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Localized Environmental Pricing of Noise Pollution in Iran

Fariba Amini[1] | **Abdolreza Karbassi**[2]✉ | **Mohammad Javad Amiri**[3]

1. Department of Environmental Planning, Aras International Campus, University of Tehran, P.O.Box 1417673133, Aras, Iran
2. Department of Environmental Engineering, Graduate Faculty of Environment, University of Tehran, Tehran, Iran
3. Department of Environmental Planning, Management & Education, Graduate Faculty of Environment, University of Tehran, Tehran, Iran

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ABSTRACT

Noise pollution has detrimental negative externalities which Scholars have attempted to evaluate the noise externalities economically, but environmental pricing has not been considerably applied to assess economically noise pollution. The present research aims to quantify the economic cost of noise pollution using the environmental pricing framework proposed by the Delft University. To realize environmental pricing frameworks, this study estimates the costs of noise pollution in the area of Tehran metropolitan. The study attempts to apply the environmental prices framework to local conditions with the assistance of GDP and Gini coefficient. The results demonstrate that the Localized Environmental Prices (LEP) mechanism is capable of internalizing environmental prices. The research indicates that LEP demonstrates the significance of noise pollution necessity to reduction. The results of present investigation show that the sum of environmental prices for noise pollution at Tehran is 56271911 €/year. It also offers a useful foundation for planners and policymakers to make more rational decisions.

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INTRODUCTION

Noise pollution is becoming a critical issue due to urbanization and industrialization. Noise pollution can generate costs to human health by causing stress, sleep disorders, and cardiovascular problems due to constant exposure to high noise levels (Hammer et al., 2014; Thompson et al., 2022; Xu et al., 2020). Swinburn et al. (2015) estimated that a mere 5-dB reduction in noise would result in approximately $3.9 billion in economic benefits annually in the US. Furthermore, noise pollution has a detrimental impact on the environment. Disturbance of echolocation (Bunkley et al., 2015; Francis et al., 2012), disrupted communication between animals (Duquette et al., 2021; Rosa & Koper, 2018), and habitat degradation (Madadi et al., 2017; Ware et al., 2015) are some of the significant impacts.

Naturally, the negative impacts of noise pollution imposes various costs on nature, human

*Corresponding Author Email: *akarbasi@ut.ac.ir*

life, and social well-being. As a result, scholars have attempted to evaluate the costs of noise pollution using different methods. The main widely used methods are hedonic pricing (HP) (Friedt & Cohen, 2021), contingent valuation (CV) (Kim et al., 2019; Ma et al., 2021), and willingness to pay (WTP) to mitigate noise pollution (Mouter et al., 2019). All studies indicate that noise pollution imposes different kinds of costs on society (Hauptvogel et al., 2021). For instance, prolonged exposure to loud noises can cause a variety of health concerns, including heart problems, hearing loss, and elevated stress levels (World-Health-Organization, 2011). Evans and Johnson (2000) claim that disclosing noise distractions lowers productivity and raises employee errors. According to Navrud (2002), various estimates place the noise cost at between 00.02 and 2.27% of GDP, and the loss of property prices at between 0.21 and 1.7 percent per decibel. As a result, monetary valuation of noise pollution could act as an effective tool to assess and manage the effects of noise pollution. In addition to the mentioned methods, environmental pricing has been developed alongside other common methods (Aravena et al., 2012; Ding et al., 2015; Zhong et al., 2020).

According to the studies on noise pollution, scholars utilized environmental pricing in various disciplines. Szczepańska et al. (2020) investigate the influences of noise pollution on real estate prices. They identified a negative relationship between the real estate market and sources of noise. This is a subject which is confirmed by scholars (Le Boennec & Salladarré, 2017; Marmolejo Duarte & González Tamez, 2009; Zambrano-Monserrate & Ruano, 2019). These studies indicate that internalizing the cost of noise into market mechanisms could incentivize polluters to reduce noise levels and create quieter, healthier environments.

