COMMUNITY LOSS OF RESIDENTIAL VALUE FROM WATER AND NOISE POLLUTION

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ABSTRACT

The impact of environmental disamenity on residential value had continued to receive attention in the property market. This study estimates community loss of residential value resulting from water and noise pollutions in the local neighbourhoods. The study areas comprised residential neighbourhoods nearby sources of such pollutions. Upon integration of the digital cadastre and house transaction data, digital maps were used to identify parcels of residential properties that were presumably affected by such pollutions in the study areas. Using the overlay and buffering functions, two proxy environmental variables were included in the regression models to capture pollution effects on residential values. The analysis disclosed that houses located closer to water and noise pollution were sold at lower prices compared to those located farther away from it. The total amount of community loss of "pollution-imposed" residential value in seven selected neighbourhoods was in excess of RM 57 million. The evidence shows that house buyers regard environmental quality as an important factor in real estate transaction. In particular, environmental disamenity resulting from water and noise pollution could have been negatively capitalised into residential values.

Keywords: environmental disamenity, water and noise pollution, residential values.

1. INTRODUCTION

How much loss of property value would a community incur as a result of environmental pollution – noise and water in particular? Although studies on the environmental impacts on property value have been widely conducted across the globe, such a loss has never been reported on the Malaysian residential market. For this reason, it is rather difficult to practically ascertain whether environmental pollution affects buyer's utility and, thus, whether it is reflected in real estate transactions. If it does, how could it be captured via the transactional evidence?

Some segments of the society tend to disregard pollution in their neighbourhoods. Part of the explanation is that they are not being deterred by this phenomenon, rather, they are more influenced by some local pulling factors such as public amenities, proximity to city centre, and neighbourhood conditions. Nevertheless, this is not a general situation. Residential values can be sensitive to environmental conditions if the society expressly concerns about the phenomena and people react to them in a certain way. For instance, unsuspecting residents who live in close proximity to a polluter can feel the effects of residual contamination both in their well-being and in their wallet. In this case, environmental pollution may lower the values of real estate (Boyle & Kiel, 2001; Patano, 2009).

Where environmental pollution negatively affects the community, it is taken into account in real estate transactions. The effects of environmental pollution may then be capitalised into residential values negatively as a result of buyer's disutility. Consequently, properties affected by pollution demonstrate a lower price level compared to those unaffected. Therefore, pollution problem is a factor that needs a particular consideration in real estate valuation besides other value factors such as location, transaction date, property type, lot position, etc. With a total of 128 formal complaints about environmental pollution in 2002, Johor Bahru can be considered as the most polluted district in the state of Johor, Malaysia (DoEM, 2005).

This study has two objectives. First, to identify environmental elements, particularly water and noise pollution and micro factors that could have influenced residential values in the study area. Second, to model and estimate the effects of environmental disamenity and other factors on residential values within the study areas.

The second part presents a brief literature on the topic. Next, data and analysis procedures are discussed in the third part. The fourth part discusses the findings of this study. Conclusion and recommendations for further studies are discussed in the last part of this paper.

2. THEORETICAL FRAMEWORK

2.1 Environment Disamenity and Residential Values

The literature on factors influencing residential property values is long established. Residential property values are determined by a multitude of factors associated with accessibility, neighbourhood, physical characteristics, social and environment (Kauko, 2003). Land value is negatively related to distance (Byroom, 1979) where the best location with higher value is in the town centre (Nelson, 1958). It is the centre of economic, market, and social activities. It has high land use competition (Khan, 1977). Land and/floor size is positively related to value (Lexington, 1971). A corner lot or an end lot, for example, has a higher value due to its larger size compared to an intermediate lot. Differences in the right of interest will also influence land value differently (Lean & Goodall, 1966).

The issue of stigmatised properties have drawn some interest in Malaysia for the past few years, but its assessment is more of descriptive nature rather than quantitative (Khairul, 2012). More studies are needed to measure the monetary effects of stigmatised properties. In the environmental context, negative externalities such as water, noise and air pollution, and visual obstruction can influence land value (Miller, 1982; Segerson, 2001; Kamarova, 2009). Some research discovered that externalities associated with industrial land use cause land value to drop (Lentz & Wang, 1982). These are examples of the simplest form of stigma.

The surrounding development refers to nearby activities that can positively or negatively affect a land parcel. For example, a housing area located nearby an industrial area may create noise, congestion and other types of environmental pollution, making the area less attractive to buyers (Zulkifli, 1995). Neighbourhood factors also influence residential values in terms of environmental conditions and population characteristics.

Demand for environmental quality within the living neighbourhoods has been increasingly important (Brasington & Hite, 2005). To encourage growth in the property market, healthy living conditions are among the basic social needs. Therefore, anything creating "shock" may adversely affect the living environment (Agee & Crocker, 2010). Specifically, so many residential neighbourhoods are plagued by environmental disamenity around the globe. They emerge in various forms such as flood (Lamond et al., 2007), hazardous waste (Gayer, 2000; McCluskey & Rausser, 2003), soil pollution (Zavadskas et al., 2007), water pollution, air pollution (Jaksch, 1970; Anderson & Crocker, 1971; Murdoch & Thayer, 1988; Smith & Huang, 1993; 1995), noise pollution (Palmquist, 1982; Hughes & Sirmans, 1992), etc.

Past studies have demonstrated the significant physical, psychological, economic or market effects of such environmental disamenity on property prices. In general, they have become negative micro-neighbourhood externalities (Li & Brown, 1980). The oldest ever been cited was perhaps air pollution, which has been regarded as a blight and a type of economic obsolescence causing retardation in the increase of land values (Grisworld, 1965).[1] Succeeding studies on air pollution include Ridker and Henning (1967),

[1] Griswold also cited *Proceedings of the First National Air Pollution Symposium*, Stanford University, 1949, that mentioned about a study on air pollution causing the declining property values of at least $25 million per year for ten years.

Anderson and Crocker (1971), Deyak and Smith (1974), Freeman (1974b), Nelson (1978), Murdoch and Thayer (1988), Brucato et al. (1990), and Smith and Huang (1995).

