

ANALYSIS OF URBAN EXPANSION SURROUNDING ARCHAEOLOGICAL ATTRACTIONS BY NORMALIZED DIFFERENCE BUILT-UP INDEX TECHNIQUE AT ANCIENT CIVILIZATION SITE OF HARIPUNJAYA KINGDOM IN MUEANG LAMPHUN DISTRICT, LAMPHUN PROVINCE, THAILAND

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Abstract: The objective of this research is to study urban expansion surrounding archaeological attractions by Normalized Difference Built-up Index (NDBI) technique at ancient civilization site of Haripunjaya Kingdom in Mueang Lamphun District, Lamphun Province, Thailand. From the survey area on October 18-20, 2022, the data was collected on important ancient sites that still appear traces around the city of Lamphun. The study found that there are a total of 13 archaeological sites, each of which is classified into 3 categories: 8 Ancient Religious sites, 4 Ancient City Wall sites, and 1 Historical site. Then, surveys of urban and built-up land cover found that within the past 20 years, light urban and built-up land, urban areas and buildings with sparse density increased by 534.45%, or about 5 times, appearing around the old city in Nai Mueang sub-district and the area where the main road passes in a corridor pattern. In addition, the medium urban and built-up land area has also grown more than three times. It can be seen that urban expansion direction in the northern and central of the study area is most located in the 5 sub-district areas: Makhuea Chae, Ban Klang, Wiang Yong, Pa Sak, and Nai Mueang. The NDBI analysis revealed that the archaeological attractions that were most affected by urbanization were the Victory Shrine Pagoda. At present, it has become a historical site in the middle of the community area. It is located in the middle of the shopping mall parking lot, and there are buildings surrounding it, causing the archaeological site to be invaded and damaged greatly. The results of this study can be used to effectively manage cultural tourism planning, especially in the ancient civilization sites in Mueang Lamphun District, to be sustainable in the future.

Key words: Urban Expansion, Archaeological attractions, Normalized Difference Built-up Index Technique, Haripunjaya, Lamphun

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INTRODUCTION

Archaeological sites are valuable and important in history, archaeology, fine arts, architecture, ethnology and academics (Richards, 2001; Carbone et al., 2020). The archaeological site is an important historical resource that reflects the past,

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traditions and culture (Rahal et al., 2020; Halim et al., 2022). Therefore, it is an important learning center for the people and society of that area, regarded as a tourist attraction as cultural resources, in other words, as a cultural heritage (Mckercher and Du Cros, 2012), and it is necessary to preserve archaeological sites to maintain their value and importance, in order not to destroy the ancient site (Global Heritage Fund, 2010; Ababneh et al., 2019). The preservation of archaeological sites is a global concern, with measures for preserving and managing archaeological sites that vary according to the suitability and context of that society. Lamphun is a province with a history of more than 1300 years, which is considered the oldest in all the ancient kingdoms of the northern region of Thailand (Ongsakun, 2000; Mukherjee, 2022). From the evidence of more than 10 stone inscriptions in the Hariphunchai National Museum in Lamphun Province, mentioning that the Hariphunchai Kingdom was established in the year 662. Haripunjaya, Hari means Vishnu and Punjaya means edible, meaning "Which Vishnu can enjoy". Haripunjaya Kingdom was built by Hermit Wasuthep, Mon people, mobilized people to build a city in the area between two rivers, the Kuang River and the Ping River. When the construction was completed, an ambassador was sent to invite Queen Chamdhevi (A.D. 662-669), who was a princess from the Lavo Kingdom (current Lop Buri), as the first king of the Haripunjaya Kingdom (Settakul, 2009; Tansukanun, 2022).

The importance of the Haripunjaya Kingdom is that of the most prosperous civilization as the center of Buddhism in the northern region. This primary civilization was the birthplace of the invention of ancient Mon characters, which influenced the inventing of Bagan, Burmese and Mon scripts for the Bagan Kingdom (modern Myanmar), as well as Lanna scripts, Tai Lue scripts, Tai Ahom scripts, and Tai Yai scripts. It is also a model of economy, politics, governance, arts, culture, and military in ancient times, and was the foundation and pattern of the Lanna Kingdom (Chiang Mai) (Winichakul, 1994; Srinurak and Mishima, 2017). The prosperity of Haripunjaya Kingdom is famous among the Southeastern people: Bagan; Angkor Wat (Khmer); Champa; Srivijaya; Nakhon Si Thammarat; Lavo; and Chinese. Haripunjaya has become a strategic city that many regions have visited in order to build diplomatic, commercial, social welfare, and well-being towards valuable cultural consensus. For this reason, the Haripunjaya period art and culture is a perfect blend of valuable arts.

King of the Chamadeviwong dynasty of Haripunjaya City reigned for approximately 620 years (A.D. 663-1293), with a total of about 50 monarchs. And at present, the kingdom has changed its status to become one of Thailand's major tourist destinations. Due to its outstanding cultural heritage, invaluable archaeological sites, leading to important historical sites, such as Wat Phra That Hariphunchai Woramahawihan Temple, where Phra Borommathat Hariphunchai is located, 1 of 8 great pagodas over 1000 years old in Thailand, also the center of Buddhism, politics, and culture of the ancient northern region of Thailand that has inherited its identity to the present day. At present, the status of Haripunjaya has changed to a modern city like Lamphun Province. It has continued to grow since the introduction of The Forth National Economic and Social Development Plan 1977–1981, resulting in Lamphun Province being the center of Thailand northern regional industrial estates. It was established around Ban Klang Subdistrict and Makhuea Chae Subdistrict, Mueang Lamphun District, Lamphun Province in 1983 (The National Economic and Social Development Board, Office of The Prime Minister of Thailand, 1977). This requires the development of infrastructure in almost all surrounding areas of Lamphun Province, to support urban expansion and key economic areas to support systematic linkages with sub-regions and regions.

