#### A GEOGRAPHICAL INFORMATION SYSTEM (GIS) AS AN INNOVATIVE APPROACH FOR PRESERVING VERNACULAR ARCHITECTURAL HERITAGE

#### \*Rohayu Daud \*\*Ab Aziz Shuaib

Abstract. This research practically investigates on how to manage and preserve valuable vernacular houses by using Geographical Information System (GIS) as an effective technological approach towards architectural preservation in Malaysia. The study explores a system correlates to create a new and innovative trend and to enhance building preservation which is frequently applied in geograph- ically oriented network computer technology. For the purposes of discovery, invention, and creation approach, data were collected using qualitative method followed by visual analytical matrix in vernacular houses; and thus, traditional houses in Kelantan have been identified, characterized and catalogued. The collaboration between architectural and GIS produces a more creative technique towards impact studies. By preserving and documenting the heritage values in the history of architecture and related bodies, it could inject more innovative paradigm in recognizing the cultural heritage that is valuable enough.

Keywords: Geographical Information System, Innovative, Preserving, Vernacular Architectural, Heritage

Abstrak. Kajian ini menyiasat secara praktikal bagaimana untuk mengurus dan mengekalkan rumah vernakular berharga dengan menggunakan Sistem Maklumat Geografi (GIS) sebagai pendekatan teknologi yang berkesan ke arah pemuliharaan seni bina di Malaysia. Kajian ini meninjau sistem yang ada hubung kait dengan mewujudkan satu tren baru dan inovatif untuk menemui pemeliharaan pembinaan yang sering digunakan dalam geografi berorientasikan rangkaian teknologi komputer. Bagi tujuan penemuan, ciptaan, dan pendekatan penciptaan, data dikumpul dengan menggunakan kaedah kualitatif dan disusuli dengan matriks analisis visual di rumah vernakular; dan dengan itu, rumah-rumah tradisional di Kelantan telah dikenal pasti, ditentukan ciri-cirinya dan dikatalogkan. Hasil seni bina dan GIS bekerjasama dalam teknik yang lebih kreatif terhadap kajian impak. Dengan memelihara dan mendokumenkan nilai warisan sumbangan ini kepada sejarah seni bina dan badan-badan yang berkaitan boleh menyuntik paradigma yang lebih inovatif dalam mengiktiraf warisan budaya yang cukup berharga.

Keywords: Sistem Maklumat Geografi, Inovatif, Memelihara, Seni Bina Vernakular, Warisan

\*Pelajar Sarjana di Fakulti Teknologi Kreatif dan Warisan, Universiti Malaysia Kelantan

\*\*Felo Utama di Fakulti Teknologi Kreatif dan Warisan, Universiti Malaysia Kelantan

# 1.0 Introduction

Geographic Information System (GIS) has generated interests in the global world today and it has been used for over 30 years in North America. Terms of GIS can be used for integration of computer technology in the application of substantive, as well as a new discipline. GIS are integrating systems which bring together ideas developed in many areas including the fields of agriculture, computing, mathematics, botany, economics and of course geography. Three broad perspectives on the GIS map focusing on the importance of processing, database and spatial analysis. Evolution of GIS is described as three main stages of resource inventory, analysis and management activities.



Figure 1. Stages in the Development of GIS Applications

GIS in architecture is still new in Malaysia compared to other countries. GIS analysis can define the significance of this entire phe-nomenon from the architectural history, (Jianwei Z., Wei C., 2013). Hence, the research questions focus on the distribution and typology of the vernacular houses, factors influence and conditions of the building answered. Besides, it generates geographical and distance factor that reflects the typology of the traditional houses. As a key site for protection and restoration in developed sites, the method has an effective performance in identifying the vital ecological areas and linkages prior to development in suburban areas (Qing C, Xue L., Xiulan H., & Jiansheng W., 2011). Therefore, a visual description and analysis of data from interviews is also valuable and it is very important to identify the reliability of research findings.

It is supported by the Economic Transformation Program that is an initiative by the Malaysian government to turn Malaysia into a high-income nation economy by the year of 2020. The program will lift Malaysia's Gross National Income (GNI) to US\$523 billion by 2020, and raise per capita income from US\$6,700 to at least US\$15,000, meeting the World Bank's threshold for high income nation. The sequence of the issue, cataloguing and promoting rural architecture will contribute to creating jobs by stimulating new economic activity, such as the promotion of cultural tourism, while preserving a valuable source of information on rural culture, recovering local construction techniques, encouraging a sense of community, and making villages and rural areas more attractive to visitors (M. Cano et al., 2013). Knowledge, skill and information are the main steps for the preservation and valorization of the whole architectural heritage (Franca Restuccia, 2013). Historic Preservation Act of 1966 by Congress, the economic and cultural values of historic architectural preservation have become widely recognized and have moved preservation issues into the forefront of public policy and popular interest (American Institute of Architects, 2010).

This paper aims at the implementation of Geographic Information System (GIS) as a computerized database with an integrated systems approach for managing traditional houses towards preservation of vernacular houses in Kelantan, Malaysia. The data are not properly documented and some of the buildings perish without being noticed by the public.



Figure 2. The Relationship between GIS, Computer Cartography, Computer Aided Design, Remote Sensing and Database Management. Source: DJ Maguire (2011)

This research addresses the issues of distribution, managing and monitoring because of its ability to support the preservation process from the results of GIS in spatial reports and digital information of map search management. It will help architectural documentation process from the use of blue print documentation to the implementation of GIS. Methods and Data Collection techniques are based on the qualitative method approach focusing on case study through the content analysis, and visual analysis checklist. This research highlights the main finding in cataloguing of traditional houses and compilation of thematic charts. This research concludes that the system conceived has interrelated logic archival system and is updatable and implementable based on user's cognitive path for their reuse, restoration or preservation with hyperlinks of the GIS database. It would fill the gap knowledge as an initial database embracing the comprehensive studies of traditional houses in timber architecture, especially in discovering its distribution and typologies in Kelantan.

### 2.0 Case Study

Researcher has chosen Kelantan as the study area and the study encompasses the entire 10 districts of Kota Bharu, Pasir Mas, Pasir Puteh, Machang, Gua Musang, Tanah Merah, Jeli, Bachok, Kuala Krai and Tumpat. The state of Kelantan is situated at the North Eastern of Peninsular Malaysia, bordering Thailand and the South China Sea. The capital of Kelantan is Kota Bharu. Kelantan is one of the Malay belts states of Malaysia and its surrounding regions with Siam influence to some extend in its city architectural designs. With a population of about 1.8 million, ninety five percent of the people are Malays. Others include, Chinese, Indians and Thais and a small percentage of Muslim Cambodians who have made Kelantan their homes since 1971. The people of Kelantan are fiercely inde- pendent and have managed to retain age-old customs and traditions. Their ability is considerably high in preserving and maintaining their rich Malay cultural heritage which is often referred to as the "Cradle of Malay Cultures".

