Geo-informatics Applications for GMS e-Culture Utilizing Open Source Software

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Abstract

Geo-informatics technologies have been utilized in the cultural heritage conservation, reservation, management, and research studies in various cases. For example, remote sensing and GIS can be used as tools for archaeological analysis. There are various cases around the world that remote sensing and GIS were used to assist archaeologists to pin point and help to identify archaeological sites. Especially, the applications of Synthetic Aperture Radar (SAR) demonstrated in various applications that had never been imagined before on how the technology can help the conventional way that is conducted by archaeologists. The applications of SIR-A for the lost city of UBAR, and AirSAR at Angkor are the two of the most well known.

In this presentation, there will be introduction by case studies. The first case, the application of remote sensing and GIS at Sukhothai world heritage site in the lower part of the northern region of Thailand is demonstrated. This case study will demonstrate on how integrated technologies can be used as tools for world heritage management and study of lives during Sukhothai period. The second case study, the information extracted from ancient maps of Ayuttaya period is compared with the current information extracted from satellite data, topographic map, and other related information. For the current study for GMS e-culture, the application of remote sensing and GIS for the identification of the royal road from Angkor to Phimai, which is a part of this research work is presented. The usage of satellite remote sensing including AirSAR, and other sources such as digital elevation model (DEM), old maps, aerial photos and ground survey will be demonstrated. The result from this study can be used by archaeologists. For example, to identify the locations that was mentioned in the royal chronicles or other documents in existing that describe the live and locations during that period. For the distribution of the information from these case studies, the open source software has been utilized through the development of internet map server. The features of Minnesota map server enable us to have a new way to present the information to more audients around the world.

By utilizing geo-informatics technologies and open source software development for GMS e-culture study, we will have a better vision of the relationship between cultures, people, between civilizations in the GMS countries. This understanding will be certainly important to the region, and to the people in the region.

1. Case Study at Sukhothai World Heritage Site

The objective of this study is to determine remote sensing and GIS research strategy to study the historic environmental condition at Sukhothai, Si Satchanalai and Kampaeng Phet World Heritage sites.

The main findings include :
1. Land Use Change Analysis
2. Population Distribution Analysis
3. Ancient Sukhothai Hydrological System
4. Comparative Study on Ancient Sukhothai City Planning

1.1 Land Use Change Analysis

By comparing the 2 aerial photos of the year 1953 and 1995, we can identify the change in land use inside and outside of the city wall. The area where the people had invaded into the ancient city can be clearly identified. If the reconstruction of the original condition is needed, these georeferenced images together with a Global Positioning System (GPS) can be used to identify the precise position of the site. In addition, the information from these georeferenced images can serve as the evident for the court of law in case of invasion to occupy the historical sites by people in the area. The figures below compare a sample location in 1953 and 1995 (Figure 2).
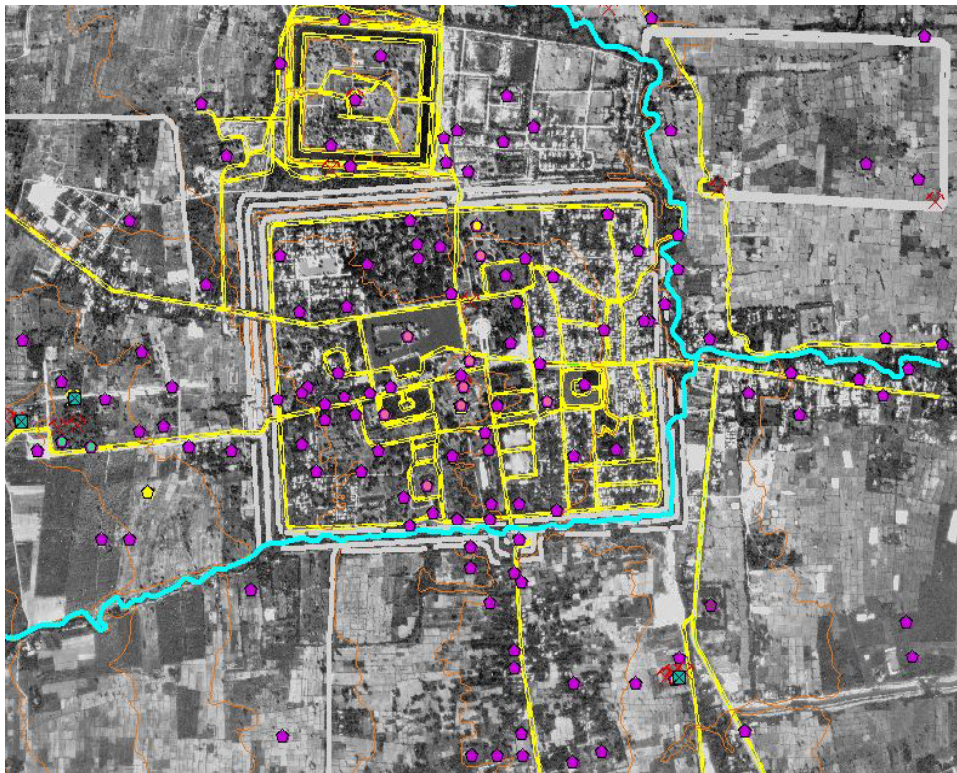

