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Exploring East-West Cultural Corridor through Ancient Communication Routes: New Paradigm in GIS-Based Cultural Studies

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Abstract

This paper will be centered on the Khmer-Thai Collaboration research project named "*Living Angkor Road Project*" (LARP) supported by Thailand Research Fund (TRF). LARP is a cross-border multi-disciplinary research aimed, firstly, to identify all the remaining portions of ancient roads radiating from the Angkor capital to different provinces of the ancient Khmer Empire, in view of an overall mapping of the network known to date; secondly, to identify and describing all the infrastructures existing along these roads: bridges, all kinds of canals, temples, remains of rest-houses and hospitals.

Since very early of the work, the core concept was enlarged. The project would target not only the archaeological remains, but also the present-day communities establishing all along these axis. The argument is simple and clear: although normal evolution, abrupt changes, and special historical events. Globally speaking, these communities are not alien to the Angkor past. In addition, they still use and worship all the said historic remains. Therefore the team would have to conduct different ethnographic surveys in the two countries.

The first step of the whole target was Angkor-Phimai road. Then, for the following steps, we are studying the continuation of the Angkor to Phimai road further away from the capital, the Angkor-Sdok Kok Thom road, called the West road, and also the continuation of this road to the area currently eastern Thailand; the Angkor-Vat Phu, called the North-East road; and the Angkor-Vijaya, called the East road. For the studies, the team benefited from the result of remote sensing surveys which significantly help the systematic ground trusting conducted during several campaigns in Cambodia, Thailand and as well as in Laos. A number of sites were excavated, and the excavation was done according to modern method, using geo-informatics, geo-physics surveys, etc.

1. Introduction

Recently, geo-informatics technologies have been utilized effectively in many applications for area studies in various fields of analyses, such as land use / land cover change, urban studies, movement of human activities, archaeological and historical studies on the conservation, preservation, management of cultural heritage, and in related studies. For example, in the case of archaeological and historical studies, GIS/RS can be used as tools for archaeological analyses. In various cases around the world, geo-informatics technologies in the form of RS and GIS have been used to assist archaeologists to pinpoint and identify archaeological sites. Examples include the discovery of a buried section of the Great Wall of China by analyzing SIR-C[*3] radar data from the space shuttle [Associated Press, 2009]. It had never been imagined before how geo-informatics technologies could effectively assist the conventional methods of archaeologists. The application of SIR-A[*4] to the lost city of Ubar [Bloom et. al, 1997] and AirSAR at Angkor are two of the best-known studies [Lertlum, et. al, 2001].

From 2005 to present, the Living Angkor Road Project (project leaders: Surat Lertlum (Thailand) and Im Sokrithy (Cambodia)) was conducted by researchers from Chulachomklao Royal Military Academy, Silpakorn University, Prince of Songkla University, Fine Art Department of Thailand and the researchers from APSARA Authority[*5], Cambodia with funding support from Thailand Research Fund (TRF). At the beginning, this project involved detailed studies of the royal road from Angkor to Phimai, its utilization, the people who lived and used the royal road, and the culture that has now disappeared. Currently, the project is studying on the other ancient roads from Angkor and related communication linkages. The most advanced technologies in the project were technologies of RS, GIS, geo-physics, and information technology and these were employed together with conventional archaeological methods. Also, in order to share information and data effectively among collaborating scholars, an information sharing system which includes gathering and retrieval functions was newly developed. In addition, it was considered that the data derived from the project could be further utilized by the other related works in the fields of land use planning and urban development related to cultural management, tourism, etc.

Even though the application of geo-informatics to cultural studies is still a new field of study, it is providing to be an indispensable to carry out the research effectively adjunct to conventional methods of cultural studies. However, the ways to apply geo-informatics to cultural studies might vary from case to case and location to location.

This paper illustrates how geo-informatics was applied to study the royal road from Angkor to Phimai and the results which were newly obtained. Also, the role and significance of applying geo-informatics to the archaeological studies are introduced.

2. Geo-spatial Data Processing in Cultural Studies

From the view point of data availability, the geo-spatial data that can be utilized for cultural studies is quite different from that employed in other applications, such as census analysis, measured data analysis, and so on. In other words, it is difficult to separate the gathering and processing of data in terms of phases of input, processing, and output which is the general pattern of information processing. The informatics specialist must understand the meaning of data and the story of the past in order to analyze it appropriately. Therefore, data that can tell us about the past can be

utilized only in collaborative work between informatics specialists and archaeologists. In most of cases, archaeological studies treat events that occurred before any geo-spatial data was recorded or produced. The best solution in this kind of study is to utilize the oldest data available, such as old aerial photographs, old maps and ancient documents [Lertlum, 2003]. This is probably the most valuable information that we can acquire when we need to study further back in time. In addition, in the current situation, high resolution satellite images such as QuickBird and IKONOS are also available, but with high cost. The utilization of existing aerial photographs is still an alternative way to analyze the target area with comparable result to high resolution satellite images [Lertlum, 2005].

In utilizing old aerial photographs for area studies, the most effective way is to integrate the old aerial photographs with other materials, such as current aerial photographs, satellite images, and the GIS database with geo-referencing information [Lertlum, 2005]. This is the critical point of utilizing old aerial photographs. Since old aerial photographs generally lack geo-referencing information, such as latitude and longitude at the corners of the photograph, it is difficult to map and position it onto other materials accurately. Therefore, the main issue with old aerial photographs lay in geo-referencing them with other material with accuracy of position and scale. To solve this issue, the geo-referencing information from current aerial photographs, satellite images, and/or the GIS database can be used for integrating the old aerial photographs. For example, Figure 1 illustrates a sample of geo-referencing of old aerial photographs with image of Landsat ETM[*6] for the Angkor area. The technologies mentioned above also were applied in the project.

