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Combining AHP with GIS in the Evaluation of Locational Characteristics Quality for Purpose-built Offices in Malaysia

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Abstract

Geographic Information System (GIS) provides good spatial data. Using map as a main feature helps to capture, analyse, manage, as well as present geographic location data. Many location analysis techniques, including GIS, have developed, mainly on a specific field. In order to evaluate the quality of locational characteristics on a commercial building such as purpose-built office (PBO), GIS application is needed. Combining Analytical Hierarchy Process (AHP) and GIS provide an effective evaluation whereby the needs of property market participants on purpose built offices can be fulfilled. AHP is a method that specialises in identifying the importance of any locational characteristics on commercial building from the tenants or occupiers perception. Thus, integration from AHP and GIS will capture the subjective as well as the objective locational quality of PBO in terms of their commercial aspects. The evaluation index system which is Locational Quality Index (LQI) has been set up through locational characteristics of purpose built office, namely the location of the commercial features, availability of transport options, transportation/ parking distance, vehicle flow, efficiency of property market. Supported by GIS improves AHP in evaluating the quality of locational characteristics of PBO which matches the need of commercial property market participants.

Keywords

Analytical Hierarchy Process, Geographical Information System, Location, Purpose-Built Office.

1. Introduction

Commercial property, especially purpose-built-office (PBO) has always been important in contributing to the property investment portfolio (Ismail et. al, 2008). As such, the supply of PBO increasing rapidly to meet the demand in the property market.

Due to its growth, investors and other property market participants are becoming more aware in applying tools in their investment decision.

This paper will highlight the locational characteristics of PBO. Location is the main factor that should be considered by property market participants before any decision is made. Based on the classic economic theories such as Von Thunen and Alonso, location of building is based on cost of transport and accessibility (Dobson et al.1996). This theory has been applied by many researchers in developing modern techniques for location analysis.

This paper, however, will discuss one of the modern techniques that can be applied for location analysis in PBO. The uniqueness of this method is that it can cover the spatial and non-spatial elements of location through the application of Analytical Hierarchy Process (AHP) in combination with Geo-information System (GIS). Data from respondent's perception as tenants or occupiers on locational characteristics of PBO has been gathered based on score using GIS. Interpretation of the results will be discussed in findings.

2. Locational Analysis of Purpose-built Offices

Location is the most important factor impacting real estate value. The study of location analysis involves many characteristics, including locational characteristics of the neighborhood and locational characteristics at the site. However, in assessing the locational characteristics of PBOs, the non-spatial characteristics such as market density also must be determined. This location analysis will be more complex especially when it involving many locational characteristics, especially on non-spatial data, but various techniques are available to assist the analysis.

There are many location analysis techniques that are applied nowadays. Among established location analysis techniques are Geo-information system as a modern technique to analyse location's quality. However, the location analysis that covers spatial and non-spatial data is very few. To solve this problem, the modern technique to analyse location must be combined with another technique that deal with non-spatial data. Hence, this paper is proposed to unveil one of the techniques in analysis location based on spatial and non-spatial data. This technique will combine GIS with Analytical Hierarchy Process (AHP) to suit locational analysis of PBOs.

Locational analysis that is applied on the PBOs usually is for valuation, appraisal, and building performance assessment. Valuers and appraisers use conventional techniques to analyse a location. Nevertheless this approach is anadequate and slow hence modern techniques such as using the GIS can improve and speed up the analysis.

Location analysis on PBO involves the environmental location and the relation with the nearby buildings. For example, in determining the office building's rental value

depends on the location distance to the prestige building (Dunse, 1998). PBOs which are situated in the Kuala Lumpur Golden Triangle have rental values that are higher if located near the Kuala Lumpur City Centre (KLCC) building compared to other buildings (DBKL, 2007). Apart from that, PBOs that are near the commuter, main roads, shopping complexes, and a good network of roads can add value to the office building (Dunse, 1998). This shows that location analysis is very crucial to determine the quality level of PBO whereby the assessment of PBO in terms of value or building performance can be more efficient and more details.

