became crucial tools in archaeological research, which inherently involves the analysis of spatial patterns. Geospatial technologies can also be considered a subfield of computer archaeology or computational archaeology, which utilizes computer-based techniques to analyze and interpret archaeological data. GTs are increasingly employed to manage spatial data, enhancing the ability to collect, store, analyze, and visualize spatial information in digital formats.

In this review article, we begin by examining studies that have employed geospatial technologies in archaeology in global contexts, with an emphasis on their historical development. Next, we analyze publication trends using bibliometric methods and discuss various applications of GTs in archaeology. We then explore how these applications have been utilized in the Sri Lankan context, with particular reference to the development of GTs in Sri Lankan archaeology. Finally, we present a discussion on future directions for the use of GTs in Sri Lankan archaeology, considering its unique local challenges as a developing nation.

WHAT ARE GEOSPATIAL TECHNOLOGIES (GTS)?

Geospatial technologies (GTs) is a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the earth and human societies.[1] They (GTs) can generally be classified into two categories: classical GTs and modern GTs. Traditional methods used for collecting, storing, analyzing, and visualizing spatial data prior to the emergence of modern advanced geospatial technologies are considered classical geospatial technologies. Some examples of classical GTs include aerial photography, which provided overhead views of the Earth's surface for mapping purposes, and topographic maps, which depicted both natural and man-made features of the landscape. These classical geospatial technologies paved the way for the development of modern advanced GTs, which enable more efficient, accurate, and dynamic methods of collecting, storing, and visualizing spatial data. Key examples of modern geospatial technologies include Geographic Information Systems (GIS), which allow for the storage, analysis, and visualization of spatial data in digital formats; Global Positioning System (GPS) technology, which provides precise location information for navigation and field data collection; remote sensing, which involves acquiring information about the Earth's surface using satellite or airborne sensors; and drones (Unmanned Aerial Vehicles – UAVs), which are increasingly used for high-resolution, real-time data collection and mapping.

GIS is widely used geospatial technology in archaeology. The term 'Geographic Information System' (GIS) was coined by Roger Tomlinson—widely known as the father of GIS—in the 1960s. Since its introduction, its definition has evolved from a computer-based mapping tool to a sophisticated scientific framework known as GIScience (Zhou 2025). A Geographic Information System (GIS) can be defined as a computer-based system with a sophisticated scientific framework used to collect, store, manage, analyze, and visualize spatial data, particularly incorporating both spatial and temporal dimensions (Goodchild 1992; Zhou 2025). Tomlinson identify the process of GIS as data gathering, data handling or the storage, manipulation and displaying, data analysis, and decision making (Tomlinson 1988). Since its beginning, GIS was developed as a decision-making tool by visualizing geographic patterns and relationships and analyzing data. However, digital mapping was one of the defining features of GIS technology in early stages (Maguire 1991). In its early stages, GIS was primarily used by archaeologists for digital mapping.

GIS system comprises four basic elements which operate in an institutional context: computer hardware, computer software, data and live ware (Maguire 1991). The data, obtained through various methods such as ground surveys, remote sensing, and other techniques, is then entered into the GIS system and stored in a geodatabase. In some cases, this data must be pre-processed or processed before it can be effectively analyzed.

Scholars have identified three generations of GIS (Zhou 2025). The earliest form is referred to as the first generation (Zhou 2025). The second generation of GIS emerged in the late 20th century, characterized by advancements in data storage, computation, and visualization capabilities (Zhou 2025). The third generation began with the rise of the 21st century, marked by the dominance of the internet and digital networking, which reshaped the ways we communicate, work, and live (Zhou 2025). As a result, data acquisition methods and information generation have significantly improved through more time-efficient tools such as mobile GIS (Li and Brimicombe 2012). Notions such as big data, service databases, and social media have contributed to transforming GIS into a universal system,

1. Available at: https://www.aaas.org/programs/scientific-responsibility-human-rights-law/overview-geospatial-project (accessed 26.06.2025).

underpinned by a strong mathematical foundation (Zhou 2025). Further, GIS science has expanded with Web GIS and cloud GIS platforms to upgrade GIS services. Over the last decade, GIS has been significantly impacted by artificial intelligence (AI) and creating a novel field of GIS called GeoAI.

Additionally, satellite imagery, Global Positioning Systems, remote sensing products and drone mapping expand the traditional GIS technology by adding novel layers. The modern improvement of spectral and spatial resolution of remote sensors has not only improved the efficiency of several archaeological projects but also has reduced the cost, and time it takes to acquire data physically on site. As a result, remote sensing has become a widely used geospatial technology in numerous archaeological projects, ranging from the detection of unexplored historical features to paleo-landscape and ecosystem studies (Lasaponara and Masini 2011). Modern remote sensing originated with the invention of the camera, but the term 'remote sensing' was not coined until the early 1960s. It was introduced by Evelyn Pruitt, a geographer who prepared a white paper with the staff of the Geography Branch at the Office of Naval Research (Fussell, Rundquist, and Harrington 1986). In the early stages, archaeologists typically relied solely on aerial photographs, but today their methods have expanded to include satellite imagery, RADAR, and LiDAR techniques (Campana 2016).

Remote sensing is categorized into two types: active and passive remote sensing. Passive remote sensing technologies acquire data by detecting naturally emitted or reflected energy in the visible, near-infrared, and thermal infrared spectra. In contrast, active remote sensing acquires data by illuminating the surface with its own energy source. Today, both technologies are used to reveal archaeological features, either directly visible on the ground surface or indirectly when covered by vegetation. Accordingly, archaeologists combine spatial, spectral, temporal, and radiometric data collected from multiple sensors to identify archaeological features.

Global Navigation Satellite System (GNSS), along with the mobile GIS, has enhanced the capability of archaeologists to conduct less destructive methods to acquire data for the groundbreaking results (Richards-Rissetto and Landau 2019; Tripcevich 2004b). GPS, originally developed as a military project by the United States Department of Defense in the early 1970s, has since evolved into a fully functioning locational identification technology for civilian use (Pearson, Ainsworth, and Thomason 2015). In the initial phase, it started with just 24 operational satellites, which only acquired data with low accuracy (Adrados et al. 2002). After 2000, it has enhanced the accuracy to less than 10 to 25 meters. Today, with advancements in technology—including the Wide Area Augmentation System (WAAS) and new civilian signals—archaeologists can achieve locational accuracy ranging from less than 2 cm to 5 m in field surveys (Chyla and Buławka 2020). Furthermore, mobile phones, Personal Digital Assistants (PDAs), and handheld GPS receivers provide archaeologists with this technology to successfully map historical sites that are hidden or difficult to explore.