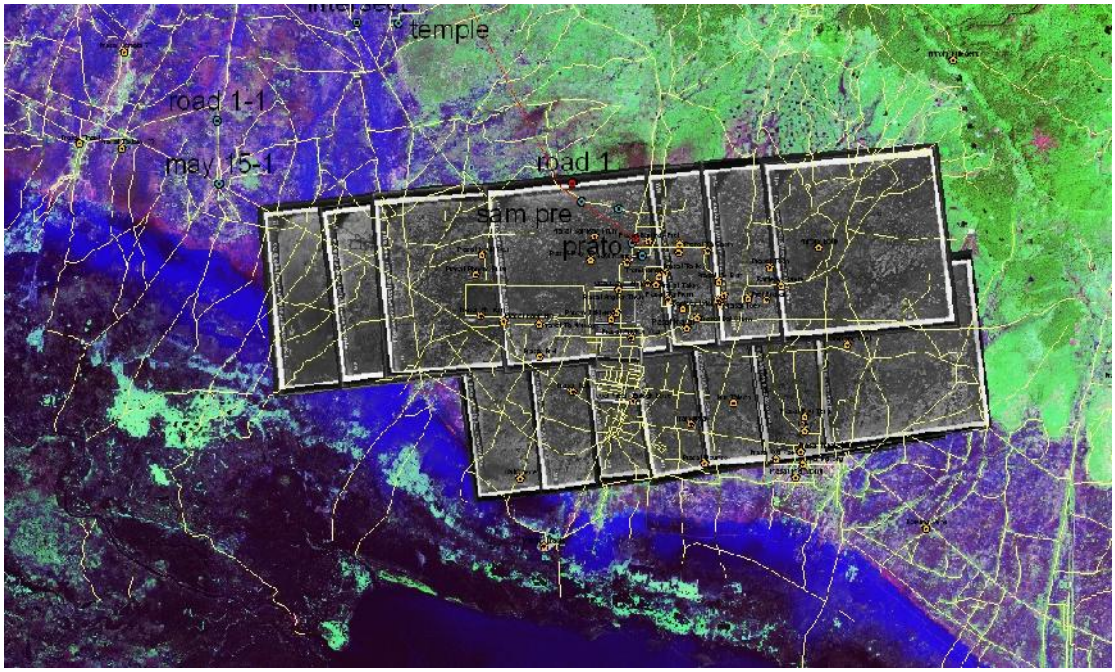


Figure 1 A sample of geo-referencing of old aerial photographs with image of Landsat ETM (2002) for the Angkor area

3. The Use of Geo-informatics for Area Study in Muti-disciplinary Approach: The study on Royal Road from Angkor to Phimai

In this research, archaeological and anthropological knowledge together with geo-informatics, geo-physics and information technologies were utilized to identify and pinpoint the ancient road from Angkor to Phimai that was described in the inscription about Jayavarman VII, the great king of Cambodia. From archaeological and historical studies, we had learnt that during his period, the Khmer empire expanded to cover most of the area of Southeast Asia. The information from the Pra Khan inscription mentioned that Jayavarman VII had built the infrastructures for the travelers along the royal road, such as 17 *dharmshala*s (chapels of rest houses) along the royal road from Angkor to Phimai [Coedes, 1941].

This research aims to study the details of this ancient road, its utilization, the people who lived and used the road, the ancient industries along it and the cultures that have disappeared and those that have been continued to flourish along the royal road. The most advanced technologies were applied in the field of RS, GIS, archaeology, anthropology, geo-physics and information technology. Information systems were also developed to gather data from this study for scholars to use. In addition, the data derived from this project can be further utilized for related works in the fields of land use planning related to cultural management, tourism, etc.

The steps that had been taken in this study were as follow:

(1) Review previous studies about the royal road from Angkor to Phimai so we can identify general view of science and technologies that can be utilized, and what should be the results from the proposed study.

(2) Preliminary analysis to utilize the result to develop GIS database for field survey planning.

(3) Conducting field surveys.

(4) Conducting geo-physics experiments.

(5) Conducting archaeological excavations.

(6) Developing GIS database from field surveys together with other related data for integrated analysis.

(7) Integrated analysis with all information.

(8) Proof the assumptions from the results of the integrated analysis.

In the following, we will explain how we had utilized geo-informatics for this study. Firstly, how we had applied geo-informatics in the beginning of the study for making survey plans (step (2)) as explained in section 3.1. After the surveys, how we applied geo-informatics to the data from surveys (step (6) and (7)) as explained in section 3.2.

3.1 Utilization of Remote Sensing and GIS for Survey Planning

In order to start the research work according to the proposed plan [Lertlum, 2007], existing archaeological data related to the royal road were gathered. Then, the GIS database was implemented to make preliminary study of the royal road from all related geo-informatics data, including old maps, aerial photos, satellite images, and location databases of all archaeological sites in the study area. The buffer zone[*7] of the linked path connecting the already known *dharmshala*s (chapels of rest houses) was created. Next, the database was used to make plans for a field survey. From analysis of this database, some parts of the royal road could be identified according to the assumption and knowledge about the pattern of the royal road, especially, in Cambodia, where the landscape has not been changed greatly, but the confirmation from the surveys were needed. The following items are the phases that were carried out:

(1) The topographic properties such as surround landscape, water ways, and linear pattern of the ancient road that can be identified by satellite images or aerial photographs, as shown in Figure 2, were listed as common properties for ancient road. This process was done manually since the classification process could not separate between the patterns of ancient road and current road. In this case, we utilized the ancient road from Angkor to the west as our sampling site (the ancient road running west from Angkor to Sadok Kok Thom temple in Thailand border area). The ancient road can be recognized, as shown by the arrows.

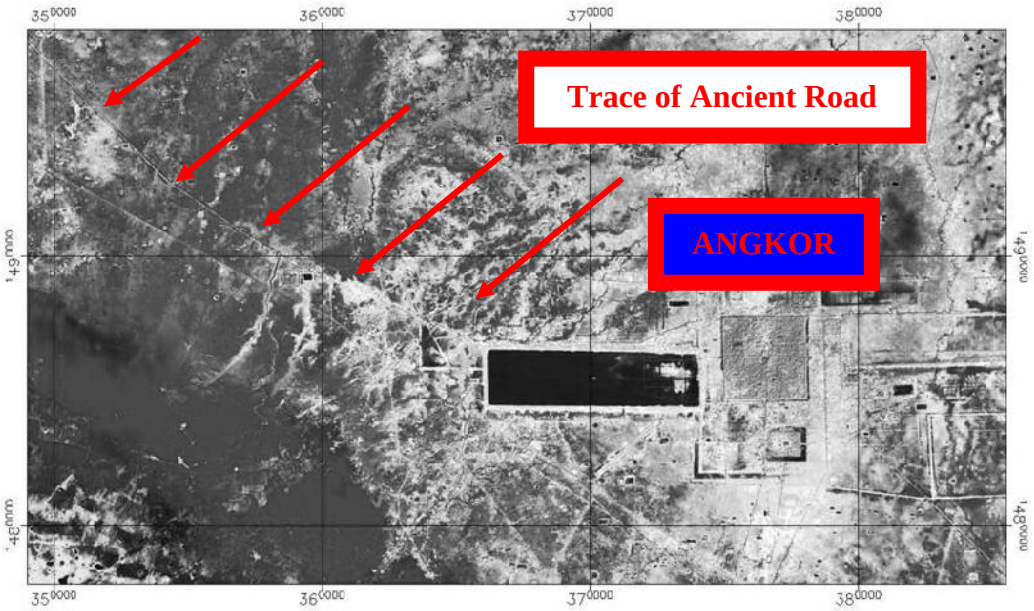


Figure 2 Ancient road running west from Angkor over Landsat ETM (2000)

(2) The locations of all the previously identified *dharmshala*s (chapels of rest houses) along the royal road from Angkor to Phimai were utilized together with aerial photos and satellite images. In particular, old aerial photographs, (World Wide series from U.S. Army taken in 1954 and Williams-Hunt collection taken during the World War II) which show little disturbance of the landscape were geo-referenced and overlaid. Such satellite images and aerial photographs were used together with the information from step (1) to trace the royal road and make a plan for field surveys. In addition, the patterns of the landscape of the area surrounding known *dharmshala*s along the royal road as sample shown in Figure 3 were compared. And we had found that all the *dharmshala*s located near water structure or water way.