There are several locational characteristics that must be determined in location analysis. All types of building have their own locational characteristics based on their types of purpose (Mohd Safian and Nawawi, 2011). For example, there are different locational characteristics on residential property compared to commercial property. Not all locational characteristics are usable in analysing location instead it must be selected to make location analysis achieve it's objective.

In determining locational characteristics of PBO, there are several locational characteristics that must be taken on board. PBOs usually are located in Central Business District (CBD). This area offers good business network among the companies of the PBOs in that vicinity. Based on a statement by Dunse (1998), even though advancement in the information technology and the changing system in office management are improving, choosing of an office building in the district of the CBD is crucial as it offers an excellent economic business environment.

In Malaysia, only a few research was undertaken to look into locational characteristics of PBO. A research by Adnan et. al (2012), have highlighted the locational criteria of PBO are Access to amenities, Access to public transport and terminal, traffic congestion and level of crime. However, this paper will highlight the locational characteristics which are location of commercial features, availability of transport options, transport and parking distance, vehicle flow, and efficiency of property market. These characteristics are gethered from the previous study based on literature review in analysing locational characteristics by GBIM (2009), Adnan et. al (2008), Rahardjati et. al (2010) and NIBS (2009). This paper, however, will not focus on locational characteristic's framework of PBO, instead it aims to unveil a technique in location analysis for PBO using a combination of GIS and AHP.

3. Methodology

This section will discuss the research methodology and conceptual framework that have been applied to recover information that is needed to complete this survey. The quantitative approach been used in this survey covers the comparison method to get the locational characteristics weightage for the quality location of each PBO in the case study vicinity which is in the Kuala Lumpur Golden Triangle area. Primer data has been gathered via questionnaires to the respondents which involve the tenants and

occupiers of the PBOs in the survey area. Secondary data has been gathered from geographical information analysis, using GIS.

3.1 Research Scope

The focus of this research analysis is on samples of five PBOs in the vicinity of the Kuala Lumpur Golden Triangle area. This is based on the area being a centre in the development of commercial property for the class of PBOs and the most developing business centre in Malaysia. The research analysis, therefore, is focused on the development of the PBOs along the areas of Jalan Raja Chulan. **Table 1** shows the list of the five PBO that are included in the research samples.

Table 1: Sample of PBOs in the Kuala Lumpur Golden Triangle Area

Purpose Built Offices	Number of storey	Number of storey for office use	Number of storey for others	Floor size (ft)	Rental space (ft)
Wisma Genting	29	29	0	33,342	4.50
Kompleks Antarabangsa	20	19	1	24,154	3.50
Menara Dion	37	36	1	27,841	3.00
Bangunan MAS	37	35	2	23,038	3.00
Menara Standard Chartered	40	40	0	28,937	4.80

3.2 Research Sampling

The population in this research comprises the tenants and occupiers of the five PBOs that are situated within the Kuala Lumpur Golden Triangle area. As many as 50 respondents were involved in this research whereby 10 respondents were from each chosen purpose built office. The overall totals of the PBOs within the Kuala Lumpur Golden Triangle area are 44 buildings; however, only five unique office buildings are accounted for as research samples.

Questionnaire forms have been used as instruments to gather primer data from the respondents whom are from among the tenants and occupiers of the PBOs in the Kuala Lumpur Golden Triangle area. The samples selected in this research are random whereby to enable and facilitate the researcher to overcome the problem of biasness, and validation in analysed the primary data.

3.3 Analytical Hierarchy Process (First Phase)

Basically, this research involves two phases of analysis, which are AHP and GIS. First phase, AHP is applied to identify the quality level of locational characteristics on PBO from respondent's perceptions. The questionnaire form is designed to gather primer data from respondents whom are the tenants and occupiers of the building. Apart than that, it will be used to identify the importance of each locational characteristic of PBO. **Figure 1**, illustrates the applied AHP framework for this research in the reason of identifying the importance of locational characteristics of PBO from respondent's perception.