Other studies on environmental disamenity and property value have focused on aircraft noise (Collins & Evans, 1994; Stansfeld et al., 2005; von Praag & Baarsma, 2005; Diaz-Serrano, 2006); traffic externalities (Hughes & Sirmans, 1992); and water quality (Epp & Al-Ani, 1979; Young & Teti, 1984). In general, these studies discovered negative effects of bad environmental quality and positive effects of good environmental quality on property prices, although there were also some anomalies (Malone & Barrows, 1990; Smith & Huang, 1993).

The degrading effects of airport noise on property value have been reported in the U.S.A. (Bell, 1997; Anon, 2004). Bell (1997) advocated that noise resulting from proximity to airport is categorised as long-term or permanent nuisance that imposes detrimental condition and reduces property value. Infrastructural projects such as the expansion of airport and construction of high-speed railways cause various kinds of unavoidable nuisance such as noise (Theebe, 2004). Polluted rivers and lakes are a form of water pollution that occurs in various parts of the world.[2] Altogether, these areas are surrounded by billions of people living in various types and quality of residential of neighbourhoods.

2.2 Measuring the Effects of Water and Noise Pollution of Residential values

The general approach to measuring the effects of these environmental disamenity is by estimating consumer's willingness to pay (WTP) with respect to different levels of pollution (Hanemann, 1999). Theoretically, consumer's WTP for a particular differentiated good can be represented by its market price (Rosen, 1974; Freeman, 1974a). It follows that, in optimum, consumer's marginal WTP equals his marginal rate of substitution between the price of the good and any of its attributes and, thus, the slope of the price function may be used to determine consumer's marginal WTP (Andersson et al., 2008).

Let´s consider the housing market in which a house is regarded as a differentiated product comprising a number of attributes (x_1,.., x_n) such as physical construction, ecological, social, neighbourhood, etc. Thus,

$$X = (x_1, x_2, x_3...x_n) \quad (1)$$

The market unveils prices that correspond to each type of house so much so that the residential value is determined by a combination of characteristics:

$$P_i(X) = P(x_{1i}, x_{2i}, x_{3i}, x_{4i}, u_i) \quad (2)$$

where P_i is residential value, x_{ni} represents housing characteristics (attributes) of and u_i denotes error term.

[2] Among the world's most polluted water bodies reported are Citarum River (West Java); Yellow River (China); Yangtze River (China); Yumana River (India); Riachuela River (Brazil); Mississippi River (U.S.A.); Sarno River (Italy); King River (Australia); Lake Tai (China); Great Lakes (U.S.A./Canada); Lake Onondaga (U.S.A.); Lake Victoria (Kenya, Tanzania, Uganda); and Lake Karachay (Russia). Source: Anon (2009).

The value that individual buyers pay for improvements in extra unit of an attribute determines the WTP or the marginal implicit price. It is calculated as the partial derivative of the hedonic price function with respect to one of its arguments:

$$\Delta P_i = \partial P(X)/\partial x_i \quad (3)$$

It is important to note that the method is applicable only when the people are aware of the existence of environmental disamenity, and are free to choose an alternative in the market. Otherwise the significant relationship with residential values could not be perceived. Based on this principle, the general approach to measuring the effects of environmental disamenity such as pollution is by estimating percentage or dollar reduction in residential values with respect to the levels of pollution involved or with respect to the possibility of being affected by pollution. Isolating a particular component of value such as proximity is a familiar and routine procedure in property valuation (Bell, 1997). In our study, we use proximity of a particular parcel to the source of effect and measure this effect on property price using the hedonic model (see Bond, 2005; Bond, 2007a; 2007b). In this context, the property value may be attached to a perceived, rather than actual, measure of water quality (see Steinnes, 1992). Particularly, in our case, we use proximity of houses to perceived water or noise pollution sites and measure the reduction in property price as a result of the pollution (Figure 1).