# 3.0 Literature Review

The system is closely related and evolves along with the constant development of software architecture and software development techniques in development of geographical science (Jin L., Xiaofang Z., Cheng Z., & Xincai W., 2012). Suitable analysis in the GIS context is a geographic or GIS-based process used to determine through systematic, multi-factor analysis of the different aspect of the terrain (Marjan J., Hanieh S., & Mostafa M., 2011). Through the integrated frameworks, the GIS database and other systems are connected to the GIS database (N. Maharajan, 2012). Moreover, geographic coordinates can be recorded if GPS data can be mapped and managed as point data on a geographical information system (GIS), they can have various usages (Koun S., 2011).

All the specific information data related to the elements can be updated and located in this system (Giovanni V., Nicola B., 2011). In time as a function of the natural geomorphological processes, evaluating their relationships with historical buildings, as well as their possible collapse and evolution can be done (Maurizio L., Maria D., & Nicola M., 2009). Research efforts to enhance and develop suitable methods for assessing the reuse or preservation alternatives of rural buildings have been remarkable (M.Cano, E. Garzón,

& P. J. Sánchez-Soto, 2013). The analysis performed and found from the results of GIS applications are the preparation of shaped spatial reports and digital information of map search and management (Md Hafiz S., Nurul Iffah Md. Z., Mohd Shahizan O., Anis Fadhilah H., Nurul H. Md. S., Lizawati Md. Y., & Ali S., 2011). Cataloguing of traditional houses in this particular area was identify- ing and compiled by manage, organize, interrogate and visualize the aspects which characterize architecture through the integration frameworks (M. Cano et. al., 2013).

								PARA	METER		
No.	AUTHORS	COUNTRY	Tittle	Architectural Heritage / Historical	Analysis G B	Vernacular Architecture	Preservation / Conservation / Restoration	Typology	Parametric Computational design	Design Element	Woodcarving
1	Franca R. et al., 2013	ITALY	A GIS for knowing Managing Preserving Catania's Historical	x	x	х	х				
2	M Case et al. 2012	CRAIN	Architectural Heritage								<u> </u>
1	Micano et al., 2015	armin	Almeria province. Spain	x	×	x	x				
3	Giovanni V. & Nicola B., 2013	ITALY	GIS Platform Oriented Towards the Building Restoration and Regeneration Processes of the Historical and Architectural Heritage Protection	x	x		x				
4	Li Rui., 2008	CHINA	Urban Heritage Conservation by GIS under Urban Renewal :A Case Study of Hankou Historical District in Wuhan, China	x	x	х	x				$\square$
5	M.K.A.M. Sulaiman et al., 2009	MALAYSIA	Aplikasi GIS di dalam Pemilihan Lokasi 'Vertical Park : Kajian Kes di Kuala Lumpur		x						$\square$
6	Rodzyah H.M.Y. et al.,2009	MALAYSIA	A Heritage Study on Kota Long Jaafar	X	X		Х				<u> </u>
7	Md Hafiz et al.,2013	MALAYSIA	A Review on Application of Geographical Information System in Town Planning in Malaysia		x						$\square$
8	Tarmiji M. et al.,2011	MALAYSIA	Peta Budaya Wilayah Utara : Metodologi dan Aplikasi		X						$\vdash$
9	Nangkula U. & M.Tajuddin R., 2010	MALAYSIA	Deskripsi Tipologi, Klasifikasi dan Analisis Perancangan Masjid di Malavsia					x		x	$\square$
10	Yao-Ru Chen et al., 2008	MALAYSIA	The Typological Rule System of Malay House in Peninsula Malaysia	x		х		x			F
11	Fairuz R.R., 2011	MALAYSIA	Generating Housing Typologies in The Local Context					X	X	X	-
12	A.A. Shuaib & O.F.Enoch., 2013	MALAYSIA	Integrating the Malay Traditional Design Elements into Contemporary Design : An Approach Towards Sustainable Innovation			x	x			x	
13	Lilawati A.W., 2007	MALAYSIA	Architectural Design of Traditional Malay House	x						x	X
14	A.A. Shuaib & O.F. Enoch., 2013	MALAYSIA	Application of Kelantan Traditional Aesthetic Values into the Architecture of Contemporary Homes	x		x				x	$\square$
15	Ismail S. et al., 2001	MALAYSIA	Variation of carved component	х		Х					1
16	Nangkula U. & Nurhananie S., 2011	MALAYSIA	Evaluating the Design and Construction Flexibility of tradisional Malay House			х				-	T
17	Seo-Ryeung Ju et al., 2009	MALAYSIA	Modernization of Traditional Malay House in the Kampong Baharu (Kuala Lumpur).					x		x	
18	A.A. Shuaib & O.F. Enoch., 2013	MALAYSIA	The Kelantan Traditional Arts as Indicators for Sustainability; An Introduction to its Genius Loci							x	
19	Zumahiran K. & Ismail S., 2008	MALAYSIA	Visual Forms Of Carved Components In Traditional Timber Houses of Kelantan and Terengganu			х					×
20	Shamsu M. & P.Z. Hanafi., 2011	MALAYSIA	Senibina Tradisi Pantai Timur Berbumbungkan Atap Singgora	x		х				x	$\top$
21	M. Sheppard., 1986	MALAYSIA	Carved structural in Palaces	×							X
22	N. Izan M.I., 1986	MALAYSIA	Ventilation Panels and Pulpit of the mosque.								Х
23	M. Lazzari & Maria D.N.M., 2009	ITALY	A new GIS- based integrated approach to analyse the anthropic geomorphological risk and recover the vernacular architecture		x	x	x				