(3) Man-made structures along the royal road were mapped. For example, water structures, ancient bridges, which were built from laterite, and ancient communities in the vicinity of the royal road, in a 1-km buffer zone on both sides of the road were explored from satellite images, aerial photographs, archaeological data, and previous survey data. This easily performed using a function in the GIS. This result also was

used for planning field surveys. Figure 4 shows the landscape of ancient community of Muang Fai from old aerial photograph (World Wide series: 1954). Muang Fai is an important ancient city of the northeast Thailand. From the buffering process, Muang Fai is within 1-km buffer zone of the royal road. This information is also very important for illustrating the relationship of the royal road to the ancient communities in the area.

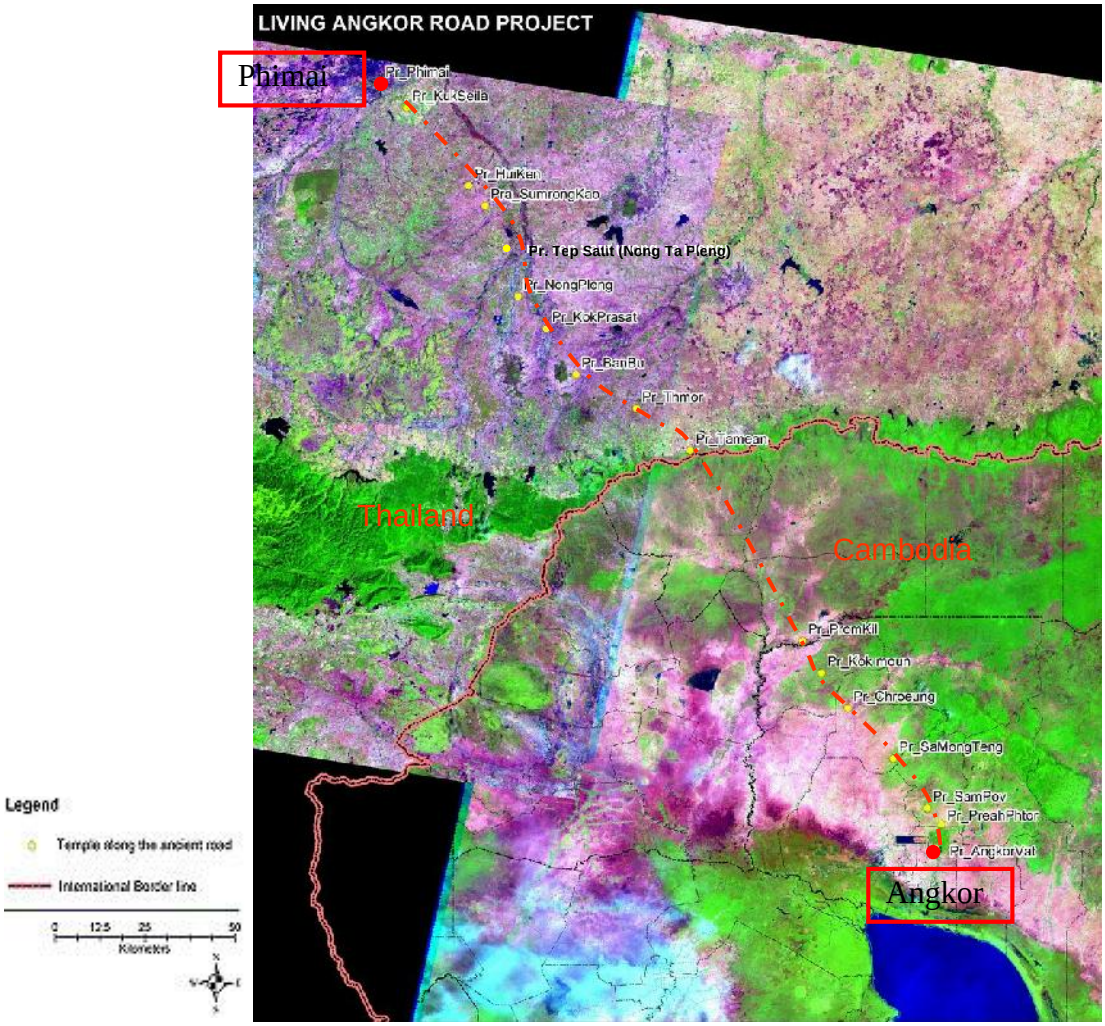


Figure 3 *Dharmshala*s (yellow dots) along the royal road on Landsat ETM (2000) (Remake : Pr stands for Prasat (stone temple))

(4) In order to identify two missing *Dharmshala*s, the information about the characteristics of locations selected for *Dharmshala*s from (2) together with the topography of the surrounding were compared with the possible locations of the two missing *Dharmshala*s. The next step was to investigate whether the possible locations located near ancient communities, ancient waterways, and the distance was within the average distance between *Dharmshala*s (approximated at 15 km. as calculated from known location of *Dharmshala*s in Cambodia) As a result, the possible locations of two missing *Dharmshala*s were located and identified by field surveys, as shown in Figure 5 and 6. One rest house is Prasart Kok Phnov in Figure 5; the other is Prasart Ampil in Figure 6. These processes required manual interpretations from the experts

of the factors listed above since the criteria was too complex for any available GIS software.