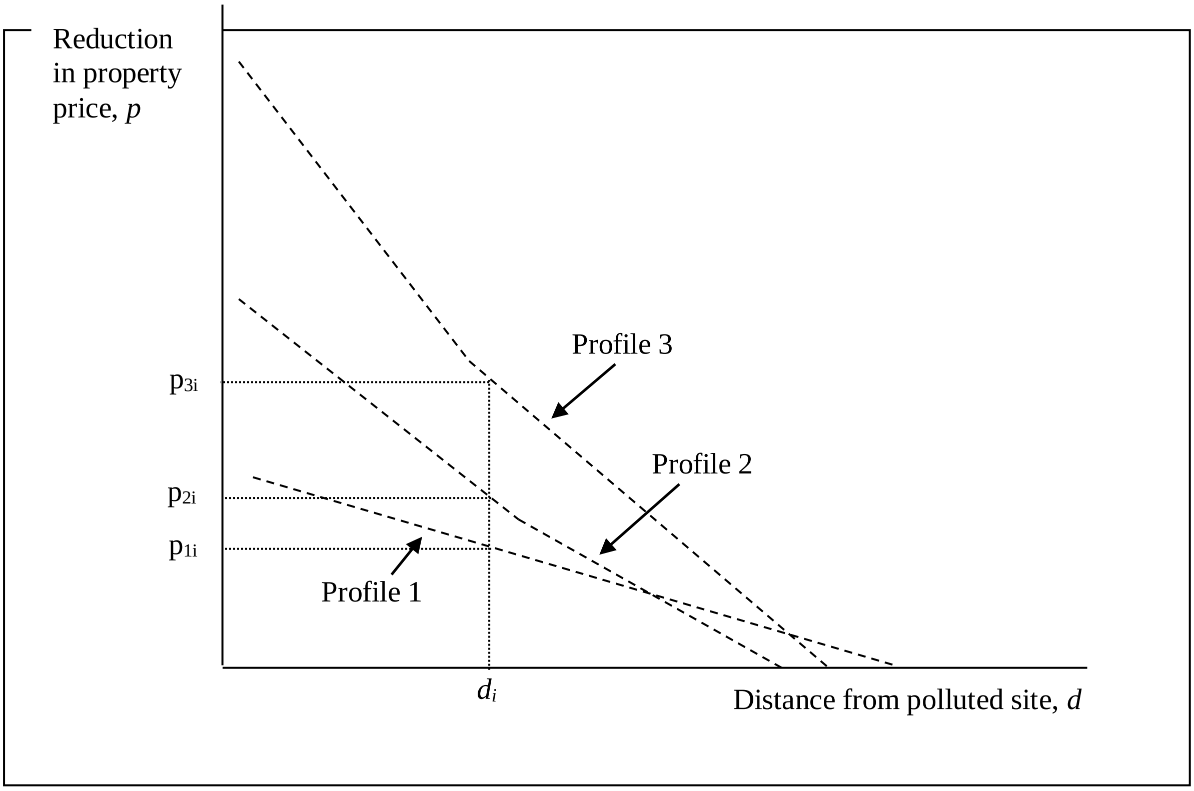

Figure 1: Proximity to polluted site and residential value (Authors' concept)

The relationship between property price reduction and proximity to a polluted site is defined by certain profiles that may represent some discriminating elements such as sub-market area or type of pollution. Thus, different profiles will exhibit different effects of environmental disamenity on property prices, given a certain level of attribute, say property distance from a polluted site. In Figure 1, let's assume that the profiles represent different types of pollution; noise (profile 1), water (profile 2) and air (profile 3). Assume that these types of pollution occur within the same market area among some cluster of properties. Given a certain level of attribute, say d_i - which is proximity - the respective effects of different types of pollution on property prices differ; p_{1i} for profile 1, p_{2i} for profile 2, and p_{3i} for profile 3.

Let say, we have a simple property price model as follows:

$$P_i = \alpha + \beta X_i + u_i \tag{4}$$

where P_i is the i_{th} observation of property price and X_i is the i^{th} observation of property attribute; α is regression intercept, β is regression slope, and u_i is error term.

In our study, we assume a situation where the regression intercepts, not the slope, are different between the two discriminating groups, water and noise pollutions, in this case. This is because we only investigate a dichotomous situation of "existence" or "non-existence" (and not the "levels") of water or noise pollution among the sampled properties so that only differentiation of the intercept dummies is required to measure pollution effects on residential values.

For capturing such effects, statistical analysis is usually applied for analysing property prices against environmental disamenity (Palmquist, 1982). The theoretical foundation of measuring environmental deprivation such as water, air and noise pollution dated back in the 1970s, whereby property data were used in the hedonic modelling of residential values. The verdict of this method is that, all else equal, if similar homes sell for less the closer they are to the source of disamenity, the conditional difference in price is interpreted as the market discount attributed to that problem.

We introduce dichotomous variables for the pollution factor such that $D = m\text{-}1$, where D is the number of dichotomous variables to be included in a model and m is the number of groups with respect to a discriminating factor under question, namely water or noise pollution.[3] The regression intercepts tell how much pollution "affected" and "unaffected" properties relatively differ from each other, which can be specified as:

$$P_i = \alpha + \beta X_i + \lambda D + u_i \tag{5}$$

The expected regressions function of pollution "unaffected" properties are given in equation (6) while that of pollution "affected" properties in equation (7).

$$\mathrm{E}(P_i \,|D = 0, X_i) = \alpha + \beta X_i \tag{6}$$

$$\mathrm{E}(P_i \,|D = 1, X_i) = (\alpha + \lambda) + \beta X_i \tag{7}$$

[3] The general rule for specifying dummy variables is discussed in many econometrics textbooks. See for example, Gujerati
(1979, pp. 209-291).

Equations (4) and (5) assume that the slope of regression equation of a given profile, β, is the same as that of other profiles. The differential effect of pollution on residential values between "affected" and "unaffected" properties is obtained by subtracting equation (6) from equation (7). Thus,

$$\Delta P_i = \delta P_i/\delta D = ((\alpha + \lambda) + \beta X_i) - (\alpha + \beta X_i)$$
$$= \lambda$$

This quantity is exactly equivalent to the value of dichotomous variable's slope in equation (5). Note that since one of the two groups is made the control group, λ should be interpreted as the amount of differential effect of pollution on residential values between the "included" and "control" groups or between pollution "affected" and "unaffected" properties. The lambda from the regression model is a parameter that is used to estimate the total loss of value resulting from environmental disamenity. It adopts the Bell's model of detrimental condition of airport noise (Figure 2).

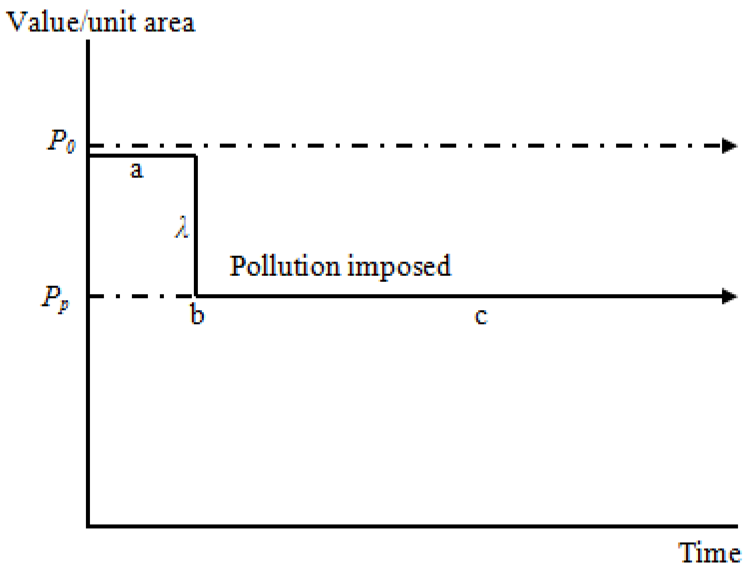

Figure 2: Value loss under imposed detrimental condition (adapted from Bell, 1997)

Point *a* is property price as if there is no detrimental condition (in our case, water or noise pollution) while *b* is the initial drop of property price upon occurrence of a detrimental condition. *Ceteris paribus*, *c* is the long-term or permanent "pollution-imposed" property price. The per unit area property price differential due to pollution is given by λ. In general, the situation in Figure 2 can be represented as

$$P_{pij} = (P_{0ij} - \lambda_{ij}) \qquad (8)$$

where P_{0ij} is price of property i in the normal situation (unaffected by pollution) in neighbourhood j, P_{pij} is the price of property i affected by pollution in neighbourhood j, λ_{ij} which is derived from the hedonic regression is price differential of property type i in neighbourhood j.