Before the advancement of modern geospatial technologies, archaeologists faced challenges in effectively presenting and visualizing their findings through maps due to limitations in accuracy, funding, and time. Google Earth, one of the largest Earth observation applications, has bridged that gap and become a vast geospatial database and platform for sharing spatial data worldwide (Luo et al. 2018). Google Earth offers a vast collection of high-resolution satellite imagery, which is extremely useful for site detection and accurate location identification. Furthermore, as part of satellite Earth observation, it offers very high-resolution (VHR) imagery for various types of exploration and visualization. The ability to generate Digital Elevation Models (DEMs) using Google Earth imagery enables archaeologists to reconstruct detailed terrain, thereby improving the accuracy of the 3D models they create. (Liss, Howland, and Levy 2017; Luo et al. 2018; Lasaponara and Masini 2011). Furthermore, even during field surveys, Google Maps serve as a navigation assistant by clearly indicating the easiest and least congested routes, while also providing travel time and other navigational details.

HISTORICAL OVERVIEW OF GEOSPATIAL TECHNOLOGIES (GTS) IN ARCHAEOLOGY

The evolution from classical to modern geospatial technologies reflects a significant transformation in the fields of geography and spatial science, enhancing our ability to understand, manage, and plan both physical and human environments more effectively. Archaeology—a discipline that incorporates spatial analysis—is one of many disciplines that has increasingly adopted geoinformation technologies.

The United States pioneered the use of geospatial technologies (GTs) in archaeology. Among the early applications of GIS in the U.S. is cultural resource management, exemplified by a case study in Sequoia and Kings Canyon National Parks, where a GIS database was developed for the accurate and comprehensive recording of archaeological sites (Wickstrom 1988). With the advancement of satellite remote sensing technology in the United States, the Arkansas Archaeological Survey utilized various satellite imagery, in combination with GIS technologies, to identify archaeological sites and site patterns (Limp 1987). Geospatial technologies were also adopted by European universities during the same period, despite the high initial costs of both hardware and software, particularly for GIS applications (Wansleeben 1988). Among its early applications of GTs in European archaeology were Digital Terrain Modelling (DTM), landscape and site analysis, site location analysis and site pattern prediction (Harris 1988; Wansleeben 1988). The development of geospatial technologies was not evident in Asia during this period, as reflected by the lack of academic publications.

The 1990s saw a noticeable development in GTs across Europe, with an increasing number of projects reflected in academic publications. The technology was applied in sub-fields of archaeology such as landscape archaeology—particularly in viewshed analysis—and European prehistory, where it was used for the development of predictive models (Kamermans and Rensink 1999; Middleton and Winstanley 1993; Wheatley and Gillings 2000). Despite being in its early stages of development, GTs proved successful in landscape archaeology and the exploration of large areas. This is exemplified by its use in the North West Wetlands Survey in western England, where it aided in identifying wetlands and landscapes under threat. (Middleton and Winstanley 1993). Researchers at Leiden University used predictive modeling to identify Paleolithic and Mesolithic findspots in the loess region of southern Netherlands, incorporating data from soil and geomorphological maps (Kamermans and Rensink 1999). The researchers, who used colourful maps to present their findings, highlighted that the main strength of GIS lies in its ability to accurately visualize research conducted through traditional methods (Kamermans and Rensink 1999). Development of archaeological sensitivity models for Cultural Resource Management was also carried out in the Netherlands during this period (Brandt, Groenewoudt, and Kvamme 1992). As GTs advanced within sub-fields of archaeology, academic books were also published on its broader application of GIS in archaeological research (e.g. Maschner 1996; Allen, Green, and E. B. W. Zubrow 1990).

The use of geospatial technologies outside the USA and Europe became more prominent after 2000, particularly in regions such as South America, Africa, Turkey, India, and New Zealand (e.g. Moyes 2002; Causey and Lane 2005; Maktav et al. 2009; Teramura et al. 2008; González-Tennant

2009). Examples include the Belize Regional Cave Project, which used spatial analysis (Moyes 2002); a landscape archaeology project on the Laikipia Plateau in Kenya that employed GIS modeling to identify pastoralist activities (Causey and Lane 2005); an exploration of the water supply system in the old city of Istanbul using GIS, GPS, and high-resolution satellite imagery (Maktav et al. 2009); mapping surface findings in the Otago goldfields, New Zealand, with GIS and GPS (González-Tennant 2009); and research into the archaeology of the Indus civilization using topographic surveys, satellite imagery, digital elevation models (DEMs), and reconstructions (Teramura et al. 2008). Geospatial technology also gained popularity in other European countries such as Switzerland, Italy, and Greece, where researchers engaged in 3D modeling, landscape archaeology using GIS and high resolution IKONOS imagery, and predictive modeling (e.g. Hatzinikolaou, Hatzichristos, and Siolas 2003; Campana and Francovich 2003; Wüst, Nebiker, and Landolt 2004). While 3D modeling gained popularity for visualizing data, mobile GIS was also introduced during this period as an efficient method for site location using GPS technology (Tripcevich 2004a; Katsianis et al. 2008). In addition, the study of human evolution and migration has also benefited from GIS technology, with GIS-based least-cost route analyses being used to support the southern dispersal hypothesis of Homo sapiens, as demonstrated by researchers at the University of Cambridge (Field, Petraglia, and Lahr 2007).

After 2010, geospatial technology revolutionized the field of archaeology, becoming an essential tool for both research and cultural resource management (CRM) in state institutions and universities. During this period, GIS became increasingly common in archaeological research and spread across Asia—particularly in countries like China, India, and even Sri Lanka. Despite being a developing nation, Sri Lanka also embraced this emerging technology. In the Upper Ying Valley of China, archaeobotanical surveys have incorporated Principal Component Analysis (PCA) to analyze settlement patterns from the Late Neolithic to the Early Bronze Age (Zhang et al. 2010). Reconstructions of archaeological sites have been among the GT applications in Chinese archaeology include the study of the royal road system to ancient Dunhuang through the integrated use of GIS and remote sensing (Luo et al. 2014), as well as the reconstruction of the defensive system of the Han Dynasty in Central Xinjiang, China (Zhu et al. 2017). In India, the combined use of GIS and remote sensing has primarily been employed to explore archaeological sites. Notable examples include the ancient Nalanda Buddhist Monastery in northern India and Srirangapatna in southern India (Rajani and Rajawat 2011; Gupta, Das, and Rajani 2017). Similarly, Sri Lankan archaeologists have used GIS technology to locate and analyze Buddhist archaeological sites in the Northern Province of the country following the end of the 30-year civil war (Jinadasa et al. 2017). GIS and remote sensing have also been developed in Middle Eastern archaeology, particularly in Jordan, where they have been used for landscape archaeology and 3D modeling (Smith and Levy 2012; Hritz 2014).

Further developments in geospatial technologies, particularly through the integration of GIS, GPS, and remote sensing, have been evident since 2020. The availability of high-resolution satellite imagery has enabled archaeologists to observe landscapes at a 1-meter resolution, providing an excellent method for predictive modeling and facilitating the exploration of larger areas, as demonstrated by a case study in Tunisia (Bachagha et al. 2020). The use of LiDAR technology has become increasingly popular in archaeology due to its ability to explore large landscapes by generating high-resolution Digital Elevation Models (DEMs) and Digital Terrain Models (DTMs), while also being capable of penetrating tree cover to reveal hidden archaeological features (Lausanne et al. 2021; Kokalj and Mast

2021). In Sri Lanka, the ancient fortress of Balana has been studied using LiDAR technology (Mendis 2022). Virtual and 3D reconstruction techniques have advanced significantly, as demonstrated by the 3D reconstruction of a house in Pompeii, showcasing the growing use of 3D technology in the virtual restoration of monuments (Campanaro and Landeschi 2022; Fabrega-Alvarez and Lynch 2022). This phase shows the increasing use of Mobile GIS as a time efficient method of recording archaeological data (Sgouropoulos, Urem-Kotsou, and Chrysafakoglou 2024; Saba 2025; Fábrega-Álvarez and Lynch 2022). Thus, by the mid-2030s, geospatial technologies have become essential tools in archaeology worldwide, supporting a wide range of applications.

