# Utilizing LiDAR Technology for Archaeological Surveys: Unveiling Hidden Insights.

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***Abstract***: *In this study, we aim to demonstrate the application of advanced remote sensing LiDAR (Light Detection and Ranging) technology in archaeological surveys, with a specific focus on analyzing the physical characteristics of historical and archaeological sites. The LiDAR survey methodology involves using equipment installed in unmanned aerial vehicles (UAVs) or large drones, in conjunction with control points marked using a global positioning system (GPS), followed by data processing using specialized software. The LiDAR survey was carried out during the archaeological survey of the ancient city of U Thong, located in Suphanburi, Thailand in 2022. The survey data includes a laser contact point density of 100 points per square meter on the terrain surface and uses the UTM coordinate system for the Point Cloud. Processed data includes Digital Surface Model (DSM), Digital Terrain Model (DTM), Digital Elevation Model (DEM), and Orthophoto aerial photography, offering high accuracies and resolutions. Importantly, the paper presents a significant discovery resulting from the LiDAR survey, where new evidence about the structure and shape of a historically significant site named "Kok Chang Din No. 1" was uncovered, refining previous assumptions about its form and function. The findings highlight the efficacy of LiDAR technology in uncovering concealed evidence, particularly in environments with dense vegetation or featuring narrow and small embankments or shallow wells. This study establishes LiDAR technology as an indispensable tool for the comprehensive analysis of ancient settlements, providing detailed insights to elucidate the nature of the settlements in the study area.*

*Keywords: archaeology, remote sensing, LiDAR*

## INTRODUCTION

Studying history and archaeology provides a wealth of academic knowledge from various fields that people in the past have left for present generations to study and learn from. This knowledge encompasses archaeology, art, architecture, linguistics, and science, and can be utilized to create economic value through activities such as cultural heritage management, creative design, information technology, and engineering. The methods of surveying archaeological sites typically involve studying documents, inspecting aerial photographs, and conducting on-site exploration with the help of local people who are familiar with the area. This helps in collecting evidence to assess the value of archaeological sites and plan for further excavations.

Remote sensing technology, particularly Light Detection and Ranging (LiDAR), has emerged as a revolutionary tool for topographic surveys. Similar to radar technology, LiDAR accurately measures the height and depth of objects or buildings on the earth's surface. When applied to the planning and analysis of historical archaeology, LiDAR technology can significantly reduce the survey time and reveal hidden evidence that would otherwise remain inaccessible.

The Geographic Information Science and Space Technology Development Agency (GISTDA) utilized LiDAR to survey the area of U Thong Ancient City in U Thong District, Suphan Buri Province. The survey produced valuable data such as the Digital Surface Model (DSM), Digital Elevation Model (DEM), and aerial photographs. The analysis of the DEM data revealed traces of archaeological evidence, including the discovery of a square-shaped clay elephant enclosure measuring 30 x 30 meters with an average height of 8 meters. This discovery challenges the previously held belief that the enclosure was round and has led to new assumptions about its construction and its potential relationship to ancient Khmer culture. Further excavation is needed to determine the age of the soil layers.

This study aims to utilize advanced remote sensing (LiDAR) technology to enhance archaeological surveys and establish links between physical, social, and cultural features at historical and archaeological sites.

## STUDY AREA

The U Thong Ancient City is situated on Lan Ta Phak Hill, around 65 kilometers north of the ancient city of Nakhon Pathom. It is located approximately 5-9 meters above the plains and 8-12 meters above sea level. The area has a slight slope to the northeast and is bordered by the Chorakhe Sam Phan River to the north, which then joins with the Suan Taeng Canal. In the eastern area, about 1 kilometer from the city wall of U Thong moat, there are still traces of a dug canal connecting the Chorakhe Sam Phan River to the low-lying area. The study area covers approximately 55 square kilometers and is located at latitude 14 degrees 21 minutes north to 14 degrees 23 minutes north and longitude 99 degrees 51 minutes east to 99 degrees 56 minutes east. (Thiwa Suphachanya, 1987)

## METHOD

### 1. Equipment Preparation.

- Unmanned Aerial Vehicle: UAV
- Light Detection and Ranging: LiDAR
- Global Navigation Satellite System (GNSS)
- Software (LiGeoReference, LiDAR360, and Pix4Dmapper)

### 2. Operating diagram.

This work can be divided into three main parts including (1) preparing equipment, (2) performing a survey flight to analyze the physical characteristics of the ancient city of U Thong using LiDAR survey technology, and (3) analysis of various important archaeological evidence that appears in the data obtained from processing LiDAR imaging data. The overview of methodology is shown in Figure 1.