It can be shown that the price of each individual property *i* in neighbourhood *j* with a land area of *A*, either under pollution-free, P_{0ij}' or pollution-affected situation, P_{pij}' is respectively given as

$$P_{0ij}' = P_{0ij}A \qquad (9a)$$

$$\begin{aligned} P_{pij}' &= P_{pij}A \\ &= (P_{0ij} - \lambda_{ij})A \qquad (9b) \end{aligned}$$

Then, the total property value in a particular neighbourhood which is pollution-free, ΣV_0 and pollution-affected, ΣV_p is given respectively as:

$$\begin{aligned} \sum_{i=1}^{N} V_0 &= n_{ij}P_{0ij}' \qquad (10a) \\ &= n_{ij}P_{0ij}A \end{aligned}$$

$$\begin{aligned} \sum_{i=1}^{N} V_p &= n_{ij}P_{pij}' \qquad (10b) \\ &= n_{ij}(P_{0ij} - \lambda_{ij})A \end{aligned}$$

It can also be shown that the total value loss of property value for the community is given as:

$$\begin{aligned} LV &= \sum_{i=1}^{N} V_0 - \sum_{i=1}^{N} V_p \\ &= n_{ij}P_{0ij}' - n_{ij}(P_{0ij} - \lambda_{ij})A \\ &= n_{ij}\lambda_{ij}A \qquad (11) \end{aligned}$$

where LV = total value loss, n_{ij} is the total number of individual properties of type *i* within neighbourhood *j* affected by the pollution, λ_{ij} is amount of hedonic price differential between pollution-affected residential properties and pollution-unaffected residential properties for a given type of property *i* in neighbourhood *j*, and A_{ij} is as defined above.

2.3 Previous Studies

Environmental disamenity resulting from water, air or noise pollution has long been researched with a focus on examining their effects on residential values. Noise pollution has been more frequently investigated, followed by water pollution, air pollution and others. Most studies have disclosed the negative impacts of all types of pollution on residential values (Table 1).

Table 1: Past Studies on Environmental Disamenity

Author	Focus of study	Data used for the dependent variable	Findings
Walters (1975)	Relationship between residential values and proximity to noise sources.	Market data for estimating shadow price of noise.	Properties closer to source of noise have lower sale prices.
Palmquist (1982)	Effect of highway noise on residential values	Repeat sales on houses.	Properties closer to source of noise have lower sale prices.
Malone and Barrows (1990)	Effect of nitrate pollution of groundwater on residential property prices.	Residential property prices.	Nitrate pollution of groundwater had no statistically significant effect on the price of residential property
Hughes and Sirmans (1992)	Effects of traffic intensity on residential values.	Single-family housing transactions data.	Substantial negative price effect of traffic externalities on residential values. The magnitude of the effect was shown to be location specific.
Smith and Huang (1993)	Meta analysis on the effects of air pollution on residential values in thirty-seven previous studies.	Residential values.	Negative and statistically significant relationships between housing prices and air pollution measures.
Collins and Evans (1994)	Effect of aircraft noise on residential residential values.	Market prices of residential properties.	There have been varying effects of noise on different property types and neighbourhoods.
Levesque (1994)	Effect of airport noise on property prices.	Sale prices of residential properties	
Eugenio *et al.* (1996)	Effect of air pollution on property prices.	Residential values.	Negative effects of air pollution on residential values
Hite (1998)	Role of information on disamenity residential real estate prices.	Residential values.	Among other things, informed buyers about disamenity (in this case landfills), bid down residential values.
Deaton and Hoehn (2004)	Impacts of landfills sited among grouped environmental hazards located in industrial zones on residential values.	Residential values.	Residential residential values are reduced by increased proximity to hazardous waste sites.

Espey, M. (2000)	Airport noise and proximity on residential residential values.	Sale prices of residential properties.	Residential values closer to airport were registered lower than those farther away from it.
Gayer (2000)	Relationship between housing prices and environmental risks from pollution.	Residential values.	Among other things, neighbourhoods with low-priced houses were associated with greater environmental risks.
Leggett and Bockstael (2000)	Potential benefits from water quality improvement, by calculating an upper bound to the benefits from a more widespread improvement.	Sales data of waterfront properties.	More polluted water (higher levels of fecal coliform) significantly depressed residential values.
McCluskey and Rausser (2003)	Causal relationship between housing appreciation rates and house location in relation to a hazardous waste site.	Resale data from individual sales transactions.	Residential property owners in close proximity to the hazardous waste site experienced lower housing appreciation rates.
Theebe (2004)	Non-linear impact of traffic noise on property prices through using spatial autocorrelation techniques to overcome the regular problems of traditional NIMBY-analysis performed by hedonic regression		Impact of traffic noise ranged to 12%, with an average of about 5%. The discount varied across sub-markets and was a non-linear function of the noise level.
Zavadskas et al. (2007)	Effects of air or noise pollution on residential values.	Property sales data.	Property prices differed depending on property location from the source of pollution, whereby it exerts a rather sizeable influence on property prices.
Cohen and Coughlin (2008)	Effects of airport noise and proximity on housing prices.	Residential values	Houses located in noisy areas (70-75 dB) sold for 20.8% less than houses located in less noisy areas (<65 dB)
Andersson et al. (2008)	Effect of road and railway noise on property prices	Residential values	Road noise has a larger negative impact on the property prices than railway noise.
Akinjare et al. (2011)	Effect of landfills on housing investment	Residential values	There was evidence of diminution in house values within 0.3 – 1.2 km radius from landfill sites.