# Table 1: Literature matrix - review of author from the literature

24	D.J. Maguire., 2012	SPAIN	An overview and definition of GIS		x					
25	M. Cano et al., 2013	SPAIN	Historic preservations, GIS, & rural development: The case of Almeria province, Spain	х	x	x	x			
26	Jacek M., 2007	CANADA	GIS-based multicriteria decision analysis: a survey of the literature		x	x				
27	Rodney H.M. & Rachel K., 2008	PORTUGAL	People Needs in The Urban Landscape : Analysis of Landscape And Urban Planning contributions					x		
28	M. Taufik, 2000	MALAYSIA	Variation of carved component	x		x				
29	Azizah S., 2000	MALAYSIA	Geometrical Pattern	x		x				×
30	M. Khairul Azhar M.S., 2002	MALAYSIA	Variations of Ventilation Panels	x		x				×
31	Ismail S., 2002	MALAYSIA	Variaton of carved component	x		x				×
32	Sabrizaa., 2010	MALAYSIA	Structural, elements and decorative	x		x			x	$\vdash$
33	Zumahiran K., 2010	MALAYSIA	Elements and decorative	x		x			x	×
34	Nazarudin et al., 2011	MALAYSIA	Warisan Hindu Buddha dan Islam di Nusantara : Satu Analisa	x		x				<u> </u>
35	A. Razak A.R., 1999	MALAYSIA	The Traditional Malay Architectural World View (with Emphasis on The Role of the Tukang)	x		x				×
36	M. Tajuddin H.M.R., 2006	MALAYSIA	The Discontinued Traditions of Malay Wood Carvings in Modem and Post Modern Architecture in Malaysia : A Failure to Develop the Discourse on Omamentation in Architectural Works	x						×
37	Mastor S., 2013	MALAYSIA	Kelestarian Falsafah Islam Dalam Senibina Warisan Melayu	х		х				<u> </u>
38	M. Firrdhaus M.S., 2013	MALAYSIA	Malaysian Vernacular Architecture and Its Relationship to Climate	х		x				1
39	S. Iskandar A., 2000	MALAYSIA	A Mathematical Explanation of The Magic Measurements	x	,	х				Ē
40	Azman S. et al., 2011	MALAYSIA	Documentation and Analysis of Tanggam System in Malay Traditional House	x		x				
41	M. Firrdhaus M.S., 2013	MALAYSIA	Traditional Values and Their Adaptation in Social Housing Design : Towards A New Typology and Establishment of "Air House " Standard in Malaysia					x	x	
42	W. Salleh W.I., 2008	MALAYSIA	The Need for a True Symbiosis of malay Culture and Its Built Environment	x		х				
43	M. Fairoz M.N., 2002	MALAYSIA	Variaton of carved component	х		x				X
44	Mastor S., 2011	MALAYSIA	ldentiti Senibina Kebangsaan Melalui Pendekatan Senibina Warisan Alam Melayu	х		х				
45	Mastor S. & W. Zaid., 2011	MALAYSIA	Peranan Budaya dan persekitaran Dalam Pembangunan rumah Kediaman Masyarakat Cina Peranakan di kelantan : Kajian Kes antara Senibina Rumah Warisan Kelantan dan Senibina Rumah Cina Peranakan di Kelantan	x		x		x		
46	Nangkula U. et al., 2009	INDONESIA	Tipologi Reka Bentuk Masjid Tradisional di Indonesia					х	x	X
47	Zumahiran K. & Ismail S., 2008	MALAYSIA	Composition of Malay Woodcarving : Case Studies on Two Tradisional Timber Houses	х		х				x
48	Seo Ryeung Ju & Saari O., 2010	MALAYSIA	A Typology of Modern Housing in Malaysia					x		

Table 1: (continued....)

# Table 1: (continued....)

49	S.D.M. Sojak & Nangkula U., 2013	MALAYSIA	Typological Study of Traditional Mosque Ornamentation in		L 1	1			1		1	1	1
			Malaysia-Comparison Between Traditional and Modern					х		x	x		
			Mosque										
50	D.S. Norlizaiha H., 2011	MALAYSIA	Corak Penempatan, Senibina dan Ruang Persekitaran Rumah										
			Melayu Tradisi	×		×				×			
51	M. Sabriza a A.R. & M. Najib D., 2005	MALAYSIA	The Symbolism of Tunjuk Langit (Finials) in The Malay	v		v				~			
			Vernacular Architecture	^		^				^			
52	Rosnawati O., 2005	MALAYSIA	The Language of The Langkasukan Motif	х						х	X		
53	Nila I.M.K.D. et al., 2012	MALAYSIA	Pengaplikasian Ukiran Kayu Melayu Dalam Senibina di										
			Malaysia	×		×					^		
54	M. M Tahir et al, 2011	MALAYSIA	Reinventing the Tradisional Malay Architecture : Creating a										
			Socially Sustainable and Responsive Community in Malaysia	х		X						x	
			Through the Introduction of The Raised Floor Innovation										
55	Nursuriani S. & Ismail S., 2013	MALAYSIA	Types of Floral Motifs and Patterns of Malay Woodcarving in	v		v					v		
			Kelantan and Terengganu	^		^					<b>^</b>		
56	S.D.M. Sojak & Nangkula U., 2012	MALAYSIA	Typological Study of Traditional Mosque Ornamentation in										
			Malaysia, an Adaption of Islamic Thoughts into Malay					x		х	X		
			Civilization										
57	Rumana R., 2007	BANGLADESH	Tradisional House of Bangladesh : Typology of House According	v		×		×					
			to Material and Location	^		^		^					
58	Ahmet E., 2012	TURKEY	Interdependence of Tradisional House Form and Settlement	¥		¥		¥		¥			×
			Pattern	~		^		~		~			~
59	Andrew D. K., 2010	USA	A Terrace Typology	х		x		x		х			
60	Vissilia A.M., 2009	ATHENS	Evaluation of a Sustainable Greek Vemacular settlement and Its	v		v	v					v	v
			Landscape : Architectural Typology and Building Physics	^		^	^					^	^
61	Chaweewan D. et al., 2002	THAILAND	Typology and Life Style Analysis of The Raft House (Ruan Pae) in					v					~
			Riverine Settlements in Thailand					^					^
62	Nangkula U. et al., 2012	MALAYSIA	Typological Study of Traditional Mosque Ornamentation in					×		×	×		
			Malaysia - Prospect of Traditional Ornament in Urban Mosque					^		^	<b>^</b>		
63	M. Sabriza a R., 2007	MALAYSIA	Analysis of The Aesthetical Elements Of The Traditional Malay	¥		¥	¥			¥			
		MALAYSIA	Architecture of Malaysia	~		^	~			~			
64	Zulkarnian H. & S.Norlizaiha H., 2012	MALAYSIA	Preservation of Malay Singgora Roof	х		х	х			x			
65	B. Othman & 7   Zainal Abidin 2011	MALAYSIA	The Importance of Islamic Art in Mosque Interior	¥			¥	¥		¥			
66	Osman A 2010	SAUDIARABIA	Conservation and Preservation of Historical Earthen Structures	×			×	~		~			
				^			^						
67	Christina B. et al., 2013	PORTUGAL	Historical Heritage : A Study to Conservation	Х			X						
68	Lu Xilin et al., 2010	CHINA	New Resolution for Historic Building Conservation by Building				×						
			Moving Technology				^						
69	R.A Livingston., 1996	USA	Nondestructive Materials Characterization for Historic	¥			¥						
			Conservation	~			~						
70	W. Hashimah W.I., 2012	MALAYSIA	Cultural Determinants in the Design of Bugis Houses	х		x				x		x	
71	Himasari H., 2012	INDONESIA											
1	1		Modernization and Cultural Transformation: The Expansion of	х		x					1		
			Traditional Batak Toba House in Huta Siallagan										
		2010/07/											1
12	Derya Oktay., 2012	TURKEY	Human Sustainable Urbanism: In Pursuit of Ecological and			v I						v	