This, coupled with the potential of Lamphun Province, which is a province adjacent to Chiang Mai only 20 kilometers, has resulted in both Thai and foreign tourists coming to travel, and the trend is increasing every year. Since the promulgation of The Fifth National Economic and Social Development Plan 1982–1986, Lamphun province has undergone urbanization, that is, more immigrants to settle in to live (The National Economic and Social Development Board, Office of The Prime Minister of Thailand, 1982). Being close to work place, with many tourist attractions, about 20 kilometers from Chiang Mai International Airport, good food and suitable climate for living, and has a unique and charming culture, makes Thais and foreigners impressed. As a result, urbanization causes some areas of Lamphun to suffer environmental and architectural impacts: some new buildings, power pylons, and telecommunication lines obscured ancient sites, some areas have encroached upon important ancient sites, which may cause damage to the archaeological attractions.

Remote sensing technology is a tool that can continuously and consistently study changes that occur on the terrain. Such topographic data is of great benefit for studying changes in terrestrial manifestations, as it provides a broad and comprehensive picture to study the relationship of such change contexts, such as monitoring the expansion of urban areas in different regions of the world, as mapping the environmental impact of rapid urbanization in the metropolitan city of Delhi, India to have applied the NDBI technique in those areas (Sharma and Joshi, 2016). In Istanbul, Türkiye, a major megacity between two continents, in Europe and Asia, land cover change studies were conducted using NDBI techniques to investigate the Urban heat island phenomenon (Khorrami et al., 2021). Raipur City of India, an urbanization study was conducted by analyzing land surface temperature in combination with NDBI techniques and using Landsat satellite image data to study the dynamics of change from 1991-2019 (Guha et al., 2021). Even the arid region of Rawalpindi City, Pakistan, the fourth largest city at the center of the hub of industrial, military, and commercial activities, has studied NDBI techniques to classify land cover to obtain information for planning groundwater use to be adequate for the activity of the topographic surface (Haq et al., 2021). A number of study guides in key regions of the world have applied the NDBI technique classifying land cover to analyze changes in urbanization. Therefore, in this research study, the principle of NDBI analysis was applied in the land cover survey, resulting in quick information, low educational budget. It also obtains data that covers a large area and has relatively high data accuracy, is ideal for environmental research and can track changes especially urbanization. This study aims to assess the changes of buildings surrounding archaeological attractions of the ancient civilization site of Haripunjaya Kingdom in Lamphun Province from 2001 until the 2022 using NDBI technique to monitor urbanization in Lamphun Province, Thailand. This research sees the benefits of Remote sensing techniques in

environmental management that can be analyzed in a spatial form and can be monitored in multiple temporals. Using the NDBI technique, the results of the study can be used as a guideline for planning and formulating a policy framework to prevent and reduce damage to the surrounding area of archaeological attractions, by providing a database as a spatial model for systematic land use planning management to support sustainable changes in the future.

Study area

In this research, the study was conducted in Mueang Lamphun district, the old town of Haripunjaya Kingdom over 1300 years ago. It has an area of approximately 480.015 km². The study area, located between latitude 18°25' N to 18°40' N, longitude 98°55' E to 99°15' E (Figure 1), is a mountainous flat terrain known as the Intermontane basin, formed by the deposition of sediment from the valley. Specifically, the study area was influenced by sediment transport from the eastern high mountains, including the Mae Ta Mountain range and the Khun Tan Mountain range, which is a crescent-shaped mountain range along the Mae Ta active fault. The sediments are caused by erosion from the influence of waterways, including the Mae Ta River and the tributaries of the Kuang River. The river has an influence to bring sediment from the high valleys to deposit into the foothills, resulting in an important geomorphological effect: the Alluvial fan, arranged along the north to south in a geomorphic feature known as Coalescing fan or Bajada in Spanish. The morphology is a Tertiary (65–1.8 million years ago) sedimentary rock with a fertile, highly arable soil. The sedimentary mound, known as Mae Kuang coalescing fan, is located in the northern part of the study area. Mae Ta coalescing fan covers both the study area and the area where Haripunjaya City was established over 1300 years ago, and has developed into Lamphun City today.

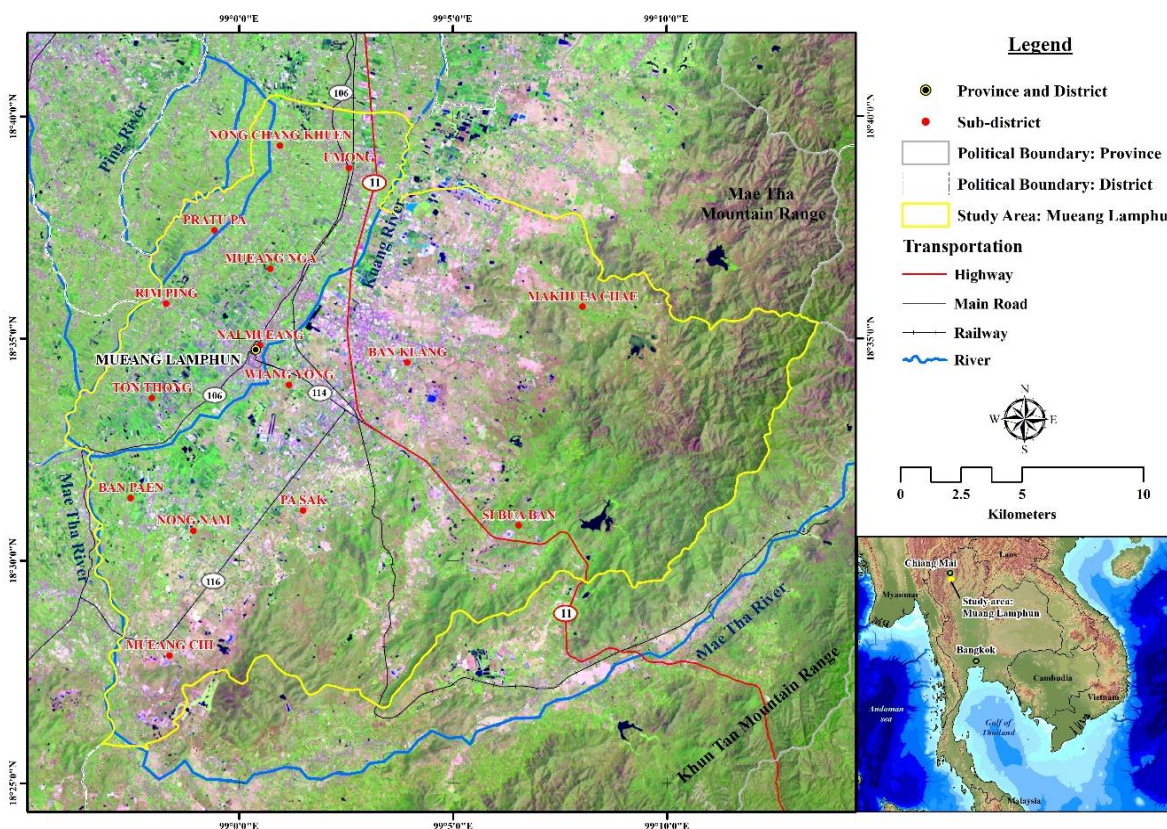


Figure 1. Location of Mueang Lamphun District, Lamphun Province, Thailand (Source: collected and processed by authors)