Ezcurra (2018) attempts to depict the current state of noise pollution and assesses the role of environmental taxation in reducing it. Łowicki and Piotrowsk (2015) evaluated noise pollution using the hedonic pricing method. They revealed that areas with higher noise pollution, especially at night, are more affordable than other areas. Zambrano-Monserrate and Ruano (2019) investigate the relationship between the increase in noise levels (dB) and the decrease in rental prices. The rate is approximately 1.97% per each dB. A study has shown that the relocation of the airport has led to an increase in residential apartments prices (Zheng et al., 2020). Milne (2019) indicates the use of environmental pricing to regulate noise pollution in the changing digital era. Baranzini et al. (2021) proposed a road pricing scheme. Despite considering noise pollution alongside other factors, they did not develop a specific framework for pricing noise pollution.

Gillen (2003) considers the impact of noise in various sectors and its cost to society. He aims to establish a framework for quantifying the economic costs of noise pollution in order to address and reduce its impact. According to Iglesias Merchan et al. (2014), they investigated the impact of nuisance in the study area and utilized the contingent valuation method to assess the willingness to pay to mitigate noise pollution. The study estimated that visitors are willing to pay 1 € for noise reduction upon entrance. Another study by Ma et al, (2021) demonstrated that willingness to pay is influenced by annoyance rate, age, income, and the noise mitigation technique. The residents' willingness to pay increased non-linearly with noise exposure level.

The literature review reveals that noise pollution has different impacts, and scholars have attempted to evaluate the economic cost of noise pollution. They apply different methods such as the contingent valuation method, willingness to pay, evaluating the pricing impact in adjacent areas, and hedonic pricing. Although many researchers attempt to consider different forms of noise pollution pricing, environmental pricing is less considered. The objective of this study is to estimate the costs of noise pollution through environmental pricing. As a result, we investigate the nuisance level in a metropolitan area. This study aims to explore environmental pricing frameworks in the area of study, and ultimately estimate the costs.

MATERIALS AND METHODS

The focus area of this study is Tehran, the capital city of Iran, which is commonly referred to as Tehran metropolitan. Located between longitude 51° 04' and 51° 36' and latitude 35° 33' and 35° 49', in terms of geographical coordinate system. The city's elevation ranges from 1030 meters to 1890 meters above sea level, with a Mediterranean climate according to the Köppen climate classification (Rubel & Kottek, 2010). Tehran receives approximately 230 millimeters of rainfall annually, which can vary over time. At the time of the study, the population of Tehran was approximately 9 million people, living over an area of 751 square kilometers. The city experiences approximately 20.26 million trips/ day (Municipality-of-Tehran, 2023), Where personal cars are the primary mode of transportation and contribute significantly to noise pollution (Figure 1).

This research is quantitative in nature and aims to calculate the pricing of noise pollution in Tehran. To achieve this, we have followed a specific set of procedures. Initially, we used the noise pollution price data calculated by Delft University (De Bruyn, Ahdour et al., 2018) as a basis for further calculation. This data provides three types of prices: at pollutant level, at midpoint level, and at endpoint level. At the pollutant level, it refers to the value of the emissions of compounds that harm the environment at the polluting level. At the midpoint level, it refers to the value for environmental issues like acidification or climate change, and at the endpoint level, it focuses on the value representing the effects of environmental pollution, such as harm to ecosystem services or human health (De Bruyn, Ahdour et al., 2018).

The CE Delft Environmental Prices Handbook aims to harmonize the values at the pollutant, midpoint, and endpoint levels to achieve a consistent valuation of environmental consequences in the form of environmental pricing. The second phase involves determining the sensitivity level of the area to determine the price base level. As population density increases in a city, ecological sensitivity also intensifies, leading to an increase in environmental damage. Therefore, there is a direct effect between ecological sensitivity and population density on the amount of damage. Consequently, we have selected endpoint levels as our basis for further calculation.

The third step involves localizing prices due to differences in prices and income levels between countries based on economic experts' opinions. Therefore, we determined the base price announced in the European Union. Due to the fact that willingness to pay is a function of a country's economic situation and its national economy as a whole, we considered Gross Domestic Product (GDP) as a localization index and calculated its ratio to European GDP using equation number 1.