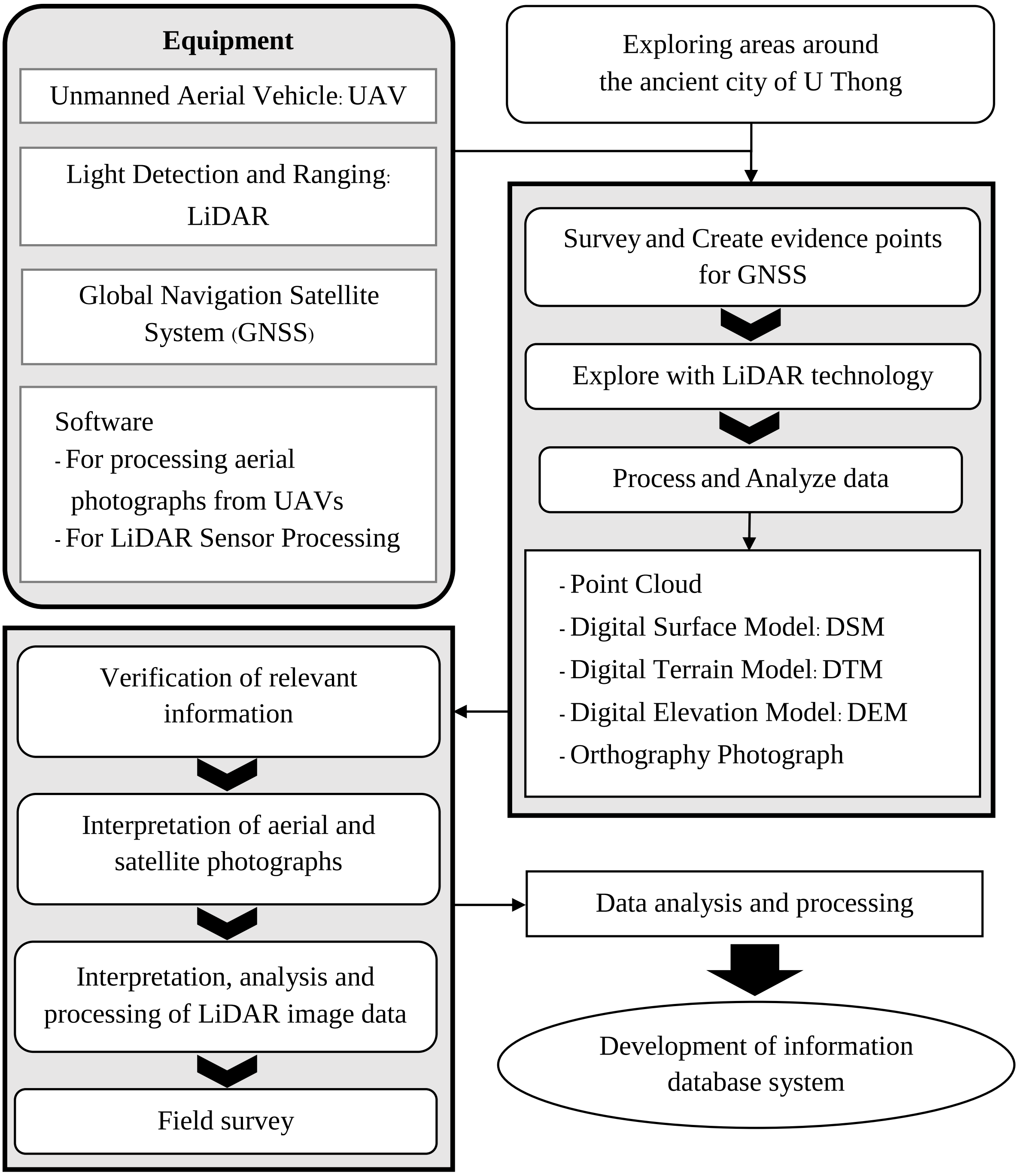



Figure 1: Operational Framework Archaeological Surveying Using advanced remote sensing technology LiDAR.