MATERIALS AND METHODS

In this study, in order to conduct an effective survey of the land cover conditions of a building, data with appropriate spatial and temporal resolution were selected, using Landsat 5 TM and Landsat 8 OLI/TIRS satellite data downloaded from Earthexplorer.usgs.gov website, as shown in Table 1, covering the years 2001, 2013 and 2022, respectively. However, the image processing process used Erdas Imagine 9.2 software to verify the data and improve its quality before analysis as radiometric and geometric were corrected. It then goes into the band combination process in the following bands: Landsat 5 TM, 2001 data, performs Band Combination 5:4:3 (Red: Green: Blue) and Landsat 8 OLI/TIRS satellites, with 2013 and 2022 data, performed a Band Combination 6:5:4 (Red: Green: Blue) before analyzing the NDBI, shown in Figure 2.

Table 1. Satellite Image Data over the Mueang Lamphun District for Analysis

Database	Acquisition date	Format	Sources
Landsat 5 TM satellite image; Path 131 Row 047	17 April 1994	Image File	https://earthexplorer.usgs.gov/
Landsat 8 OLI/TIRS satellite image; Path 131 Row 047	27 March 2013	Image File	https://earthexplorer.usgs.gov/
Landsat 8 OLI/TIRS satellite image; Path 131 Row 047	26 March 2022	Image File	https://earthexplorer.usgs.gov/

A spatial analysis process for detecting different types of land cover and tracking changes in each type of land use, using the NDBI technique. The principle of remote sensing was applied in this study, especially in areas with human-caused land-use activities. Urban area, industrial area, commercial area, including agricultural area, it is necessary to apply NDBI in Mueang Lamphun area. At present, the study area has a lot of urbanization, and inevitably affects archaeological sites, with the NDBI being the indexes for the analysis of built-up area (Li and Chen, 2018; Waiyasuri, 2021). The build-up areas and bare soil reflects can be classified as Short-wave Infrared (SWIR) in combination with NIR (Guha et al., 2021; Kombate et al., 2022). Therefore, in the Landsat 5 TM satellite, Band 5, which is a SWIR band with electromagnetic wavelength between 1.75 to 1.75 μm , is analyzed together with Band 4 (NIR), as in Equation 1. However, Landsat 8OLI/TIRS uses Band 6, which is SWIR1 (1.566-1.651 μm), to be analyzed together with Band 5, which is the NIR spectrum in the NDBI study (Li and Chen, 2018; Guha et al., 2021; Kombate et al., 2022), as shown in Equation 2.

$$\text{NDBI (Landsat 5TM)} = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4}) \quad (1)$$

$$\text{NDBI (Landsat 8OLI/TIRS)} = (\text{Band 6} - \text{Band 5}) / (\text{Band 6} + \text{Band 5}) \quad (2)$$

The analysis result is NDBI between -1 to +1 (Mathew et al., 2017). Negative value of NDBI represent water bodies whereas higher value represents build-up areas. NDBI value for vegetation is low (Mahmood et al., 2021). The NDBI analysis can quickly and efficiently determine land cover types, urban areas and buildings.

For validity after the NDBI analysis, validation was conducted by comparing the data obtained from the field survey and land-use data from the Land Development Department (LDD) in the study area, with overall accuracy and kappa coefficient (Congalton, 1988; Ababneh et al., 2019), as in Equation 3 and 4, respectively.

$$\text{Overall accuracy (OA)} = \frac{1}{N} \sum P_{ii} \quad (3)$$

Where: N = Total number of test pixels, and $\sum P_{ii}$ is Total pixels that are correctly classified.

Kappa coefficient, a classification accuracy measurement, multiplies the total pixels in all the ground truth classes by sum of confusion matrix diagonals, subtracting sum of ground truth pixels in class times, and the sum of classified pixels in the class, summed over all classes, divided by the entire pixels (Congalton, 1988; Ababneh et al., 2019),

$$\text{Kappa coefficient} = (\text{OA} - \frac{1}{q}) (1 - \frac{1}{q}) \quad (4)$$

Landsat images used Overall Accuracy values and Kappa coefficients (KHAT) to assess the accuracy of each type of classification for identification of the area (Jia et al., 2018).

< 0, less than chance agreement,

0.01–0.40, poor agreement,

0.41–0.60, moderate agreement,

0.61–0.80, substantial agreement,

0.81–1.00, almost perfect agreement.

Land cover classification by NDBI method, the result is a land cover model that covers the study area, which is the key result to know what appears to be a spatial database, created as a database in GIS. Land cover analysis was then performed at different intervals to determine the change in land cover (Jia et al., 2014), as in Equation 5.

$$\Delta = [(A_2 - A_1) / A_1 \times 100] / (T_2 - T_1) \quad (5)$$

Where Δ is the proportion of the change in land use pattern (percent).

A_1 is the type of land use at the first time (T_1)

A_2 is the type of land use at the second time (T_2)

The results are shown as the land cover ratio of each type on the map, which shows the land cover change pattern for 2001 - 2022, along with the Change Detection comparison chart from the Overlay analyst, using the Tabulate area tool in ArcMap 10.3.