Figure 1 GIS database of Sukhothai world heritage site

1.2 Population Distribution Analysis

By using the information derived from this research, including the location and distribution of temples in the area together with other information such as the hydrological maps, topography maps, etc. The analysis revealed that the population density was high in the central (inside the city) and west side of the city outside of the city wall. The population density in the northern and southern part ranked the second. The density in the eastern part seems to be the least dense population when comparing the density of temple sites in the region with other parts of the city. This result is based on the assumption that the people might live in the area surrounding the temples, which is still the custom until today in Thailand. In Thailand, there

is always at least a temple in a community. This assumption is not applied with the temple sites in the western side outside the city wall.

1.3 Ancient Sukhothai Hydrological System

One of the most promising results from this current study is the hydrological system study. From the analysis of remote sensing data, topographical maps, ancient mound systems and previous study on the ancient hydrological system, we can integrate this information and analyze these information together and reveal ancient irrigation system as shown in Figure 3 and Figure 4.
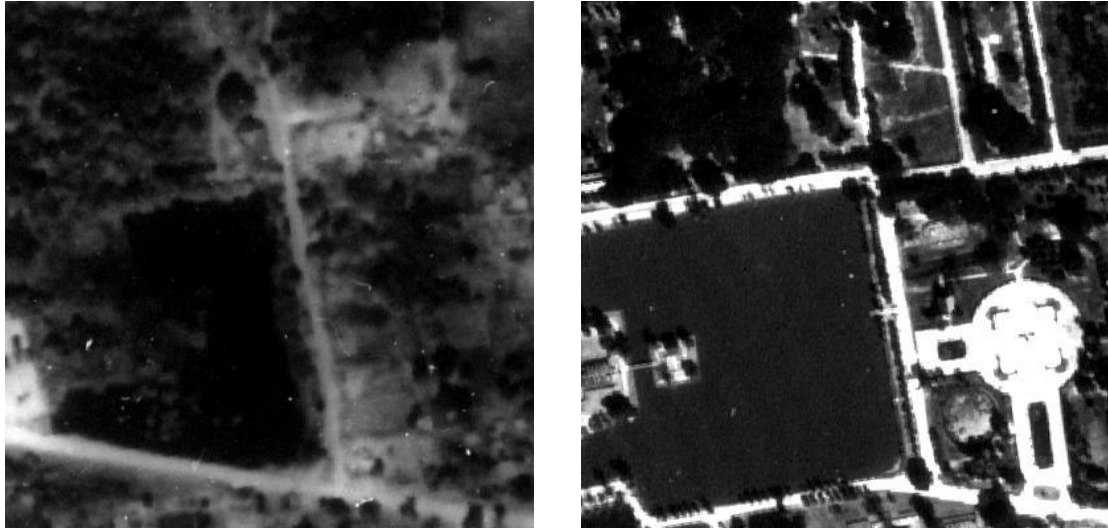