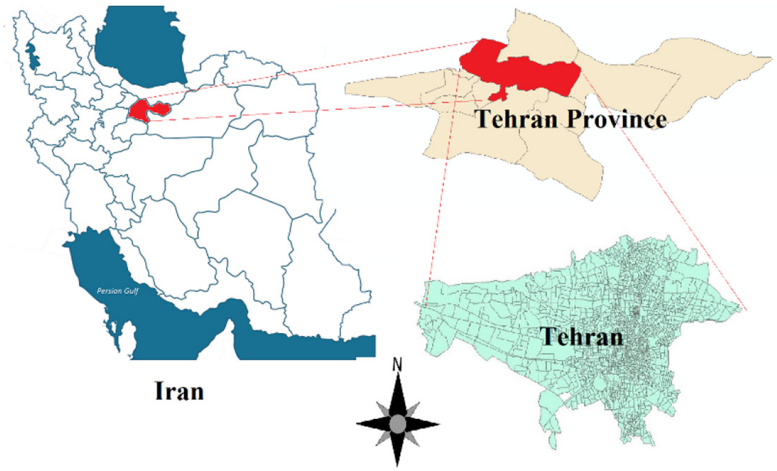

Fig. 1. Area of study in the present investigation

IE = (EU GDP / IGD) (1)

IE = The ratio of Iranian GDP in comparison with European Union GDP
EUGDP = European Union Gross Domestic Product
IGD = Iranian Gross Domestic Product

The GDP index alone does not indicate economic situations because of unbalanced income distribution among different social groups in society. Therefore, we need a secondary index that reflects the effect of unbalanced distribution on pricing. For this purpose, we considered the Gini coefficient as a second index. Based on equation number 2, we have included its effect in pricing.

$$\text{LEP} = \frac{\text{Noise Environmental Price}}{(\text{EU GDP} / \text{IGDP})} * (1 - \text{Gini Ratio}) \quad (2)$$

LEP = Localized Environmental Price
EUGDP = European Union Gross Domestic Product
IGDP = Iranian Gross Domestic Product.

The final step involves providing noise pollution data. Average noise pollution is calculated per month in each city district using noise pollution data obtained from 35 noise control stations in Tehran.

RESULTS AND DISCUSSION

Environmental pricing refers to the monetary value assigned to environmental pollution based on its impact on society. The Delft University of Technology has developed an index that quantifies this cost in €/kg (in this article €/dB) of pollutant (De Bruyn, Ahdour et al., 2018), which is measured. Environmental pollution, specifically noise, imposes different costs on society, and these basic measured costs are outlined in Table 1. For the purposes of this research, these costs serve as a fundamental basis for further investigation.

The objective of this research is to localize noise environmental prices (LEP) for Tehran metropolitan. While the LEP is presented in € and calculated for European countries, localization prices for Iran are required. To achieve this, GDP and Gini coefficient are assumed as two main factors for modifying prices for local use (refer to the Methodology section). Consequently, the ratio of Europe's gross domestic income to Iran's gross domestic income should be calculated based on equation 1 and Table 1, respectively.

The ratio of Eurpean Union GDP to Iran GDP is calculated as 8.47 (World Bank, 2023). Then, the noise pollution price calculated in Table 2 is divided by 8.47 to calculate the estimated price of Europe based on Iran's gross income. At this stage, the Gini coefficient is used, which is an expression of fair distribution of wealth at the societal level. According to the Iranian Statistics Center (2022), the Gini coefficient is approximately 0.38 (Table 2) (Iran-Statistics-Center, 2022). The next step is localizing the environmental prices, which is carried out in Table 3.

Table 1. Environmental prices for road-traffic noise nuisance (€2015/dB (Lden)/person /year; De Bruyn, Ahdour et al., 2018)

Noise nuisance	Lower	Central	Upper
50-54 dB(A)	18	22	27
55-59 dB(A)	36	42	50
60-64 dB(A)	38	45	56
65-69 dB(A)	69	83	101
70-74 dB(A)	73	87	108
75-79 dB(A)	77	92	116
80>= dB(A)	78	95	120

$$LEP=\frac{\text{Noise Environmental Price}}{(\text{EU GDP / IGDP})} * (1-\text{Gini Ratio})$$

$$LEP=\frac{\text{Noise Environmental Price}}{(8.47)} * (1-0.38)$$

The suggested framework of environmental prices offers a seven-level environmental price systemfor noise pollution caused by road traffic which is the basis for further LEP estimation. The lowest LEP refers to a range of 50-54 dB noise pollution, while the highest levels belong to a range of 80 dB and above. The amount of LEP for the lowest level is approximately 1.96 €/capita annually, and the estimated LEP for 80 dB and above is approximately 8.78 €/capita annually (Table 3).