WHY GEOSPATIAL TECHNOLOGIES (GTS) FOR ARCHAEOLOGY?

Archaeology is a discipline focused on the study of material culture to understand the biological and behavioral evolution of past humans (Lock and Pouncett 2011; Scerri and Will 2023; Tryon, Pobiner, and Kauffman 2010), has greatly benefitted from the integration of geospatial technologies. This integration leads to a streamlined (Breeze et al. 2015), cost-effective and time-efficient way to conduct fieldwork and laboratory tasks to achieve more effective results (Alwan and Jaber 2022; Brandt, Groenewoudt, and Kvamme 1992; Yao et al. 2023).

Reliable and accurate data are often a fundamental part of drawing meaningful results and conclusions. Therefore, since the inception of the discipline, archaeologists have employed various field data collection methods. Traditional techniques such as ground surveys, excavations, soil and sediment analysis, artifact collection, and cataloguing have been heavily relied upon (Andrews 1981; Bintliff and Degryse 2022; Campbell et al. 2017; Goalen 2005; Veselinović et al. 2021; J. Zhang and Yang 2023). However, these methods are often time-consuming, cost- and labor-intensive, and may limit efficiency while raising doubts about the accuracy of data in critical environments, such as rugged terrain (Brandt, Groenewoudt, and Kvamme 1992). With the integration of geospatial technologies, including GIS, remote sensing, LiDAR, GNSS, GPS, 3D scanning, photogrammetry, and mobile GIS, the traditional field of data collection has transformed into a cost-effective and efficient battlefield, which facilitates highly precise and accurate outcomes (Chase et al. 2012; William Fred Limp and Barnes 2014; McCoy 2021). For example, drones and remote sensing technologies collect data remotely from study areas that may be inaccessible or environmentally sensitive (Stek 2016). LiDAR technology enables the detection of archaeological features hidden beneath dense forests or tree cover (Rostain et al. 2024). Mobile GIS facilitates real-time spatial data collection by reducing the time-consuming nature of manual data capture and recording, while seamlessly connecting fieldwork with indoor data analysis. Therefore, archaeologists are now capable of making accurate digital maps and performing spatial analysis even in the field.

Unlike non-spatial data, managing spatial data is not easy with conventional data management practices. However, with geospatial technologies, archaeologists can efficiently manage complex geographic information using a geodatabase—a repository originally designed to handle large spatial datasets. This capability allows archaeologists to manage and analyze both spatial and non-spatial data simultaneously, enhancing their understanding of past human behaviour. Tobler's First Law of Geography says: "Everything is related to everything else, but near things are more related than distant things" (Miller 2004). Accordingly, the exploration of a single historical site often leads to exploring another, ultimately revealing broader cultural and social patterns and other parallel cultures over large geographical areas. Therefore, it is more beneficial to explore large areas rather than isolated study sites. With geospatial technologies, analyzing spatial patterns, trends, interconnectedness, and similar features across larger areas has become much easier. Therefore, instead of limiting themselves to isolated site-specific studies, archaeologists can now expand their investigations to comparatively large areas and multiple locations to explore broader historical dynamics.

METHODS

Firstly, a bibliometric analysis is employed in this study to assess the volume, impact, and thematic evolution of the scholarly literature. Secondly, a systematic literature review was conducted, focusing on publications from the period 1970 to 2025, primarily sourced from Google Scholar. Finally, interviews were conducted with professionals in the field of archaeology to explore advancements in the application of geospatial technologies (GTs) within Sri Lankan archaeology.

APPLICATIONS OF GEOSPATIAL TECHNOLOGIES (GTS) IN ARCHAEOLOGICAL STUDIES

To understand the use of geospatial technologies (GTs) in archaeological studies, we employed a bibliometric analysis approach. Bibliographic data for scholarly publications were obtained through the OpenAlex application programming interface (API). Developed by the non-profit OpenResearch Foundation, OpenAlex is an openly accessible and open-source bibliometric database that supports a wide range of academic inquiries (Priem, Piwowar, and Orr 2022; Krause and Mongeon 2023). It provides extensive and multidisciplinary coverage, encompassing more than 250 million scholarly works, thereby serving as a valuable resource for conducting comprehensive research and analytical studies across various fields (Haunschild and Bornmann 2024).

The search query was ("Geospatial Technology" OR "GIS" OR "Geographic Information System" OR "Remote Sensing" OR "Drone" OR "Unmanned Aerial Vehicle") AND ("Archaeology" OR "Archaeological Survey" OR "Heritage Mapping"). To explore the research landscape within the selected domain, this study utilized VOSviewer, a specialized software tool developed for constructing and visualizing bibliometric networks. In order to limit our search, we used only the "Social Science Field Application."

Figure 1 presents a network visualization of key terms identified within our analyzed dataset, generated using VOSviewer. The size of each node reflects the frequency of the term's occurrence, while the connecting lines indicate co-occurrence, with thicker lines signifying stronger associations. The distinct color-coded clusters reveal thematic groupings of these terms.

Visualization highlights "computer science," "biology," "engineering," and "political science" as central concepts within the dataset. Furthermore, the interconnectedness of various clusters demonstrates significant interdisciplinary relationships. For instance, the strong links between the "computer science" cluster and the "geography," "mathematics," and "archaeology" cluster underscore the close relationship and potential overlap between these fields within our data. These findings offer a visual representation of the main areas of focus and key interdisciplinary connections within the analyzed data, providing valuable insights into the structural relationships among various concepts."

The clustering analysis identifies several distinct international collaboration networks. For example, prominent clusters include a United States–based cluster and an Indonesia–based cluster. In addition to these, Russia, China, and Poland are also visible in the collaboration networks.