73	Noorul H. & Anuar T., 2013	MALAYSIA	Aspects of Privacy in Muslim Malay Traditional Dwelling Interiors in Melaka	х		х							x
74	Nguyen T. L., 2013	VIETNAM	Cultural and Social Elements in the Development of Green				x					x	x
76		<b>T</b> 1 1 1 1 1	Architecture in vietnam										
/5	Chipang L & Shinming C., 2015	TAIWAN	Concentration of Cultural Heritage from The Viewpoint of The	~			~						
			Participation of Coldular Heritage non-me viewpoint of me	^			^						
70	Perles T. S. M. Zeiles S. 2012	MALAYCIA	Participation of cocal organization			<u> </u>			<u> </u>			<u> </u>	
/0	Rosan I. & W. Zallan 3., 2012	INTALATOIA	Surveying on the cultural approaches for the Melaka Malay	х		X							
77	Drinuesha N & Naima C C 2011	ALCERIA	The role of traditional know how in sustaining ushap										
	bribbechely, & Nama C. C., 2011	ADDENIA	anviconments: the Cashah of Algiers in Algeria	х		X							
78	Lee V. Let al. 2013	MALAYSIA	The Roles of Cultural Spaces in Malaysia's Historic Towns: The										
			case of Kuala Dungun and Taining	x			x						X
79	Noorul Huda B & Anuar T 2013	MALAYSIA	The Concept of Privacy and the Malay Dwelling Interior Space		-	<u> </u>			<u> </u>			-	
			Planning			X							X
80	Ruslinda K., 2012	MALAYSIA	Penyesuaiaunaan Semula Rumah Warisan Tradisional Melavu										
	· · · · · · · · · · · · · · · · · · ·		Rumah Tok Su Di Kampung Warisan, Alor Star	x		X	x					×	
81	Nangkula U. et al., 2011	MALAYSIA	Design Flexibility of Growing and Transformable House in										
			Malaysia	×		×						×	×
82	Makay D. & Olosz E., 2010	HUNGARY	Research, Planning and Interventions Guide for Historic Roof				~						
			Structures with Baroque Character				^						
83	Qing C. et al., 2012	CHINA	A GIS-based Green Infrastructure Planning for Sustainable		×							~	
			Urban Land Use and Spatial Development		<b>^</b>							<b>^</b>	
84	Koun S., 2011	JAPAN	Analysis of Scenic Perception and Its Spatial Tendency: Using		x								x
			Digital Cameras, GPS loggers, and GIS										
85	Marjan J. et al., 2011	TEHRAN	Application of sustainable urban development in										
			environmental suitability analysis of educational land use by		X							X	X
			using AHP and GIS in Tehran										
86	AhnsY. et al., 2003	MALAYSIA	GIS and development control system for a local authority in Metaologic		x								x
	Abubakas A. E. & Kalabaasi C. 2012		Maraysia Madaliana University OK Anabitantura Presid On Consist						<u> </u>			<u> </u>	
•/	Abubakal A. E. & Kalawall C., 2012	MALATSIA	Origeted Architecture for the Tourism Magning Needs		X								X
88	lin Letal 2012	CHINA	The Origin of Building GIS Software Development Model			<u> </u>			<u> </u>			<u> </u>	
~	511 E. C. C. J. 2012	Crimes.	The origin of banding dio outside bardiophilare induar		X				X				
89	Wang X., 2012	CHINA	Urban planning and management information systems analysis		x					x			x
			and design based on GIS										
90	N. Maharajan., 2012	INDIA	GIS Based Service Oriented Architecture Approach for		x								x
			Electric Distribution										
91	Janweiz. & Wei C., 2013	CHINA	Materials analysis of traditional Chinese copper halls using XKF		X	X							
	0.111 2013	CLUNA	and dis. Kumming Copper hail as a case study										
52	Q1 W., 2015	CHINA	Constant of the Strategies of Industrial Building Heritage	x			x						
92	Noorfadhilah M. R. & Shamzani A. 2012	MALAVSIA	Decumentation and Conservation Guidelines of Melaka			<u> </u>			<u> </u>			<u> </u>	
	Noonadhian W. C. Grananzan A., 2012	MIGRO IVIO	Heritage Shophouses				х	х					x
94	Wu H. et al., 2010	ITALY	Historic Buildings: Long Term Stability Evaluation Using										
			Wireless Sensor Networks	x					×				
95	Francesca D. F., 2005	UNITED KINGDOM	Sustainable "Living" Heritage Conservation Through										
I.	l ·	l	Community-Based Approaches	×	Į	×	×		ļ	ļ	J	X	J .
96	Johannes W., 2010	SINGAPORE	Urban Environment and Human Behaviour: Learning from	~		v .	~	~				~	
			History and Local Wisdom	×		× 1	×	×				×	
97	Anh T. N. et al., 2011	VIETNAM	An investigation on climate responsive design strategies of			v	×						
			vernacular housing in Vietnam			^	^						
98	Mahsa R. et al., 2011	IRAN	Sustainability, architectural topology and green building			×						x	
			evaluations of Kashan-Iran as a hot-arid region										
99	Shahrul Y. S. et al., 2013	MALAYSIA	Heritage Conservation and Regeneration of Historic Areas in	x			x						
			Malaysia										
100	Wannasilpa P., 2012	THAILAND	Participatory Planning in Urban Conservation and				x						х
404	Nexteel and 2012	INDONISIIA	Regeneration: A Case Study of Amphawa Community										
101	Noviaru et al., 2012	INDUNESIA	Independent Interaction of information technology	х		x	х						
102	Names et al. 2012	INDONESIA	Architectural Structural Survey of Groups of Traditional	<b>—</b>		<u> </u>							
102	Nanae 3. et al., 2015	INDUNESIA	Architectural structural survey of Groups of Traditional	х		x	x						
			Timber Houses in South Nias, Indonesia										
103	Andi J. R. B., 2010	INDONESIA	Perkembangan Struktur dan Konstruksi Rumah Tradisional Suku	x	I –	x							
			Bajo di Pesisir Pantai Parigi Moutong										
104	Roslan T. & Mzailan S., 2012	MALAYSIA	Surveying on the cultural approaches for the Melaka Malay	х		x							
1	1	1	houses		1	1	1	1	1	1	1	1	

Table 1: (continued....)