To calculate the total LEP, we need to consider two main factors: first, the annual average noise pollution in the city, and second, the population in the study area. In this regard, we obtained the annual average noise pollution from the municipality of the study area, which is depicted in Figure 2. The noise pollution in Tehran shows a spatial variability. While the

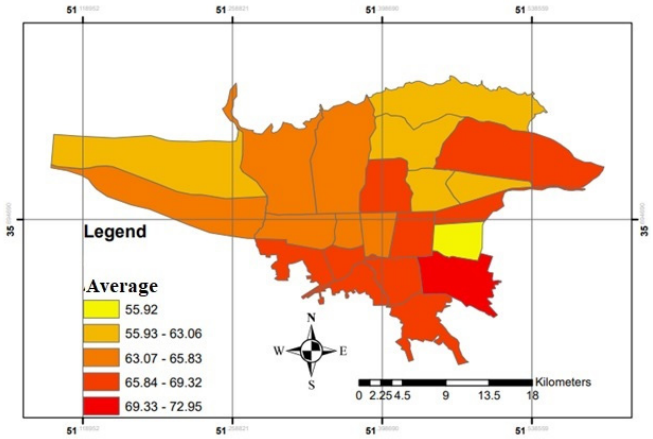

Fig. 2. Annual average of noise pollution in (dB) across the municipality districts of Tehran 2022. (Municipality-of-Tehran, 2023)

Table 2. The GDP and Gini coefficient data

Parameters	Year 2022 (US$)
EU GDP/ capita	37149.6086
Iranian GDP /capita	4387.82572
Gini coefficient for Iran	0.3877

(Iran-Statistics-Center, 2023; World-Bank, 2023)

Table 3. Estimated basic LEP for road traffic (high sensitivity and in €/dB interval/ person) for Iran

Noise nuisance (dB)	Endpoint level (€)	LEP(€)
50-54	27	1.96
55-59	50	3.6599
60-64	56	4.099
65-69	101	7.39
70-74	108	7.90
75-79	116	8.49
80>=	120	8.78