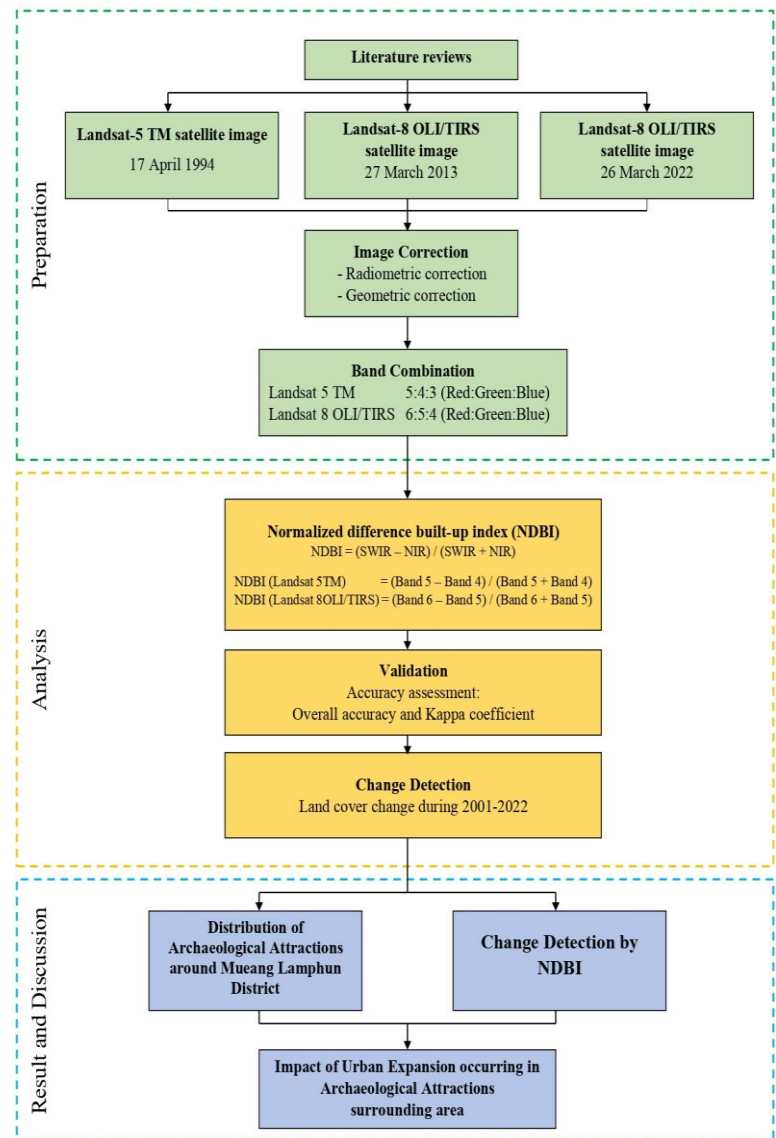


Figure 2. Flowchart of Methodology

RESULTS AND DISCUSSION

Distribution of Archaeological Attractions around Mueang Lamphun District

Since the area was once an ancient civilization site of Haripunjaya Kingdom, which flourished in arts and culture, traditions, economy, politics and governance, stupa, pagodas and temples were built around Muang Lamphun District.

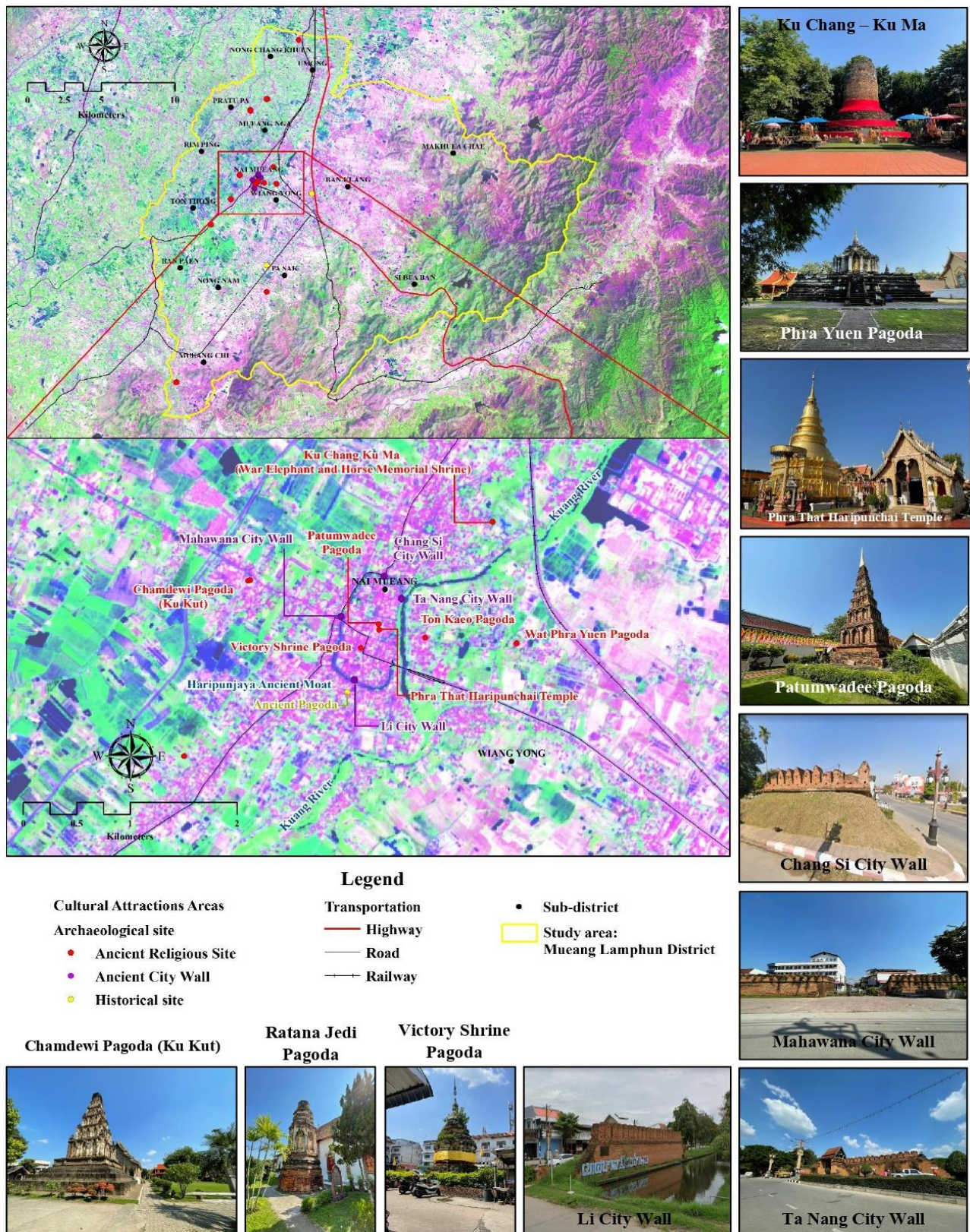


Figure 3. Ancient Civilization Site of Haripunjaya Kingdom in Mueang Lamphun District, Lamphun Province (Source: field survey, October 2022)