Table	1: (continued)	

105	Mawar M., 2012	MALAYSIA	The Misconceptions of Negeri Sembilan Traditional Architecture	х		х	х						
106	Hamed N. et al., 2013	MALAYSIA	Assessing of Critical Parametrs on Earth Architecture and Earth										
			Buildings as a Vernacular and Sustainable Architecture in			x						X	
			Various Countries										
107	Esteve S. et al., 2012	SPAIN	Bamboo, from traditional crafts to contemporary design and			v						×	
			architecture			^						^	
108	Hamed N. et al., 2013	MALAYSIA	Building Evaluation based on Sustainable Development using			x						¥	
			Questionnaire System			~						~	
109	Tarek A. & Ghada M. R., 2012	SAUDI ARABIA	The impact of sustainability trends on housing design identity			х						x	
			of Arab cities										
110	Javad E. & Shabnam A. N., 2011	IRAN	Sustainable Systems in Iranian Traditional Architecture			х						x	
111	Supawadee C. et al., 2012	THAILAND	Transformation of Local Living: Buddhist ThaiCommunities and	v		v						v	
			Vernacular Houses around Songkhla Lake Basin	1 ^		^						^	
112	Parinaz K., 2011	IRAN	Harmonization between climate and architecture in vernacular	¥		¥							
			heritage: a case study in Yazd, Iran	~		~							
113	Noor Hanita A. M. et al., 2012	SAUDI ARABIA	Vernacular Wisdom: The basis of formulating compatible living	x		x				x			x
			environment in Oman										
114	M.S. Surat et al., 2012	MALAYSIA	Mengenalpasti Tahap Kesejahteraan Seni Bina Warisan Melayu	x		x							
			Melalui Konsep Islam										
115	Nila Inangda M. K. D., 2012	MALAYSIA	Pengaplikasian ukiran kayu melayu dalam seni bina di Malaysia	x		х					x		
116	Sumardianshah S. et al., 2012	MALAYSIA	Tradition and transformation: the structure of Malay										
			woodcarving motifs in craft education	^		*					*		
	PRESENT STUDY (2014)	MALAYSIA	Identifying Inventory and Typology of Traditional Houses in										
			Kelantan Towards Architectural Preservation in Malaysia	x	X	X	X	X	х	x	х	x	x
			* TOTAL	71	21	71	31	19	3	26	15	24	22
			* PERCENTAGE	24	7	23	10	6	1	9	5	8	7
				96	96	96	96	96	96	96	w.	~	96
					~	~	20		~	~	~		~

Author	Parameters Studied	Major Findings
Franca R. et al. (2013)	Architectural Heritage, GIS, multimedia, knowledge	Creating a fundamental cognitive framework by using A GIS for Urban Architecture, elaborating a structure that is able to collect data which can be constantly implemented, and immediately be consulted
M. Cano et al. (2013)	Rural buildings, Reuse, Cataloguing, GIS Analytic Hierarchy Process	Methodology provides an efficient method for the inventory and characterization of buildings in a particular area based on GIS.
Giovanni V. & Nicola B. (2013)	GIS, Historical, Typological, Diagnostic	All the specific typological, historical and diagnostic data information related to the architectural elements pertaining to the restoration action can be found at this scale of representation of GIS database.
Li R. (2008)	Urban Heritage Conservation, Sustainable Development, GIS	Focused on designation of a GIS-based conceptual model for urban heritage conservation. The theoretical background is framed by literature review, including meaning of urban heritage conservation, means and method about urban heritage conservation and renewal, and needed data for conceptual model
M. K. A. Mat <u>Sulaiman</u> et al. (2009)	GIS, Vertical Park, <u>Kajian Kes</u> Kuala Lumpur	Determining the most appropriate site selection and potential for any development that would be reserved. The decision is also more precise by using (1)
M. Hafizetal (2013)	Geographical Information System, Town Planning Application	Helped to solve the problem that exist in town planning in terms of data development, preparation spatial from statistics, preparation of report, maps digital information searching and management of geographic information.

#### Table 2: Selected Studies on GIS from the Literature

# Table 2: (Continued.....)

Tanniji M. et al. (2011)	Peta Budaya, Sistem Maklumat, Geografi, GiS Sumber, Terbuka	GPS-related cultural and geographic information systems have enabled the shared culture of information online and in space to the user. Process improvement and application of spatial data, especially data from raster data to the data vector will be able to create applications that better cultural map and interocity
Maurizio L. & Maria D. N. M. (2009)	GIS; Vemacular Architecture; Decay index; Anthropic risk; Geomorphology; Southem Italy	The use of an integrated cognitive approach for definition of the historical-artistic and architectonic values of the <u>Rabatana</u> historical sites, implemented in a GIS platform, allowed to verify the priorities of eventual interventions of recovery and conservations of buildings analyzed.
D. J. Maguire. (2011)	Map processing databases and spatial analysis	Best described as an integrated collection of hardware, software, data and live ware which operates in an institutional context. Three main views are evident, namely, the map, database and spatial analysis views. The key features which differentiative GIS from other information system are the general focus on spatial entities and relationship, together with specific attention to matial
Jacek M. (2007)	GIS-based, <u>multicriteria</u> decision analysis	The last 15 years have evidenced remarkable progress in the quantity and quality of research in integrating GIS and MCDA. The multi field of GIS-MCDA has been widely and strongly adopted within the GIS community.
Qing C. et al. (2012)	Green infrastructure; ecological connectivity; the patch-comidor- matrix model; sustainability; landresources.	The GIS-based Ecological Connectivity Index method developed was used to evaluate the functional connectivity among the land units, by which the ecological connectivity pattem wasidentified and