The process of conducting a LiDAR survey to analyze the physical characteristics of the ancient city of U Thong encompasses three operational steps:

1) Generating flight plans and establishing ground control points

This step involves two main tasks: creating control points and conducting surveys (see Figure 2), both of which are facilitated using remote sensing technology or the Global Positioning System (GPS).

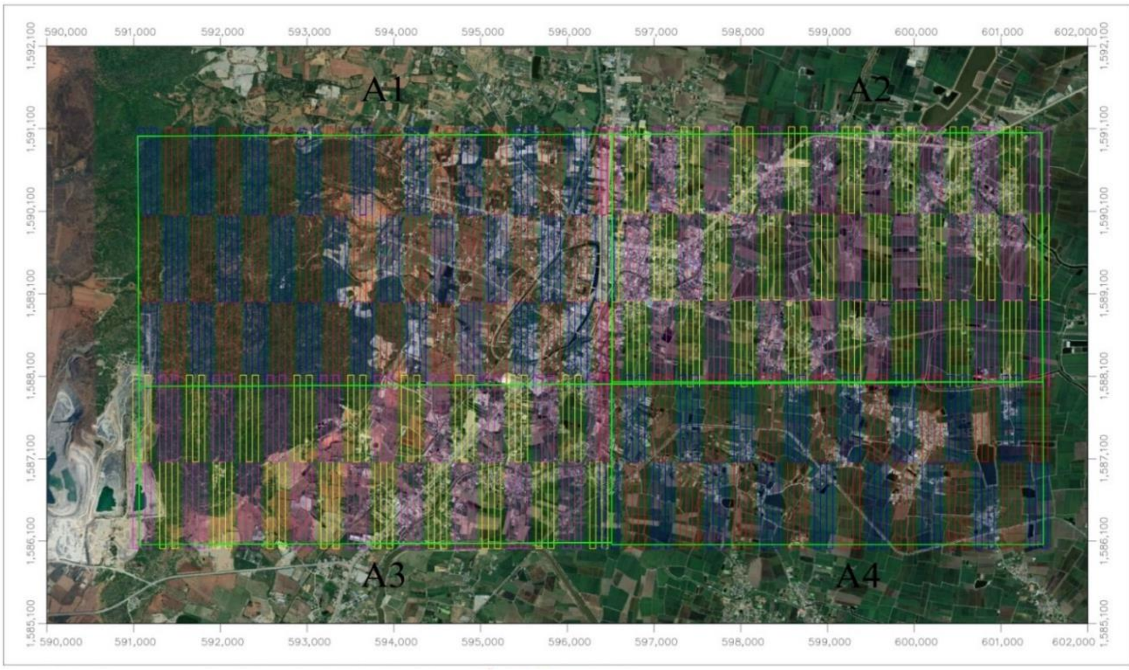



Figure 2: Plan flight route.

2) Employing a LiDAR sensor and Orthographic Photography mounted on Unmanned Aerial Vehicles (UAV) to capture data over the study area.

The LiDAR or laser topographic survey system will be affixed to a UAV. It captures data by emitting laser pulses towards the target and measuring the time it takes for the pulses to return. The accuracy of the terrain height is within the range of 5-10 centimetres, and the density of the Point Cloud on the ground is 100-200 points per square meter. Orthographic aerial survey flight has a resolution of 5-10 centimetres per image point (cm./Pixel). Figure 3 illustrates the operation work in LiDAR survey.