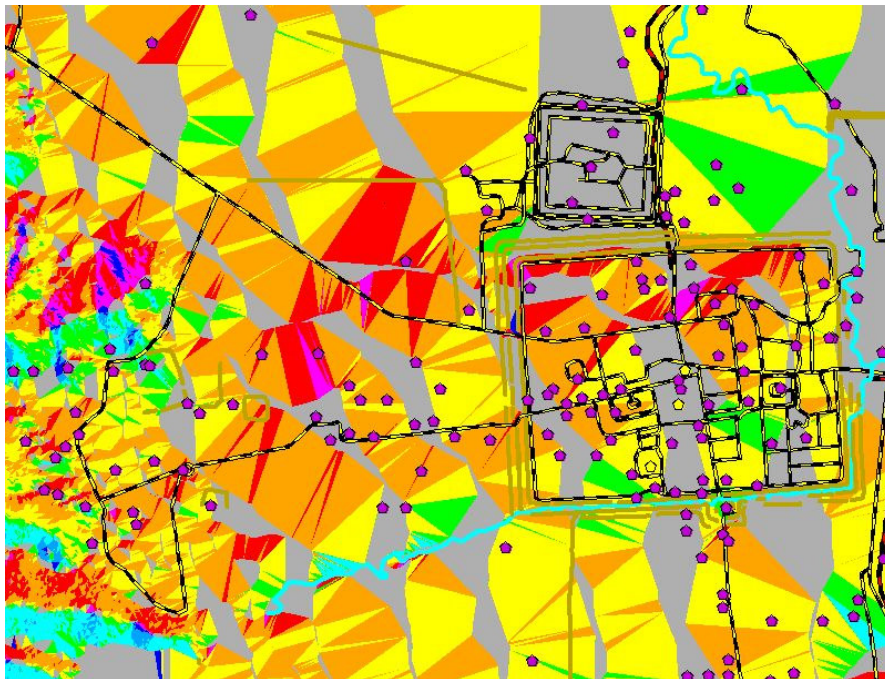Figure 2 The aerial photo of Wat Sra Sri from 1953 compared to 1995

Figure 3 The aspect map showing the slope and direction which can use to predict water flows in the area surrounding the city

1.4 Comparative Study on Ancient Sukhothai City Planning

From the observations of the plan of Sukhothai city from aerial photosmaps, the detailed study had been conducted to study ancient Sukhothai's city plan. This study confirms with the preliminary observation from the archaeologists that the first community (under Khmer control) had set up their settlement around the area of Wat Pra Phuy Luang in the northern area of Sukhothai city. Later on, after Thai took over the territory and built the city, they had built up the city in the area below the first settlement.
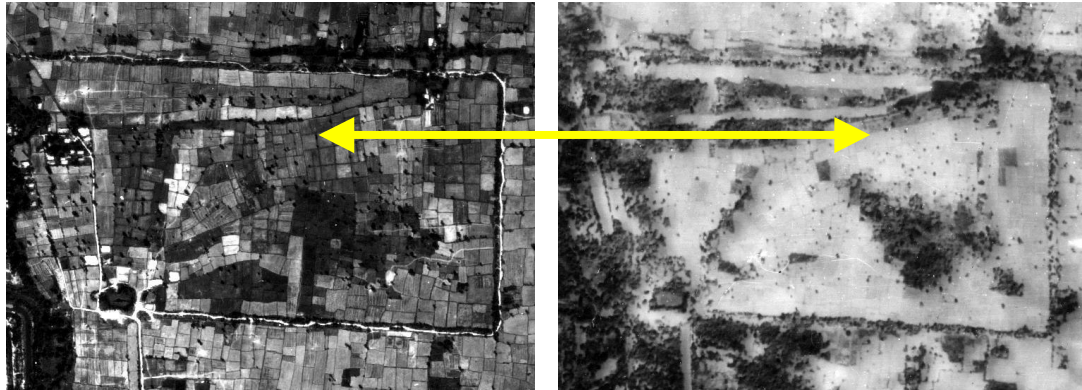