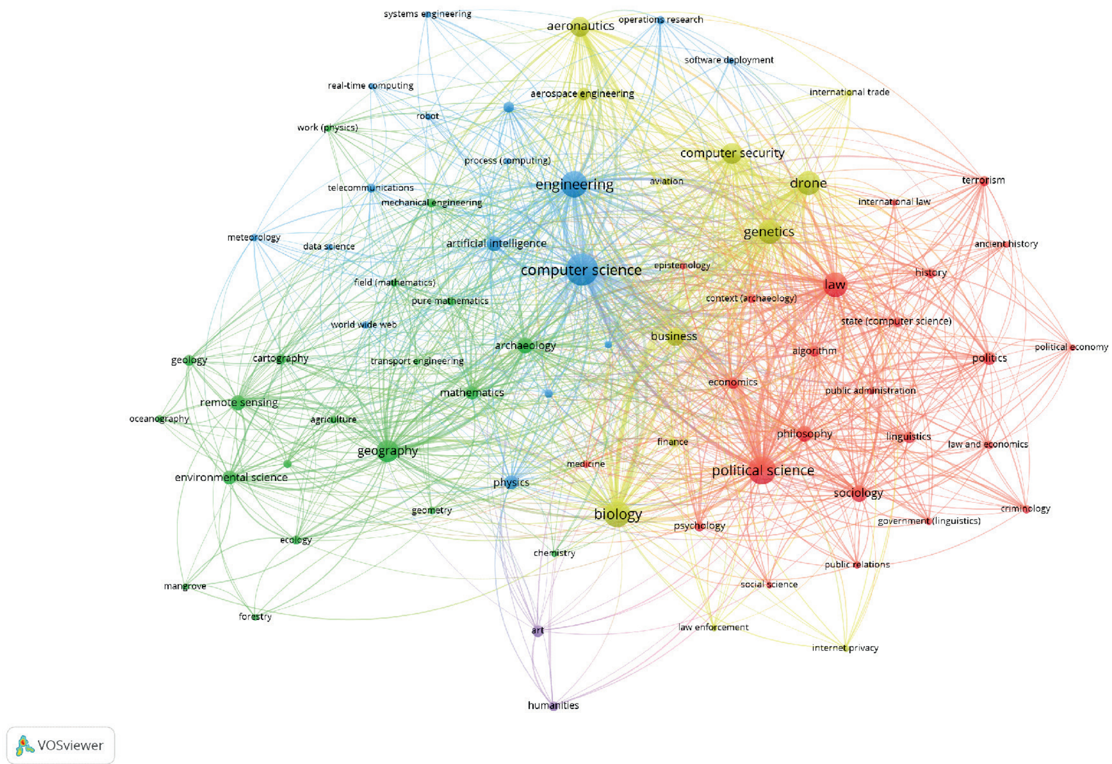

Figure 1: Networking of the country collaborations

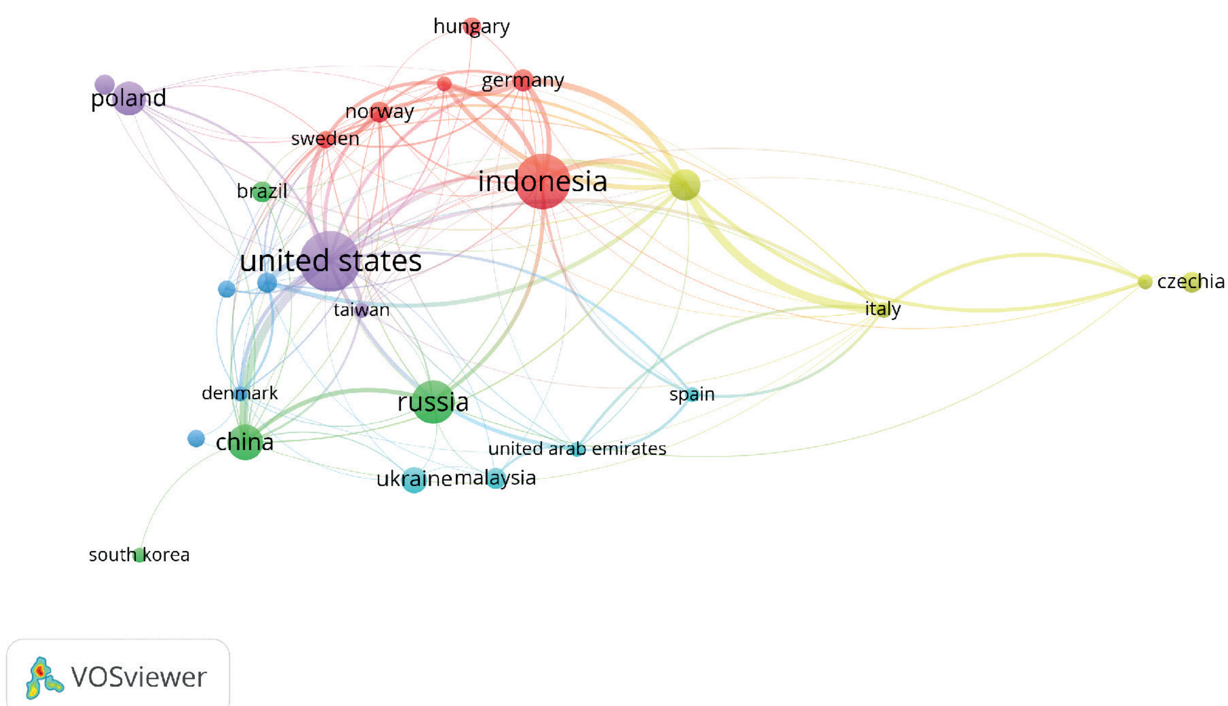

Figure 2: International collaboration networks

THE APPLICATION OF MODERN GEOSPATIAL TECHNOLOGIES (GTS) IN ARCHAEOLOGY: A GLOBAL PERSPECTIVE

(a) Archaeological prospection: Archaeological Predictive Modeling (APM)

One of the most popular applications of GTs in archaeology is the discovery of archaeological sites through archaeological predictive modeling (APM). This was among the earliest uses of GIS technology in archaeology, emerging during the late 20th century. APM integrates the topographical and environmental variables—such as proximity to water sources, elevation, slope, and soil types—with the available archaeological and historical data, to find the areas that have high probability of past human activities. APM acts as a decision support system to obtain useful information for planning field surveys in large areas and facilitating new discoveries; saving time and resources (Danese et al. 2014). The APM is a powerful tool for preventive archaeology, cultural heritage mitigation, vulnerability assessment and improving the sustainability of cultural heritage resources (Nicu, Mihu-pintilie, and Williamson 2019).

Site selection using GIS typically follows a structured process. The first step in predicting the location of archaeological sites involves collecting data on both environmental and cultural factors. This includes information on topography, soil types, vegetation, water sources, and proximity to known archaeological sites. These datasets are then integrated into a GIS platform, usually by creating separate layers for topography, soil, vegetation, land use, and related features. The next step is data analysis to identify patterns and spatial relationships. This involves applying spatial analysis techniques such as overlay analysis, buffer analysis, and spatial interpolation. Based on the results of these analyses, a predictive model is developed to highlight areas with a high probability of containing archaeological sites.

