GEOSPATIAL ANALYSIS IN MONITORING LAND USE ENCROAHMENT INTO HERITAGE SITE IN BUJANG VALLEY

Intan Siti Zulaikha Mastor, Norzailawati Mohd Noor, Muhammad Faris Abdullah and Alias Abdullah

International Islamic University Malaysia

ABSTRACT

This paper attempted at studying the applications of GIS and satellite remote sensing as a land use planning tool in monitoring a development expansion surrounding heritage area in Bujang Valley, Kedah. This research identified the development expansion around the heritage sites in determining a specific boundaries for heritage site in the context of land use planning. The analysis of catchment area for heritage sites has been identified by using GIS and satellite image of SPOT 5.The analysis of development pattern was obtained from temporal images of SPOT 5 using images and layering techniques which have been tested in Bujang Valley, Kedah. The results showed that there were prominent changes in the study area throughout the 11 year period (2004-2012). Supervised land classification analysis showed significant changes of land covers of forest, agriculture and built-up area. Overall, forest land was converted to agriculture and built-up areas while in some localities agriculture land was converted into built-up areas especially in the surrounding areas of the heritage sites. This study showed there was greater value in terms of archaeology and anthropology in handling the issues of urbanization. Simultaneously it presented the analysis of remote sensing and GIS technology which have provided a new direction in handling this issues globally.

Key Words: Heritage sites, GIS, remote sensing, land use, Geospatial analysis, conservation

INTRODUCTION

Rapid urban development and forest clearing for plantation have been a threat to the preservation of heritage sites, especially when they begin to encroach into heritage areas. Similar situation can be seen occurring in Sungai Petani, Kedah, where urban development and plantation activities were beginning to encroach into the heritage site in Bujang Valley. The threat was even more

pressing, considering the conventional methods engaged in documenting heritage sites in Malaysia, which are photograph and note taking (Erna et.al., 2013), were the laborious and the consuming photographing and undertaking. Because they were time consuming, the use of these conventional methods may result in the process of heritage sites documentation and preservation being overwhelmed by the pressure to develop the area. If left uncontrolled and not well monitored, there would be a real possibility that urban development and other physical development may jeopardise the heritage sites in Malaysia, not only those that have already been listed, but especially those that were currently being researched and studied.

Heritage sites provide a glimpse into our distant past. They are valuable evidences that need to be protected and preserved. The legal provision and measures to protection of heritage sites in Malaysia is stipulated in several Acts including the National Heritage Act 2005. For instance, the Act requires that buffer zone of 200 metres be provided surrounding listed heritage sites in order to protect the sites from being encroached by urban or other types of development. Although the Act makes provisions for listed site, no provision is accorded to site that is yet to be listed. This puts the sites which have just been discovered under risks of being destroyed by encroaching development.

Heritage sites require research and documentation prior to being listed. However, research and documentation are time consuming. Thus, while heritage sites are being researched and documented, rapid development may already encroached into the areas and may also ruin the historical evidences on the sites. For instance, recently the Shrine Sungai Batu (Site 11) in Bujang Valley was cleared for development. This issue has raised many questions including the status of land use of the area and the power to gazette heritage site lied in the hand of which authority. In the case of Site 11, the main issue was the difficulty to determine the boundary of the buffer zone since currently there was no recorded data on the location of the unearthed shrine complex on the site since the area was still being researched by a group of researchers from Universiti Sains Malaysia (Mokhtar et.al., 2010).

The use of geospatial technology, for instance the application of geographical information systems (GIS), could help estimate the risk of heritage sites being encroached by development. For instance, Eric et.al. (2012) use GIS to measure spatial vulnerability of heritage sites. Meanwhile, Lyon and Hitchcook (as cited by Miller, 1981) use remote sensing (RS) applications in documenting historic and prehistoric sites. In terms of detecting the heritage sites remains, Banerjee et.al. (2013), Shivankar et.al. (2014) and Pendiebury et.al. (2009) use temporal resolution to detect changes over time by targeting the area of the heritage sites.