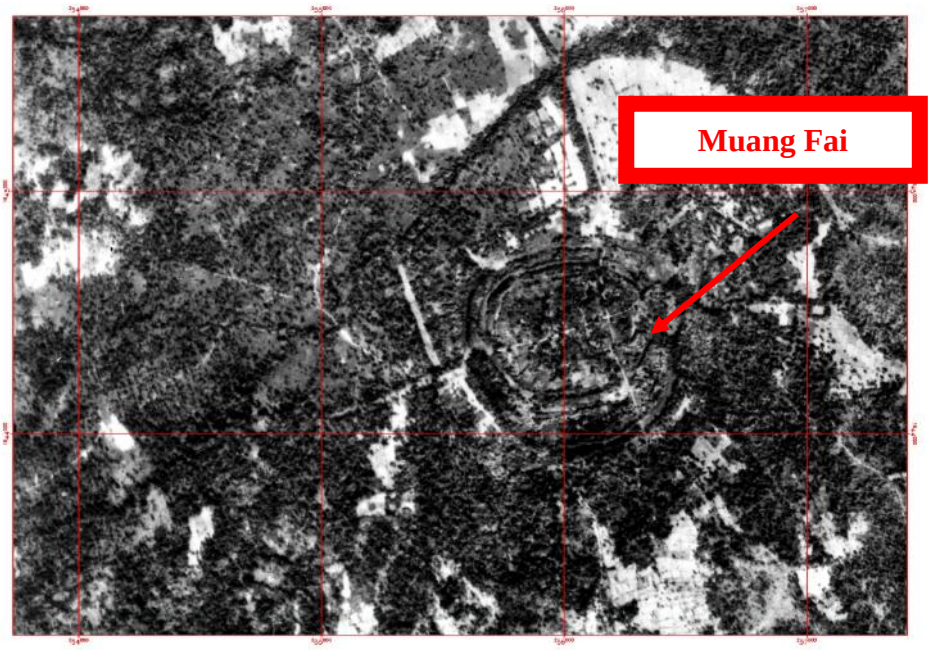


Figure 4 Ancient community Muang Fai in 1954 aerial photograph

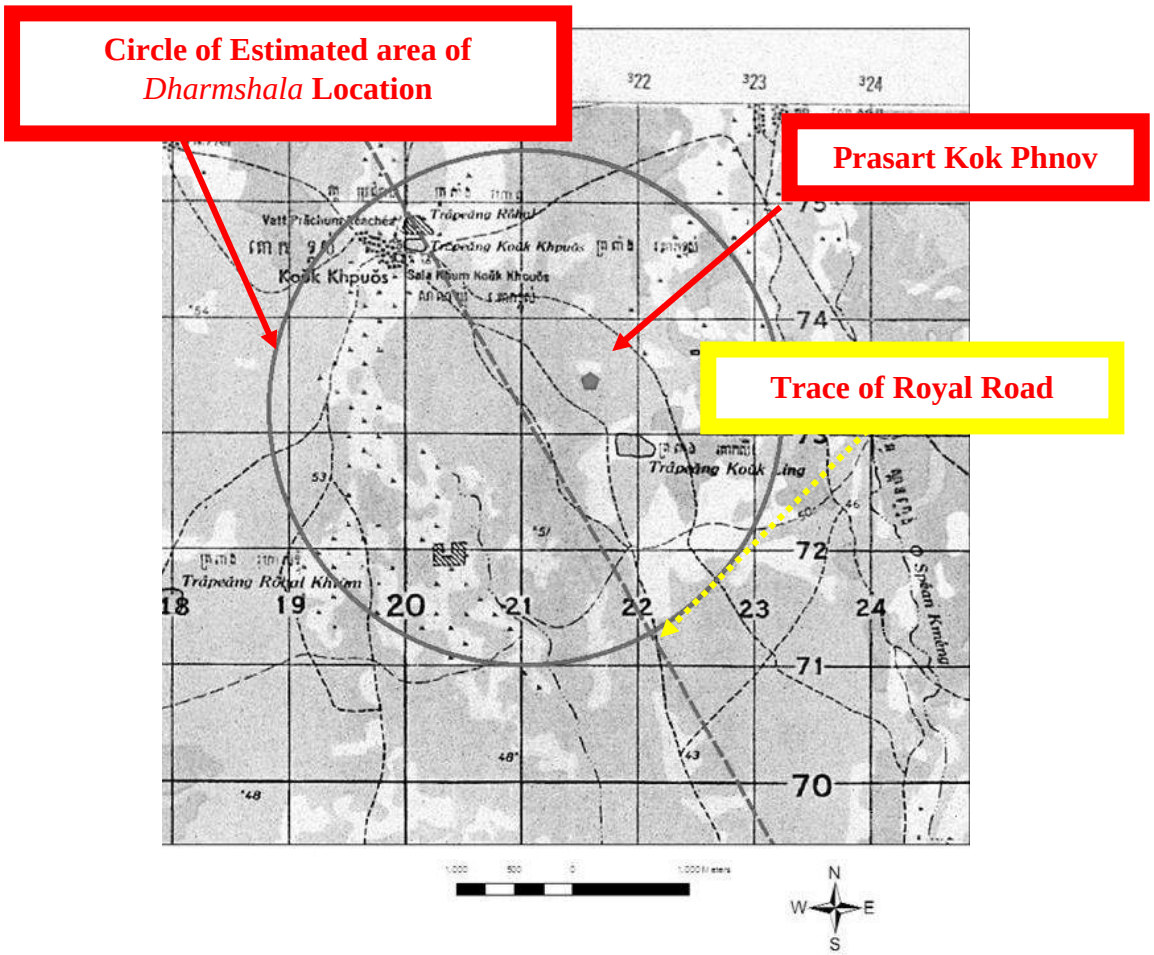


Figure 5 Location of Prasart Kok Phnov and the predicted area (inside circle) [Topographic map (1: 50,000)]

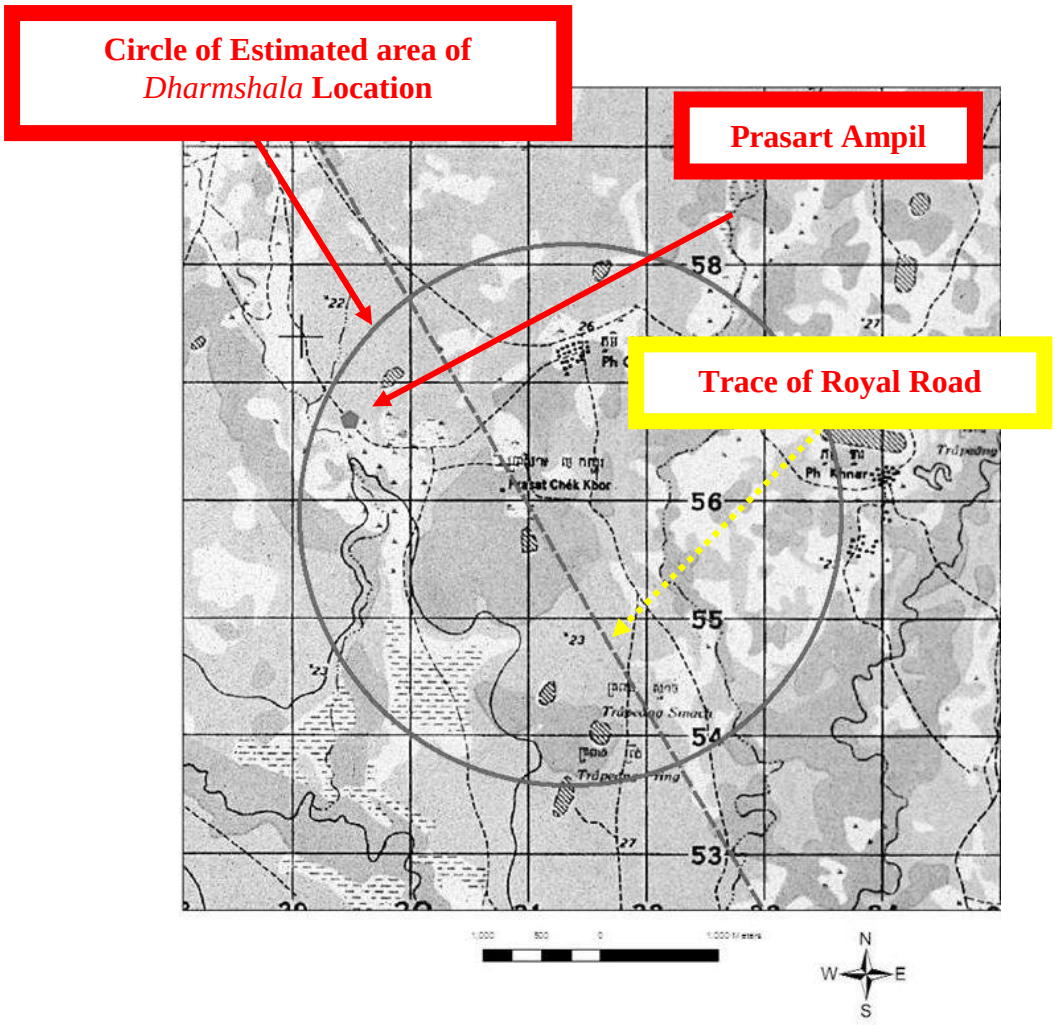


Figure 6 Location of Prasart Ampil and the predicted area (inside circle) [Topographic map (1: 50,000)]