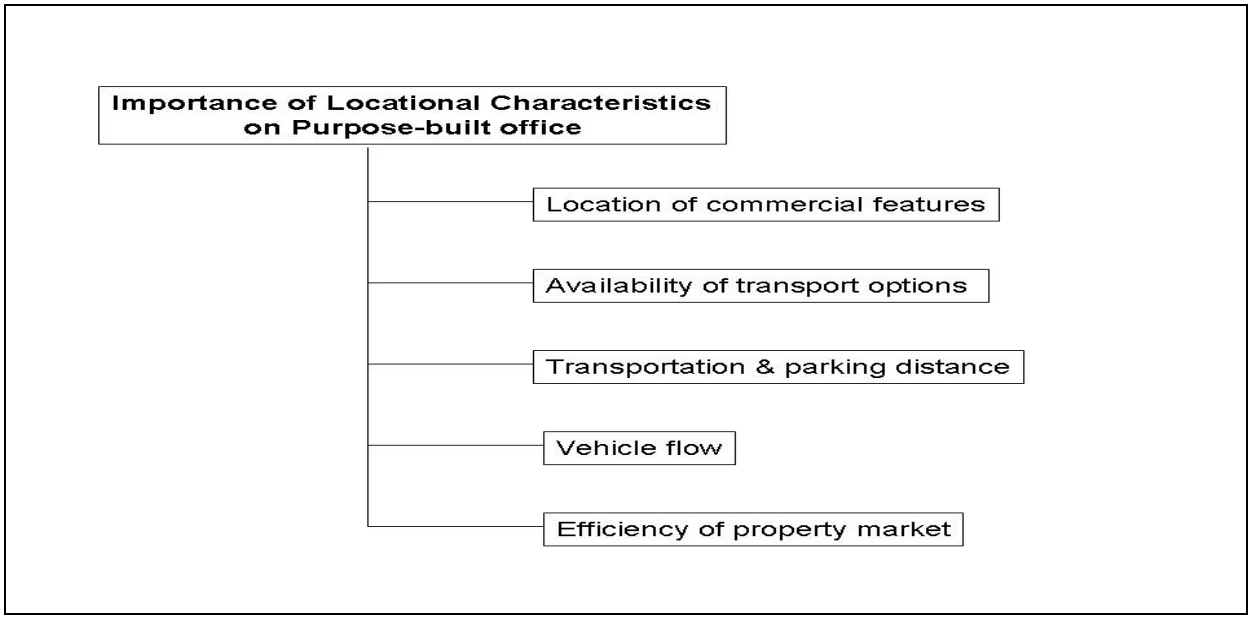

Figure 1: Analytical Hierarchy Process (AHP) framework on Locational Characteristics of Purpose-built office

AHP method was done to access the weightage for each applied characteristics in the evaluation of the locational characteristics of PBO. **Table 2**, illustrates on how the characteristic's weightage of the PBO in this research is achieved via the AHP. This weightage is very crucial to develop the systematic ranking to be applied for the evaluation of the PBO in getting the characteristics which are based on respondent needs.

Table 2: Weightege Diagram of Locational Characteristics

CHARACTERISTICS	← WEIGHTAGE →																	CHARACTERISTICS
Location of commercial features	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability of transport options
Location of commercial features	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation & parking distance
Location of commercial features	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vehicle flow
Location of commercial features	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Efficiency of property market
Availability of transport options	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation & parking distance
Availability of transport options	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vehicle flow
Availability of transport options	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Efficiency of property market
Transportation & parking distance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vehicle flow
Transportation & parking distance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Efficiency of property market
Vehicle flow	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Efficiency of property market

Table 2, shows how to obtain the weightage based on the AHP method. All the respondents have different opinions on the importance of each characteristic. In this section, respondents would have to state and choose the suitable and important characteristic in determining the level and weightage of quality for every characteristic for the occupied PBO. **Table 3**, illustrates the applied scale in deciding each weightage for the locational characteristics of the PBO.

Table 3: The Applied Scale to Determine the Weightage

The Fundamental Scale For AHP		
Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favoured very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6 and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance		

Source: Saaty, 2001

Via this scale, the researcher analyses each answer from the perspective of the main importance for each characteristic that is compared by the respondent. This is because the respondent will make the decision of the importance of each characteristic by comparing one characteristic with the other to identify the importance of locational characteristics by respondent's perception.