Remote sensing has also been used to determine changes in land cover in the vicinity of heritage sites. Application of RS through analysis and digital interpreted data could provide relatively accurate estimation on the changes in the land cover of the peripheral of heritage sites. For example, Bassini et.al. (2009), in an archaeological study, use RS technology to detect different land use cover of Arpi. Meanwhile, Banerjee et.al. (2013) determine land cover change of Central India through a designated timelines using radiometric sensitivity sensor as specific spectral bands that detect different electromagnetic wavelength changes based on the colour of the land covers. The same method is used in Almeria by M.Cano et.al. (2013). Through image registration process, RS is also able to automatically sense changes through detection of linear features based on GIS data and RS image (Deren, 2010). This method requires high accuracy of pixel-based and, hence precise registration of multi-temporal images are necessary. In historical landmarks management, early use of aerial photograph is to identify the location of buried antiquities (Kaimaris et. al., 2011). Overall, RS have been proven to be able to help in detecting heritage evidences on site, assisting in manipulating data in order to manage the sites detected and finally accentuating the possibilities of future land activity surrounding the area (R.Lasaponara et. al., 2011).

In the archaeological field, spatial dimension is one of the most important analyses. In this regard, GIS can be a big help since GIS provides the technology that enables spatial data to be stored, systematised, visualised, managed, analysed and presented. GIS is also able to assist in the analysis of the cultural

landscape of the study area. In a study conducted by Papadopoulos et.al. (2012), the small theatre and amphitheatre of the ancient Ierapytna in Greece were rediscovered by integrated geophysical method. The layering process of reproduction of the geo-referenced and digitized map of the location of the archaeological ruins, and the rectified satellite image of the modern city of Ierapytna where the two monuments stipulated were superimposed on the map produced.

Research and heritage management study in Indian prehistory by Pappu et.al (2010) shows the application of RS and GIS in generating thematic maps used for demarcation of raw material sources and investigates the variability in site distribution through time. Hemeda (2012) applies the ground penetrating radar (GPR) for both architectural heritage monuments and anthropological research. Hemeda (2012) in the study on the preservation of Habib Sakini Palace, uses GPR to detect the targeted monuments underground. In the physical restoration of monuments, the use of RS in terms of microwave is used by Pieraccini et.al. (2008) in structural testing of historical heritage site towers in Italy.

In cognisance of the most effective methods above, hence, this paper discusses the use of geospatial technology to monitor encroachment of urban development into heritage areas. The use of such technology can help quickers monitoring of land use change surrounding heritage sites. A case study was conducted in Bujang Valley, Kedah.

MATERIAL AND METHODS

The Study area

Bujang Valley (*Lembah Bujang* in local language) is located in Sungai Petani, Kedah, or more specifically in Merbok district of Kuala Muda. Bujang Valley is home to ancient shrines and archaeological relics that provide significant evidences of early civilisations of the Malay Peninsula. Bujang Valley heritage area includes three discovery sites which are Sungai Merbok, Bukit Meriam and Sungai Muda. The excavation, relocation and rehabilitation of shrines and relics found in these three areas are under the management of the Department of Museums Malaysia

and are being supported by the Department of National Heritage Malaysia. The excavation work at Sungai Batu site is being undertaken by the Centre of Global Archaeological Research, Universiti Sains Malaysia.

It is determined that Bujang Valley had once been a thriving civilisation dating back to more than 2,000 years ago. With the demise of the civilisation currently, only the remnants in the forms of shrines and relics remained that were found throughout the Bujang Valley complex. It is estimated that there are more than fifty of these ancient shrines existed within the area. The excavation work is ongoing, but slowly, since many of the physical monuments exist subsurface. However, the site is susceptible to pressure of rapid urbanisation due to the lengthy excavation process. Bujang Valley is located near to Sungai Petani, which is one of the rapidly growing towns in the State of Kedah. It is feared that the rapid development of the town may encroach into the heritage sites at Bujang Valley before excavations are completed. Thus, this study looks into land use management techniques that may be used as one of mitigation measures to preserve and conserve the heritage site, towards gazetting it as a protected area in the future preparation of statutory plan.

Figure 1: The study area, showing distribution of shrines found at Bujang Valley until 2011
(Source: Department of Museums Malaysia, 2014)

Satellite Datasets and Data Processing

This study used GIS and satellite remote sensing in monitoring the development pattern in areas surrounding Bujang Valley. For the analysis, five SPOT-5 Mode J System Corrected satellite images covering the Bujang Valley area were acquired from the Malaysia Remote Sensing Agency. The images were for years 2004, 2007, 2009, 2013 and 2014. The images were analysed using ERDAS IMAGINE 2014 in order to obtain comprehensible format from the raw data. The pre-processing level for the images was 2A, which was rectified to match the standard projection UTM WGS 84, without using ground control. Remote sensed images for SPOT-5 J consists of four spectral bands and with 30 meter resolutions.

