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ESTIMATING THE ECONOMIC VALUES OF URBAN ENVIRONMENTAL AMENITIES AND DISAMENITIES THROUGH RESIDENTIAL PROPERTY PRICES: EVIDENCE FROM WESTERN PESHAWAR, PAKISTAN

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ABSTRACT

This study examines how environmental amenities and disamenities are capitalized into residential property values in western Peshawar, Pakistan, using the hedonic pricing method (HPM). The analysis is based on transaction records of 338 residential properties and considers their structural, neighborhood, locational, and environmental characteristics. Given evidence of spatial dependence in residential property prices, a spatial lag specification is employed to account for interactions among geographically neighboring properties. The results indicate that structural characteristics, including house age, number of bedrooms, guestroom availability, and green open space, are positively associated with residential property values. Similarly, good street conditions and corner locations exhibit positive and statistically significant relationships with house prices. Among the environmental attributes, greater distance from a polluted stream is positively associated with property values, suggesting that proximity to polluted waterways represents a residential disamenity. Access to recreational sites also exhibits a positive and statistically significant association with house prices. The estimated spatial dependence parameter is positive and statistically significant, highlighting the importance of accounting for spatial interactions in urban housing markets. These findings emphasize the economic significance of environmental quality and recreational amenities in residential property markets and provide evidence to support urban policies aimed at controlling industrial pollution, rehabilitating polluted waterways, improving land-use planning, and expanding recreational green spaces.

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Introduction

Some goods we consume can be viewed as bundles of attributes. For example, houses have distinguishing attributes such as floor area, number of bedrooms, location, and environmental characteristics. Variations in these attributes result in differences in house prices within a market. The hedonic pricing method (HPM) for non-market valuation uses housing market transactions to estimate the implicit values of environmental amenities. Consumers' choices of housing locations and the associated environmental amenities are observable. The choice of a house and its associated price reflects an implicit choice over the environmental amenities associated with that house and their corresponding implicit prices. This study aims to model house prices in western Peshawar, focusing primarily on their physical, neighborhood, and environmental attributes, particularly air and drinking water quality. Several studies have employed the hedonic pricing method to estimate the implicit economic values of property characteristics and environmental attributes. Important contributions include Boyle and Kiel (2001), Palmquist (1999, 2005), and Smith and Huang (1993), who reviewed and examined the application of hedonic models in environmental and property valuation. Empirical applications have also examined the effects of environmental disamenities, particularly proximity to landfills and waste disposal sites, on residential property values (Nelson et al., 1992; Reichert et al., 1992). However, such studies are relatively rare in Pakistan. Understanding society's preferences and willingness to pay for urban environmental amenities can help improve urban residential planning and development.

Peshawar is the capital city of Khyber Pakhtunkhwa Province, Pakistan. Over recent decades, rapid population growth and urbanization have increased pressure on the city's housing and land resources. The expansion of built-up areas has contributed to the conversion of agricultural land into residential and other urban uses, particularly through unplanned urban sprawl and ribbon development (Samiullah et al., 2019). These developments, combined with inadequate urban planning, have created challenges relating to environmental quality, infrastructure, and access to basic services.

Hayatabad Industrial Estate (HIE), located in western Peshawar, is an important industrial centre comprising numerous manufacturing units. Industrial activities in the estate generate wastewater containing different physical, chemical and potentially toxic contaminants. Research conducted at HIE has documented industrial effluent pollution and inadequate wastewater treatment, with the existing treatment facility demonstrating limited effectiveness in reducing several pollution parameters to the prescribed National Environmental Quality Standards (Rehman et al., 2016). Similarly, Khan et al. (2023) investigated industrial wastewater, sludge, and vegetation around the estate's drainage channels and identified cadmium contamination exceeding permissible limits for irrigation water. Industrial wastewater discharged into drainage channels and nearby freshwater systems can consequently pose risks to aquatic ecosystems, agricultural resources, and communities dependent on these water sources. In Pakistan, the deterioration of surface and groundwater quality due to industrial and municipal effluents has been identified as an important public health concern (Azizullah et al., 2011).