3.4 Geo-information System (Second Phase)

The second phase is the section that analyses information regarding the level of quality score of the locational characteristics of PBOs. In this section, using GIS as a tool to evaluate spatial data on locational characteristics of PBOs and give scores to each locational characteristic that are achieved by that particular PBO. The method in this section is named Network Analysis method. Through this method, the quality level of locational characteristics will be achieved in a more organised and complete manner as the form of spatial data. **Table 4** shows the applied scale in deciding the score for the locational characteristics of PBO.

Table 4: The scale to determine the score of the locational's quality index

SCORE	DEFINITION	EXPLAINATION
0	NONE	*Not Applicable*
1	POOR	*Below Average*
2	AVERAGE	*Average*
3	EXCELLENT	*Above Average*

Source: Saaty, 2001

This scale, however, have been applied from Saaty (2001) AHP method. This is how AHP and GIS have been integrated whereby these scores which are from AHP were used to rank the locational characteristics in network analysis. As such, the locational characteristis which are location of commercial features, availability of transport options, transport and parking distance, vehicle flow, and efficiency of property market were determined using this scale in network analysis.

Network analysis is the most reliable method to determine distance to date. The application of GIS software which is *ArcGIS 9.3* have been used in analysing GIS spatial data specific on network analysis. **Figure 2**, shows samples of PBO that have been identified by *ArcGIS 9.3* in research area, which is in Golden Triangle of Kuala Lumpur.

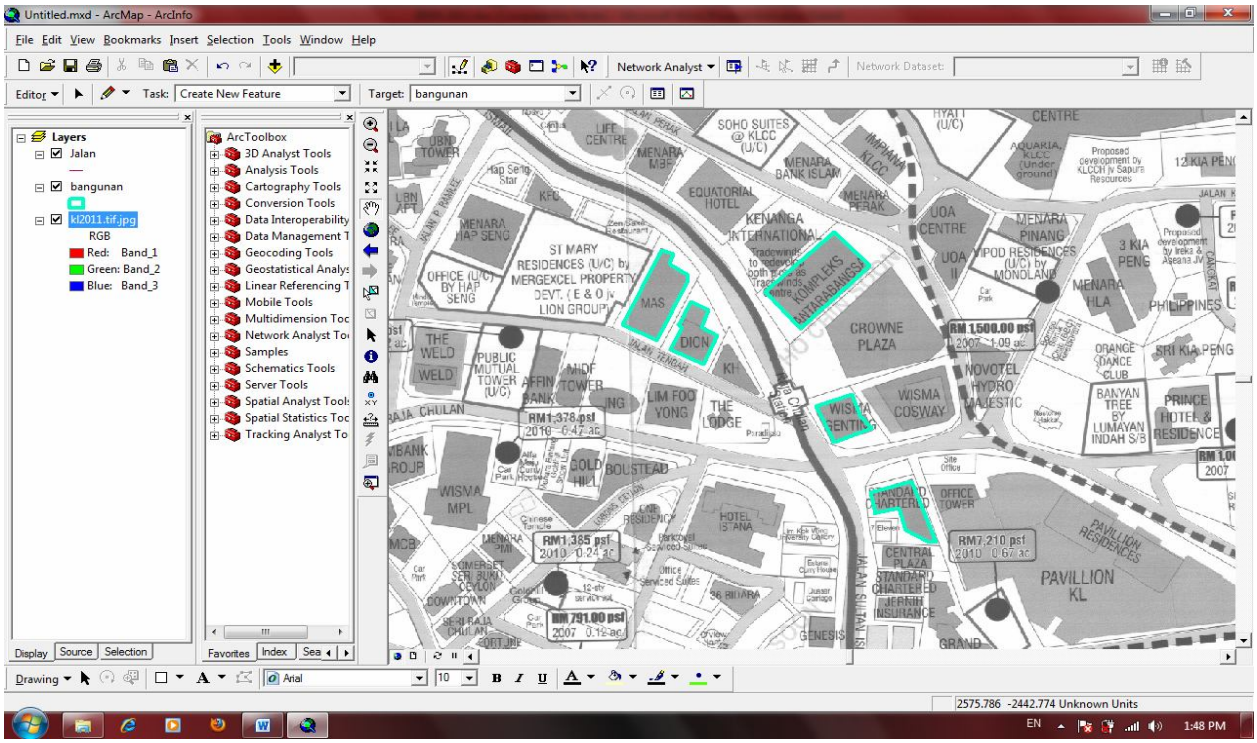

Figure 2: Identifying samples of PBO using ArcGIS 9.3.