(a) (b)

Figure 2: SPOT 5 J Satellite images a) without pre-processing stage and b) after pre-processing (Band 4, 3, 2)

Meanwhile, GIS data for Kuala Muda district was obtained from the Federal Department of Town and Country Planning Peninsular Malaysia. GIS data were used to identify future land use planning for the study area. This data were then cross-referred with the Kuala Muda Local Plan 2020. This was to determine the current and future land use of the surrounding areas and to determine whether the proposed future land use of the surrounding areas would have negative impacts on the preservation of the heritage area.

ANALYSIS AND FINDINGS

Boundary Determination

Based on the records obtained from Department of Museums Malaysia, the distribution of the shrines in Bujang Valley are scattered mainly into three main complexes, which are the Bujang Valley complex, Sungai Batu complex and Bukit Meriam complex. The location of these complexes and the distribution of shrines are as shown in Figure 3 below.

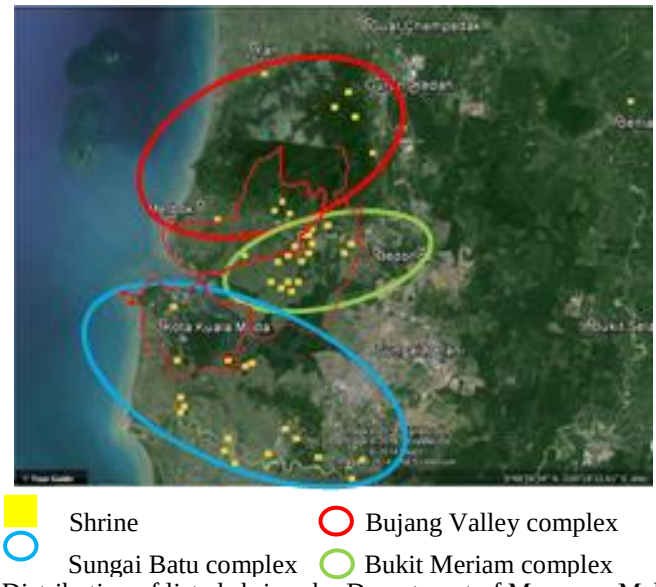


Figure 3: Distribution of listed shrines by Department of Museums Malaysia, 2011

The yellow markings show the shrines found in Bujang Valley from the earliest excavation until presently. All three main complexes are located near to Sungai Petani town centre. Thus, with the rapidly growing Sungai Petani town, there is a risk of urbanisation encroaching into the heritage sites. Due to their close proximity to the town, the Sungai Batu complex and the Bukit Meriam complex face higher risk of urbanisation encroachment.