Figure 4 The aerial photo of the reservoir on the north east corner of the city of 1953 comparing to aerial photo of 1995

2. Case Study of Ayuttaya's Multi-temporal GIS database

Ayuttaya was a capital of Thailand (Siam) empire between the period of 1283- 1767. For the case study of Ayuttaya study, the data from various sources and various time periods had been utilized. The oldest information utilized was the ancient map produced by French missionary during 1687 period. The newest information is the satellite images, including optical, infrared, synthetic aperture radar. The integrated information is very useful for the study of life during Ayuttaya peiod. Further work is started on integrating this information with other cultural information. From this study, the locations that had been mentioned in the royal chronicles of Ayuttaya, the reports that were written by European who visited Ayuttaya could be identified precisely by the locations that could be extracted from the GIS database that is developed.
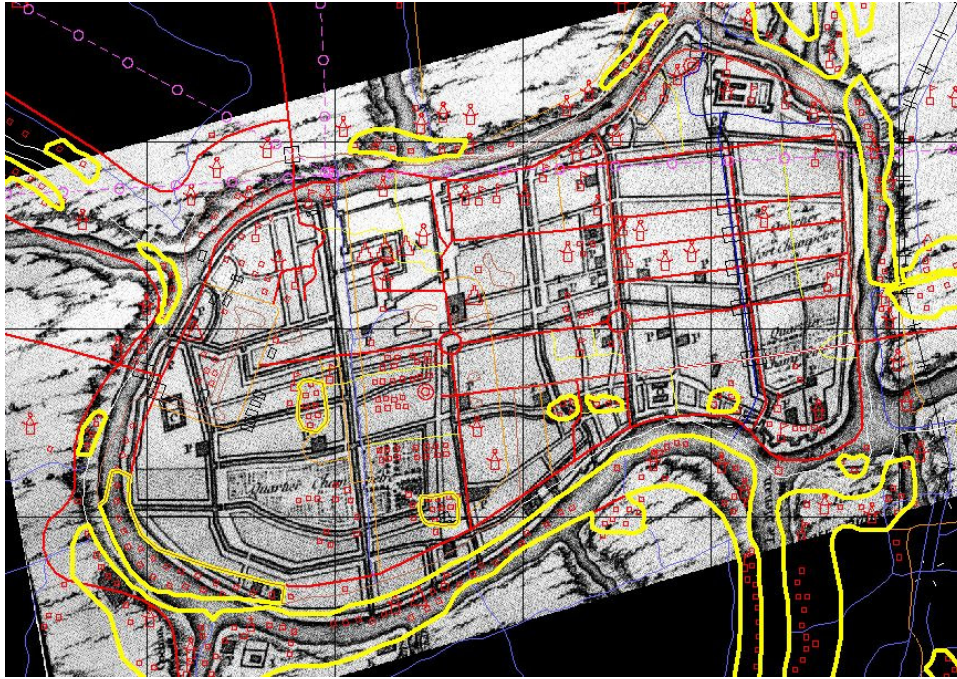
Figure 5 Multi-temporal GIS database of Ayuttaya Ancient City, Thailand