HPM provides an important economic tool for identifying and quantifying the environmental costs imposed on third parties through negative externalities associated with urbanization and industrial activities. Environmental pollution, including poor air and water quality, unpleasant odors, and limited access to recreational amenities, can reduce residential desirability and property values, imposing economic costs on nearby households that are not necessarily reflected in market transactions or industrial production costs. By examining variations in house prices in relation to environmental and neighborhood characteristics, HPM helps estimate the implicit monetary values of environmental disamenities. Such evidence is particularly important for informing pollution control policies, environmental regulation, and urban planning in developing cities such as Peshawar.

Methodology

Data Collection

This study was conducted in Western Peshawar, Khyber Pakhtunkhwa (Figure-1). In Western Peshawar, the main human settlements include Hayatabad, Nasir Bagh, Canal Town, and Palosai, where air and water pollution are major environmental concerns. These areas are drained by the Hayatabad Stream, an important tributary of the Kabul River. The stream is formed by the confluence of the eastern and western Hayatabad streams, which originate on the northern and southern slopes of the Bara Hills, respectively. Most industries in the Hayatabad Industrial Estate lack wastewater treatment facilities, resulting in the direct discharge of untreated industrial effluents into the stream. These pollutants eventually reach the Kabul River, an important source of water for drinking, irrigation, fish farming, and other industrial and municipal uses.

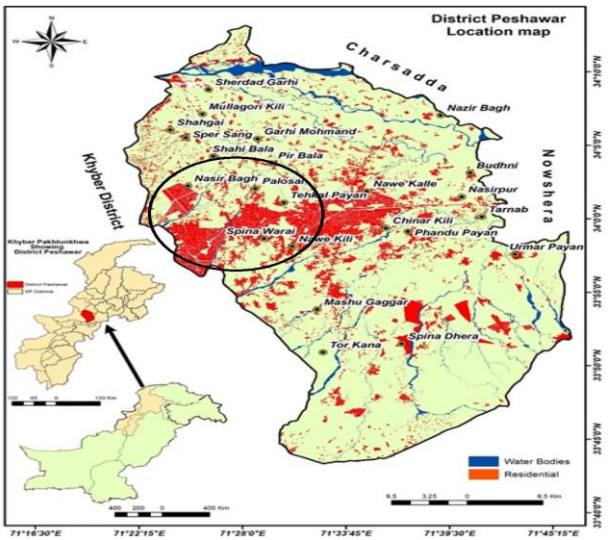


Figure 1. District Peshawar (Adopted from Ahmad et al., 2021)

Documented sale records of 338 houses sold since 2016 in Hayatabad, Nasir Bagh, Canal Town, and Palosai were obtained from local property dealers. Information on the structural, locational, neighborhood and environmental characteristics of the selected houses was collected from property dealers and community members.

House prices recorded in different years were adjusted to constant prices using the Consumer Price Index (CPI), with the latest study year (2025) serving as the base year. Historical transaction prices were multiplied by the ratio of the CPI in the base year to the CPI in the respective transaction year to obtain inflation-adjusted house prices.

Econometric Analysis

As HPM assumes that the market price of a residential property reflects the combined value of its structural, neighborhood, locational, and environmental characteristics, accordingly, the house prices were specified as a function of these attributes. Mathematically, it can take several forms, including linear, semi-log, double-log, and quadratic specifications. Based on Box–Cox test, the following linear function was finalized for this study:

$$P = X\beta + \varepsilon \dots \dots (1)$$

Where:

- P: house price per marla (272.25 square feet).
- X: a set of structural, locational and environmental characteristics of a house
- β: coefficient of X, showing marginal contribution of an individual property characteristic to residential price, holding other included characteristics constant.

Ordinary least squares (OLS) was initially employed to estimate the Linear HPM. Post-estimation diagnostic tests were later conducted to examine multicollinearity, heteroscedasticity and spatial dependence. The mean variance inflation factor (VIF) was used to assess multicollinearity, while the White test was applied to examine heteroscedasticity. Spatial dependence was investigated using Lagrange Multiplier (LM) diagnostics, including the robust LM-lag and robust LM-error tests.