Land Use Change Detection

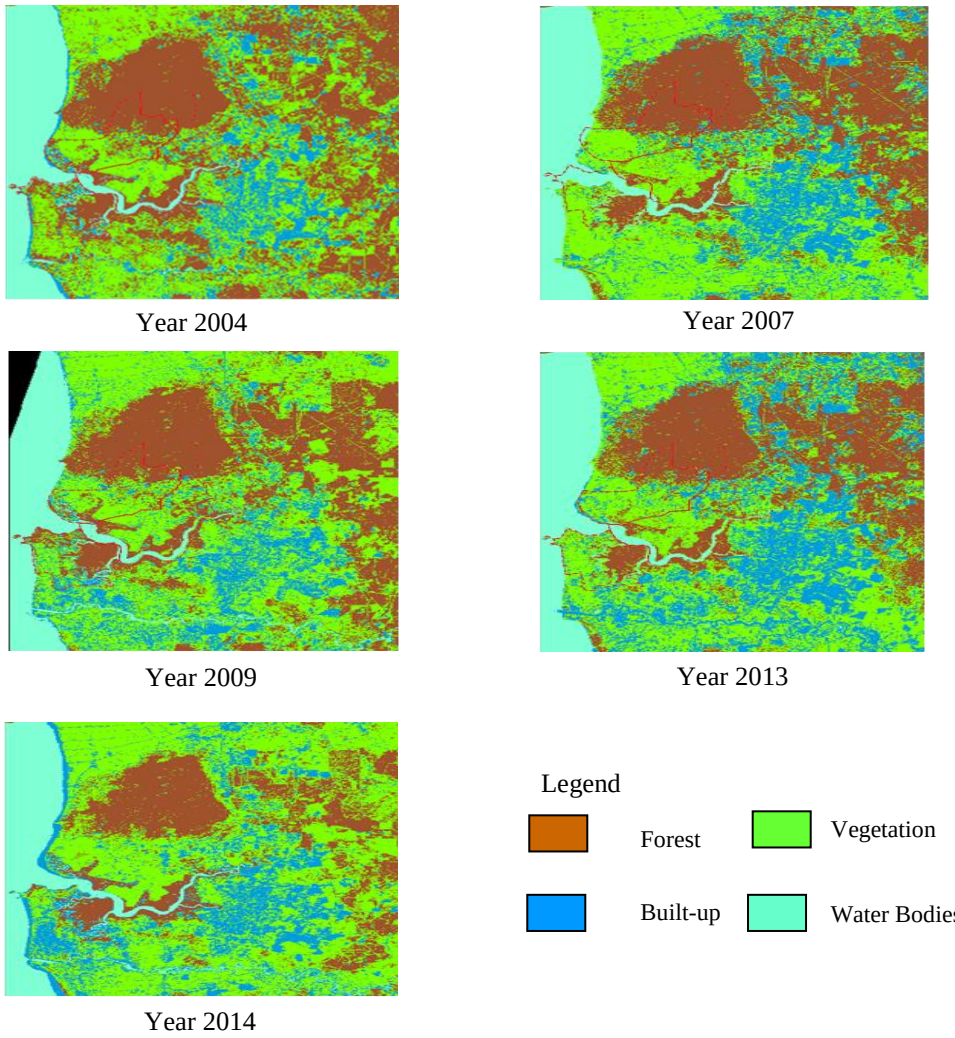


Figure 4 : Temporal land use classification in study area obtained from SPOT-5 J images

The change detection analysis was undertaken to identify the changes in land cover of the study area. The acreage for four types of land cover were determined for each of the satellite image's year. Subsequently, the acreage was compared based on a time series analysis to determine the changes in land cover acreage over the years. The results are as shown in Table 1 below.

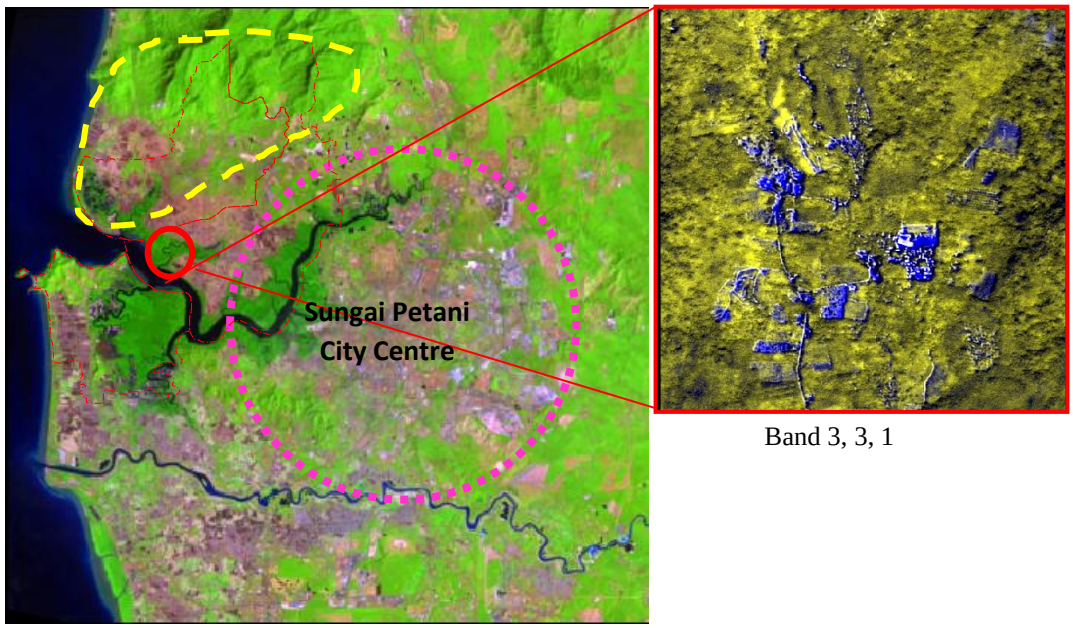
Table 1: Comparison of area between land use class from year 2004 until 2014 of Sungai Petani