3. Case Study of Royal Road from Angkor to Phimai

In this study, the remote sensing and GIS data available for the study included old maps (1900's), current maps (1982), old aerial photos (1954), satellite images: Landsat TM, Landsat ETM, JESRS-1 OPS, JERS-1 SAR, ADEOS, and AirSAR data of Phimai and Phanom Rung area. These data were studied together with archaeological information that has been studied before by various archaeologists in Thailand and aboard. The outcome of this study revealed new findings such as:

1. Ancient irrigation system in the Phimai area
2. Communication system, which had been called Royal Road from Angkor to Phimai, in Cambodia area and in Thailand area have different characteristics
3. The application of remote sensing and GIS for archaeological study can confirm the assumptions that archaeologists had proposed about the Royal Road from Angkor to Phimai, and the perception about the Royal Road in Thailand area has to be modified.

The figures below illustrate some of the data that had been utilized for this research.

The identification of historic roadway and human settlement of Khmer empire using remote sensing / GIS is focused on the integration of the applications of current technology to the field of cultural heritage. Only with the current technologies, the research topic such as this one can be conducted with low budget equipments, as it would require very expensive equipments 10 years ago. It is hoped that the result of this study will illustrate that the cultural heritage can be assisted by new technologies to this globalization era.

In addition, one of the main result from this study reveal that by applying only remote sensing and GIS techniques to study archaeology is not the sufficient way to proceed. The information and knowledge from archaeological, environmental, and common knowledge are also very important to the analysis study.

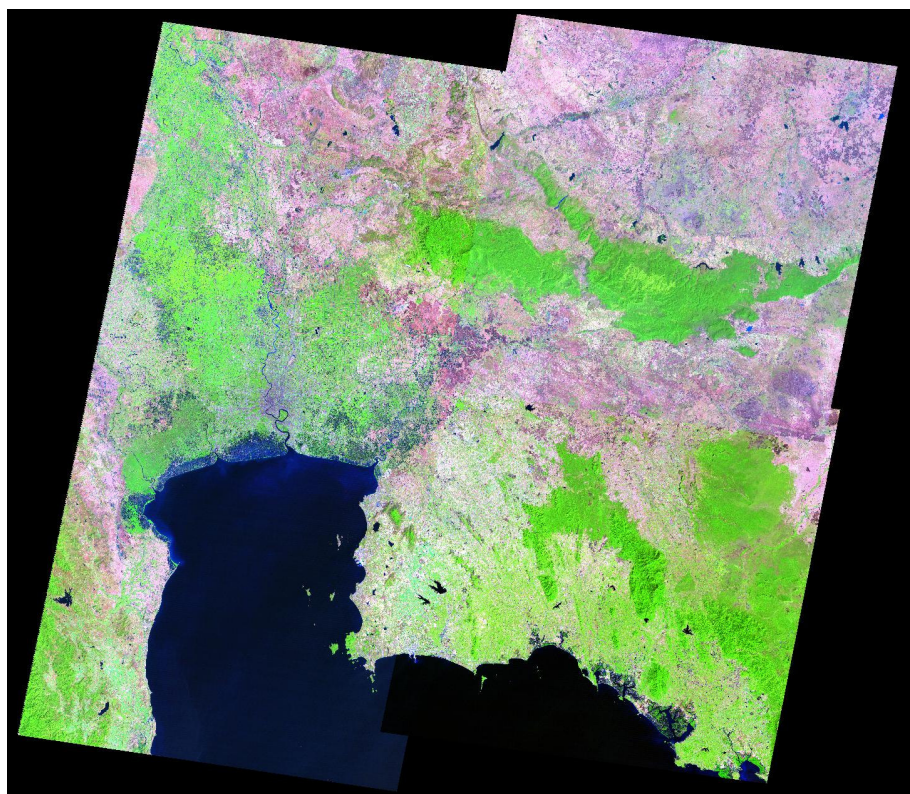Figure 6 1954 Areal Photograph of Phimai area