Most studies use hedonic regression for examining price-pollution relationship in linear, intrinsically linear, or non-linear forms. The first two functional forms are more frequently applied in the majority of studies.

In our study, we applied linear regression to capture the effects of water and noise pollution on residential values. The reason for this linear specification is that we only use dichotomous variables through buffering of distance of houses from the sources of environmental disamenity, within a short distance. Furthermore, each of the study areas covered only a small geographic span. Therefore, we do not expect a non-linear relationship between residential values and environmental disamenity.

3. DATA AND ANALYSIS PROCEDURE

Two independent geographic areas with different scenarios of environmental pollution were conducted. The first was an area within the Central Johor Bahru Municipality comprising some residential neighbourhoods in the vicinity of polluted rivers of Sg. Melayu, Sg. Danga, and Sg. Skudai. The sampled parcels were located within Taman Perling, Taman Sutera and Taman Baiduri. The second was an area within the Senai-Kulai jurisdiction comprising residential neighbourhoods within airport, road/highway, and/or industrial noise-disturbed Taman Perindu, Taman Perindustrian Murni Senai, Taman Senai Utama and Taman Seri Senai.

Location/site plans of both geographic areas were obtained from Kulai Municipality (MPKu) and Central Johor Bahru Municipality (MBJB), respectively, while digitised maps of the areas were obtained from Department of Surveying and Mapping Malaysia (JUPEM). Data on environmental quality (water, air and noise) for both geographic areas were obtained from Department of Environment Malaysia's (DoEM). Information on the sources and impacts of pollution on the society, especially health, was obtained from secondary publication as well as unstructured interviews with the environmental officers in charge of both areas. Overall, this study has discovered that air and noise pollution in Johor Bahru is under control whereas water pollution is generally alarming. Property and sales data were obtained from Department of Valuation and Property Services, Johor Bahru.

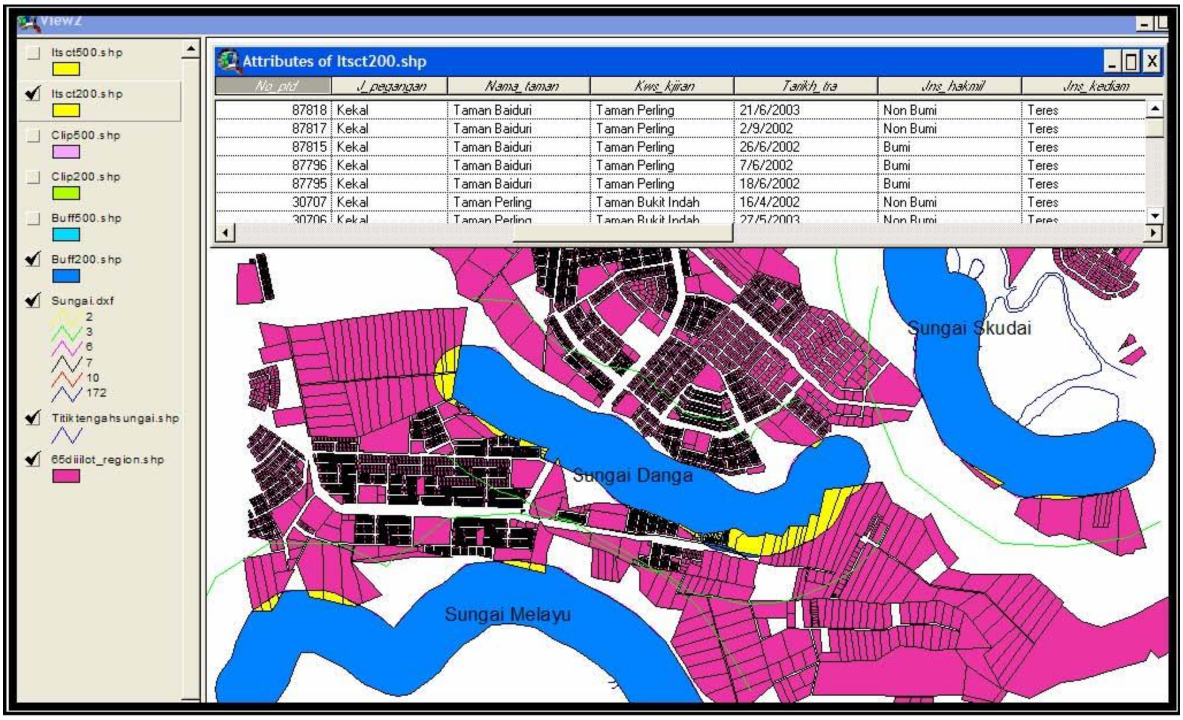

Figure 3: Parcels of residential properties located at a distance less than 200 meters from polluted rivers.