Five PBOs have been identified within research area, and it's located along Jalan Raja Chulan of Kuala Lumpur. This software helps to calculate distance based on proposed characteristics and give ranking to each locational characteristic as the basis to combine it with AHP data. Further details will be discussed in the analysis section.

3.5 The combination of Analytical Hierarchy Process and Geo-information System

After attaining the score value for every characteristic in GIS and also the weightage of each characteristic in AHP, mathematical approach will be applied to establish the quality level of locational characteristics on PBO. This method is achieved from the unique mathematical equation as shown in **Figure 3**. This method facilitates the research to evaluate the quality level of locational characteristics in the form of Locational's quality index (LQI) from the results obtained from AHP and GIS. This method also has been used by many researcher who were applied the modification of AHP.

$$\sum_{i=1}^{5} \left(\text{Characteristic Weight}^{*} \frac{\sum \text{Factor Score}^{*} \text{Factor Weight}}{\sum \text{Factor Weight}} \right)$$

5 = Five Locational Characteristics
i = Index
∑= N-Ary Summation
*= Multiplication

Figure 3: Mathematical Approach in Combining AHP and GIS

After this index is accomplished, ranking for all the PBO samples will be obtained based on the Locational Quality Index (LQI). The highest ranking shows the quality level of locational characteristics on PBO is high and also the lowest ranking is vice versa. This index is achieved from the range of 0 – 100% whereby the PBO's locational quality index value is in the form of percentage.

4. Data Analysis from AHP and GIS

In an attempt to identify the perception of PBO's tenants on the locational characteristics of PBOs, a survey was conducted on tenants and occupiers in the PBOs within research area. The group of tenants was categorised into five specific groups consisting of all the PBOs as samples in this research. Accordingly, the analysis was set in two sections involved AHP for tenant's perception of the relative importance for locational characteristics between each other and GIS for the scores of locational characteristics on PBOs.

4.1 Analytical Hierarchy Process Analysis

Analytical model measured the locational quality of five PBOs that could be seen in **Table 5**. Each building was assessed for the relative importance of locational characteristics using the AHP for determined these characteristics are more or equal important than others. This process was made for ranked these characteristics based on weightage for the locational characteristics in PBO's quality assessment. This paper, however, will only show one pattern of all analysis which is data from PBO namely Wisma Genting.

Table 5: Analytical Model Measurement (Wisma Genting)

	Location of commercial features	Availability of transport options	Transport and parking distance	Vehicle flow	Efficiency of property market
Location of commercial features	1	3/1	1/3	1/4	1/4
Availability of transport options	3/1	1	1/4	1/5	4/1
Transport and parking distance	3/1	4/1	1	1/5	4/1
Vehicle flow	4/1	5/1	5/1	1	4/1
Efficiency of property market	4/1	1/4	1/4	1/4	1

1	= Equal Importance
3	= Moderate Importance
5	= Strong Importance
7	= Very Strong Importance
9	= Extreme Importance
2,4,6,8	= Intermediate Values

In AHP, the matrix algebra (Eigenvector) was used for turn the matrix into ranking of weightage. Table 6, shows the final process to get ranking priorities from a pairwise matrix by using AHP.