Figure 7 Landsat TM (1999) mosaic of study area

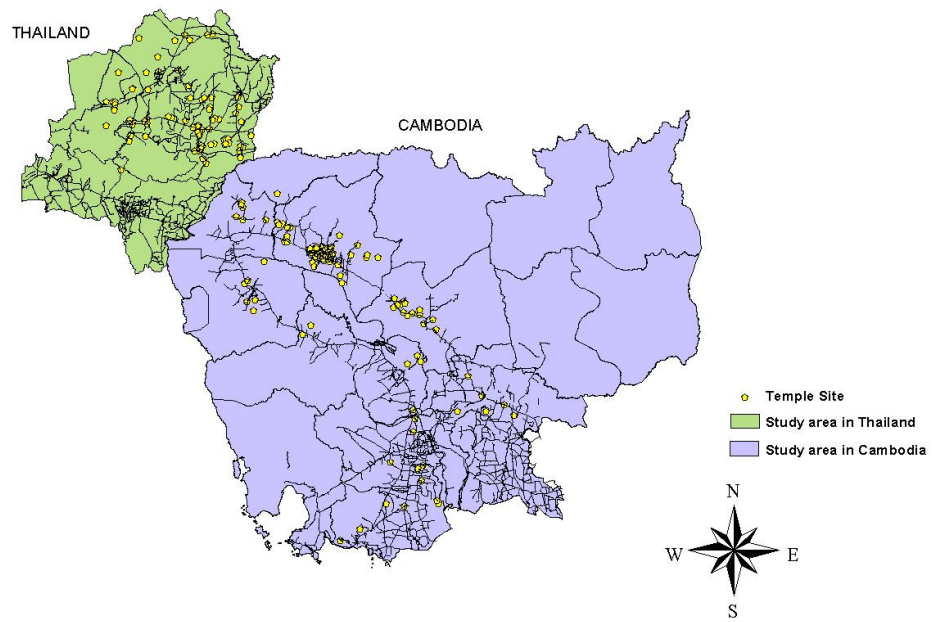## Temple Sites of Khmer's Period in Thailand and Cambodia

Figure 8 GIS database of Khmer temples sites in Cambodia and Thailand

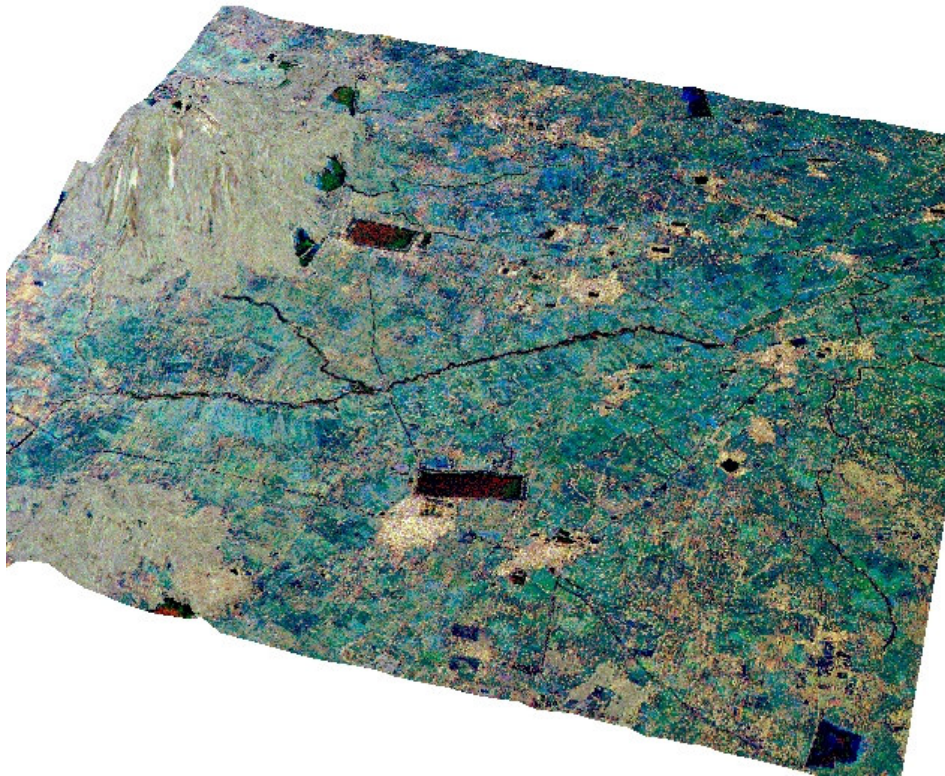Figure 9 AirSAR data of Phanom Roong area