The diagnostic results provided evidence of spatial lag dependence in residential property prices. Consequently, the spatial lag hedonic pricing specification (SL-HPM) was employed to account for spatial interactions among neighboring properties. The spatial lag model incorporated a spatially weighted dependent variable to capture the influence of neighboring property prices on individual residential property values.

$$P = \rho WP + X\beta + \varepsilon \dots \dots \dots (2)$$

Where:

- WP: Spatially weighted neighboring house prices per marla.
- ρ (rho) : Spatial lag coefficient, measures the extent of spatial dependence in the housing market

Results and Discussions

Summary statistics

Table 1 presents the descriptive statistics of the structural, neighborhood, and environmental characteristics of the selected houses, along with their prices per marla.

The structural attributes included house age, number of bedrooms, availability of a guest room, kitchen size, attached bathrooms, and green open space within the house. Neighborhood characteristics included the location of the selected house within the street, street conditions, and average house size in the neighborhood. Environmental characteristics included the distance from the polluted stream and proximity to recreational sites. Distance from the polluted stream was used as a proxy for exposure to air and groundwater pollution associated with industrial effluents. It was assumed that houses located closer to the polluted stream experience greater exposure to pollution than those located farther away.

The descriptive statistics indicate that the average house size in the study area was 8.5 marlas, with an average price of Rs. 1000000 per marla. Of the sampled houses, 45 percent were less than 10 years old, 67 percent had more than three bedrooms and 63 percent had a guest room. Furthermore, 26 percent had large-sized kitchens, 63 percent had attached bathrooms and 42 percent had green open spaces.

Regarding neighborhood characteristics, 10 percent of the sampled houses were located on corner plots, while 75 percent were situated on streets with good conditions, characterized by a minimum width of 12 feet and properly constructed drainage and street-lighting systems. The average house size in the sampled neighborhoods was approximately 7.16 marlas.

The environmental characteristics indicate that the sampled houses were, on average, located 349 meters from the polluted stream. Furthermore, only 24 percent of the houses were within a 30-minute walking distance of recreational sites, indicating relatively limited access to nearby recreational facilities.

Table 1 Summary Statistics

Variables	Mean	Std. Dev.
House price per marla	1000000	557210
House age	0.45	0.49
Bedroom	0.67	0.47
Attach bathroom	0.63	0.48

Guestroom	0.63	0.48
Green open space	0.42	0.49
Kitchen size	0.26	0.44
Neigh, average house size	7.16	3.90
Street condition	0.75	0.43
Corner plot	0.10	0.31
Distance to pollution (stream)	349.27	193.41
Distance to recreation site	0.24	0.43

Source: Survey data

Diagnostic tests

Ordinary least square (OLS) estimation approach is used to estimate the linear HPM (model –1) . Before using the estimated results for policy recommendations, post estimation diagnostic tests were conducted.

The diagnostic test results presented in Table 2 indicated that the estimated HPM does not suffer from serious multicollinearity, as the mean Variance Inflation Factor (VIF) is 1.54. However, the White test indicated the presence of heteroscedasticity, with chi-square statistics of 98.66 (p = 0.0027). Since the p-value is below the 5% significance level, the null hypothesis of constant error variance was rejected. Consequently, heteroscedasticity-robust standard errors was an option for getting reliable statistical results. Furthermore, the spatial LM test results indicated insignificant spatial error dependence but significant spatial lag dependence. This influence of the prices of geographically neighboring properties highlighted the need to account for spatial lag dependence in the final hedonic pricing model. Thus for the correction of spatial lag dependence in HPM, a Spatial Lag Hedonic Pricing Model (SL-HPM) was used instead of using the OLS based HPM with robust standard errors.