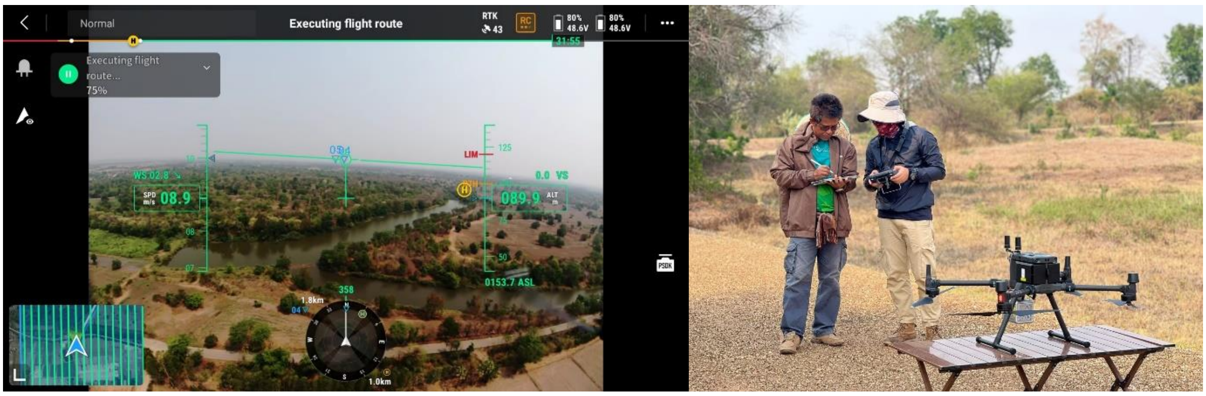



Figure 3: Operating UAVs and Capturing data over the study area.

3) Reporting on survey results and processing

This involves generating five types of survey and processing production flight reports, including Point Cloud, Digital Surface Model (DSM), Digital Terrain Model (DTM), Digital Elevation Model (DEM), and Orthographic Photograph.

In the final process, we undertook 5 steps to analyze crucial archaeological evidence from LiDAR data:

1) We collected and reviewed relevant information, including research reports, historical and archaeological survey reports, theses, and excavation reports from both domestic and international sources.

2) We interpreted aerial and satellite photographs to examine the topographic characteristics and settlement environment of the study area, with a detailed focus on the ancient city area.

3) We analyzed and processed LiDAR image data to interpret trace evidence related to ancient cities, such as ancient sites and traces of moats and dams.