Country-specific case studies from Switzerland (Castiello and Tonini 2021), Denmark (Giatsiatsou 2023), Northern Italy (Magnini and Bettineschi 2021), Lebanon (Diwan 2020) , Morocco (Nsanziyera et al. 2018), Romania (Nicu, Mihu-pintilie, and Williamson 2019), Tanzania (Alders 2023), India (Pal et al. 2025), and China (Cui 2024) shows practical uses of archaeological predictive modelling. An APM based on geo-environmental features—such as elevation, slope, distance to rivers and lakes, water saturation, and agricultural suitability—that are likely to influence the location of Roman sites has been developed in the Canton of Zurich, northeastern Switzerland (Castiello and Tonini 2021). In identifying the possible locations of Iron Age sites in the Bekaa Valley, Lebanon, researchers used six geo-environmental factors: distance to rivers, distance to cropland, slope, aspect, elevation, and terrain texture (Diwan 2020). In a study conducted in the Awsard area in southern Morocco, the Analytic Hierarchy Process (AHP)—a multi-criteria decision-making method that integrates archaeological data, environmental factors, geospatial analysis, and predictive modelling—was applied to identify previously unknown archaeological sites (Nsanziyera et al. 2018). Potential factors such as aspect, topography, terrain, vegetation, and environmental conditions were integrated into the model. The model was developed using a 21 km² zone containing 233 known sites (Nsanziyera et al. 2018). Subsequently, 530 unknown sites were validated across a 980 km² area, achieving an accuracy rate of 93% (Nsanziyera et al. 2018). Advances in remote sensing, especially the availability of high-resolution satellites with thermal and infrared capabilities, have contributed to the development of APM (Nsanziyera et al. 2018).

(b) Archeological prospection: LiDAR technology

The integration of remote sensing (RS)—a non-destructive method—through GIS technologies in archaeological research has demonstrated clear cost-effectiveness compared to traditional fieldwork methods (Skousen and Friberg 2021). One such emerging technology is Light Detection and Ranging (LiDAR), a remote sensing technology that uses laser light to measure distances to the Earth's surface and generate high-resolution, three-dimensional maps of landscapes and objects. Its ability to penetrate tree cover has made LiDAR an accurate and effective method for archaeological prospection in extensive forested areas (Štular, Lozić, and Eichert 2023; Mendis 2022; Kokalj and Mast 2021). This has led to a rapid transformational change in archaeological research, especially in Mesoamerican archaeology (Nunes-Pereira et al. 2019). The technology has used uncover the ancient Maya buildings Chactún, one of the largest Maya urban centers in the central lowlands of the Yucatan peninsula using The Global Ecosystem Dynamics Investigation (GEDI), a full waveform lidar instrument mounted on the International Space Station (Kokalj and Mast 2021). Consequently, this non-destructive approach helps conserve both time and resources when conducting large-scale archaeological investigations, particularly in challenging or adverse environments.

Another example of research conducted in a challenging environment—characterized by dynamic coastal, post-glacial, and rainforest conditions—is found on Quadra Island, Canada (Lausanne et al. 2021). In this case, researchers employed a novel methodological approach to archaeological prospection for palaeo-coastal sites by integrating local relative sea-level history, LiDAR-derived geomorphic data, and GIS-based potential mapping (Lausanne et al. 2021). LiDAR technology has been used to explore specific archaeological sites, as demonstrated by case studies from the UK and Sri Lanka. A case study on Chun Castle in South-West England, which employed LiDAR and UAV (Unmanned Aerial Vehicle) photogrammetry to generate 3D models for identifying archaeological features of the ancient site, highlighted the potential for new discoveries (Kadhim and Abed 2021). Similarly, a case study from Sri Lanka focusing on the 16th-century fortress of Balana utilized LiDAR technology and QGIS methods, leading to the detection of trench-like features associated with the fortifications (Mendis 2022).

(c) Spatial analysis

Spatial analysis techniques in GIS are widely applied in archaeology to identify and interpret past human behaviors and the landscapes shaped by them. Among the most commonly used spatial analysis tools in archaeology are archaeological predictive modelling (APM), terrain and elevation analysis using Digital Terrain Models (DTMs) and Digital Elevation Models (DEMs), and 3D modelling for the virtual reconstruction of sites and structures. Viewshed analysis, as well as buffer and proximity analysis, are also widely used. Other important spatial analysis techniques in archaeology include cost surface and least-cost path analysis (LCP), density and distribution mapping (such as kernel and Kernel Density Estimation (KDE) and point pattern analysis), catchment analysis (including site catchment analysis), change detection and temporal analysis, and network analysis.

Visibility of viewshed analysis contributes significantly to landscape archaeology by reconstructing the visual panorama of a study area during the past (Malaperdas 2021). It is among one of the early uses of GIS for archaeology. Madry and Rakos use viewshed analysis and optimum path analysis to investigate the relationship between Celtic hillforts and Celtic roads in the Burgundy region of France (Maschner 1996). It enables the exploration of defensive roles of sites (Zhu et al. 2017) and thus it has been widely used in analyzing the visibility of fortresses and towers (e.g. Kantner and Hobgood 2016; May 2025).Viewshed analysis has been increasingly and effectively applied in conjunction with site location analysis, as well as with least-cost path modelling (e.g. Zhu et al., 2017). The least cost paths (LCP) emerged as the primary technique for modeling past human movements through landscapes (Howey 2011). Gustas and Supernant used LCP as a cost-effective and efficient method to analyze coastal human migration during the Late Pleistocene on the Northwest Coast of the Americas (Gustas and Supernant 2019). A growing body of research indicates that its application in human migration studies remains prevalent (e.g. Kealy, Louys, and O'Connor 2018; Teramura et al. 2008; Nir et al. 2021)

(d) Field data collection and analysis: Mobile Geographic Information System (MGIS) and mobile mapping

Mobile Geographic Information Systems (MGIS) extend traditional desktop GIS beyond the office, enabling individuals and organizations to localize, collect, store, visualize, and even analyze geospatial data in the field (Gao and Mai 2017). MGIS, typically operated via tablets and smartphones, can be used without the need for specialized GIS professionals. It is easier, faster (Jinadasa et al. 2024; Ames et al. 2020; Fabrega-Alvarez and Lynch 2022; Sgouropoulos, Urem-Kotsou, and Chrysafakoglou 2024), and, more cost-effective (Pažout 2023; Fábrega-Álvarez and Lynch 2022; Jinadasa et al. 2024; Tripcevich 2004a; Saba 2025; Fabrega-Alvarez and Lynch 2022), which has led to its gradual rise in popularity. In addition, it offers ergonomic touch-screen operation, customizable portable projects, support for a wide range of GIS-compatible formats, and interoperability with desktop applications without the need for data conversion (Pažout 2023). The availability of open-source mobile field mapping software (OSS) like QField in QGIS (Saba 2025; Pažout 2023; Fábrega-Álvarez and Lynch 2022) has also contributed to the growing popularity of MGIS as a data collection and analysis method. In addition, ESRI's ArcGIS offer field mapping software like ArcPad (Tripcevich 2004b) and ArcGIS Survey123 (Jinadasa et al. 2024) with certain free versions. MGIS allows users to collect data using customized questionnaires with digital, geocoded information including photographs. It also allows users to monitor the progress of fieldwork and also provides data analysis capabilities.