Table 2: (Continued.....)

		divided into the core, the buffer,
		the transitional zone and the no
		or low connectivity areas.
Koun S. (2011)	Scenic perception; visitor-	Visualization of the spatial
	employed photography; spatial	distribution of categorized data
	analysis; kernel density	is effective to understand
	estimation; urban park; digital	visitors' visual experiences of
	camera; GPS; GIS;	specific spatial characteristics.
		Digital cameras are nicely
		combined with GPS loggers and
		GIS for research.
Marian J. et al. (2011)	Sustainable urban development:	Environmental suitability
	suitability analysis; GIS;	analysis is a process of
	analytical hierarchy process	systematically identifying or
	(AHP)	rating potential locations with
		respect to environmental
		capacity. The role of GIS in
		landuse suitability analysis has
		evolved to determine the
		appropriateness of a given area
		for a particular use such as
		educational land use.
Ahris Y. et al. (2003)	GIS; Development control;	Urban planning activities will
	Local authority; Planning;	continue to look for ways to
	Malaysia	hasten processing and
		transparency in all scope of
		work. Without such data sharing
		GIS will not achieve its main
		objective to create an efficient
		and transparent service to the
		public and GIS will remain as
		part of exhibition materials and
		tools for map production only.
Jianwei Z. & Wei C. (2012)	Chinese traditional architecture;	The KCH is a typical example
	Copper hall; X-ray fluorescence;	that illustrates the materials used
	Geographic information system;	in traditional Chinese copper
	Architectural history	halls. The XRF analysis
	-	indicates that the materials used
		in the KCH are bronze, brass,
		and red copper. From the GIS
		analysis and the discussion, the
		different alloys are found to be
		deliberately chosen according to
		the function of each component
	CIE SOA man lagatar mahila	in the entire structure.
Abubakar A.E. & Kalaivani C.	GIS, SUA, mapiocator, mobile	Modeling a new GIS
(2012)	services, web services, JSF, GIS	architecture to re-organize the
	mapphing	GIS information in a definite
		mechanism could help to
		overcome these issues

	Table 2: (Continued.	)
Jin Luo et al. (2012)	software engineering, GIS software architecture, building software development	A revolutionary change of the GIS secondary development will be brought about inevitably, which frees us from traditional software development models, thoroughly changes the current situation that only programmers can do software development, and makes software developers more competent.
Wang X. (2012)	GIS ; Urban Planning; Information System; Design	The system design is the key to achieve "integrated graphics", aims to improve planning and management of office efficiency and work quality, the specification of a book the two card approval of administrative licensing work processes, and to improve planning and management of external services
N. <u>Maharajan</u> (2012)	GIS, Service Oriented Architecture, Electric Distribution	and public image. The Data model assists in automation of the Business process and for better delivery to the customers. The Business Processes such as SCADA. WMS are modeled inside GIS environment and it works across the system enabling seamless data flows.



Figure 4. Research Design

Figure 4 describes the first stage involving the historical and theoretical review where it covers the basic understanding of the research parameters.

Second stage requires the author to identify the historic preservation factor towards geographical typological influence in traditional houses where is focusing on the facade treatment (aesthetical elements). This is achieved by reviewing measured drawing by Centre for the Study of Built Environment in the Malay World (KALAM) at the Department of Architecture in the Universiti Teknologi Malaysia (UTM) and Arkib Warisan Senibina Timur (ARWARIS)'s collection belongs to Department of Architecture in the Kolej Kemahiran Tinggi MARA Pasir Mas, Kelantan. This will lead to a certain understanding to identify distribution and typology of the houses, significances and elements. The drawings are analysed according to the detailed documentation by using visual analysis matrix and visual analysis characteristics.

Stage 3 requires the author to finalize the sample/case study from the material gathered from the second stage by giving Visual Analysis Checklists to another owner of the traditional house from this particular area if we find that house is suitable for this research so that more materials can be gathered from the owners. During the in-depth interviews, the author uses a template visual analysis matrix that indicates all the particular items that could be carried in this research. The templates are used as aids for the identification of the distribution and typology.

NO.	CODE	NAME OF BUILDING	FLOOR PLAN	FRONT ELEVATION	YEAR	FIRST OWNER'S NAME	ADDRESS NO.	CODING
1	RKB001	Rumah Encik Hussein			1900	Encik Hussein	No 1409, Jin Post Office Lama, Kota Bharu, Kelantan	LONG. N 06°08'02.4" LAT. E 102°14'10.1" ALT. 41m
2	RKB002	Balai Besar Tengku Fatimah Zaharah		FT From Reventing and And	1894	Tengku Fatimah Zaharah	No 2800, Jalan Pengkalan Chepa, Kampung Seri Wangsa, Padang Garong, Kota Bharu, Kelantan	
3	RKB003	Rumah Che Mat			1910	Che Muhammah Che Harun	No 1519, Jalan Post Office Lama, Kota Bharu, Kelantan	LONG. N 06 <sup>6</sup> 08'05.8" LAT. E 102 <sup>°</sup> 14'08.9" ALT. 27m
4	RKB004	Rumah Che Wan Muhamməd			1900	Haji Wan Muhammad Haji Awang	No 199, Jalan Atas Banggol, Kota Bharu, Kelantan	LONG. N 06 <sup>6</sup> 08'14.0" LAT. E 102°14'13.9" ALT. 14m
5	RKB005	Rumah Haji Wan Salleh Fathi Isa			1934	Haji Wan Salleh Fathi Isa	Hulu Market, Kampung Dato', Kampung Laut 1, Kota Bharu, Kelantan	

Figure 5. Visual Analysis Coding

Stage 4 is to analyse the data through the visual analysis matrix, visual analysis coding, photography, sketches and visual analysis checklists will be generated by GIS for the demographic tabulation and further analysis of the data using content analysis which comprise trace evidence and textual analysis from the measured drawing will elicit findings. This study incorporates spatial information technology applications such as GIS, GPS and data applications from google earth.



Figure 6 : Geographical data bank

The "geographical data bank", which involves the study area and the buildings together through all the districts in Kelantan, was created by supplying information regarding the architectural preservation.