Table 6: Computing the Final Eigenvector (Wisma Genting)

						Sum The Row Total	Normalize
Location of commercial features	689.6996	548.2838	142.7391	72.9292	488.1656	1941.8170	**0.1025**
Availability of transport options	963.6692	689.3168	190.3383	95.7514	736.4443	2675.5200	**0.1413**
Transport and parking distance	1501.4180	1146.5810	306.9129	154.954	1116.6930	4226.5590	**0.2232**
Vehicle flow	2971.8400	2221.6990	587.8370	304.445	2091.6940	8177.5140	**0.4318**
Efficiency of property market	732.2318	484.8482	133.4689	70.6360	495.1337	1916.3190	**0.1012**
						18937.7300	1

From **Table 6**, shows the final eigenvector for pairwise comparison analysis in AHP. The graph in **Figure 4** also shows 'Vehicle Flow' is the most importance characteristic with 0.4318 and 'Efficiency of Property Market' is the least importance characteristic with 0.1012. 'Transport and Parking Distance' is twice as least as 'Vehicle Flow' with 0.2232. 'Location of Commercial Features' and 'Availability of Transport Options' have an average from the importance characteristics based on the tenant's feedback.

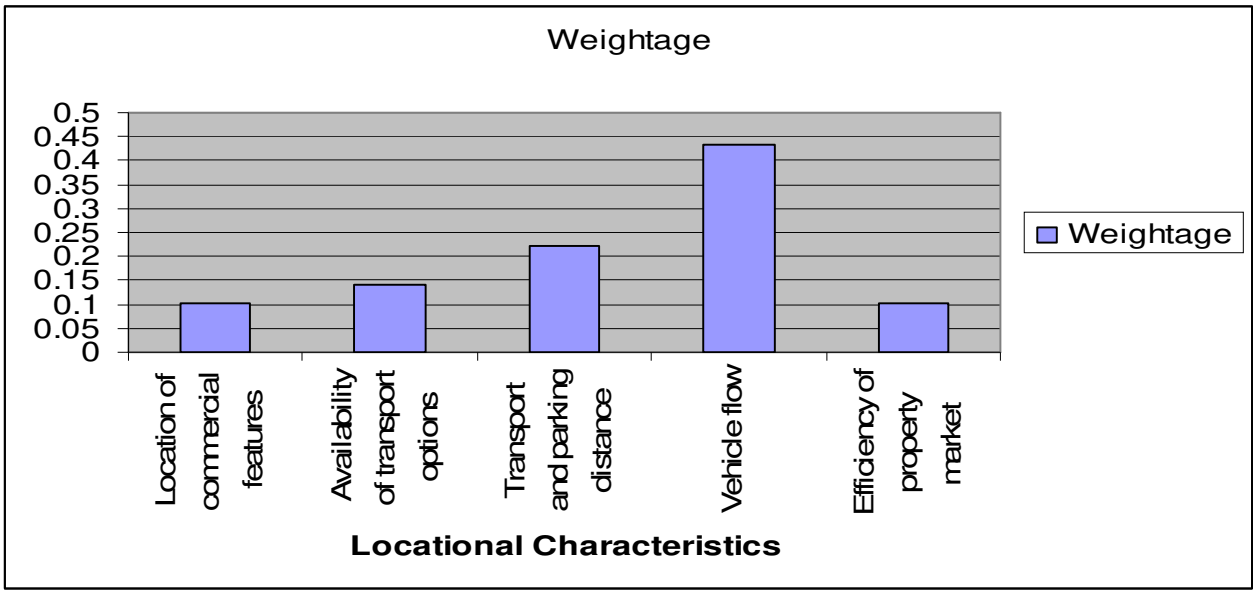

Figure 4: Ranking of Locational Characteristics Weightage (Wisma Genting)

The graph illustrates the importance of locational characteristics of PBO can be facilitated into ranking of weightage whereby the need of tenants and occupiers can be generated from subjective to objective in terms of quality level.

4.2 Geo-information System Scores and AHP Weightage

From *ArcGIS 9.3*, the network analysis has done to form the score on locational characteristics of PBO as research samples. The scale of scores can be seen in **Table 4**, whereby this process helped to merge with AHP. **Table 7**, shows the scores of locational characteristics from GIS analysis and weightage from the result of AHP.