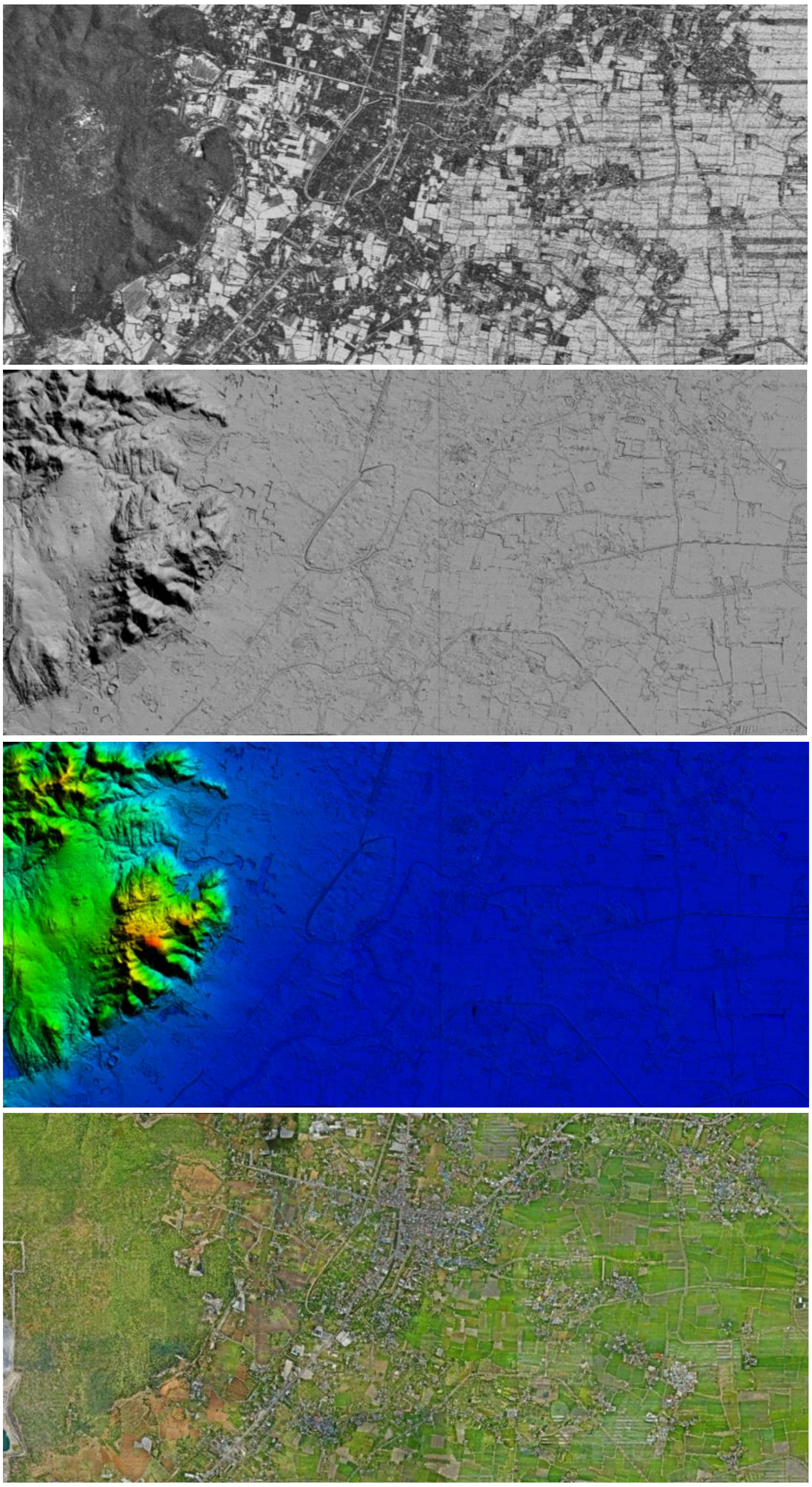
4) We conducted field surveys to verify the interpretation of trace evidence related to archaeological sites of ancient cities based on LiDAR image data and other relevant information.

5) We developed an information database system by analyzing and compiling GIS data dictionaries to prepare historical and archaeological geographic data layers. This involved creating a geographic information database system related to ancient cities with detailed descriptions of Attributes.

## RESULTS AND DISCUSSION

During a survey flight utilizing advanced remote sensing technology (LiDAR) to cover the ancient city area of U Thong and nearby areas, a total area of approximately 55 square kilometers was covered. The survey was conducted using a LiDAR sensor device that can record data in multiple returns. The accuracy of the IMU/INS system installed in the LiDAR machine is within 0.038 degrees along the Azimuth (Heading) line and 0.008 degrees along the Altitude (Roll/Pitch) line. The survey data has a density of 100 points per square meter, and the Point Cloud is in the UTM coordinate system. TGM2017 is a model for converting the height above the geoid, and after correction, the accuracy is checked by random inspection at 15 points covering the 55 square kilometer area. The processed survey data includes a Digital Surface Model (DSM), Digital Terrain Model (DTM), Digital Elevation Model (DEM) elevation data, and aerial photographs with an image point resolution of 0.10 meters, as shown in Figure 2. Once the LiDAR data is received, it can be utilized for the analysis and interpretation of various traces of evidence, including natural and detailed cultural landscapes related to the ancient city of U Thong. This analysis is to be conducted by archaeological experts to create a geographic information database related to the ancient city of U Thong, as shown in Figures 4 and 5. Finally, the new findings in archaeology sites can be mapped and reported in Figure 6.