(5) In order to identify the royal road passing Dong Rek mountain, the integrated activities of GIS analysis, interview local community were conducted. The identifying of the proximity of the location of the royal road pass through Dong Rek mountain was firstly done by analysis of the elevation data (SRTM), as shown in Figure 7, to identify the lowest slope area in the vicinity of the royal road crossing the Ta Mean pass. This finding was predicted based on location data of the Ta Mean *Dharmshala* on Dong Rek mountain and related information. The location of the pass was confirmed by the field survey. In order to locate the proximity of the location of the pass, we used the result of SRTM analysis of the slope and aspect of the area surrounding Ta Mean *Dharmshala* onward to Cambodia side of the royal road. From the slope and aspect of the area, we found that the lowest slope area is location on the southeast of Ta Mean *Dharmshala* and Ta Mean Thom (the important Khmer temple on the southeast of Ta Mean). Since the area was thought to still contain many land mines, the next step was to interview local community about the history of the pass, and in what direction that their ancestors had used the pass over the mountain. The result of the interviews corresponded with the result from our analysis. Their ancestors had used the path on the southeast of Ta Mean *Dharmshala* to cross the Dong Rek mountain. Then, we conducted the survey along the path on the southeast of Ta Mean *Dharmshala*. As a result, we discovered the ancient road over the pass that was constructed of laterite, as shown in Figure 8.

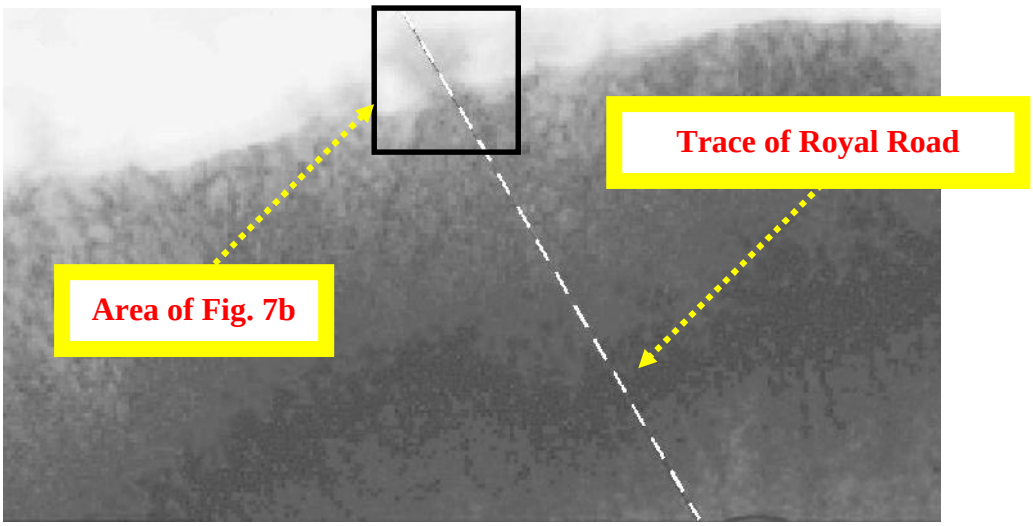


Figure 7a The elevation of the area that the royal road passing Dong Rek mountain [SRTM data (90 m. resolution)]
Remark : dark gray->light gray: low->high elevation

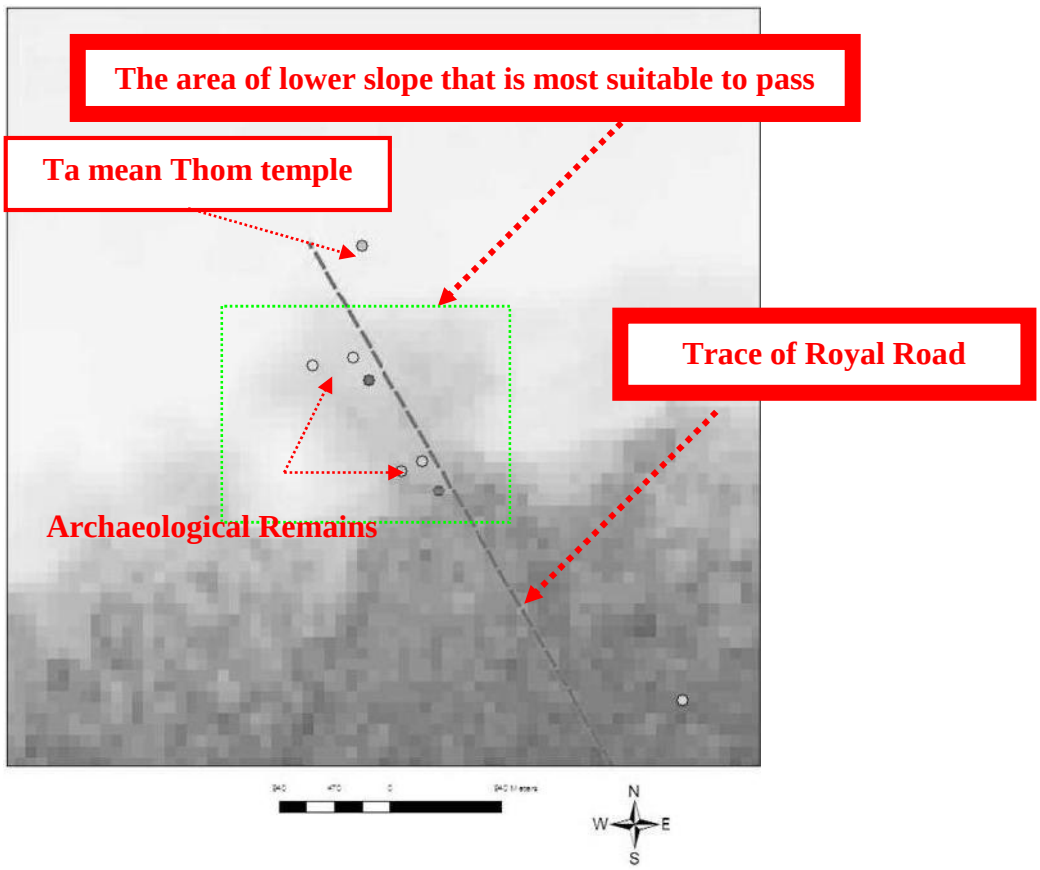


Figure 7b The detail of royal road passing Dong Rek mountain [SRTM data (90 m. resolution)]

3.2 Analysis of Survey Data

After the surveys, the information and data collected from all fields of study, including locations of archaeological sites, archaeological samples, topographical situation, and location of ancient communities, were integrated and analyzed. In this