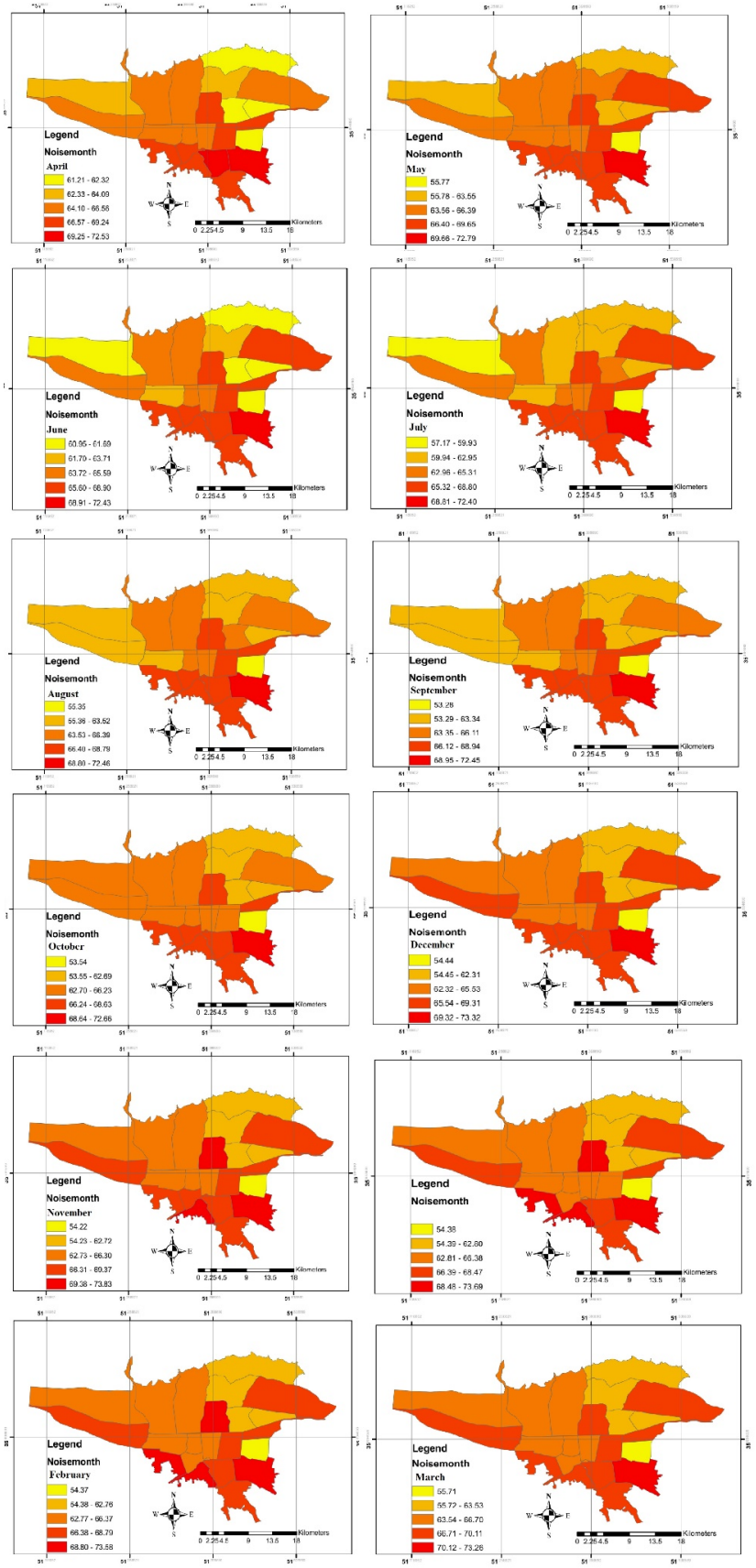

Fig. 3. Monthly noise pollution level in dB across the municipality districts of Tehran 2022 (Municipality-of-Tehran, 2023)

southeast part of the area experiences more noise pollution, the northwest part is relatively calm (Fig. 2). It is worth mentioning that variety of factors influence the noise spatial variability such as: urban density, land use, the main function of area, and concentration of access network.

It is evident that noise pollution also exhibits temporal variability. Figure 3 illustrates the temporal noise pollution in different months of the year. The noise pollution depends on the behavior patterns of people which are influenced by a variety of factors. For example at the beginning of the school season (in September) or the preparations for the new Iranian year in March, the urban traffic increases significantly which has direct impact on noise pollution. The results indicate that noise pollution does not follow a fixed pattern; however, in general, the southeast region is noisier compared to the northwest region, which experiences less noise pollution.

The second factor required for calculating LEP is the population. As a result, the estimation of the population for 2022 is being considered in Tehran (Municipality-of-Tehran, 2023), which is based on the national census conducted in 2016. Due to the rapid growth of Tehran's population (Sharifi & Hosseingholizadeh, 2019; Talkhabi et al., 2022), the data from 2016 cannot be assumed as a reliable base for further calculations, so we consider the latest population estimate for further calculations. The population of Tehran in 2022 was approximately 9,031,762. District 9 is the least populated district in Tehran, while District 4 is the most populated district (Figure 4).

The calculated LEP for Tehran is approximately €56,271,910.96. The cost of noise pollution in Tehran, is approximately €6.20/capita/year, but it is not evenly distributed throughout the city, While the LEP in District 9 is approximately €782,060, it is approximately €7,109,719.47 in District 4 (Table 4).

The results revealed that the mechanism of LEP is able to internalize environmental price signals. This outcome is consistent with the findings of Neitzel et al. (2017) and Yao et al. (2021). Exposure to environmental noise has different negative impacts, as highlighted by Hammer et al. (2014). These impacts can impose economic costs on individuals and society (Farooqi et al., 2022). Swinburn et al. (2015) demonstrated that reducing noise levels would result in annual economic benefits of $3.9 billion in the US. This outcome aligns with the findings of this research. Navrud (2002) mentioned that the noise cost ranges from 0.02 to 2.27% of GDP. The calculated modified noise pollution cost in this research is approximately 0.14% of GDP.