However, from the survey area on October 18-20, 2022, the data was collected on important ancient sites that still appear traces around the city of Lamphun. The results showed that there was a total of 13 archaeological sites, each of which was classified into 3 categories: 8 Ancient Religious sites, 4 Ancient City Wall sites, and 1 Historical site. The details of the location from the survey area are shown in Table 2 and Figure 3. The survey study revealed that there are archaeological sites in the Ancient City area, which are within the Haripunjaya Ancient Moat at 3 sites: Phra That Haripunchai Temple, Patumwadee Pagoda, and Victory Shrine Pagoda. Phra That Haripunchai Temple and Patumwadee Pagoda is an

archaeological site that represents the administrative center of the Haripunjaya Kingdom over 1300 years (11th century AD) in Wat Phra That Haripunchai Woramahawihan Temple, which has now become a Buddhist landmark and a beautiful cultural attraction of Lamphun Province. Phra That Haripunchai Temple is one of the 12 great stupas of Thailand, is a relic of the year of the Rooster's birth. Inside Phra That Haripunchai is a pedestal for enshrining the urn containing the Buddha's relics. This relic has been an important sanctuary in Thai Lanna since ancient times. On the full moon day of the 6th lunar month, there will be a worship and watering ceremony for the relics every year. And in the present, such ancient tourist attractions are still being renovated to this day.

Around Lamphun, there are Haripunjaya Ancient Moat, and also 4 ancient city wall ruins: Chang Si city wall on the north, Ta Nang city wall on the east, Mahawana city wall on the west, and Li city wall on the south. Outside Haripunjaya Ancient Moat also found distribution of important archaeological sites as follows: Chamdewi Pagoda and Ratana Pagoda, where contains the ashes of Queen Chamadevi, west of Lamphun, about 1 km from Mahawana city wall. North appears Ku Chang Ku Ma (War Elephant and Horse Memorial Shrine), a cylindrical stupa, a war elephant cemetery "Pu Kam Nga Khiao" of Queen Chamadevi and a horse tomb of Chamadevi's son, 1.8 km

away from Chang Si city wall. In the east of Lamphun, there are two important pagoda sites, namely Ton Kaeo Pagoda and Wat Phra Yuen Pagoda, which are approximately 700 m and 1.4 km from Ta Nang city wall, respectively. And to the south, an unidentified Ancient Pagoda was found, in the Li Temple near the Li city wall, the most recently discovered archaeological site. It can be seen that the coordinates of the Cultural Attraction areas are recorded with a global positioning system (GPS). The tool records geo-coordinated system location data. The results of this research by recording the location of ancient tourist sites, allow us to determine how they are located in the surrounding environment. This is consistent with the work of Li et al. (2017) applying GPS Tracking to a historic site in Gulangyu, China to create a set of spatial databases overlay with data in the community area, to create understanding in the community not encroaching the historic sites. Due to the rapid urbanization of Gulangyu, it is also developing as a tourist destination (Li et al., 2016; Li et al., 2017). Even the integration of remote sensing, digital photogrammetry, laser scan, GPS, GIS, etc., has also been studied to find important ancient sites (Luo et al., 2014; Green et al., 2019). Therefore, Geo-informatics technology is essential for accurate and efficient exploration of archaeological sites to develop into cultural attractions.

Change Detection by NDBI

Based on the analysis of Landsat satellite imagery, the NDBI technique was applied in this research. It is a technique of obtaining land cover spatial data, especially areas covered by cities and buildings, with effective accuracy (Simwanda and Murayama, 2018). NDBI levels range from -1.00 to 1.00 with high negative values represent forest area and water bodies, high positive values represent higher built-up, and levels close to zero value represent areas

covered with agricultural land. The results showed that the NDBI level classified land cover into 8 important classes (Table 3) as follows: NDBI levels 0.10 to 1.00 are urban and built-up land cover levels, where 0.40 to 1.00 are found in the area with the highest density of urban areas, 0.20 to 0.40 are moderately covered urban areas, and 0.10 to 0.20 is an area covered by low-level urban areas. For agricultural areas in the study area, the NDBI level is between -0.10 to 0.10 and the area covered by swamp, paddy field, and forest area shows the NDBI level in negative values. However, the results of this research were able to classify the Urban and built-up land area effectively. This contrasts with the Cuca and Agapiou (2021) study, which found the NDBI study of Urban and built-up land areas in terms of high positive values in the Historic Cities' Centers, Nicocia in Cyprus. For the detection of historical landscape changes in Lake Victoria Basin, Kenya using the NDBI technique, it was found that high positive values represent the territory of the area where urban expansion occurred (Onyango and Opiyo, 2022) and in the Lahore district in Pakistan applying to find rapidly developing city.