Case studies using MGIS systems are common in both the East and the West. In the Hualfín Valley, Catamarca, Argentina, a total area of 53 km² was surveyed using the QField application on smartphones (Fabrega-Alvarez and Lynch 2022). Despite the area's vastness and challenging terrain, the survey was successfully conducted by a small team within a short period (Fabrega-Alvarez and Lynch 2022). MGIS and Mobile Mapping are particularly beneficial for surveying and collecting data in larger areas with limited time (Ames et al. 2020). For this reason, MGIS has become an excellent method for surveying historic cities such as Sabbioneta in northern Italy (Treccani et al. 2024) and Kandy in Sri Lanka (Jinadasa et al. 2024), both UNESCO World Heritage cities. In Sabbioneta, researchers employed a mobile mapping system utilizing the Leica Pegasus:Two Mobile Mapping System (MMS), which was vehicle-mounted and operated via a remote computer. This approach enabled them to conduct a comprehensive and accurate survey of the entire city within a relatively short timeframe (Treccani et al. 2024). Despite these benefits, researchers have identified a key drawback of MGIS, which is the difficulty of locating sites in densely forested areas due to poor GPS signal reception, as observed in a case study conducted in ʻĀṣūr and Bjamʻāsh in Syria (Saba 2025). However, QField has the capability to operate without a phone signal in remote areas, as demonstrated in the case study in the Hualfín Valley (Fábrega-Álvarez and Lynch 2022).

(e) 3D GIS and virtual reality (VR)

3D modelling has become one most popular geospatial applications in archaeology, leading to the growing use of the term "3D GIS" in archaeological publications (Riel 2016; Drap 2017; Halabi et al. 2022; Apollonio, Gaiani, and Benedetti 2012; Wüst, Nebiker, and Landolt 2004; Pepe et al. 2021; Richards-Rissetto 2017; Dell'Unto et al. 2016; Campanaro and Landeschi 2022). 3D GIS allows archaeologists to spatially store, share, visualize, and analyze complex archaeological features within a virtual 3D environment (Halabi et al. 2022). The contribution of GIS to 3D reconstruction lies in maintaining the geospatial accuracy of reconstructed monuments or sites, ensuring their precise placement in real-world locations. 3D GIS is used for digital reconstruction, classification, management and visualization of archaeological excavations, monuments, and heritage sites (Apollonio, Gaiani, and Benedetti 2012). In addition, 3D GIS also enables the integration of georeferenced historical images and virtual 3D reconstructions (Halabi et al., 2022). Various software applications are available for 3D mapping in archaeological research. Among them, ESRI's ArcScene—a specialized 3D GIS and visualization tool—enables archaeologists to explore and analyze spatial data within a three-dimensional environment. In addition, ArcGIS 3D Analyst, an extension for ArcGIS Pro, supports advanced 3D data creation, editing, and analysis. While ArcScene and 3D Analyst have been widely used by archaeological 3D modelling (e.g. Campana & Francovich, 2003; Dell'Unto et al., 2016; Katsianis et al., 2008; Pepe et al., 2021), there are also other commercial software packages and tailor-made programmes developed for specific archaeological projects. Open-source software (OSS) is also available for 3D modeling. jReality, a Java-based, open-source, and full-featured 3D scene graph package designed for 3D visualization, has been used to model the ancient Castle of Shawbak—also known as 'Crac de Montréal'—one of the best-preserved rural settlements in the Middle East (Drap, 2017).

In archaeology, 3D GIS is commonly used for the reconstruction of monuments and sites, including virtual reconstructions (Pierdicca et al. 2015; Balletti et al. 2015; Dell'Unto et al. 2016; Campanaro and Landeschi 2022). This enables archaeologists to visualize monuments in their original context and understand how they might have appeared in the past. Campanaro & Landeschi (2022) imported a virtually reconstructed Pompeian house into GIS environment to investigate how illumination influenced the social experience of elements such as graffiti and wall paintings. Virtual reality (VR) or augmented reality (AR) has the capability of adding virtual objects in the physical reality, allowing users to interact directly with exhibitions (Pierdicca et al. 2015). In addition, 3D GIS has also been used to identify the degradation of wall paintings by obtaining multiple layers of the paintings in a room of a Pompeian house (Campanaro and Landeschi 2022).

3D GIS is also used for the geo-referenced digital recording of archaeological excavations. It enables data storage in databases and supports data classification and analysis. By exploring excavations in a 3D environment, archaeologists can gain deeper insights into spatial relationships and stratigraphy. A notable example is the excavation of the prehistoric site at Paliambela Kolindros, Greece, where integrating the recording workflow within a single GIS platform enabled the rapid and cost-effective creation of a comprehensive digital archive. (Katsianis et al. 2008).

3D GIS models allow archaeologists to examine stone constructions, such as columns, through the segmentation of their components, as exemplified by a case study from the Pompeii archaeological site

(Apollonio, Gaiani, and Benedetti 2012). It has also been used analyze the visibility of archaeological landscapes, as demonstrated by the case study of the Maya city of Copan (Richards-Rissetto 2017). Advances in 3D technologies, such as airborne LiDAR and aerial photogrammetry, have enabled the acquisition of vast amounts of geo-referenced 3D data to locate, map, and visualize archaeological sites within their surrounding landscapes. GIS contributes by offering locational precision, data layering, and complex spatial analysis. Virtual Reality (VR) further enhances the experience by providing a synesthetic, or multi-sensory, immersion into ancient landscapes. The integration of these technologies has enabled researchers to model and quantitatively assess visibility in the ancient Mayan landscape of Copan (Richards-Rissetto 2017). 3D modelling with GIS integration has also been used for Landscape and Visual Impact Assessment (LVIA) of Neolithic stone circles in the Lake District of the UK (Ibbotson, 2024).

Furthermore, 3D GIS is widely used to safeguard and manage heritage through digital documentation and to raise public awareness via websites (e.g. Dell'Unto et al., 2016; Halabi et al., 2022; Pepe et al., 2021). The 3D GIS project of the Murwab site in Qatar serves as a case study of a public archaeology initiative, available on a website where 3D GIS is used to model the site and its findings (Halabi et al. 2022).

(f) Multitemporal analysis

Multi-temporal analysis, conducted using remotely sensed or satellite imagery, has become a widely used approach in archaeology due to its ability to detect spatiotemporal changes within archaeological sites (Cowie 2018). GIS techniques are commonly employed to analyze such imagery, utilizing both commercial and open-source software. ArcGIS Pro, ERDAS IMAGINE, and ENVI are among the commercial options available for processing remotely sensed data, offering standardized analysis capabilities. Open-source software such as QGIS and GRASS GIS are also widely used due to their cost-effectiveness and user-friendly interfaces.

In multi-temporal studies, a sequence of satellite images captured at different time intervals over the same geographic area is analyzed, enabling the detection of both natural and anthropogenic modifications. Multi-temporal analysis is particularly important in archaeology for detecting site degradation, looting, illicit excavations, land encroachment, and for comparing changes over time (Agapiou 2020; Payntar 2023; Kopij et al. 2024). The comparison of past and current images allows researchers to identify changes in land use, assess damages, and evaluate potential threats such as infrastructure development, agricultural intensification, urban expansion, and illicit activities like looting and vandalism (Vincent et al. 2024; Vella et al. 2015). This is a cost-effective method for monitoring large areas that require continuous field visits and particularly beneficial for physically inaccessible regions. Thus, satellite imagery has become a popular method for assessing war-related looting, which can often be identified by the presence of excavation holes (looter's pits) visible in the imagery. Researchers have used satellite image analysis to detect evidence of looting in conflict zones such as Syria (e.g. Agapiou, 2020; Casana, 2015; Casana & Laugier, 2017; Masini & Lasaponara, 2020). Masini and Lasaponara (2020) used Google Earth images of 2011, 2013, 2014, 2016 and 2017 to detect the war looting of Tell Sheikh Hamad in Syria. Agapiou (2020) analyzed cloud-free, medium-resolution multispectral Landsat 7 ETM+ imagery from January 2011 and April 2012 to assess systematic and extensive looting at the archaeological site of Apamea in Syria, following the onset of the Syrian war. The study concluded that the high temporal revisit frequency of the Landsat sensor enabled the detection and mapping of looting activities through observable spectral changes in the archaeological landscape, despite the 30-meter spatial resolution of the sensor (Agapiou 2020).