Figure 10 3D model from AirSAR data of Phanom Rung area

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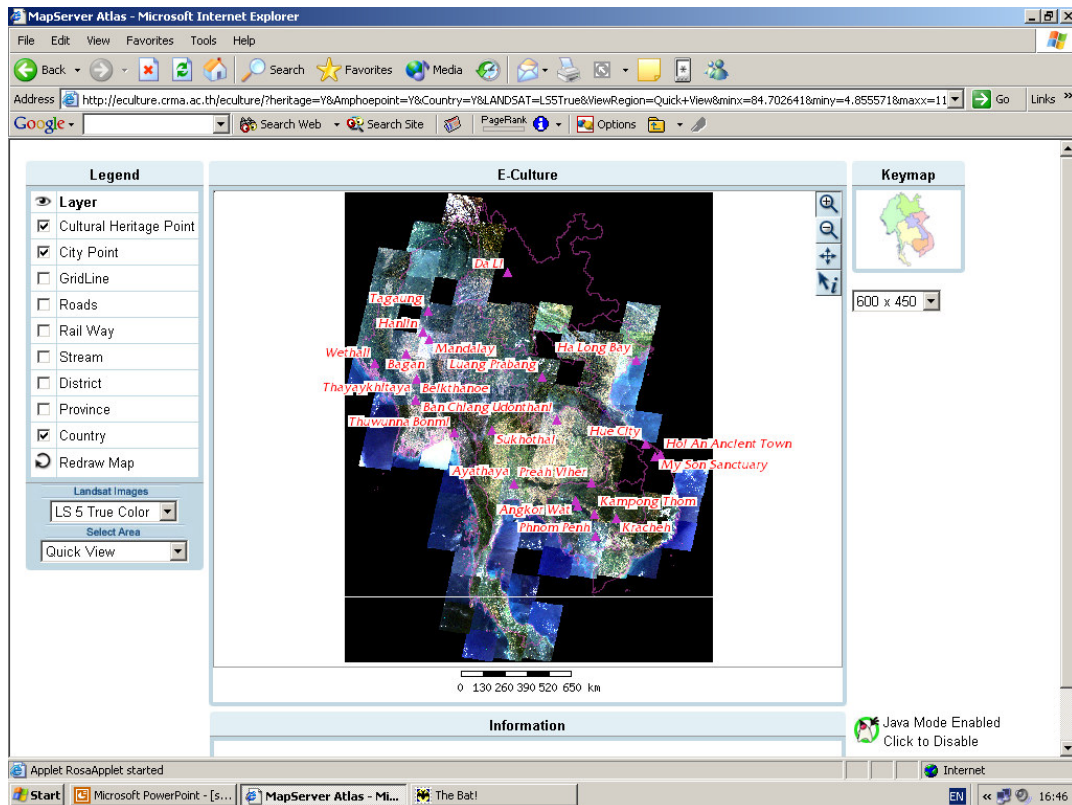
Figure 11 Sample output from **eculture.crma.ac.th**

The system that has been developed is in the form of internet map server containing the cultural heritage information. The name of the site is "**eculture.crma.ac.th**". The detailed system consists of:

Computer Set
- Pentium IV 2.4 C (FSB 533 MHz)
- DDR Ram 512 MB
- Hard disk (40 GB + 120 GB)
- CDROM 52x
- UPS