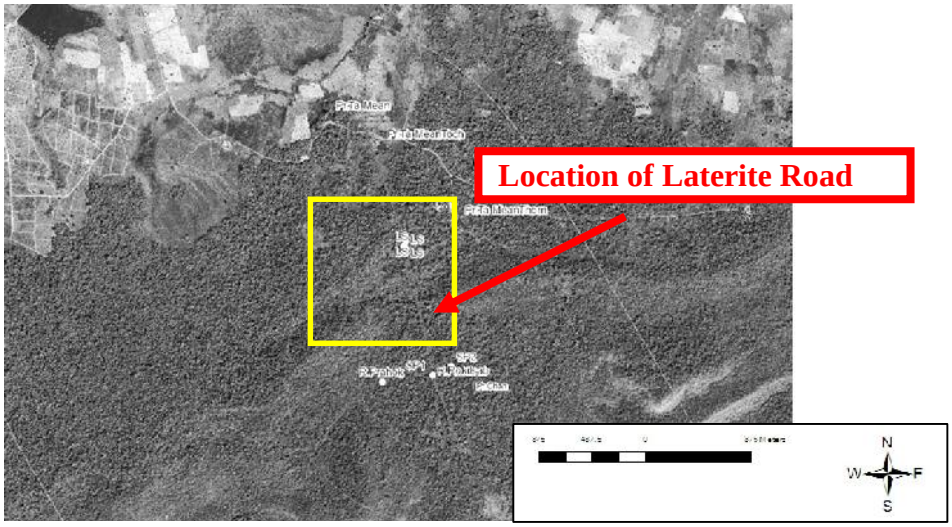
study, experience had shown that RS and GIS technologies alone cannot be utilized effectively in archaeological research. In order to achieve the aim of a project to identify and study the detailed of the royal road from Angkor to Phimai, a multi-disciplinary approach is the most significant and suitable. The results of the analysis are as follows:

(1) Identifying the Ancient Road Network

From the field surveys and RS/GIS and archaeological analyses, we learned that the ancient road was not a single road, but it was consisted of network of ancient roads to ancient communities and ancient industries. By utilizing GIS analyses, we identified the function of these small ancient roads. The result of this part of the study illustrates the effectiveness of GIS analyses. A sample of network of ancient road in Cambodia side is illustrated in Figure 9, where there are 2 small ancient roads connecting the royal road to the ancient communities in the vicinity.

(1) Scenery of the road

(2) Shoulder of the road



(3) The road in satellite image (IKONOS, 2003)

Figure 8 The road over the Dong Rek mountain

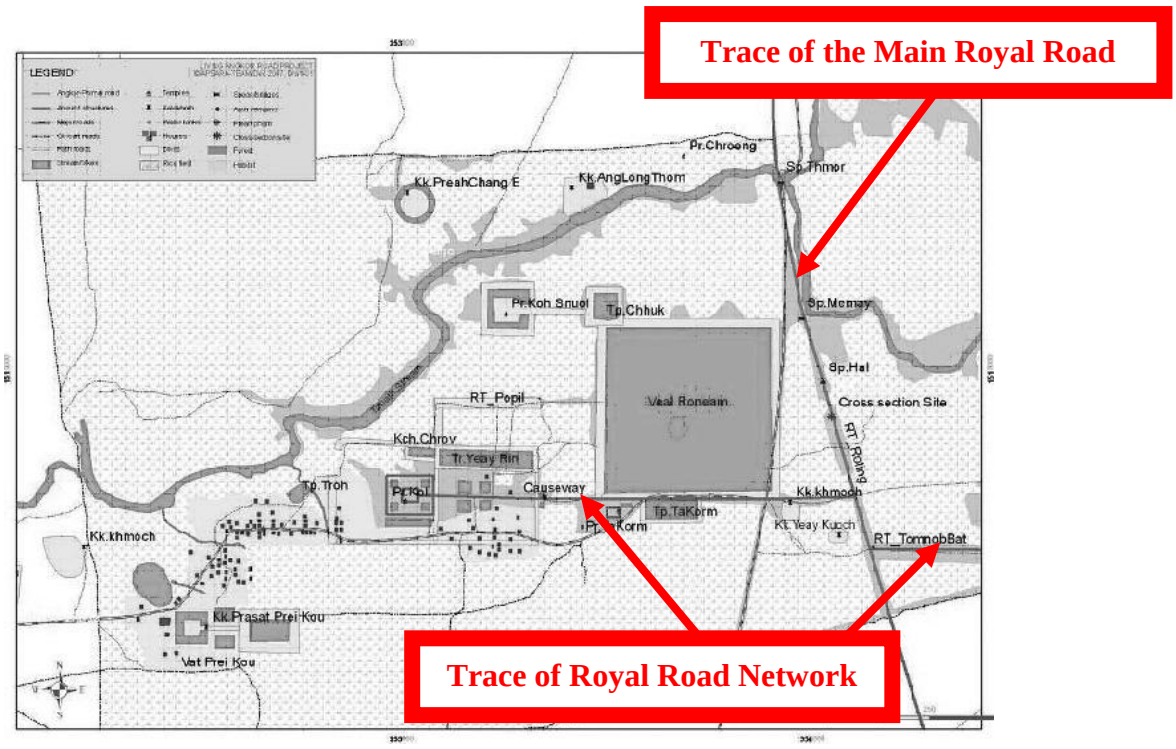


Figure 9 A sample of network of ancient road to ancient community in Cambodia (source: APSARA authority, Cambodia)

(2) Identifying the Relationship between Ancient Industry and the Royal Road

The relationship between ancient industry and the royal road was identified by the mapping of the ancient industry sites from the surveys in the buffer zone of the royal road estimated using GIS. From the mapping, ancient industry sites, such as ceramic kiln sites and iron smelting sites, were found to be concentrated in the vicinity of the royal road. The highest concentration of ancient industry sites along the royal road from Angkor to Phimai is located in Ban Krud, Burirum Province, Thailand on the border area between Thailand and Cambodia, part of this area is illustrated in figure 10. In addition, the artifacts collected during the surveys could be identified as products from these ancient industry sites. The mapping of these ancient industry sites was valuable to proof that the royal road was used for transporting goods between Angkor and Phimai.

(3) Remote Sensing for Geology Analysis of Ancient Industry Sites

In the case of the iron smelting industry, we utilized the ASTER satellite images to analyze the raw material that was used for the iron smelting process. Archaeological analysis of the iron smelting sites in Ban Krud, Burrirum Province, Thailand, in the buffer zone of the royal road as mentioned in (2), indicated the raw material for the iron smelting industry must be laterite with sufficiently high iron content. We utilized the ASTER images of the area to calculate its geological index[*8]. In this case, we calculated the geological index from the ratio of band 4 and 5 from ASTER. This index can yield the concentration of laterite with the high index value. From the calculation, it was considered that the area was once rich in laterite, as shown in Figure 11. The light color in Figure 11 means a high density of laterite. However, we could not use this analysis alone to prove assumption about the geology of the area, since the geological index from ASTER can be affected by the land cover. We also then performed a geo-physics analysis of the studied area, including the study of

magnetic anomaly together with the study of rock types, which also indicated that the area was rich in laterite. From these studies, it was concluded that one reason that the area was selected for setting up ancient industry sites was because of the presence of the raw material to produce iron.

In terms of the environment, the satellite images and aerial photographs show that the area was formerly dense forest, providing an important source of firewood. In addition, analysis of SRTM showed that all the ancient industry sites that we had identified were located on the high ground of an ancient flood plain, as shown in Figure 12.