Types of Land Cover	Year										Average Rate of Change (2004-2014	
	2004		2007		2009		2013		2014			
	Area (acre)	%	Area (acre)	%	Area (acre)	%	Area (acre)	%	Area (acre)	%	Area (acre)	% (+/-)
Forest	117.4	41.5	116.2	39.0	93.23	31.7	84.68	28.5	65.75	22.2	98.45	(-)33.1
Agriculture	98.6	34.8	108.1	36.3	123.0	42.0	107.1	36.0	141.7	47.6	115.6	(+)39.0
Built-up	29.12	10.3	35.69	11.9	42.06	14.3	69.3	23.2	53.99	18.1	46.03	(+)15.5
Water Bodies	37.79	13.4	37.55	12.6	35.08	12.0	36.84	12.3	36.03	12.1	36.71	(-)12.4

From the table, the average rate per year for built-up area increase to 98.45 acre per year with 33% change rate within 11 years period. Due to the rapid development covering in Sungai Petani, most of the forest and agriculture area converted into built-up areas to cater for the over spil population from Seberang Perai, Penang. It shows the mass development happening in Sungai Petani is mostly caused by the effects from development in the regional area.

Development Pattern around Heritage Area

From the image monitoring from SPOT-5 J obtained from the year 2004 until 2014 aided by ERDAS IMAGINE 2014 software, the three main complexes are monitored in terms of development of the surrounding area based on the changes of land covers at the respective complexes.



Band 3, 3, 1

Band 4, 3, 2

Figure 6: Location of Bujang Valley complex in Sungai Petani context

Figure 6 shows the position of Bujang Valley shrines complex in Sungai Petani context. Based on the area monitoring throughout 11 years, the built-up development is slow due to the geographical earth surface of Bujang Valley complex that is surrounded by forest and located very near to Jerai Mountain. However, the area has an active of land use activity generally oil palm plantation under the category of agriculture.

Among the three main complexes of the heritage sites in Sungai Petani, Sungai Batu complex is the most impacted by developments. This complex is the nearest to Sungai Petani town centre where some of the current excavation activities are still ongoing along the main road of Merbok-Semeling that connects the town centre to Pantai Merdeka. Site 11 that has been demolished by the developers is located within this complex, which final boundary of the physical evidence is yet to be determined.