Mapserver Application Software Component
- Linux Mandrake 10 RC1
- Minnesota mapserver Version 4.01
- Gd version 2.0.20
- Gdal version 1.1.9
- Php version 4.3.4
- Proj4 version 4.4.7
- Ming version 0.2a
- Curl version 7.10.5
- Png library version 1.2.5-10
- Tiff library version 3.5.7-11
- Pdf Library version 4.0.1-1
- Zlib version 1.2.1-2
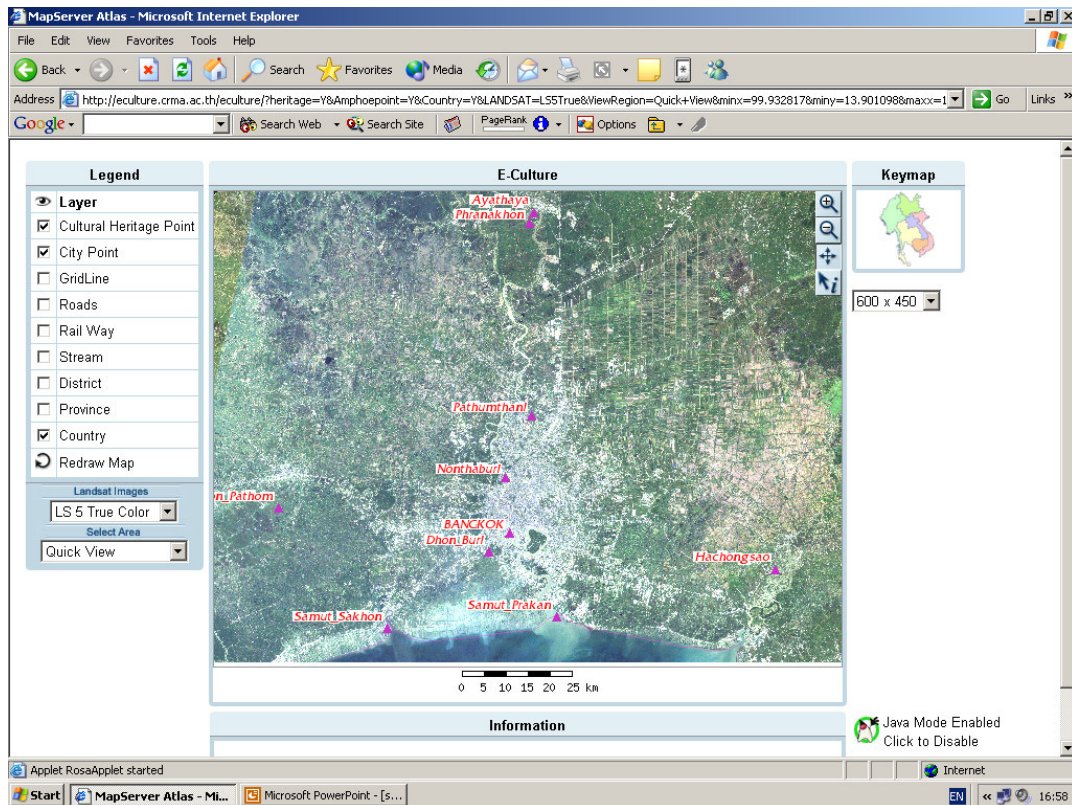- Freetype6 library version 2.1.7-4

Figure 12 Sample output from **eculture.crma.ac.th**

5. Conclusion

These case studies demonstrate the usefulness of remote sensing and GIS technologies for the archaeological study, cultural heritage management, and related fields. The archaeological study could benefit from the applications of remote sensing and GIS. In the near future, when the work on new archaeological research begins, the new finding may be discovered in the sequence of the study. With the integration with other fields of development in archaeological research, the new knowledge will arrive at the door step of the scholars around the world. This will begin the new era of information technology.

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