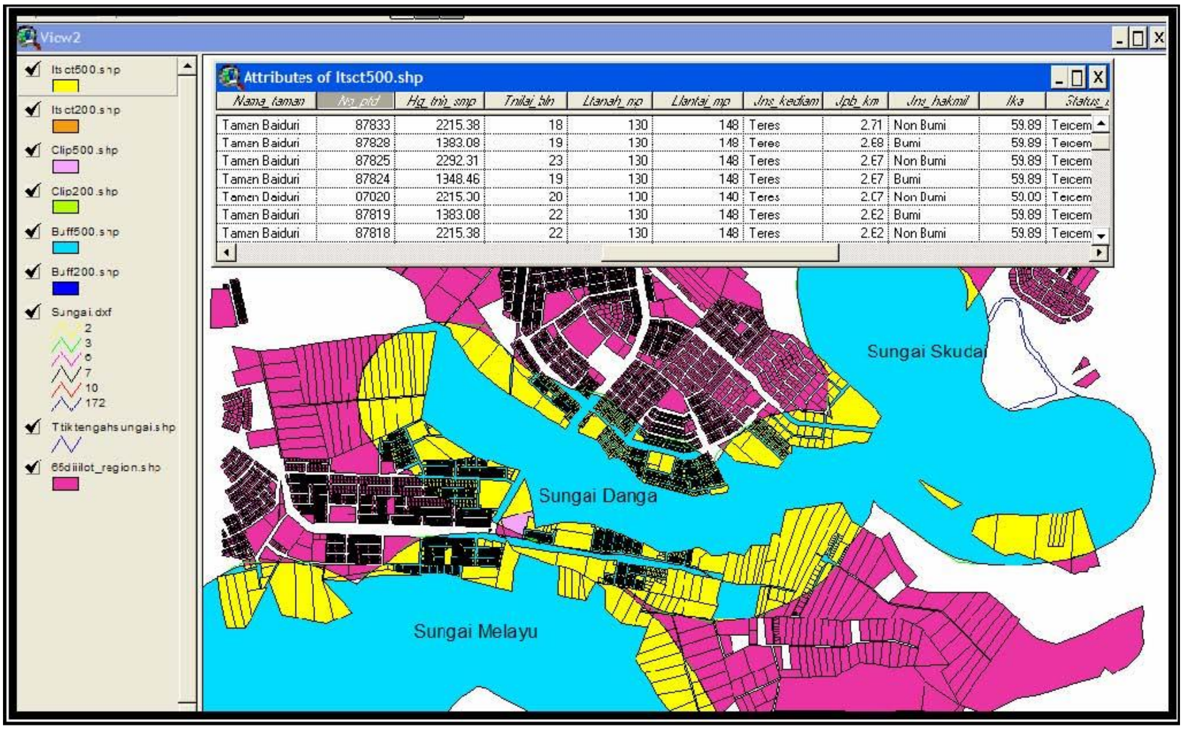

Figure 4: Parcels of residential properties located between 200 and 500 meters (inclusive) from polluted rivers.

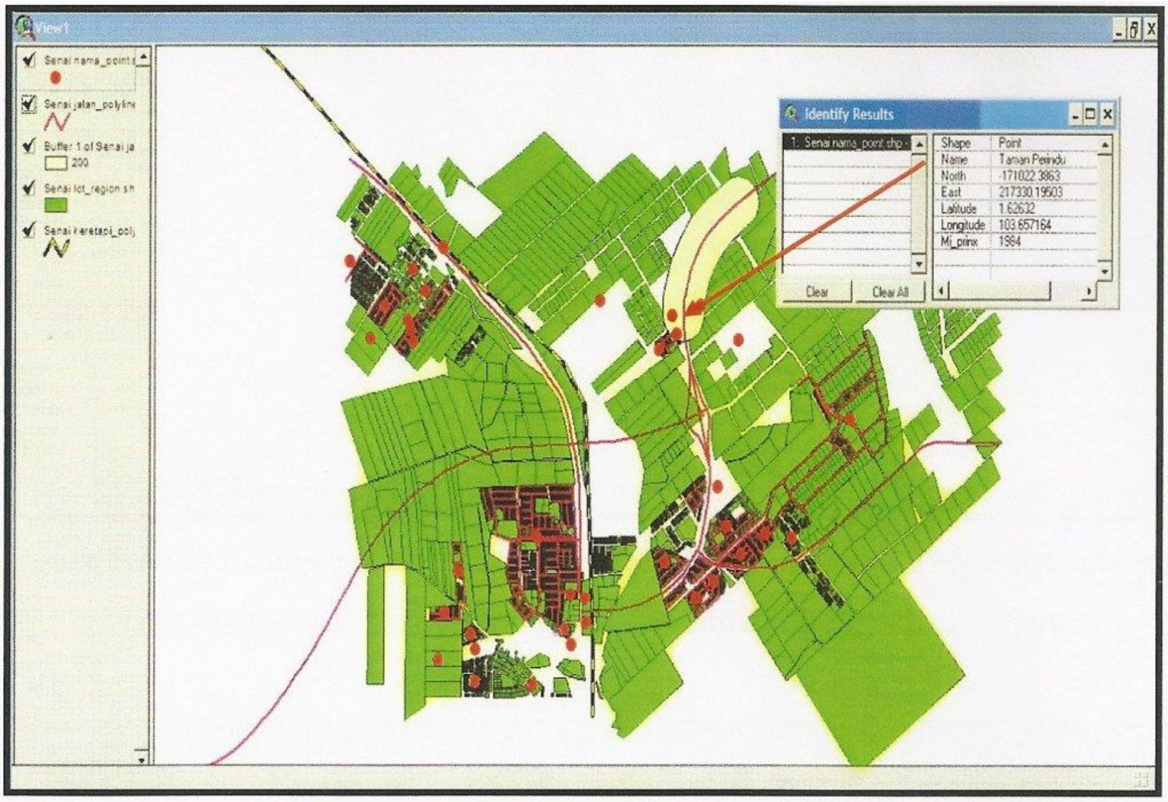

Figure 5: Parcels of residential properties located between 200 meters (inclusive) from noise-emitting trunk road.

Arc View 3.3 and MapInfo were used for parcel-based mapping of the first and second geographic areas, respectively, in order to spatially identify each sampled transacted property. Then, buffer and overly operations were performed to select "river pollution" affected parcels of residential properties along three rivers in the study area, namely Sg. Skudai, Sg. Danga and Sg. Melayu. Based on environmental quality index (EQI) developed by DoEM, these rivers have been classified by DoEM as polluted rivers (Figures 3 and 4).

Similar operations were also performed to select "noise disturbance" affected parcels of residential properties within the Senai-Kulai area, using a GIS base map (Figure 5). The sources of noise disturbance were Sultan Ismail International Airport (60-75 dBA) for Taman Perindu, railway lines (60-65 dBA) for Taman Senai Utama, road traffic (60-65 dBA) for Taman Seri Senai and factories (60-70 dBA) for Taman Perindustrian Murni Senai (DoEM, 2005).

The buffering and overlay operations have resulted in as many as 298 parcels of sampled residential properties, in the first geographic area, and 230 parcels of sampled residential properties in the second geographic area. All together, as many as 528 residential units were taken as sample in this study.