Table 2: Post estimation diagnostic tests

Problems	Diagnostic test	Results Statistics	P-Value
Multicollinearity	VIF	Mean: 1.54	-
Hetroscedasticity	White Test	$\chi 2 = 98.66$	0.0027
Spatial error dependence	Lagrange Multiplier	LM= 7.503	0.006
	Robust Lagrange multiplier	RLM = 0.251	0.617
Spatial lag dependence	Lagrange Multiplier	LM = 17.015	0.000
	Robust Lagrange multiplier	RLM = 9.762	0.002

Source: Survey data

Estimated Hedonic Pricing Model (Spatial Lag Model)

The spatial lag hedonic pricing model indicates that residential property values are significantly influenced by structural, neighborhood and environmental characteristics. Among the physical attributes, houses less than ten years old command approximately 20.76% higher prices, while properties with three or more bedrooms and a guestroom are associated with 15.68% and 18.36% higher prices, respectively. Similarly, the presence of green open space is associated with a 20.32% increase in property values. In contrast, houses with larger kitchens and attached bathrooms have insignificant effects. Regarding neighborhood characteristics, good street conditions and corner plots are associated with approximately 15.43% and 20.13% higher property prices, respectively. Although average neighborhood house size exhibits a positive elasticity of 0.051, its effect is statistically insignificant, suggesting limited evidence of an independent relationship with residential property values.

Environmental characteristics also play an important role in determining residential property prices. The elasticity of distance from the polluted stream is estimated at 0.206, indicating that a 1% increase in distance from the stream is associated with approximately 0.206% higher house prices. This finding suggests that households capitalize the adverse effects of stream pollution and associated environmental disamenities into residential property values. Furthermore, properties located within walking distance of recreational sites command approximately 60.12% higher prices, highlighting the capitalization of recreational amenities into housing values. Importantly, the spatial lag coefficient ($\rho = 0.90$) is positive and statistically significant ($p < 0.001$), indicating substantial spatial dependence in residential property prices. This suggests that property values are geographically interconnected, potentially reflecting neighborhood-level similarities in infrastructure, environmental quality, accessibility and socioeconomic characteristics. The high spatial dependence further justifies the use of a spatial lag specification rather than relying exclusively on a conventional hedonic pricing model.

Table 3 Estimated SL-HPM

Explanatory Variables	Linear Model		t stat.	P value
	Coef.	Elasticity		
Physical Characteristics	207574.3	20.76%	4.4	0.000
House age (1 if less than 10 years, 0 otherwise)				
Bedroom (1 if 3 or more, 0 otherwise)	156776.1	15.68%	2.5	0.011
Attach bathroom (1 if yes, 0 otherwise)	-20083.9	-2.01%	-0.6	0.550
Guestroom (1 if yes, 0 otherwise)	183583.3	18.36%	2.8	0.005
Green open space (1 if yeas, 0 otherwise)	203210.0	20.32%	3.3	0.001

Kitchen size (1 if large, 0 otherwise)	-100271.0	-10.03%	-1.5	0.144
Neighborhood characteristics	6381.0	0.051% per 1% increase	0.9	0.362
Neigh, average house size (marlas)				
Street condition (1 if good, 0 otherwise)	154301.2	15.43%	2.8	0.006
Corner plot (1 if yes, 0 otherwise)	201313.1	20.13%	2.7	0.007
Environmental characteristics	590.0	0.206% per 1% increase	4.1	0.000
Distance to polluted stream (in meters)				
Distance to recreation site (1 if within walking distance, 0 otherwise)	601200.0	60.12%	10.0	0.000
Constant	863430.5	-	3.6	0.000
Rho	0.9	-	3.9	0.000

Conclusion and Policy Recommendations

The findings demonstrate that residential property prices are significantly influenced by structural, neighborhood and environmental characteristics. Housing attributes, including the number of bedrooms, guestroom, green open space and house age, positively influence property values, while neighborhood infrastructure, particularly street conditions and corner locations, also contributes to higher prices. Importantly, environmental amenities, particularly proximity to recreational green spaces, enhance residential property values, whereas greater distance from polluted streams is associated with higher prices, highlighting the negative capitalization of environmental disamenities in the housing market.

The findings highlight the importance of integrating environmental considerations into urban planning and development policies. Government authorities should strengthen environmental regulations, improve industrial pollution monitoring and promote the adoption of cleaner production and pollution-control technologies. Effective land-use planning should ensure appropriate separation between industrial activities, polluted waterways and residential settlements. Furthermore, investment in wastewater treatment, stream rehabilitation, urban green spaces and recreational facilities should be prioritized. These measures can improve environmental quality, enhance public well-being and promote sustainable urban development while potentially increasing residential property values

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