Multitemporal analysis is also useful in identifying urban encroachment of archaeological sites as shown by Casana and Laugier (Casana and Laugier 2017). The authors demonstrated the increasing new construction in the ruined areas of the city of Raqqa, Syria, between 2013 and 2016 during ISIS occupation, using true-color satellite imagery from 2011, 2013, and 2016.In a study conducted in Peru's Lower Moche Valley, Payntar (2023) applied the Random Forest machine learning algorithm to Landsat satellite data spanning from 1985 to 2020 to identify land use changes. The analysis revealed that the expansion of industrial, residential, and agricultural developments in the region led to the destruction of 364 out of 477 previously identified archaeological sites (Payntar 2023). In this study, the author utilized QGIS—free and open-source software—and global 30-meter resolution Landsat satellite imagery accessed through the USGS's Earth Explorer to conduct remote sensing analysis, demonstrating a cost-effective and technologically advanced method for accurately assessing archaeological site destruction. Similarly, researchers conducted a cross-correlated multi-temporal analysis of 187 archaeological sites in the Qazvin Plain, northern Iran, to assess the type and extent of damage to cultural features over a 40-year period (1980s–2020s). Utilizing online open-access satellite imagery platforms such as Google Earth, Bing Maps, and data from the European Space Agency, along with QGIS, the study revealed that the most significant threats to archaeological sites and heritage places were posed by natural hazards, looting, and violent destruction, rather than by agricultural activity or construction (Zaina and Nabati Mazloumi 2021).

(g) Cultural Heritage Management (CRM)

In cultural heritage management, site monitoring, identification of potential threats, and risk mitigation have emerged as key advantages of using geoinformation technologies. Researchers have integrated GIS and RS technologies in identifying cultural heritage monuments and sites that are endangered by both anthropogenic and natural hazards such as earthquakes, floods, fires, rockfalls, and urban sprawl (e.g. Agapiou et al., 2015; Elfadaly et al., 2020; Hadjimitsis et al., 2013; Moise et al., 2021; Themistocleous & Danezis, 2020). In the case study of the Paphos area in Cyprus, various types of remote sensing data were analyzed to create a spatial hazard database. Low-resolution MODIS imagery was used to retrieve burned areas, medium-resolution Landsat 5 TM and 7 ETM+ imagery supported the monitoring of urban expansion, landslides, and salinity, while high-resolution QuickBird imagery facilitated the calculation of landslide and erosion parameters (Agapiou et al. 2015).The study demonstrated that GIS and remote sensing constitute non-destructive, cost-effective, and systematic methods for the management and monitoring of cultural heritage sites (Agapiou et al. 2015). The integration of GIS and remote sensing technologies has been effectively employed in sustainable urban heritage management by facilitating the identification of urban sprawl and changes in the urban skyline (Elfadaly, Eldein, and Lasaponara 2020; Moise et al. 2021). Researchers assessed the impact of urban sprawl on the ancient city of Jeddah by analyzing land use and land cover changes between 1966 and 2017 using multi-temporal satellite data and GIS techniques (Elfadaly, Eldein, and Lasaponara 2020). Furthermore, the spatial analysis capabilities of GIS enable continuous monitoring and forecasting of environmental changes that may threaten cultural heritage, establishing GIS as an effective decision-support system in heritage management.

In addition to serving as a decision support system in heritage management, GTs arewidely used for cultural heritage documentation. This application spans from the recording of individual monuments to the development of comprehensive heritage databases. For instance, the documentation of the façade of St. Nicholas Church in Pisa, Italy, employed computer-aided design (CAD) and GIS technologies for detailed architectural recording (Lezzerini et al. 2016). On a broader scale, the documentation of industrial heritage has been exemplified through the creation of a geodatabase for the Eurocity of Guadiana and the olive mills in Écija, located in Portugal and Spain, respectively (Ferreira Lopes, Moya Muñoz, and Rosa 2023).

GEOSPATIAL TECHNOLOGIES (GTS) IN SRI LANKAN ARCHAEOLOGY: DEVELOPMENTS, CHALLENGES, AND FUTURE POTENTIAL

The use of geospatial technologies (GTs) in Sri Lankan archaeology began in the late 1990s, promoted by the (state) Department of Archaeology (DoA), Postgraduate Institute of Archaeology (PGIAR) of University of Kelaniya and other universities. The earliest use of geospatial technologies in Sri Lankan archaeology can be traced to the Pinwewa-Galsohonkanatta Archaeology Programme of 1997—a collaborative project between the University of Peradeniya and the State Department of Archaeology. In the first phase of the project, Iron Age burial sites in Galsohonkanatta and the surrounding areas were surveyed. The findings were geolocated using GPS, mapped with GIS, and a corresponding database was created (Samaratunga 2000). In 1999, the Postgraduate Institute of Archaeology (PGIAR) of the University of Kelaniya conducted a GIS training programme for archaeology professionals and academics, in collaboration with Uppsala University, Sweden.

In 1998, the DoA initiated the Sites and Monuments Record (SMR) Project, aiming to register all archaeological sites in the country in a GIS database (Whitfield 2000). The project was developed by Chris Whitfield, a British volunteer, with the support of the officer who had received the above-mentioned GIS training. By 2002, the DoA had established a GIS Unit, led by the same trained officer. This Unit grew in hardware and software by mid 2010s and it continued site recording and preparation of site maps using geoinformation technologies (interview 2025). DoA closely worked with Urban Development Authority (UDA) in GT related work during this phase, which is better equipped in GTs in expertise and resources (interview 2025).

By the end of 2010, the officials with master's degrees in geo-informatics had joined the Department of Archaeology. Capacity-building programmes on geospatial technologies for officials of the Department of Archaeology were conducted both in Sri Lanka and abroad during this phase. A few officials received GIS training at the Postgraduate Institute of Science (PGIS), University of Peradeniya in 2011, and at the Survey Department in 2013, a pioneer in the use of geospatial technologies in Sri Lanka (interview 2025). In 2013 and 2014, officers of the DoA received training in remote sensing at the International Centre on Space Technologies for Natural and Cultural Heritage (HIST) in China under the auspices of UNESCO (interview 2025).