Table 7: Combining AHP and GIS Data (Wisma Genting)

Locational Characteristics	Raw Score (GIS) (0 – 3) A	Characteristic Weight (0 – 1.00) B	Weight Characteristic Score (0 – 3.00) A X B
	GIS	AHP	GIS + AHP
Location of commercial features	3	0.1025	0.3075
Availability of transport options	2	0.1413	0.2826
Transport and parking distance	2	0.2232	0.4464
Vehicle flow	3	0.4318	1.2954
Efficiency of property market	2	0.1012	0.2024
		1	**2.5343**

From the results, it shows that locational characteristic's quality of Wisma Genting after being combined GIS, and AHP is 2.5343. Based on AHP theory, the result can be converted into percentage whereby this calculation can be seen as below.

$$\frac{2.5343}{3} \times 100\% = 84.47\% @ 84\%$$

As such, the Locational Quality Index (LQI) of Wisma Genting is 84%. Hence, the final percentage index of locational characteristics of PBO for all research samples can be seen in **Table 8**.

Table 8: Percentage of Locational Quality Index (LQI)

Purpose-built offices	Percentage of LQI
Wisma Genting	84 %
Kompleks Antarabangsa	71 %
Menara Dion	54 %
Bangunan MAS	58 %
Menara Standard Chartered	81 %

Figures 5 illustrates on the spatial perspectives for LQI on research samples. Research samples are in the neighborhood region whereby it proves that the percentage of LQI is not significant. However, further study is needed to identify the core locational characteristics that can influence the LQI index.