The conventional regression model was specified to capture the effects of property's physical attributes (lot and floor size, house type, lot position); neighbourhood and location; market conditions (transaction date), legal characteristics (freehold, leasehold, and ownership type), and environmental elements, in particular water and noise pollution (buffer 1, buffer 2). These variables are shown in Tables 2 and 3.

4. RESULTS AND DISCUSSION

4.1 Basic Results

The regression results for both geographic areas are shown in Tables 2 and 3. Based on the F-values, the models were significant in explaining the factors that influenced residential values in the study areas albeit a low level of R^2 = 0.412. This could have indicated possible exclusion of some relevant variables and/or model misspecification. However, addressing this issue was not intended in this study. On the basis of t-values, except for a few variables as indicated, all other variables can be considered to be significant determinants of residential values, including the variables representing water and noise pollutions.

Table 2: Regression results for the first geographic area (Dep.: per sq. m. residential values)

R^2		0.412		
F-value		13.159		
Standard error of estimate		309.930		
Sample size		298		
		Coefficient	*t-value*	
Constant		928.216	3.212	*
Neighbourhood maturity	(1= more developed; 0=less	445.357	3.380	*
developed)[a]		-7.299	-1.506	*
Date of transaction	(number of months from	-2.039	-5.607	*
1/12005)		1.613	1.178	*
Land area	(sq. m.)			*
Floor area	(sq. m.)	-733.689	-3.762	*
House type:		14.886	0.063	
Terraced	(1=yes; 0=no)			
Semi-detached	(1=yes; 0=no)	139.973	1.153	*
Lot position		458.368	2.960	*
Intermediate lot	(1=yes; 0=no)	16.998	0.267	
Corner lot	(1=yes; 0=no)	885.083	3.322	
Ownership type	(1=Non-bumiputra;	509.486	2.785	
0=bumiputra)		847.503	4.995	*
Holding type	(1=freehold; 0=leasehold)	-0.293	-2.880	*
Perling	(1=yes; 0=otherwise)			
Bukit Indah	(1=yes; 0=otherwise)	-305.068	-2.666	*
Distance from CBD	(km)	-174.377	-1.823	*
Water (river) pollution				*
Within 200 m from source	(1=within the distance;			*
0=otherwise)				*
Within 200-500 m from source	(1=within the distance;			*
0=otherwise)				*
				*

[a] Level of development is assessed from various aspects, including age of neighbourhood, local economic profile, and level of services provided in a particular area; [b] Outside a 500 m range was used the control group. * Significant at $\alpha = 0.05$; ** Significant at $\alpha = 0.01$.

4.2 Disbenefits of Water and Noise Pollution on Residential values

The variables representing house distance from polluted Sg. Skudai, Sg. Melayu and Sg. Danga were statistically significant. Houses sited within a buffer of less than 200 m from these rivers have shown a larger amount of drop in residential values compared to houses sited within a buffer of 200-500 m from them. Overall, based on the regression coefficients, the closer the distance of a house to a polluted river, within a distance of 0-500 m, the lower was its market price compared to a comparable house sited further away from it, whereby the margin of price reduction was in the range of RM 174-305/sq. m. There was also some evidence that noise pollution has had a negative effect on residential values. The closer the distance of a house to the source of noise, within a distance of 0-500 m, the lower was its market price compared to a comparable house sited further away from it, whereby the margin of price reduction was in the range of RM 119-245/sq. m.

Table 3: Regression results for the second geographic area (Dep.: per sq. m. residential values)

R^2		0.40		
F-value		18.165		
Standard error of estimate		162.596		
Sample size (N)		230		
		Coefficient	*t-value*	
Constant		21,433.24	2.055	*
Date of transaction	(number of months from	5	-3.982	*
1/1/2003)		0.0001	-1.786	*
House type	(1=single-storey terraced;	-36,427	8.336	*
0=other types)		319.358		*
Holding type	(1=freehold; 0=leasehold)		1.086	*
Lot position[a]		36.498	0.080	*
Intermediate	(1=yes; 0=no)	2.998	-5.793	
End	(1=yes; 0=no)	-2.244		
Floor size	(sq. m.)		-7.289	
Noise pollution[b]		-245.242	-3.663	*
Within 200 m from source	(1=yes; 0=no)	-118.690		*
Within 200-500 m from source	(1=yes; 0=no)			
				*
				*
				*
				*

[a] Corner lot was used as the control group; [b] Outside a 500 m range was used the control group. * Significant at α = 0.05; ** Significant at α = 0.01.

By comparing Tables 2 and 3, environmental disamenity resulting from water pollution could have been more impactful than that resulting from noise pollution. The differential disbenefits of water pollution compared to noise pollution on residential values is in the bracket of (305-245)/305 x 100 = 19.7% to (174-119)/174 x 100 = 31.6% more per sq. m. of land area.[4] Based on the regression results, a simple simulated residential value

[4] Caution should be exercised in this comparison though, since both models have different specifications. Furthermore, the models represent two different sub-markets; the comparison is valid assuming that houses and property sub-markets in both geographic areas are reasonably comparable. Notwithstanding this, additional analysis from the

schedule for the study areas can be constructed to guide in the decision-making (Table 4). The effects of water and noise pollutions on residential values in the table are assumed to be exclusive of each other. As a matter of fact, there can be combined effects resulting from concurrent pollution of both types at a particular site. However, this dimension of effects was not the focus of this study implying a need for a further investigation in the future.

Table 4: Price schedule of houses "with" and "without" environmental pollution

Type of house	Average land area (m^2)	Average normal price "without" pollution (RM/m^2)*	Average price "with" pollution (RM/m^2) based on proximity*			
			Water		Noise	
			< 200 m	200-500 m	< 200 m	200 -500 m
Terraced houses	143	1,171	866	997	926	1,053
Semi-detached houses	171	1,652	1,347	1,478	1,407	1,533

Note: * For the terraced houses, a figure of RM 167,500 per unit is used while for the semi-detached houses, a figure of RM 282,500 per unit is used for computation.