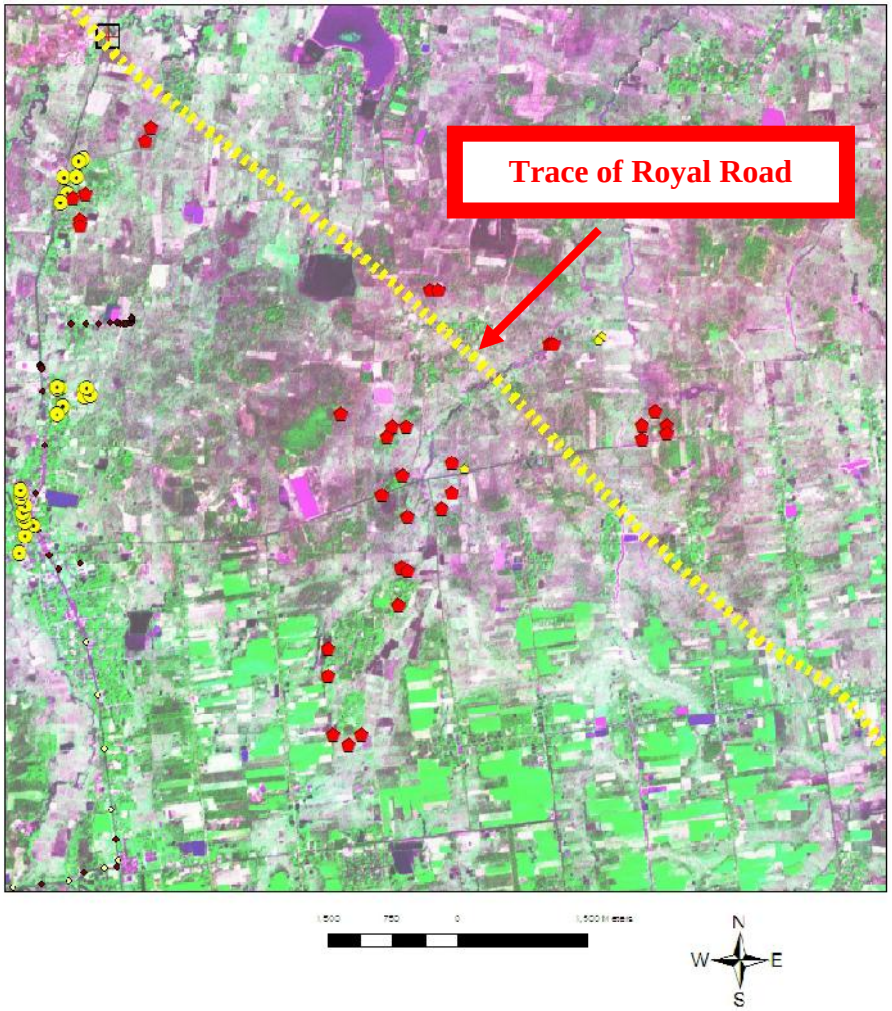


Figure 10 The relationship between ancient industry and the royal road in Ban Krud, Burirum province, Thailand with Landsat ETM (2000) as background (the red dots are ceramic kiln sites, the yellow dots are iron smelting sites)

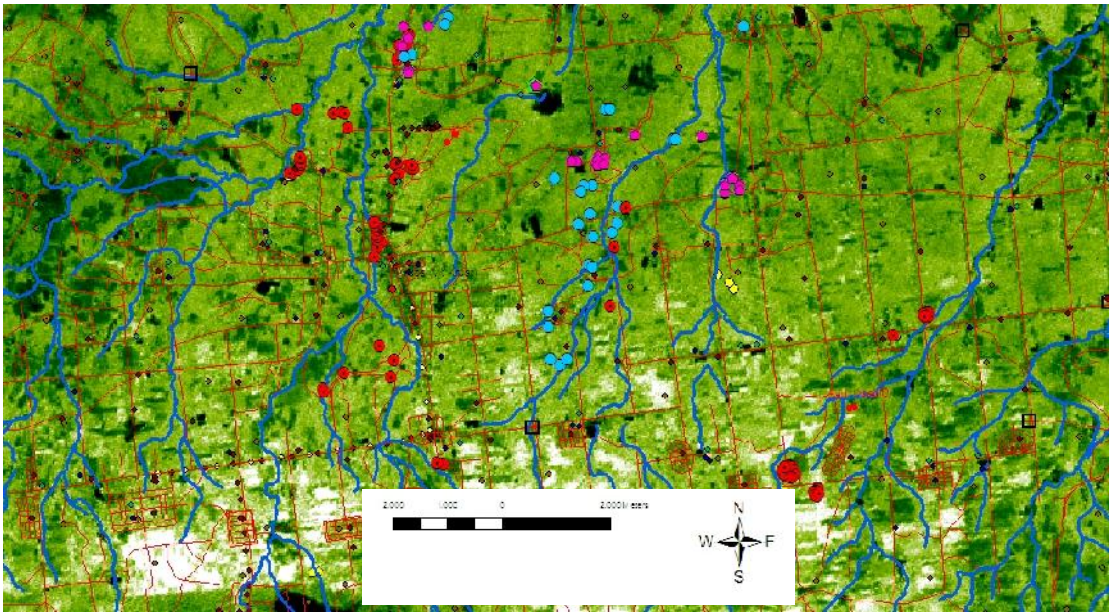


Figure 11 ASTER Geological Index of Ban Krud Area with ancient industry sites [Geological Index (Channel 4/5) image]
Remark : dark green->medium green->light green : low->medium->high laterite content
The red dots are iron smelting sites, the blue and purple dots are ceramic kiln sites)

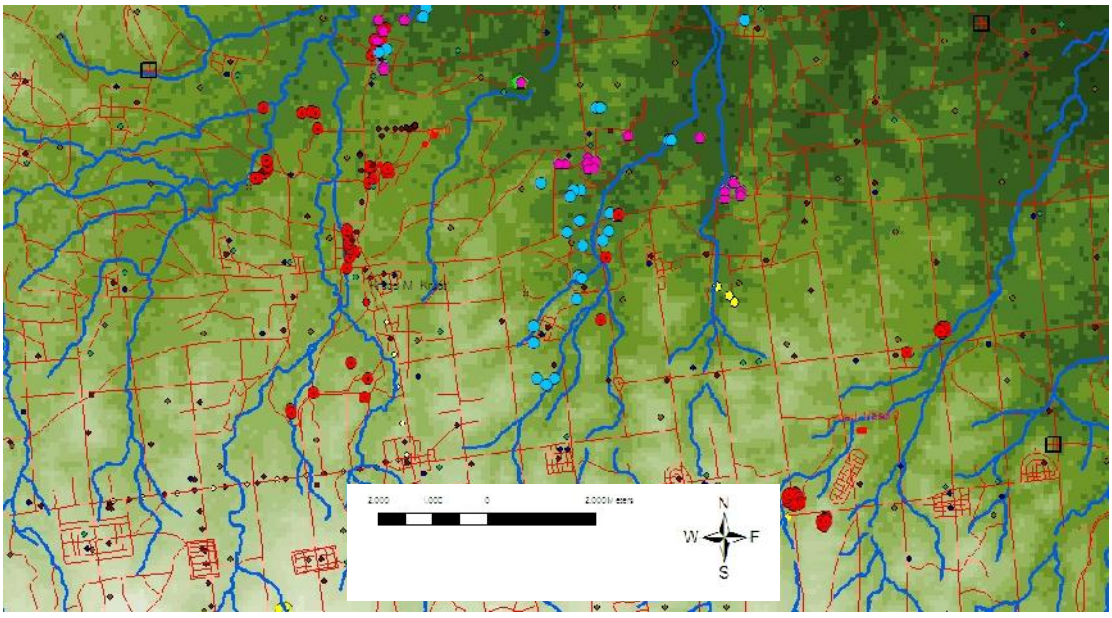


Figure 12 SRTM image of Ban Krud area with ancient industry sites
Remark : dark green->medium green->light green : low->medium->high elevation
The red dots are iron smelting sites, the blue and purple dots are ceramic kiln sites)