Figure 7. All the Specific Typological, Historical and Diagnostic/Detail Data Information Related to the Architectural Elements Pertaining to the Restoration Action can be Found at this Scale of Representation of GIS Database

(Giovanni V. & Nicola B., 2013)

Spatial data refers to data such as the location of the district boundary map in Kelantan, including border state, district and subdistrict. While the data is not space, it refers to features or elements that describe a location. Field study involving the process of questionnaire, taking photographs and sketches of the facade typology and further use of GPS tries to obtain the location information of each traditional house involved. Collection is done by using a Global Positioning Systems (GPS) to record the exact location on the earth's surface in the form of latitude and longitude coordinates. Process formats change from GPS to GIS shape files. Location information from GPS downloadable to GIS workspace as initial preparation process data can be displayed in a GIS environment system (Figure 5).

Stage 5 concerns the conclusion and recommendation that come out with the documentation of the findings.



1800 - 1850 🔊	1850 - 1900	1900 - 1950 🚿	1950 - 2000
COORDINATE I LONG. N 0F0Y25.4" UXE 102141027 VGA 1800 TYPE AUMANT TANG DUA HEAS	COORDINATE   LONG VER TER: INC. TOPIC RUMAN RUMBUNG TOPIC REALING COM	COORDINATE I LONG, N ORTOPOLAT LAR E DOTOROLAT THE REMARK RUNNE REMARK	COORDINATE   LDNG. VEAL YEAR 1950 TYPE BEAMAN BEIN TYPE BEAMAN BEIN
COORDINATE : LONG LAT YEAR INNE FRANKLING TYPE RUMAN RUMBERING TYPE RUMAN RUMBERING	COORDINATE: LONG, N OF WY DO, 2 LAT E 102 WY DA # YEAR: INC YEAR: INC TITLE RUMAIN LIMAS	COORDMATE + LONG, N ORDMATE + LONG, N ORDMATE + VEAL 100 TYPE: REMAIN LENKS REINCALL BELANDA	COORDINATE : LIDIG LAZ YEAR 1959 TYPE REJARN BOD TYPE REJARD BOD
	COORDINATE I LONG. N ORTUTIS J LATE INCOMPTS VEAL INCOMPTS VIEAL INCOMPTS TYPE, REMAIN RUMBUNG MINING CINA		COORDINATE : LONG, N 697 VEAR 1990 TYPE: ELMAN ROT: TYPE: ELMAN ROT:
	COORDINATE LONG. LONG. LAC YEAR INSS TYPE: COMMINATION OF EXMAN LIMA AND	COREMANT : LONG. VEA: 100 VEA:	COORDINATE   LCMG, N GOT LAZ E 120 COOR TYPE: ELGARAT ROT TYPE: ELGARAT ROT
	COORDINATI ( LIANC, LIAL TAR, INS THE RUMAN RUMBUNG	COORDINATE I LONG, N G CONTOLP THE REGISTRATE I YEAR 1900 THE REMAIN RELINNE REMAIN RELINNE REMAIN RELINNE	COORDINATE IDAGE N 692 VIAL 191 THE REMARK POTO THE REMARK POTO
	COORDINATE: LONG MAX VEAR: INEE TITP: RUMAH LEAKS MAX	COORDMATE: LDNG URA VLAR 1900 THE RUMAH POTONG PERAK	COORDINATE I LENKE, N 677 LAE & 827 117 YEAR 1851 TYPE: RUMAN ROTO
	COORDINATE LONG, N 6109724.4 LAR E 10216192.7 YEAR 1881 TYPE RUMAN ROTONG PRAAK	COORDMATE   LONG LAZ YEAR 1900 TYPE REMAY POTONIC	COORDINATT I LONG, N 07 I GAZ 1932 TYPE SUMAH 1070 TYPE SUMAH 1070 TYPE SUMAH 1070
	COORDNATE : LONG, YGAR, EBH TYTY, RAMAI RUMBUNG	COOKDRAFTE I LONG, LAI VEAE 1000 TYPE LONG 12	COORDINATE   LONG, N OT X LAZ E NO TH

Figure 9 : Time line by Coding

From the figure 9, research found that a wide variety of traditional houses adorned the timber houses of Kelantan as identified from 1800 – 1970 years through visual analysis. They were Rumah Tiang Dua Belas, Rumah Limas Bungkus/Belanda, Rumah

Potong

Perak, Rumah Siam, Rumah Bumbung Panjang Cina, Rumah Bujang Berserambi/Dua Beradik, Rumah Bumbung Perabung Lima/ Pecah Lima. It is supported by the literature about the relationship between political, economic, social factor, background of the owner's and aesthetical element were reflected in the overall typology and distribution of the traditional houses. Figure 10 clearly defines the typology of traditional houses that have been analysed during this research.





Figure 10: Typology of the Kelantan Traditional Houses





Figure 10: (Continued....)

#### 4.0 Discussions & Findings

The findings of the study are also consistent with previous researches on implementation of GIS (Franca R. et al., 2013; M.Cano et al., 2013; Giovanni V. & Nicola B., 2013; M. Hafiz et al., 2013) found significantly related between the implementation of GIS in ar- chitectural preservation and conservation. Another study also has established a strong evidence related to the architectural elements pertaining to the restoration action found at this scale of representation of GIS database (Tarmiji M. et al., 2011; Maurizio L. & Maria D. N. M., 2009; D. J. Maguire., 2011). If a positive sign of moving forward is more transparent approach apart from building up as the implementation of e-preserving would very much speed up the overall conventional preservation process. (Ahris Y., Foziah J., Susilawati S., Ruslin H., & Abdul Rashid I., 2003).

The research highlights the main finding in cataloguing of vernacular houses, preserving a valuable source of information and compilation on thematic charts. Stimulatingly, further investigation shows that practically, apart from the geographical factors, political, economic, social, religious, the owner's migration, type of employment, relatives factor and craftsmen and are also the key factors to change the typology and distribution of vernacular architecture in Kelantan. Kelantan traditional houses were defined by visual forms of the house (type of roof style), circulation layout of the house, types of aesthetical elements and the principles of composition. The meaning and the significance of the traditional houses were skilfully crafted and formatted by the craftmen and was attributed with the qualities of this visual attributes and synchronized with the types of the visual forms. Thus, the development of aesthetical elements has given identity to a vernacular type of dwelling architecture of its own for the specific house forms in this north-eastern region of Peninsular Malaysia.