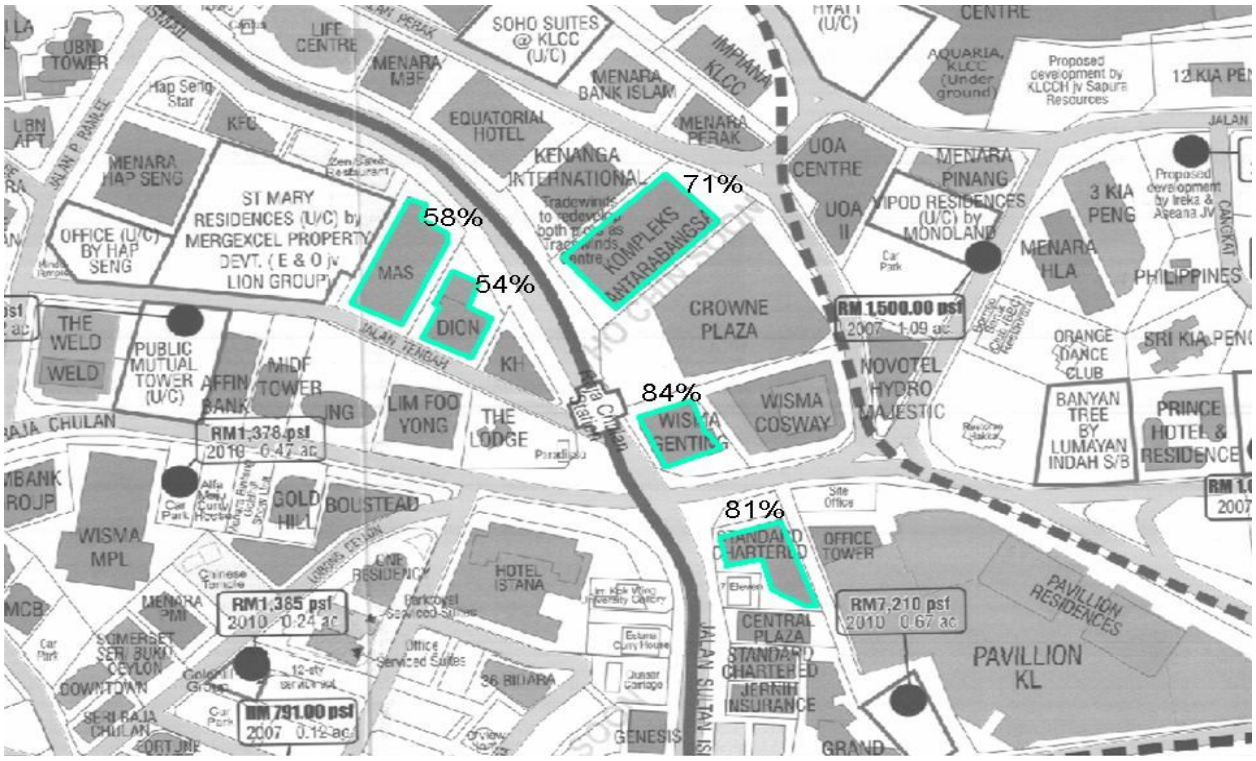

Figure 5: Percentage of Locational Quality Index (LQI) on Research Samples

5 Conclusion

The analysis carried out illustrates the relative importance and scores of each characteristic in determine the locational quality of PBOs, specifically, and the Malaysian PBOs generally. In times of economic uncertainty and rapid technological changes, especially in the research area, influence the development of PBOs in the property market. Otherwise, based on the tenant's perception from AHP and scores from GIS represents the non-spatial and spatial data are useful in determine the level of locational's quality of PBOs, especially in the research area.

This paper provides understandings on the locational characteristics and scores of each characteristic as well as the possible factors that can severely impact its overall performance of the PBOs, specifically on location. There is a significant amount of pressure on the owners, tenants and investors to be more involved in a proper and more efficient in enhance the level of locational quality for PBOs.

The analysis revealed that the quality of location on PBOs created by decisions of perception as reflected in changes made within the level of location quality each of the PBO can have impacts on changes to the property market performance. Question appears whether the changes are only unique to the Malaysian context. To provide an answer to this question, further study is needed to be expanding in improving PBO market in Malaysia.

References

Adnan, M.Y., Daud, M.N and Razali M.N (2012), Property specific criteria for office occupation by tenants of purpose built office buildings in Kuala Lumpur, Malaysia, Emerald Group Publishing Limited.

Adnan, M.Y. and Daud, M.N. (2008), Identifying the Potential Criteria and Sub-Criteria for Classification of Office Buildings in Malaysia, International Real Estate Research Symposium 2008, Kuala Lumpur.

Dobson S.M. and Goddard J.A (1996), Commercial Property and the Location Decision. Location Science, Vol. 4, No. ½, pp. 49-67, Elsevier Science Ltd.

Dunse, N. & Jones, C. (1998). A hedonic price model for office rents. Journal of Property Valuation and Investment, Vol. 16, 297-312.

Dewan Bandaraya Kuala Lumpur (2007). Annual Report. Department of Valuation and Property Management, Kuala Lumpur City Hall.

E. E. Mohd Safian and A. H. Nawawi (2011). The Evolution of Analytical Hierarchy Process (AHP) as a decision making tool in property sectors. International Proceeding of Economic Development and Research. Volume 6 May 2011. Bali, Indonesia. ISSN 2010-4626.

E. E. Mohd Safian, M. Bagdad and A. H. Nawawi (2011). The Characteristics of Purpose Built Offices in Malaysia: A Review of Issues. Construction Management Construction In the Twenty-First Century (CITC IV). Julai 5 -7, 2011. Kuala Lumpur. ISBN: 1-884342-02-5.

Ismail. M, (2008). Globalisation And Its Impact On Institution And Urban Change In Klang Valey. National Real Estate Research Coordinator (NAPREC), Research Grant Report.

National Property Information Centre (2007). 2007 Property Market Report. Kuala Lumpur, Malaysia: Valuation and Property Services Department.

NIBS (2009). Get Energized about High Performance Building - Apr 02 2009 - http://www.nibs.org/index.php/nibs/newsevents/news/Entry/getenergizedabouthighperformancebuilding.

Rahardjati, Retno and Khamidi, M. Faris and Idrus, Arazi (2010). The Level of Importance of Criteria and Sub Criteria in Green Building Index Malaysia. In: International Conference on Sustainable Building and Infrastructure (ICSBI 2010), 15-17 June 2010, Kuala Lumpur Convention Centre.

Saaty, T. (2001). Decision Making with Dependence and Feed Back the Analytical Network Process. 2nd ed., University of Pittsburg, Pittsburg: RWS Publications.