As Getzenr and Zak (2012) state, noise pollution has negative economic impacts, which various scholars have attempted to quantify. However, LEP provides a more straightforward

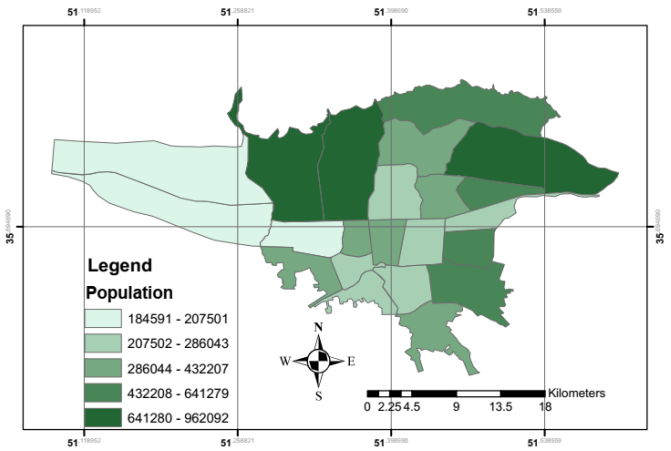

Fig. 4. Distribution of population across the Tehran municipality districts 2022 (Municipality-of-Tehran, 2023)

Table 4. Environmental prices for road traffic nuisance (€/dB (Lden) person/year) estimated based on the average noise pollution in Tehran in 2022

Districts	Noise Pollution (dB)	Pollution price/ capita (€)	Population (2020)	Total LEP (€)
1	62	4.099	543311	2227031.789
2	65.05	7.39	743408	5493785.12
3	63.04	4.099	352155	1443483.345
4	66.75	7.39	962073	7109719.47
5	64.93	4.099	905056	3709824.544
6	69.32	7.39	271107	2003480.73
7	61.13	4.099	313115	1283458.385
8	61.09	4.099	474056	1943155.544
9	64.54	4.099	190793	782060.507
10	65.185	7.39	337883	2496955.37
11	65.83	7.39	318082	2350625.98
12	67.06	7.39	239635	1770902.65
13	67.77	7.39	230645	1704466.55
14	55.85	3.66	512232	1874769.12
15	72.95	7.9	675837	5339112.3
16	68.27	7.39	254409	1880082.51
17	67.04	7.39	312619	2310254.41
18	68.76	7.39	442798	3272277.22
19	68.98	7.39	272472	2013568.08
20	67.34	7.39	387281	2862006.59
21	65.68	7.39	201,952	1492425.28
22	62.9	4.099	221,631	908465.469
Total			9162550	56271910.96

method of valuation for these impacts. It is worth mentioning that environmental pricing has the potential to influence the long-term reduction of noise pollution if it is considered as a policymaking tool. Additionally, by developing a network of systematic noise control and recording using up-to-date and smart technology, the accuracy of outcomes will be increased.

According to an estimate, reducing noise pollution can lead to significant economic benefits, making it a worthwhile endeavor. It is imperative to decrease the noise pollution. Noise reduction will result in a significant decrease in the associated costs.

Additionally, this calculation provides a foundation for urban planners and policymakers to make more informed decisions. In this regard, different strategies such as developing green infrastructures (Pérez et al., 2018; Darabi et al., 2023) and urban parks (Darabi et al., 2018; Tashakkor et al., 2020) are recommended in general to improve the quality of the environment and reduce noise pollution. However, the results suggest that mitigating noise pollution should be prioritized by first, reducing nuisance from the source; second, create appropriate infrastructure to lessen noise of traffic (Attal et al., 2021); and third, utilizing the ecological design principles (Darabi et al., 2022; Darabi H. & Saeedi I., 2013) and nature based solution to create barries and absorbe the noise and reduce the tranformation rate (van den Bosch & Ode Sang, 2017). Furthermore, focus on investigating the causal relationship between noise production and identifying effective factors while considering economic values are the subject of future studies

CONCLUSION

This research focuses on quantifying the economic cost of noise pollution using the environmental pricing framework proposed by Delft University. The objective was to determine whether quantifying the economic cost of noise pollution is capable of assigning prices to noise pollution in the Tehran metropolitan area. The results showed that the LEP mechanism is capable of internalizing environmental prices. The total estimated LEP for Tehran is approximately €56271911 per year. This study found that LEP can be used to assess the economic cost of noise pollution and demonstrate the significance of reducing noise pollution requirements. The research suggests that efforts to reduce noise pollution can lead to considerable economic benefits and provide a rational basis for decision-making by planners and policymakers. Furthermore, the study highlights the negative economic impacts of noise pollution and the need for a straightforward method of valuing these impacts. Examining the proposed procedure in other countries and investigating its effectiveness and comapreing the LEP with social costs are subjects of future studies.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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