Result Product



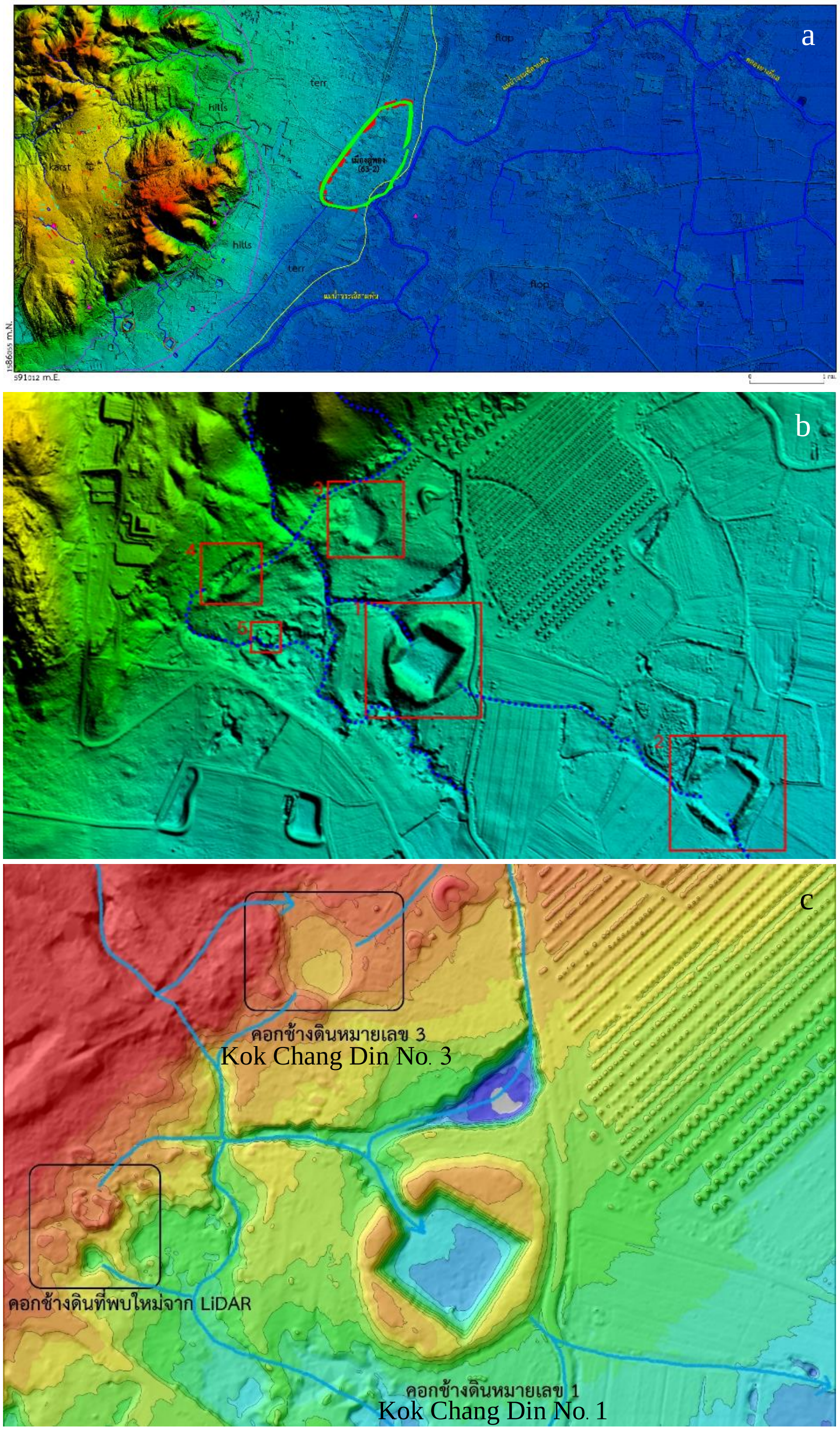
Digital Surface Model: DSM

Digital Terrain Model: DTM

Digital Elevation Model: DEM

Orthophoto

Figure 4: The images of DSM, DTM, DEM, and Orthophoto




Interpretation of LiDAR data reveals traces of archaeological sites and ancient waterways, indicating consistent past water management on mountains, foothills, and plains, possibly linked to ancient cities.

a: Showing evidence of archaeological sites and ancient waterways

b: Revealing evidence of the ancient site of Kok Chang Din at 5 different locations

c: It provides new evidence regarding the structure and layout of the archaeological site known as "Kok Chang Din No. 1". This necessitates a study of the construction of the new elephant stable and excavation to ascertain the age of the soil layers.