From Table 4, we can further analyse how much environmental disbenefits cost the community of their property value. In other words, the loss can be regarded as the environmental disbenefits that erode the community's wealth. From our survey, the number of residential properties (single- and double-storey terraced and semi-detached houses) sited within 500 meters from polluted rivers in the study area was estimated to be 2,037 units. The breakdown of these properties by neighbourhood is shown in the second and third columns of Table 5. The *Property Market Reports* (2009, 2010) reveals that the average price of the residential properties 'without pollution' in the study area was RM 197,500 per unit while the average price of the residential properties 'with pollution' in the study area was RM 163,252 per unit. Using the regression results and equation (11), the breakdown of property value loss to the community is shown in Table 5. The total value loss based on the sampled properties in the study area amounts to about RM 58 million.

Property Market Reports (2007-2010) disclosed that the average property price was quite comparable in both geographic areas, i.e. RM 150,000 per unit for single-storey and RM 245,000 per unit for double-storey terraced house. The *Property Market Reports* (2009, 2010) disclosed that, on average, single-storey semi-detached houses were priced in the circa RM 185,000 per unit while double-storey semi-detached houses were priced in the circa RM 320,000 per unit on both geographic areas.

Table 5: Estimate of community loss of property value due to environmental disamenity

Type of house	Affected properties (number of units)		Price differential and value loss 'with' pollution (RM)			
	Disamenity type:		Water		Noise	
	Price differential:*		305.068	174.377	245.242	118.69
			Distance buffer (m)			
	<200	200-500	< 200	200-500	< 200	200-500
Terraced houses (land area = 143 sq. m.)						
Sg. Skudai	10	80	436,247.24	1,994,872.88	-	-
Sg. Melayu	17	22	741,620.31	548,590.04	-	-
Sg. Danga	20	152	872,494.48	3,790,258.47	-	-
Taman Perindu	94	112	-	-	3,296,543	1,900,939
Taman Senai Utama	80	154	-	-	2,805,568	2,613,791
Taman Seri Senai	140	144	-	-	4,909,745	2,444,064
Taman Perindustrian Murni Senai	103	85	-	-	3,612,169	1,442,677
Total 1			2,050,362.03	6,333,721.39	14,624,025.70	8,401,471.65
Semi-detached houses (land area = 171 sq. m.)						
Sg. Skudai	3	62	156,499.88	1,848,744.95	-	-
Sg. Melayu	2	55	104,333.26	1,640,015.69	-	-
Sg. Danga	20	228	1,043,332.56	6,798,610.48	-	-
Taman Perindu	63	67	-	-	2,641,992.07	1,359,831.33
Taman Senai Utama	75	74	-	-	3,145,228.65	1,501,903.26
Taman Seri Senai	86	24	-	-	3,606,528.85	487,103.76
Taman Perindustrian Murni Senai	33	32	-	-	1,383,900.61	649,471.68
Total 2			1,304,165.70	10,287,371.12	10,777,650.17	3,998,310.03
Grand Total			3,354,527.73	16,621,092.51	25,401,675.88	12,399,781.68
Community loss of value	57,777,077.79					

Note: * Price differentials are derived from the dummy variables' coefficients for water and noise pollution as shown in Tables 2 and 3. Information on the affected properties was obtained from the field survey.

4.3 Study Implications: Environmental Disamenity and Sustainability

Sustainability is an endless issue and hundreds of social, economic and environmental indicators are being established (Zavadskas et al., 2007) to unravel its concept and application. In the context of our current study, property price behaviour is one of those indicators. In general, if property prices are favourable in the free market, sustainable property market can be justified, especially in terms of investment opportunities. This is because levels of property prices have a close relationship with investment opportunities, say investment returns. Where market can sustain (high) property prices, it will encourage property demand for ownership and/or investment. This will provide an opportunity for favourable investment returns to property owners. Environmental disamenity beset such an opportunity.

Negative capitalisation of residential value as reflected in the drop in residential values is a signal of depriving effects of environmental disamenity on property market. Unfortunately, those who suffer from these disamenities remain uncompensated (Grundy, 1996). This will discourage a healthy property market. Therefore, such a signal must be relayed to the society as a means of urban management strategies, particularly, those related to sustainability.

So far, systems for sustainability evaluation have ignored market-based indicators (see for e.g. Zavadskas et al., 2007, Table 1). As a matter of fact, an approach should be developed to use market-based indicators for evaluating property market sustainability and, in turn, for evaluating urban sustainability. Using property price as a basis for measuring environmental disamenity on the society is an application on one side. Specifically, property price based spatial index of environmental disamenity can be constructed and used as an indicator of the level of urban sustainability. Neighbourhoods with large effects of environmental pollution on residential value, for example, can be marked as unsustainable living areas.

On the other side, market prices of properties can also be used to estimate windfall gain by property owners as a result of environmental quality improvement (Leggett & Bockstael, 2000). One option is to reduce the level of water, air, and noise pollution and to assess how such reduction can improve residential values. These values, in turn, can be used to gauge whether or not property market sustainability can be achieved through environmental improvement.

5. CONCLUSION

Our analysis has discovered that houses affected by water and noise pollutions have been sold at a lower price compared to those unaffected by them. This study has provided some evidence that house buyers could have considered environmental quality as an important factor in property transactions. In particular, environmental disamenity resulting from water and noise pollutions could have been negatively capitalised into residential values.

An indirect impact of environmental disamenity is unsustainable property market due to value loss to the community. Therefore, this study has made a point that market-based indicators be used to evaluate urban sustainability through measurement of environmental disamenity caused by pollution. Specifically, property price-based spatial index of environmental disamenity can be constructed and used as an indicator of the level of urban sustainability. Neighbourhoods with large effects of environmental pollution on residential values, for example, can be marked as unsustainable living areas or grounds of property value loss.

If this index is accepted in the environmental management, it will become an important environmental indicator that relays a meaningful signal into the property market.

6. ACKNOWLEDGEMENT

We are grateful to Nadila Hamidi and Shamree Liew who have provided the data for the study.

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