Since 2006, the GIS Unit of the Department of Archaeology (DoA) has been working to record archaeological sites across the island with the aim of creating a geodatabase. Site recording was carried out district by district, and most of these projects were government-funded, with only a few exceptions. Archaeological sites in the Matara District in southern Sri Lanka were recorded with Dutch funding during 2007 and 2008 (interview 2025). After the end of the 30-year civil war in 2009, there was a need to record archaeological sites in the war-affected Northern Province. The first phase of the project—recording sites in the Mullaitivu District—was carried out during 2010 and 2011, funded by the UNDP (interview 2025). According to the officials of the Department of Archaeology, the initial phases of the project were very challenging, especially due to landmines and dense forest areas, and were supported by the Sri Lanka Army (interview 2025). The entire project, comprising 18 phases, was completed in 2015 (interview 2025). Archaeological site recording of eastern Province, also affected by the war, was completed during 2016-2019. In order to cover the entire country, 15 officers received GIS training at the Postgraduate Institute of Science (PGIS), University of Peradeniya in 2017 (interview 2025). In addition, they were also trained in drone mapping. Each regional archaeology office in the country was equipped with a laptop, a GPS device, and at least one trained officer to carry out this task. These officers were responsible for data collection, which contributed to the development of a geodatabase and web GIS portal for archaeological monuments of Sri Lanka in 2016 (interview 2025). This project was a collaboration between the Department of Archaeology and GIS Solutions Pvt. Ltd.—the sole distributor of ArcGIS in Sri Lanka—which has been working closely with the DoA's GIS unit since 2016 (interview 2025). As of June 2025, this geodatabase contains 2,723 archaeological sites and is accessible through the official website of the Department of Archaeology.[2] The web portal, available in three languages—Sinhalese, Tamil, and English—allows users to visualize and search for archaeological monuments, represented as dots accompanied by basic information.[3] It also features a web GIS dashboard that enables users to track the progress of site documentation by district.[4] In addition, the project has provided online access to a GIS story map of the Ruwanweliseya Stupa in the Sacred City of Anuradhapura and a story map journal of the archaeological monuments on Delft Island in northern Sri Lanka—both of which represent pioneering geospatial initiatives in Sri Lankan archaeology.[5] This web portal has also been utilized by other government institutions, including the National Spatial Data Infrastructure (NSDI) programme of Sri Lanka (interview 2025). However, there is still a lack of published literature on these pioneering initiatives in the use of geospatial technologies in Sri Lankan archaeology.

In general, we see a dearth of publications in using geospatial technologies to Sri Lankan archaeology. With the growing practical use of geospatial technologies (GTs) in recording archaeological monuments in Sri Lanka, Wijesundara et al. (2016) discussed the challenges and issues arising from the lack of standardized metadata for documenting spatial and temporal information in heritage preservation (Wijesundara, Sugimoto, and Narayan 2016). Mendis created a GIS-based inventory of the indigenous Kandyan and Dutch fortifications of Sri Lanka using geospatial technologies (Mendis 2020). A case study that used Mobile GIS to record nearly 500 monuments in the UNESCO World Heritage-listed city of Kandy—the capital of Sri Lanka's last kingdom—highlighted the cost-effectiveness and efficiency of Mobile GIS in surveying and monitoring urban heritage (Jinadasa et al. 2024). The use of GTs extended beyond monument recording since the 2020s. GIS-based viewshed analysis was used to identify the diachronic landscape characteristics of archaeological sites spread over a 1,256-hectare area in Ihala Kalwella Ulpatha (Anuradhapura District, Sri Lanka), across three

2. Available at: https://archaeologysl.maps.arcgis.com/apps/dashboards/ee768c26d09a4fddbea4a44e3f2e3048 (accessed 26.06.2025).
3. Available at: https://archaeologysl.maps.arcgis.com/apps/webappviewer/index.html?id=f46193fc96c44eadaa43bae6ab708766 (accessed 26.06.2026).
4. Available at: https://archaeologysl.maps.arcgis.com/apps/dashboards/ee768c26d09a4fddbea4a44e3f2e3048 (accessed 26.06.2025).
5. Available at: https://archaeologysl.maps.arcgis.com/home/webmap/viewer.html?webmap=104cba998b4c40c1ab146f685e37867c (accessed 26.06.2025)

phases: the prehistoric, Iron Age, and historic periods (Jayarathne 2024). Incorporation of LiDAR DEMs for archaeological researches was seen for the first time in the case study of Balana Fort in 2022. LiDAR-derived Digital Elevation Models (DEMs) were first used in archaeological research in Sri Lanka in 2022, as demonstrated by the case study of the Balana fortress. The 2×2 meter pixel resolution DEM used in this study was sufficient to identify a rampart wall that had not been previously documented (Mendis 2022).

Despite notable achievements, several challenges remain in the use of geospatial technologies in Sri Lankan archaeology. Geospatial expertise is often lacking among archaeologists, as archaeology is traditionally a humanities-based discipline in Sri Lanka. Therefore, greater collaboration is required between archaeologists and experts or practitioners in geospatial technologies. Partnership government institutions such as the Survey Department, is helpful in obtaining satellite imagery and digital data. Due to limited collaboration, advanced applications such as archaeological predictive modelling, 3D modelling and reconstructions, temporal analysis, GIS-based recording of excavations, and the use of augmented reality (AR) and virtual reality (VR) are either rarely used or entirely absent in Sri Lankan archaeology. Another major constraint is the lack of funding; however, this could be significantly mitigated through strategic collaborations, particularly with government agencies and academic institutions. Since archaeology is primarily taught as a humanities subject in most Sri Lankan universities, the integration of geospatial technologies into the curriculum has been limited. This gap could be addressed through the inclusion of interdisciplinary courses in future syllabus revisions, specifically focusing on the application of geospatial technologies in archaeology. Bachelor's degree programmes in GIS and geoinformatics were introduced only about four years ago, and so far, only one batch of graduates has completed the programme. However, many of these graduates are likely to pursue careers in other fields rather than archaeology.

CONCLUSIONS

Geospatial technologies (GTs)—which began to develop over half a century ago—have undergone tremendous advancement globally, providing archaeologists with powerful tools to interpret the past efficiently and cost-effectively. Originating primarily in the United States and Europe, GTs have now spread across global archaeology, influencing practices in regions such as the Americas, the Middle East, China, and India. While these technologies are widely used in those regions, their adoption in Sri Lanka has been more limited. Although the Department of Archaeology in Sri Lanka has been using GTs for over 25 years, their application has largely focused on site recording, public data sharing, and visualization. Most research has concentrated on documenting heritage monuments. More advanced, as well as commonly used, applications—such as viewshed analysis, LiDAR-derived Digital Elevation Models (DEMs), and Mobile GIS—only began to emerge in the 2020s. However, there remains a notable lack of publications and practical use of GTs in areas such as archaeological predictive modelling (APM), 3D modelling and reconstruction, temporal analysis, virtual reality (VR), and excavation data recording. Thus, while Sri Lankan archaeology has a foundational exposure to geospatial technologies, it still lacks the comprehensive integration of these tools into archaeological analysis. Therefore, future collaborations—including international partnerships—and greater intervention are needed at both academic and institutional levels to promote the effective application of geospatial technologies in investigating the past human cultures of Sri Lanka.

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