Figure 5: The archaeologist analysis results.

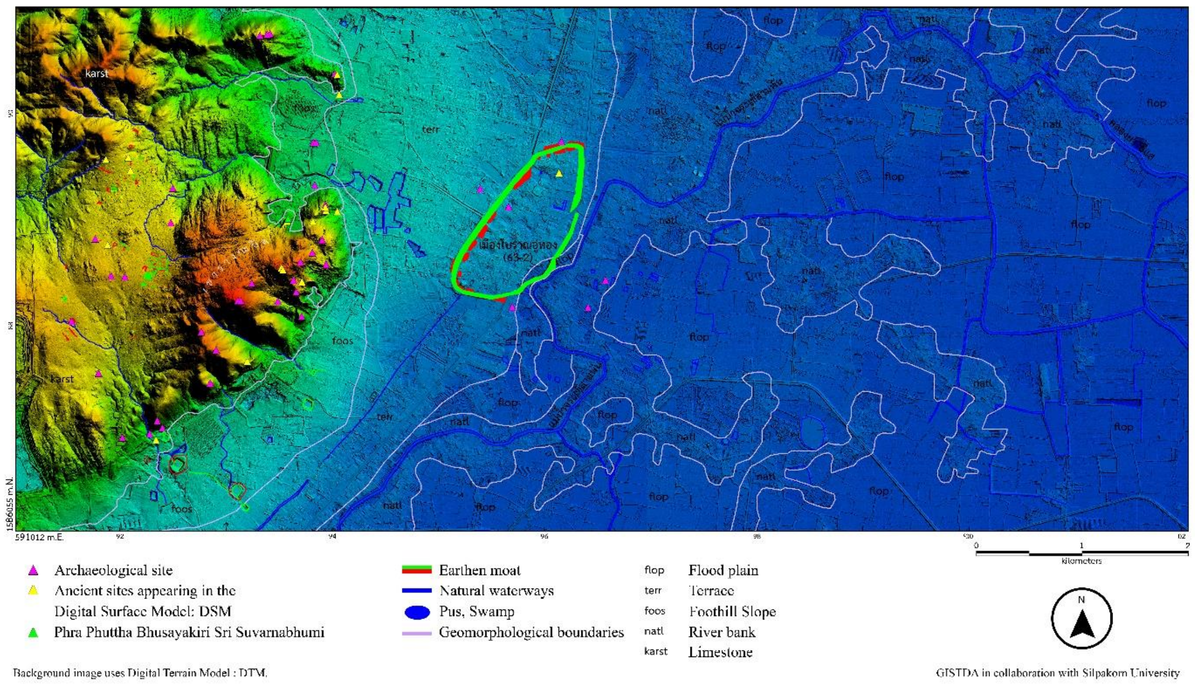



Figure 6: Operating UAVs and Capturing data over the study area.

## CONCLUSION AND RECOMMENDATION

In summary, the utilization of LiDAR Scanner technology for surveying and analyzing historical archaeology has presented significant advancements in streamlining survey planning and reducing the associated time requirements. This technology has effectively exposed previously inaccessible evidence, facilitating valuable connections with other knowledge sources and contributing to a comprehensive narrative of the surveyed area. The resulting insights have not only deepened our multidimensional understanding and appreciation of the region but also hold promise for sustainably enhancing its cultural and economic value.

Moreover, the analysis and interpretation of the data have highlighted the pivotal role of LiDAR-derived height models in studying cultural evidence, particularly in challenging environments characterized by dense tree coverage or featuring narrow embankments and small, shallow ponds. The discernment of size and shape through LiDAR-generated elevation model images has been particularly noteworthy in these contexts.

It is clear that while aerial photographs and satellite images are indispensable for studying ancient settlement environments, LiDAR data plays a crucial role in capturing present-day information, allowing for a holistic understanding and a more precise description of the settlements within the study area.

In conclusion, the outcomes stemming from the application of LiDAR Scanner technology in historical archaeology surveying and analysis not only enhance our comprehension of the past but also have the potential to significantly influence future research and conservation endeavours.

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