4. Current Study

Currently, by utilizing the methodology that had been developed from the study of the royal road from Angkor to Phimai, we are studying the continuation of

the Angkor to Phimai road further away from the capital, the Angkor-Sdok Kok Thom road, called the West road, and also the continuation of this road to the area currently eastern Thailand; the Angkor-Vat Phu, called the North-East road; and the Angkor-Vijaya, called the East road. For the studies, the team benefited from the result of remote sensing surveys which significantly help the systematic ground trusting conducted during several campaigns in Cambodia, Thailand and as well as in Laos. A number of sites were excavated, and the excavation was done according to modern method, using geo-informatics, geo-physics surveys, etc.

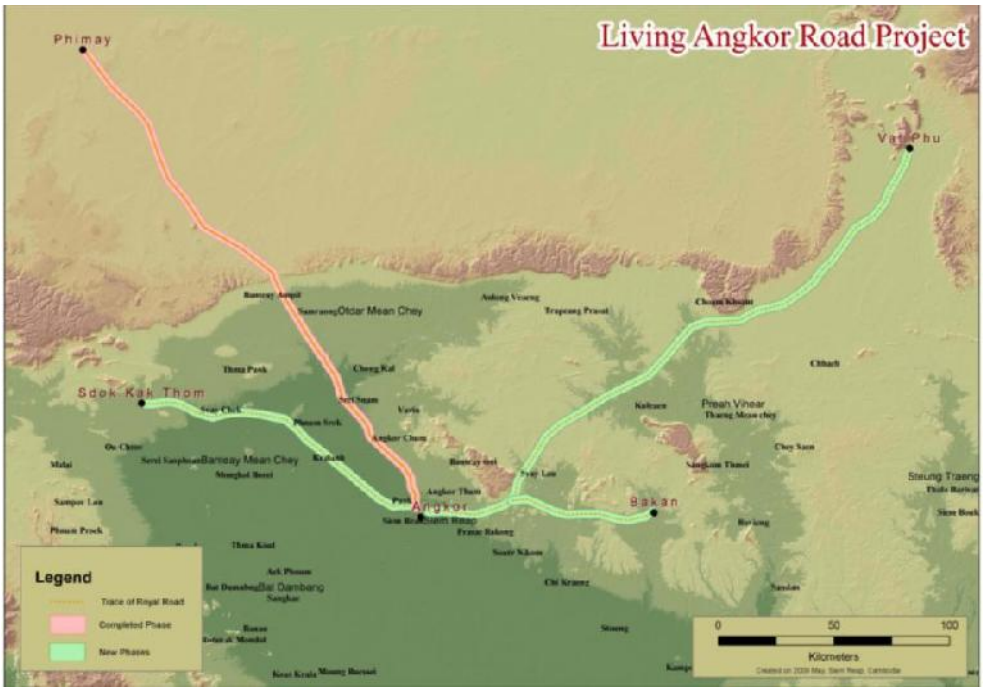


Figure 13 Ancient roads from Angkor under previous and current study

In addition, we are studying the ancient roads in different period of time to understand about the communication system in the region. This knowledge will be significantly important to understand the relationship of people, civilization, and culture during different period of time in the region.

5. Conclusion

This paper described one application of geo-informatics technologies to cultural studies. In a multi-disciplinary study, the important point in the research process is for researchers to understand the approaches that were selected. In each participating disciplines, the environment and methodology for research differs. Therefore, researchers have to take into consideration how to apply geo-informatics technologies to cultural studies. The environment of the landscape together with the objective and the data available are the most important elements to be considered before a study can be conducted. On the other hand, it is said that in most cases, geo-informatics technology alone cannot be applied to research, especially in cultural studies. Related fields of research need to be utilized in order to accomplish the mission of the project in the form of a multidisciplinary approach.

Figure 14 Multi-temporal study of ancient communication systems in the region

In the study of the royal road from Angkor to Phimai, we discovered several features of the ancient road. The most important items are as follows: (1) Two missing *dharmshala*s (chapels of rest houses) were identified (Figure 15). (2) Ancient laterite bridges were found along the ancient road in Cambodia (Figure 16). (3) Ancient industry sites were confirmed along the ancient road in both Cambodia and Thailand (Figure 17). (4) Ancient communities were identified along the ancient road in both Cambodia and Thailand.

Prasat Ampil Prasat Kok Phnov

Figure 15 Identified missing *dharmshala*s

Figure 16 Identified ancient bridges

Figure 17 Field survey in one of ancient industry sites
(source : APSARA authority, Cambodia)

[*1] ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer): It can be used for investigating geological survey, resource exploring, global warming, acid rain, and so on. Resolution is 15 m. Scanning width is 60 km. Scanning interval is 16 days.

[*2] SRTM (Shuttle Radar Topographic Mission): The SRTM is digital elevation data produced by NASA originally. URL: http://srtm.csi.cgiar.org/Index.asp

[*3] SIR-C (Spaceborne Imaging Radar-C): The SIR-C is part of an imaging radar system that was flown on board two Space Shuttle flights (9 - 20 April, 1994 and 30 September - 11 October, 1994). The USGS distributes the C-band (5.8 cm) and L-band (23.5 cm) data. URL: http://eros.usgs.gov/products/satellite/sirc.php

[*4] SIR-A: See above [*3]. The SIR-A used an L-band SAR HH-polarized system, which was capable of 40 m resolution in images whose swath widths were 50 km (31 mi).

[*5] APSARA Authority: Authority for the Protection and Management of Angkor and the Region of Siem Reap, URL http://www.autoriteapsara.org/en/apsara.html

[*6] LANDSAT ETM: Landsat with the Enhanced Thematic Mapper sensor. The ETM instrument included an eighth band with a spatial resolution of 30 m. This data can be applied for land use mapping, geology, hydrology, environmental monitoring, and so on.
URL: http://landsat.gsfc.nasa.gov/about/

[*7] Buffer zone: One of functions which provided by GIS technologies. This function allows users to specify appropriate buffer area from the original point, line, and polygon.

[*8] Characteristics for geological ingredients. The satellite image ASTER can be used for sensing the geological characteristics.

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