Table 2. Locations of Haripunjaya ancient civilization archaeological attractions, surveyed between 18-20 October 2022

Site	Cultural Attraction areas	Type	Latitude	Longitude
1	Chamdewi Pagoda (Ku Kut)	Ancient Religious Site	18.5816	98.9961
2	Ratana Jedi Pagoda	Ancient Religious Site	18.5816	98.9963
3	Patumwadee Pagoda	Ancient Religious Site	18.5778	99.0076
4	Phra That Haripunchai Temple	Ancient Religious Site	18.5773	99.0077
5	Victory Shrine Pagoda	Ancient Religious Site	18.5758	99.0061
6	Ton Kaeo Pagoda	Ancient Religious Site	18.5767	99.0119
7	Wat Phra Yuen Pagoda	Ancient Religious Site	18.5762	99.0199
8	Ku Chang Ku Ma	Ancient Religious Site	18.5867	99.0178
9	Chang Si City Wall	Ancient City Wall	18.5819	99.0081
10	Mahawana City Wall	Ancient City Wall	18.5785	99.0043
11	Ta Nang City Wall	Ancient City Wall	18.5800	99.0097
12	Li City Wall	Ancient City Wall	18.5730	99.0055
13	Ancient Pagoda	Historical Site	18.5714	99.0055

Table 3. NDBI result of land cover classes from 2001, 2013, and 2022

NDBI value	Land cover area						Land cover classify	
	2001		2013		2022			
	km ²	%	km ²	%	km ²	%		
-1.00 to -0.50	215.988	45.00	16.847	3.51	5.021	1.05	Forest area	
-0.50 to -0.10	56.318	11.73	89.552	18.66	11.023	2.30	Swamp and Paddy field	
-0.10 to 0.00	156.798	32.67	208.361	43.41	194.221	40.46	Agricultural land	
0.00	25.048	5.22	17.725	3.69	186.187	38.79		Light
0.01 to 0.10	13.800	2.87	124.188	25.87	12.917	2.69		Medium
0.10 to 0.20	12.063	2.51	21.357	4.45	64.471	13.43	Urban and built-up land	
0.20 to 0.40	0.000	0.00	1.945	0.41	6.166	1.28		Light
0.40 to 1.00	0.000	0.00	0.040	0.01	0.009	0.00		Medium
Total	480.015	100.00	480.015	100.00	480.015	100.00	Dense	
Overall accuracy	83.51		80.43		78.11			
Kappa coefficient	81.76		79.62		76.64			

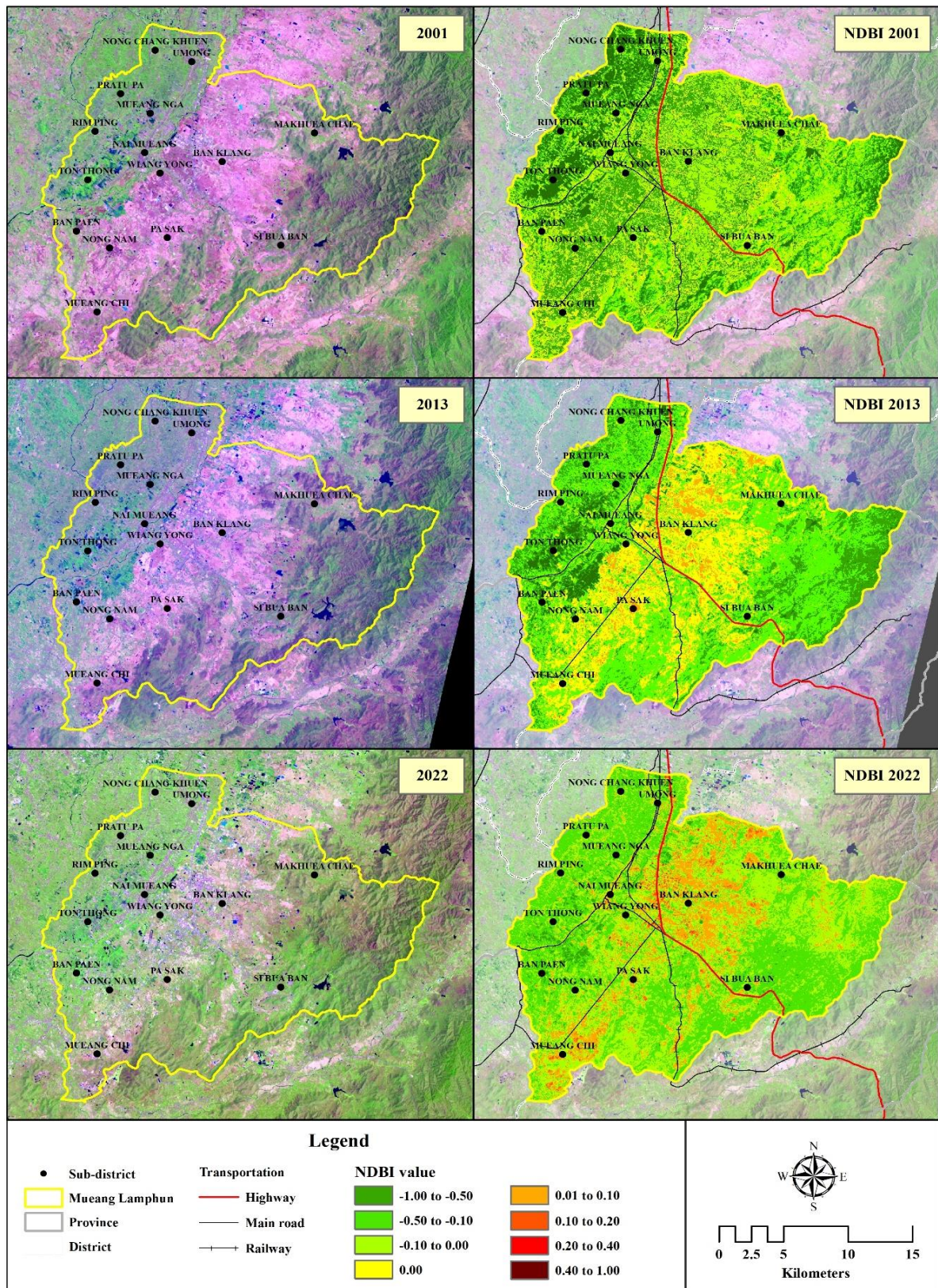


Figure 4. Landsat Satellite Image and NDBI map of the Mueang Lamphun District, Lamphun Province (Source: by authors)