Kelantan traditional houses were defined as visual forms of the house (type of roof style), circulation layout of the house, types of aesthetical elements and the principles of composition. The meaning and the significances of the traditional houses were skilfully crafted and formatted by the craftmen and was attributed with the qualities of this visual attributes and synchronized with the types of the visual forms. Thus, the development of aesthetical elements has given identity to a vernacular type of dwelling architecture of its own for the specific house forms in this north-eastern region of Peninsular Malaysia. Dominant aesthetical elements as an examples like type of walls or carvings, singgora roof tiles, ekor itik, tunjuk langit, tebar layar and buah buton were probably formed to serve a identifying characters to the architectural form of the timber houses. They include Rumah Tiang Dua belas, Rumah Bum- bung Perabung Lima, Rumah Potong Perak, Rumah Bujang Berserambi, Rumah Limas Bungkus/Belanda, Rumah Bumbung Panjang Cina, Rumah Siam.

This study also shows that the proposed method is effective for the formation of an inventory and documentation in a specific area (Kelantan, Malaysia) based on GIS. This working method allows the addition of new data and analysis of the work of traditional rural buildings in a way that not only raises awareness of the region's potential for tourism but also charting the path for the user. Therefore, this method is an aid for the promotion of tourism as well as the production of rural building codes that will assist in the management, restoration, or both by the public or any private individual. Microsoft Excel was chosen as a tool for building database. Because it is a program for creation and administration of databases for everyday use, it allows greater access for all users in database management. Through high level of innovation and new technologies, the importance of GIS in the tourism development sector can be connected. Effective model in the context of tourism applications can also be implemented based on a mix of mobile computing as a multimedia approach with GIS technology. This will contribute to job and wealth creation by revealing heritage values for tourist attraction and also recover aesthetic elements on the verge of diminishing.

GIS can included in the architectural syllabus to ensure that the benefits of GIS architecture is fully adapted in order to coordinate the preservation, conservation and restoration of buildings with higher efficiency and centralization. Today's technology has enabled us to access large quantities of data in a virtual image where the GIS database developed here is capable of downloading applications like Corel Video Studio and SatNav to mobile devices. This makes the resource more vivid and interesting to study for those who really want to know the cultural heritage.

# 5.0 Conclusions

Architectural heritage can be developed through a multi-disciplinary learning in this era of global technology. The theoretical background is framed by literature review, focusing on typology and inventory of the Traditional houses and the implementation of GIS. The developed model is used as a reference to the complexity of natural and social evolution; cognitive model based on the structure of the culture of the place, which describes the process of transformation and modification.

The quantity of documentation and information obtained during the research and the following graphics processing are influenced by the number of dimensions of the information systems. The database is presented as an open structure to any possible integration. The structure developed is open to the integration of environmental communicator, capable of allowing active collaboration between subjects that can connect to exchange, compare and discuss the themes and experiences related to the sustainable development.

As a result, it is important for the Local Authorities on preservation reference, architect, town planner, academician and researcher, tourism industry and creating employment opportunities. Promoting and cataloguing vernacular architecture from tourism point of view is informative, intensive and sensitive industry in which GIS is expected to play an important role. It is to ensure pleasant traveling with the amount of details in the data (Abubakar A. E., Kalaivani C., 2012).

For future work, the research needs to list the details of the GIS function in architectural system that have been developed to arrange and operate on building preservation and conservation. This is because through the application of GIS software, monitoring results can be standardized, effective and more organized in architectural development. Hence, the purpose of the study is to preserve regional architectural heritage. It also provides direction on architectural heritage towards generating economic potential and creating 'Genius Loci' of traditional architecture towards sustainable development. This method continues toward comparative studies on other state buildings in spreading traditional building codes in three-dimensional region in order to ensure that conservation of buildings is more comprehensive and effective.

#### References

Abubakar A. E., Kalaivani C. (2012). "Modeling a Homogenate GIS Architecture Based On Service Oriented Architecture for the

Tourism Mapping Needs". International Journal of Scientific & Engineering Research 3, no. 1.

Ahris Y., Foziah J., Susilawati S., Ruslin H., & Abdul Rashid I. (2003). "GIS and Development Control System for a Local Authority in Malaysia". PERGAMON, Habitat International no. 27: 683–96.

Giovanni V., Nicola B. (2011). "GIS Platform Oriented Towards the Building Restoration and Regenaration Processes of the Histori- cal and Architectural Heritage Protection". n.d.: 634–40.

Jianwei Z., Wei C. (2013). "Materials Analysis of Traditional Chinese Copper Halls Using XRF and GIS: Kunming Copper Hall as a Case Study". ELSEVIER 2:74–84.

Jin L., Xiaofang Z., Cheng Z., & Xincai W. (2012). "The Origin of Building GIS Software Development Model". ELSEVIER, IERI Procedia 2:914–20.

Koun S. (2011). "Analysis of Scenic Perception and Its Spatial Tendency: Using Digital Cameras, GPS Loggers, and GIS". ELSEVIER Procedia Social and Behavioral Sciences 21:43–52.

Maguire, D. J. (1991). "An Overview and Definition of GIS." Geographical Information Systems: principles and applications, ed. David J. Maguire, Michael F. Goodchild and David W. Rhind. Essex: Longman Scientific & Technical, 1:9-20.

M. Cano, E. Garzon, P.J. Sanchez-Soto. (2013). "Historic Preservation, GIS, & Rural Development: The Case of Almería Province, Spain". ELSEVIER, APPLIED GEOGRAPHY 42:34–47.

Marjan J., Hanieh S., & Mostafa M. (2011). "Application of Sustainable Urban Development in Environmental Suitability Analysis of Educational Land Use by Using AHP and GIS in Tehran". ELSEVIER Procedia Engineering (International Conference on Green Buildings and Sustainable Cities), no. 21:72–80.

Maurizio L., Maria D., & Nicola M. (2009). "A New GIS-based Integrated Approach to Analyse the Anthropic-geomorphological

Risk and Recover the Vernacular Architecture". ELSEVIER Journal of Cultural Heritage 10S:e104-e111.

Md Hafiz S., Nurul Iffah Md. Z., Mohd Shahizan O., Anis Fadhilah H., Nurul H. Md. S., Lizawati Md. Y., & Ali S. (2011). "A Review on Application of Geographical Information System in Town Planning in Malaysia". JISRI JOURNAL OF RESEARCH AND INNO- VATION IN INFORMATION SYSTEMS (n.d.):38–47.

N. Maharajan. (2012). "GIS Based Service Oriented Architecture Approach for Electric Distribution". CIS Journal, Journal of Emerg- ing Trends in Computing and Information Sciences, no. 3:1567–81.

Qing C, Xue L., Xiulan H., & Jiansheng W. (2011). "A GIS-based Green Infrastructure Planning for Sustainable Urban Land Use and Spatial Development". ELSEVIER Procedia Environmental Sciences 12:491–

498.