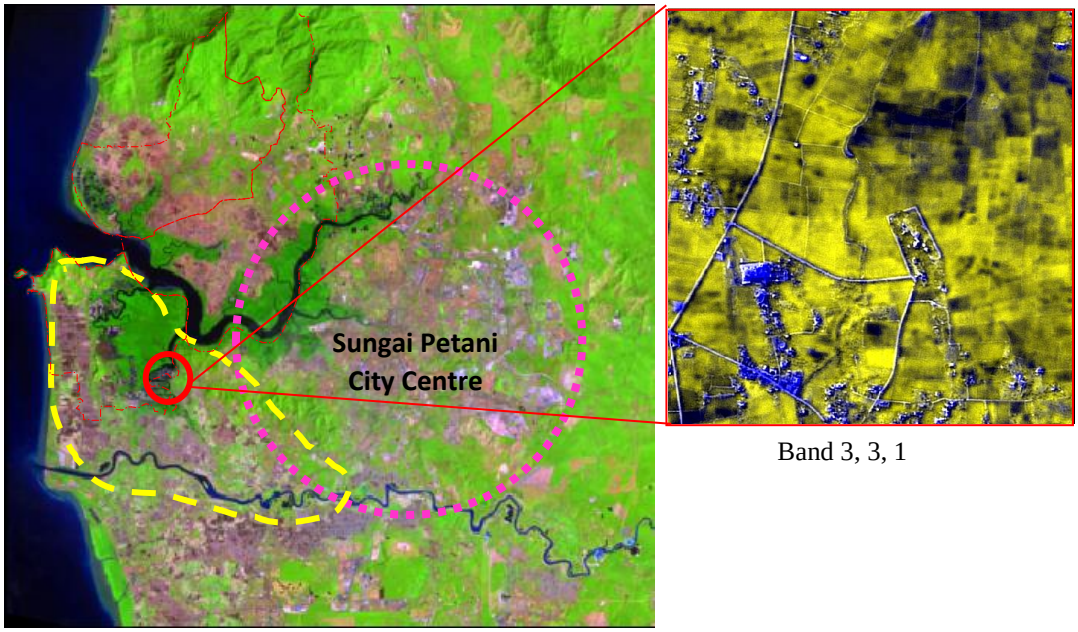
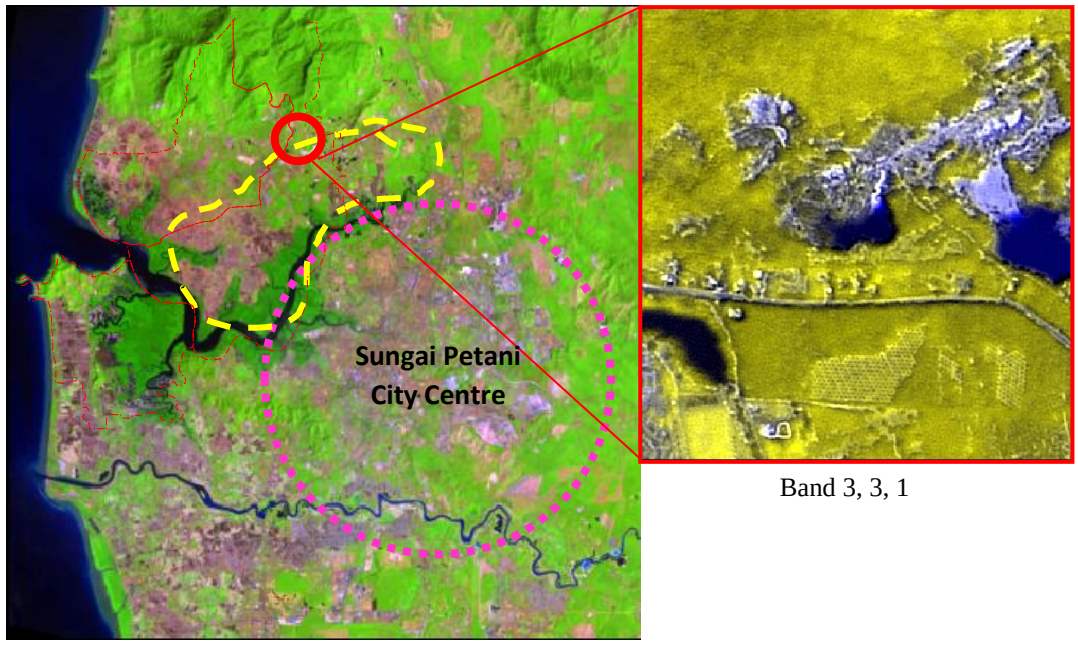


Figure 7: Location of Bukit Meriam complex in Sungai Petani context

Bukit Meriam complex is located on the southern part of Sungai Petani, near to the state border of Seberang Perai, Penang. Currently, the land use activities for that area and its surrounding are agriculture and residential. Paddy fields and villages surrounded the location of the shrines complex, acting as buffer zone as required by law since as the land is mostly privately owned. However, the buffer zones are still susceptible to threats of development pressure encroaching from Penang, as inclurial areas are spreading up north wardly, taking the advantage of Penang Port's strategic location, thus planning for more residential included in statutory plan, Kuala Muda Local Plan 2020. Based on the images monitoring, heritage area of Bukit Meriam may face threats of development resulting in the need for buffer zones around the area.



Band 3, 3, 1

Band 4, 3, 2

Figure 8: Location of Sungai Batu complex in Sungai Petani context

Menaging Existing Heritage Sites

The current condition of heritage sites has been compromised as shown by the analysis results, with the most rapid development being currently happening in Sungai Petani. Huge differences are clearly shown in the built-up area change rate and unbuilt-up change rate. Legally, there are only two heritage areas gazetted under the designated heritage preservation sub-section in Kuala Muda Local Plan 2020 which are Bujang Valley complex and Sungai Batu complex. Bukit Meriam Complex is yet to gazetted based on this local plan.

Even for the gazette area, the risk still exists, as whereby Site 11 was demolished even though the site is under the designated heritage preservation area. Development pressure is occurring from two sources; Sungai Petani town center and Seberang Perai which happen to affect development pattern around the heritage area. Conventional methods of determining

and recording archaeological heritage sites that are practiced in Malaysia nowadays are not at par with other countries as such Europe that has fully utilized these technology.