The urbanized district had an NDBI level close to 1.00 (Mahmood et al., 2021). All of the above studies revealed differences that most did not classify the level of building density according to the NDBI level. But most agree that the technique is used for analysis and follow-up in urban expansion and urbanization, in order to plan for orderly managing land use in urban areas and minimizing the impact on historical sites. From the NDBI analysis, the results of the research on urban and built-up land expansion in Mueang Lamphun district were evident. From Table 3, urban density levels showed that light urban and built-up land areas experienced the greatest increase. From 2001 with an area of 12.063 km²

(2.51% of the total area) has been expanded until in 2022 the area is 64.471 km² (13.43% of the total area). It can be seen that in the past 20 years, the area of light urban and built-up land has increased by 534.45% or about 5 times, appearing around the old city area in the Nai Mueang sub-district and where the main road cuts through in a corridor pattern (reference). Additionally, the medium urban and built-up land areas have also grown more than three times. From Figure 4, the direction of expansion is seen in the northern and central areas of the study area, which are in the 5 sub-district areas: Makhuea Chae, Ban Klang, Wiang Yong, Pa Sak, and Nai Mueang. Especially in the Makhuea Chae and Ban Klang districts, there is considerable expansion and density of medium urban and built-up land. This is because the area is an important industrial estate area, namely the Northern Region Industrial Estate, which is the largest industrial estate in northern Thailand. As a result, there is a noticeable expansion of residential communities in the area, and the business and service sectors are actively engaged in economic activities in the area. Importantly, in Wiang Yong, Pa Sak, and Nai Mueang, they are areas that support community expansion occurring in Makhuea Chae and Ban Klang districts, especially Wiang Yong and Nai Mueang, which are directly affected by the expansion of urban and built-up land from these two districts, as they are ancient community areas in the old city near industrial estates and with convenient transportation routes.

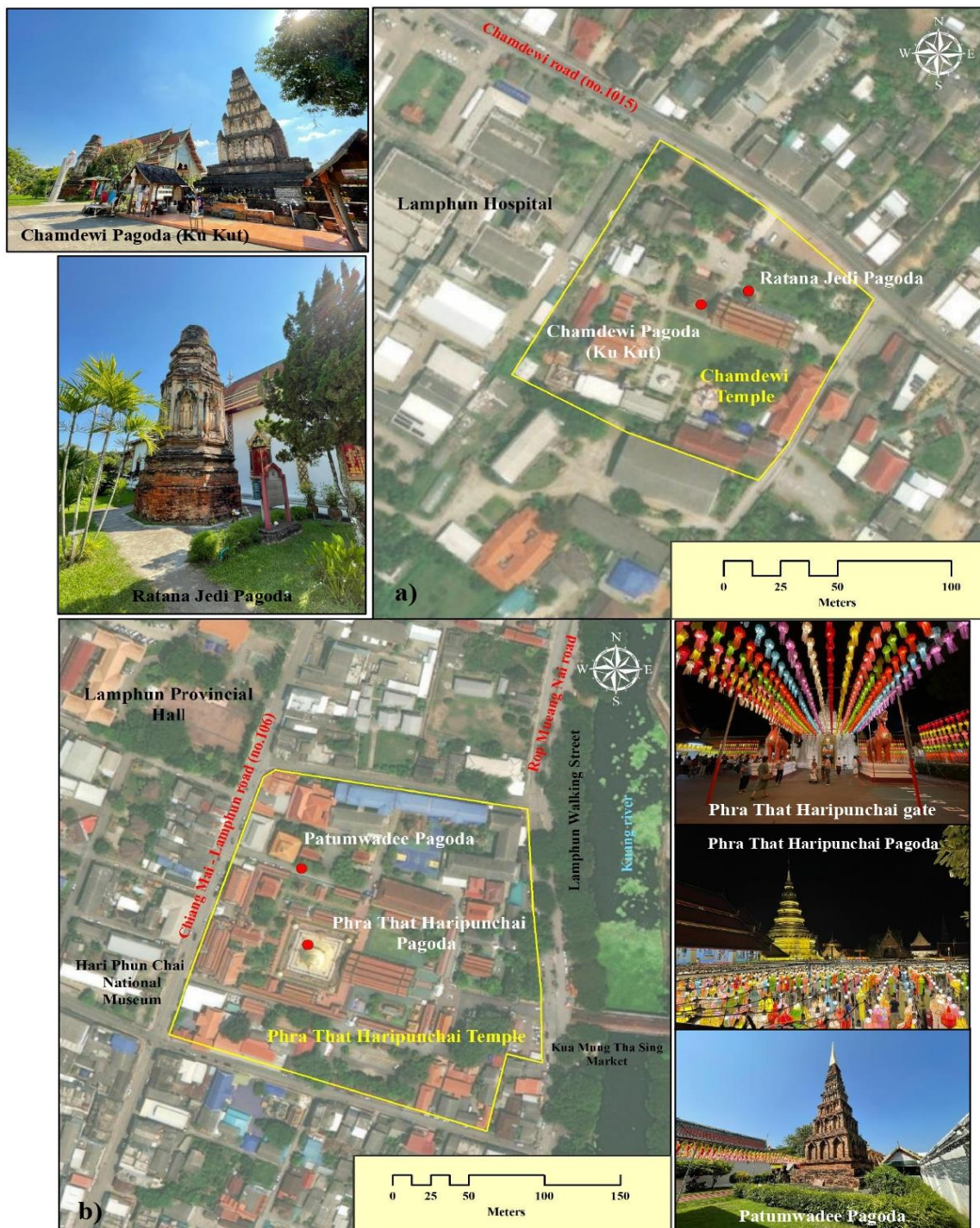


Figure 5. Well-maintained archaeological attractions sites in Chamdewi Temple (a) and Phra That Haripunchai Temple (b) (Source: field survey)

Impact of Urban Expansion occurring in Archaeological Attractions surrounding area

The expedition took place Oct. 18-20, 2022, to explore each archaeological attractions, record its location with GPS, and import it into the GIS database, for analyzing the impact of urban expansion occurring in archaeological attractions surrounding area, obtained by NDBI analysis. The study found that archaeological attractions are divided into three main groups: Restored Groups, Unrestored Groups, and Renovated Groups, detailed below:

The group that has been restored is well-maintained archaeological attractions sites include Chamdewi Pagoda (Ku Kut), Ratana Jedi Pagoda, Patumwadee Pagoda, Phra That Haripunchai Temple, Ton Kaeo Pagoda, Wat Phra Yuen Pagoda, and Ku Chang Ku Ma. Most of such places are in important temple areas, so they are treated with special care, such as Chamdewi Pagoda (Ku Kut) and Ratana Jedi Pagoda are located within Chamdewi Temple (Figure 5a). Chamdewi Temple was built in the A.D.749 that is important in both history and archeology, as evidenced by the inscription found that the royal son of Queen Chamdhevi was King Mahantayot and Anantayot ordered this temple to be built for the cremation.