CONCLUSION

GIS and remote sensing are two tools of urban and regional planning that are able to set up and speed up geo-database. these two tools also allow digital achieve of archaeological findings and studies to be systematically documented. These methods enables urban and regional planning department to function as a one-stop database unit that key players in the built environment such as planners, architects and local authority, can refer to. Having the database would help to ensure that more attention is given to developing the area near to the heritage sites whereby the utilisation this analysis as a guideline would simultaneously protect the national heritage treasures. After evaluating the pattern of developments in this study, some constraints have been discovered such as the precision of data obtained needed to be more accurate up to 10 meters, for the purpose of ensuring smooth monitoring process. Hence, both satellite data and survey works combined are needed in order to ensure the reliability of the results. Without holistic enforcement of the acts and policies from the authority, at both national and local, levels, the preservation and conservation of these heritage sites may not able to be conducted successfully. Over prioritisation of development over protection of national heritage sites leads to jeopardizing high value evidences in term of archaeology and anthropology as Klang Valley is known to be the earliest civilization in Southeast Asia. Remote sensing and GIS have proved to be of great importance and assistance for these kinds of works because accurate and high resolution data is made easily available by the local agency.

ACKNOWLEDGEMENT

The authors are indebted to the Federal Department of Town and Country Planning Peninsular Malaysia, Malaysian Remote Sensing Agency and local authorities in Kuala Muda for providing invaluable data that were used in this study.

REFERENCES

Cristiana Bassani, R. M. (2009). Specific spectral bands for different land cover contexts to improve the efficiency of remote sensing archeological prospection: The Arpi case study. *Journal of Cultural Heritage vol.105*, e41-e48.

Dimitris Kaimaris, S. S. (2011). GIS of Landmarks Management. *Journal of Cultural Heritage vol.12*, 65-73.

Eric de Noronha Vaz, P. C. (2012). Urban heritage endangerment at the interface of future cities and past heritage: A spatial vulnerability assessment. *Habitat International vol.36*, 287-294.

Erna Warnita Bachad, Z. M. (2013). GIS Application and Geodatabase for Archeological Site Documentation System: Bujang Valley, Malaysia. *Developments in Multidimensional Spatial Data Models*, 173-189

Hemeda, S. (2012). Ground Penetrating Radar Investigations for Architectural Heritage Preservation of the Habib Sakakini Palace, Cairo, Egypt. *International Journal of Conservation Science vol.3, Issue 3*, 153-162.

John Pendiebury, M. S. (2009). Urban World Heritage Sites and the Problem of Authenticity. *Cities vol.26*, 349-358.

M.Cano, E. P.-S. (2013). Historic Preservation, GIS and Rural Development: The Case study of Almeria province, Spain. *Applied Geography vol. 42*, 34-47.

Massimiliano Pieraccini, M. F. (2009). Structural testing of Historical Heritage Site Towers by Microwave Remote Sensing. *Journal of Cultural Heritage vol.10*, 174-182.

Miller, W. (1981). Remote Sensing Techniques in Historical Site Discrimination. *Remote Sensing of Environment vol. 11*, 463-471.

Mokhtar Saidin, J. A. (2010). Issues and Problems of Previous Studies in the Bujang Valley and the Discovery of Sungai Batu. *Bujang Valley and Early Civilisations in Southeast Asia*, 17-26.

Nikos G. Papadopoulos, A. S. (2012). Rediscovering the small theatre and amphitheatre of ancient Ierapytna (SE Crete)

by integrated geophysical methods. *Journal of Archeological Science*, 1960-1973.

Pranita Shivankar, D. D. (2014). Remote Sensing Study of the Vacinity of a UNESCO World Heritage Site in Maharashtra using Multi-Temporal Satellite Imagery. *IOSR Journal of Applied Physics*, 70-74.

R. Lasaponara, N. M. (2011). Satellite Remote Sensing in Archeology: Past, Present and Future Perspectives. *Journal of Archeological Science vol.38*, 1995-2002.

Ruman Banerjee, P. K. (2013). Reconstruction of contested landscape: Detecting land cover transformation hosting cultural heritage sites from Central India using remote sensing. *Land Use Policy 34* , 193-203.

Shanti Pappu, K. A. (2010). Applications of satellite remote sensing for research and heritage management in Indian prehistory. *Journal of Archeological Sci*