Figure 6. Under-restored archaeological attractions sites in Victory Shrine Pagoda (a) and 4 Ancient city gates (b) (Source: field survey, October 2022)

Then build a square pagoda with a gold top, called Suwanajangkot Pagoda. However, the area to the northwest adjacent to the wall of Wat Chamdewi is Lamphun Hospital, a large provincial hospital with a large number of people coming in and out every day. The two ancient ruins may be indirectly affected by periodic noise and vibrations.

Patumwadee Pagoda and Phra That Haripunchai Temple is an important landmark since the 9th century AD, built by King Athitayaraj in A.D.897 as the administrative center of the Haripunjaya Kingdom. The Patumwadee Pagoda is 50 meters northwest of Phra That Haripunchai, built by Queen Pathumwadee, the wife of King Athitayaraj. Pathumwadi Chedi is also known as Suwanakot Jedi Pagoda (Suwana means golden) (Figure 5b). The place has long been a sacred place of worship and the center of the mind of Thai people; therefore, it has been well taken care of and has not suffered from environmental impact. Ton Kaeo Pagoda is now a folk museum about the traditions and culture of the Yong or Lue people, who migrated from Shan State, Myanmar and Xishuangbanna, Yunnan Province of China. Wat Phra Yuen Pagoda is inside Wat Phra Yuen, located on the east bank of the Kuang River. There is a standing Buddha statue that is the highlight of this pagoda. The art of the pagoda is in the Bagan style. Ku Chang Ku Ma is located in the northern part of the study area.

This place contained the remains of the royal elephant, “Pu Kam Nga Khiao”, which was the royal elephant of Chamdhevi with great strength. When this elephant died, a stupa was built to contain the elephant's remains in this place. At present, the Fine Arts Department has restored it to be in perfect condition. Most of the under-restored groups are archaeological attractions that are difficult to maintain, due to their location in the community and close to transport links, directly receiving environmental impacts, whether air pollution or noise pollution. Such sites include Victory Shrine Pagoda, Chang Si City Wall, Mahawana City Wall, Ta Nang City Wall, and Li City Wall. Especially the Victory Shrine Pagoda, a former place of worship and gathering of troops, to build the morale of the warriors before the war. When the battle was won, this pagoda was built. It is now an archaeological site in the middle of the community area, located in the middle of the parking lot of Cham Fha Plaza Mall. The Victory Shrine Pagoda used to be part of the Chaimongkhon temple area. But with the expansion of the city and construction, the ancient site was invaded and greatly damaged (Figure 6a).

As for the city gates in all 4 directions, namely Chang Si City Wall, Mahawana City Wall, Ta Nang City Wall, and Li City Wall, only the remains of the city wall are visible in the middle of the intersection. It is directly affected by the vibrations from the passing vehicles and the sound waves from the signal, which would have a negative effect on the archaeological site. At present, there is a lack of maintenance or restoration from relevant agencies (Figure 6b).

And finally, the group being restored is an ancient historical site near the Li City Wall on the south side of the study area. The archaeological site of Wat Sangkharam (Li Gate) is located in Nai Mueang Subdistrict, Mueang District. Wat Sangkharam is an old temple from the reign of Queen Chamdhewi. It is said to be a temple of Wat Si Mum Muang, a temple located outside the southern city wall. Pottery amulets of various craftsmen, Haripunchai-style pottery and a large group of human skeletons were discovered: Cauldron containing human bones of Haripunchai culture, fire burner bone fragments, glass beads, clay amulets, candlesticks, Song Dynasty Chinese white porcelain pottery, bronze ornaments, iron tools, roof tiles, and densely scattered brick fragments. At present, in 2022, a more concrete exploration of the archaeological site is undertaken. From the study of impact of urban expansion occurring in archaeological attractions surrounding area, there are well-maintained cultural attractions, which mostly appear around the major temple districts. There are still some sites, in the middle of the community and transportation routes, difficult to maintain. However, there is still a tendency for relevant agencies to take better care and maintenance. It can be seen that the urban area and buildings expanding on the north and northeast is the location of the Northern Region Industrial Estate, the largest industrial estate in northern Thailand. Government agencies should regularly monitor and control environmental pollution standards such as air, noise, and water pollution. Since November through February is the strong northeast monsoon season, it can easily carry material that damages as ancient sites. Water pollution should have measures for wastewater treatment bases before discharging into natural water sources, as the industrial estates are located along the Kuang River.

CONCLUSION

Mueang Lamphun District, Lamphun Province has a long history of thousands of years, showing many ancient sites and archeology. At present, some places have developed into cultural attractions to attract both Thai and foreign tourists to experience the culture and traditions of the Haripunchai people. With the context of the urban expansion from Chiang Mai, Lamphun is directly affected because it is a secondary city located only 20 km from Chiang Mai. With the efficiency of remote sensing and Landsat satellite imagery data, the land cover covering the study area was obtained, which applied the NDBI technique to examine urban expansion in Mueang Lamphun district, showing the direction of the urban area's expansion very well. Specifically, the north, northeast, and central regions showed high positive NDBI values showing significant urbanization. Such techniques have been used to analyze the impact on tourist attractions such as important ancient sites, as some of them still lack the attention of relevant agencies. This research therefore presents the data from the analysis with the aforementioned techniques to solve problems and plan land use in Mueang Lamphun District. Such spatial data can be used to effectively manage the planning of cultural tourism, especially in the ancient civilization sites, in various ways in accordance with land use. This is for the government, the private sector, and the local community to participate with each other in jointly conserving the cultural attractions in Mueang Lamphun District to be sustainable in the future.

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